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The affordances of innovative learning environments for deep learning: educators' and architects' perceptions

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Abstract
Recent learning environments research conducted in Australasia reports positive correlations between innovative learning environments (ILEs) and students' deep learning. Yet, understandings about *how* ILEs may support teachers' professional practice and students' learning activities are limited, with little research having been conducted into how different spatial affordances may—or may not—enhance opportunities for effective teaching and learning. This study investigated the *affordance for learning* perceptions of educators and architects with respect to the *action possibilities* for deep learning in both ILEs and more traditional classrooms. The study identified a taxonomy of affordances found to enhance opportunities for varied pedagogical approaches. In addition, differences were found between educators' and architects' perceptions of *affordances for learning*, revealing a need to better understand how both groups might learn to recognise and subsequently take advantage of *action possibilities* for deep learning.

Keywords Affordances · Action possibilities · Innovative learning environments (ILEs) · Deep learning

Introduction

New school buildings are generally designed by architects and inhabited by teachers and students—often without extensive consultation between parties. During past decades, the 'stability' of traditionally designed schools, where classrooms predominated as well-understood physical and social structures, meant that designers and educators were able to occupy a comfortable 'middle ground', where both envisaged

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pedagogies based on teacher-focussed instruction and associated spatial arrangements. However, in more recent years, there has been an increasing appetite to enable a wider range of pedagogical approaches than considered possible within traditional classrooms. As architects are not trained educators, nor teachers instructed on how to manipulate the physical environment to support their practices (Newton 2009), such 'disruption' has called into question assumed relationships between space and educational practice and demanded further inquiry into how designers and educators can work together to develop new socio-spatial arrangements.

Innovative learning environments (ILEs) (OECD 2013) may be considered "the product of innovative space designs and innovative teaching and learning practices" (Mahat et al. 2018). These spatio-pedagogical environments deviate from traditional classroom settings through an intention to facilitate a variety of collaborative, participatory, and independent teaching and learning approaches aimed at supporting the development of students' twenty-first century skills (Imms 2016). These new environments extend conventional understandings of school building typologies for both designers and inhabitants.

Adopting Gibson's (1979) ecological approach to perception and affordance theory as methodological tools, this study investigated the ways in which innovative learning environments (ILEs) can be interpreted and productively inhabited by teachers and students. Gibson defined affordances as the *action possibilities* resulting from the relationship between user and environment. He argued that user perception is critical to identifying the action possibilities offered by an environment, and that spatial affordances may lie latent until actualised by individuals.

The specific purpose of the study was to seek insights into *how* spatial affordances may—or may not—enhance opportunities for varied pedagogical practices/approaches, with an emphasis on students' deep learning. The study investigated the *affordance for learning* perceptions of educators and designers. It explored insights into the *action possibilities* for deep learning in both ILEs and more traditional classroom settings. In doing so, the project explored what might be described as spatio-pedagogical 'entanglements' (Ingold 2008), i.e. the interwoven relationships between people, space, and objects that 'grow' and 'move' to become learning environments.

Recent learning environments research conducted in Australasia (Imms et al. 2017) has reported positive correlations between innovative learning environments (ILEs) and students' deep learning (Biggs 1987; Fullan and Langworthy 2013; Kember et al. 2004). Yet, understandings about *how* ILEs may support effective teaching and learning are limited. Whilst ILEs are intended to enable a wider range of pedagogical approaches than traditional classroom environments, they can act as awkward enclosures for conventional teaching practices when teachers are not inclined to proactively engage with and take advantage of these settings (Halpin 2007). To this end, there is little research into ways of supporting teachers to adapt their practices to leverage the opportunities of ILEs and develop effective student-centred teaching approaches (Blackmore et al. 2011).

The research reported was derived from a PhD study positioned within the Innovative Learning Environments and Teacher Change (ILETC) Australian Research Council (ARC) Linkage project. The ILETC project was designed to respond to the significant investments that have been—and are being—made in school facilities/

learning spaces in Australia and New Zealand, with a view to supporting teachers, students, schools and school systems to generate productive ILE ‘entanglements’ (Ingold 2008).

Deep learning

Character education, citizenship, communication, collaboration, critical thinking and problem solving, and creativity and imagination were identified by Fullan and Langworthy (2013) as the central tenets of twenty-first century skills. They linked these skills with deep learning, an established concept in education research literature.

Researchers first referred to ‘surface’ and ‘deep learning’ in the 1970s. Marton and Säljö (1976), for example, aligned surface learning with memorisation and deep learning with an emphasis on understanding and placing meaning in content. Meanwhile, Biggs’ (1970, 1978, 1979) research into students’ study approaches helped establish a consistent language around key terms such as ‘surface’, ‘deep’ and ‘achieving’ (Biggs 1987; Mahat et al. 2018). More recently, Frey et al. (2017) adopted similar terms, where ‘surface’, ‘deep’ and ‘transfer’ referred to the acquisition and consolidation of initial knowledge (surface), interaction with skills and concepts (deep) and organising, synthesising and extending conceptual knowledge (transfer).

Deep learning ‘climates’ are believed to increase students’ sense of purpose, connection to the ‘real world’, and engagement with learning (Fullan et al. 2018). Deeper learning is also thought to build new relationships with and between learners, their family, communities and teachers, and deepen human desire to connect with others to do good—contributing to the development of skills needed to thrive in a modern world (Fullan et al. 2018).

A sensitivity to the key concepts associated with deep learning, including twenty-first century skills development, helped inform the design of this study—towards seeking new understandings about the relationships between ‘space’ and ‘action’ (practice) in schools.

Affordance theory

The concept of affordances provides a useful framework to bridge understandings of ‘space’ and ‘action’ towards an appreciation of spatial environments (Atmodiwirjo 2014). The term affordance was originally coined by environmental psychologist J.J. Gibson in 1979. He defined affordances as action possibilities resulting from the relationships between the user and the environment. He indicated that affordances within the environment exist regardless of whether they are perceived by users or not, but may lie latent until actualised by individuals.

Subsequently, theorists have suggested that not only is perception critical for affordances to be enabled, but cultural contexts influence peoples’ ability to perceive them (Norman 1988; Gaver 1991; McGrenere and Ho 2000; Ingold 2008; Lindberg and Lyytinen 2013; Rietveld and Kiverstein 2014). So, whilst Gibson suggested that learning is not required to perceive an affordance, Gaver (1991) argued that “users interpretations may change and learning processes [may] lead users to pick up successively more ‘effective’ affordances” (Lindberg and Lyytinen 2013).

Heft’s (1988) paper on the affordances of children’s environments illustrated a range of affordances perceived by children that may not be perceived by less able-bodied adults, as well as the benefits of a functional rather than form-based language to describe affordances. He adopted terms like ‘climb-on-able’ to describe features of a tree, a fence or a bench, and ‘sit-on-able’ to highlight the action possibilities of a stone slab, a bench and a stair. He promoted a functional-language approach to defining affordances suggesting that they rely on the combined properties or qualities of the feature and ability of the user to enable them to be ‘climb-on-able’ or ‘sit-on-able’.

Affordance theory has been explored and applied within multiple disciplinary fields. Its application in human–computer interface design (e.g. Tweed 2001; Norman 1988) has been most notable, but the same concepts have also been adopted in architecture (Koutamanis 2006; e.g. Maier et al. 2009; Atmodiwirjo 2014) and interior design (Kim et al. 2007, 2011). Nevertheless, the term affordance is not commonly used, nor generally well-understood in the domains of architecture and interior design, including within school design.

Maier et al. (2009) suggested that the lack of understanding within architectural circles of the concept of affordances relates to the historical separation of form and function dating back to the writings of Vitruvius, who suggested that form (firmitas), function (utilitas) and beauty (venustas) were separate but competing architectural requirements. To this end, Koutamanis suggested that there is a commonly held belief that “the capable architect caters for such aspects [affordances] intuitively” (2006, p. 347). Yet, he commented that architects can also be “insensitive to practical problems that conflict with higher, usually aesthetic norms” (2006, p. 357), resulting in built environments designed in ways that do not entirely reflect user’s needs, nor their affordance (action possibility) requirements.

Affordances for learning

It is posited here that introducing an affordance perspective to the field of school design may create a valuable and meaningful bridge between architectural designers and the inhabitants of learning spaces (i.e. teachers and students), towards creating better spatio-pedagogical settings for teaching and learning. Historically, prominent architects have harboured corresponding opinions. Dutch architect Herman Hertzberger (2008), for instance, promoted the need for architects to better understand the relationships between spatial design and learning. He argued:

> Architecture has unfailingly approached the designing of schools from a less than critical position. All the while, it seems, architects meekly followed their briefs and were mainly concerned with formal aspects of the exterior without busying themselves with spatial opportunities that might lead to better education, and with the role they themselves might fulfil there (Hertzberger 2008).

With this in mind, correlating different perspectives on the relationships between spatial design and the daily practices and activities of teachers and students may begin the critical process of developing a lexicon of affordances (Lindberg and Lyytinen 2013) that architects and people in schools can call upon to better integrate and intertwine space and action.

Methodology

Towards a taxonomy of learning environment affordances

Taking our lead from Gibson's (1979) ecological approach to perception, the initial phase of this study focussed on developing an understanding of the affordances that different architects and educators *see* in learning environments of varied types. Using affordance theory as a methodological tool, the objective was to gain insights into the types of affordances people perceive in learning spaces and develop a taxonomy of learning environment affordances that may be used to direct subsequent phases in this study, as well as learning environment design and research conducted by others.

For the purposes of the project, the following definition of affordance in the context of education spaces was devised: *learning environment affordances are qualities of the environment (space, objects and people) which enable perceived teaching and learning activities and behaviours*.

Site selection

Data were collected from a sample of 30 people, including 20 educators and ten architects, across five sites in Australia and New Zealand. These multiple case study sites (Bryman 2004) included four schools (two primary and two secondary) and one museum learning environment.

The four schools were sampled from a data set collated by the ILETC project via a survey that was undertaken to collect baseline data about the types of learning spaces found in Australian and New Zealand schools and the variety of pedagogical approaches employed within them. The survey received 822 responses from primary and secondary school principals, or their nominated delegate. Respondents were asked to provide their perspectives on the types of learning spaces, teaching approaches, teacher mind frames and the nature of deep learning occurring in their schools. All items for teacher mind frames and student learning were positively worded on a four-point Likert scale, enabling mean values of teacher mind frames and student learning to be calculated for each school (Imms et al. 2017).

Schools that rated highly in the ILETC survey with respect to collaborative learning and team teaching in ILEs and traditional classroom environments were chosen as the focus for this study. The learning spaces at each site were categorised according to Dovey and Fisher's (2014) learning space typologies (A–E)—types A and B being more reflective of traditional classroom spaces, and types D

Fig. 1 Dovey and Fisher 2014. Adapted by Imms et al. (2016) (Illustration P. Soccio)

Table 1 Case study sites

	Primary school	Secondary school	Museum
Traditional	Site 1 Learning space type B	Site 2 Learning space type C	
ILE	Site 3 Learning space type C	Site 4 Learning space type E	Site 5 Learning space type D

and E more reflective of ILEs (refer Fig. 1). Type C spaces represented a ‘middle ground’ that offered traditional or ILE configurations. Whilst a school with type A spaces was not included in the sample, Site 1 was representative of the traditional self-contained classroom typology.

The selection of sites was supported by a telephone census of school principals and museum educators to clarify if their school/museum engaged in interdisciplinary programs, and whether these programs operated in ILE or traditional environments. Refer Table 1 for summary of sites with further description of each site described below.

The museum learning space was selected to gauge if affordances in a non-school context varied from those observed in schools, potentially extending the breadth of the resulting taxonomy of learning environment affordances. The selected museum learning space was designed to support interdisciplinary science, technology, engineering, arts and maths (STEAM) programs for visiting primary and secondary school students. These programs included a focus on collaborative learning activities and team teaching.

Case study sites

Site 1 (primary school learning space) featured three demountable classrooms clustered around a shared covered timber deck (refer Figs. 2, 3, 4). The classroom selected as a focus contained a wet area, with sink, and furniture predominantly comprising two-seater tables and stackable polypropylene chairs.

Site 2 (secondary school learning space) was one of four classrooms arranged around a shared foyer/lounge area. The classrooms were paired, with a retractable wall between. The retractable wall was permanently closed (refer Figs. 5, 6, 7), effectively creating four separate classrooms. Furniture was predominantly two-seater tables and polypropylene chairs.

Site 3 (primary school learning space) was a paired classroom with an opened retractable wall, a small breakout room, well-defined wet areas and a glazed wall to

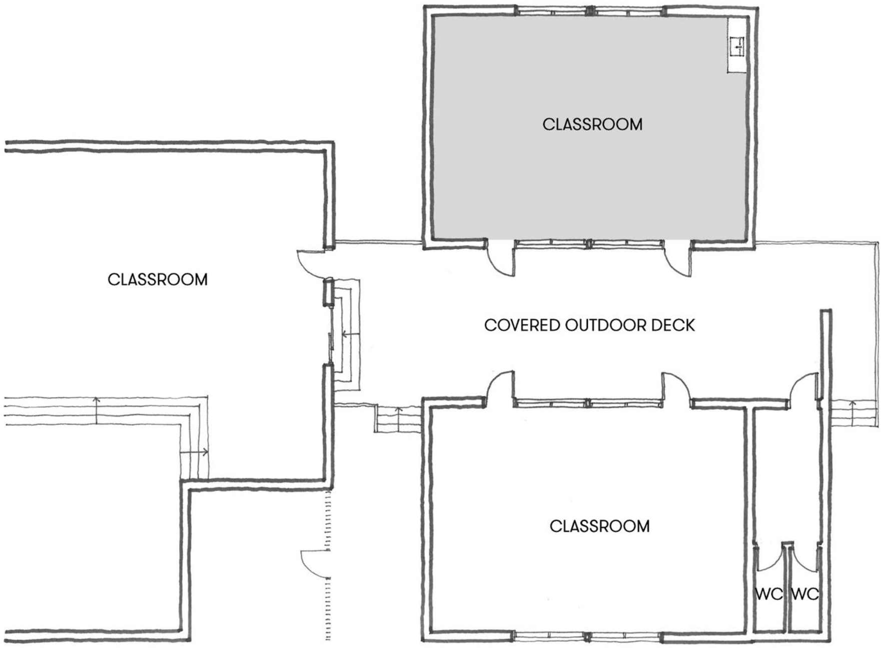

Fig. 2 Plan diagram of Site 1

Fig. 3 Site 1 classroom

Fig. 4 Shared timber deck outside Site 1

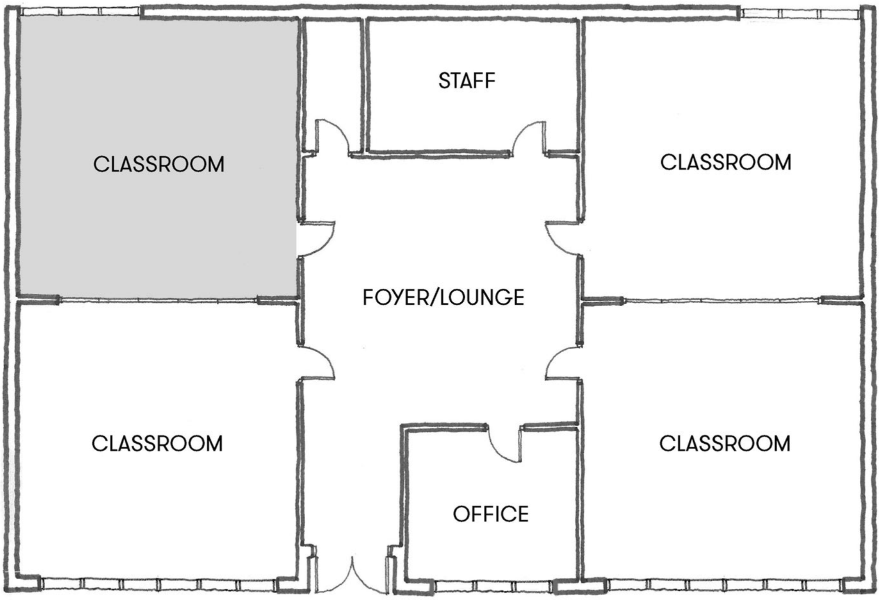

Fig. 5 Plan diagram of Site 2

Fig. 6 Site 2 classroom

Fig. 7 Site 2 foyer/lounge with classroom beyond

a shared walkway (refer Figs. 8, 9, 10). A diverse range of furniture included moveable tables of varied shapes, a range of seating options for individuals and groups, and integrated storage options.

Site 4 (secondary school learning space) was a large open space about the size of two typical classrooms with higher than average ceiling heights (refer Figs. 11, 12, 13). This space was connected to a teachers' workspace and laboratory and comprised a range of moveable tables and varied seating options of different heights and styles.

Site 5 (museum learning space) was an open space approximately the size of two classrooms with a separated 'Makerspace' that containing a wet area and other zones defined by technology resources, e.g. virtual reality space, digital touch tables, 3D printers (refer Figs. 14, 15, 16). There was a range of moveable furniture, extensive accessible storage provision and open floor space (Fig. 15).

Participant selection

Four teachers and two architects participated at each of the five sites (refer Table 2). Teachers were selected in consultation with school principals to reflect three different career stages. Where possible, the teachers at each site represented each of the following career stages:

- Early-stage teacher (0–2 years);

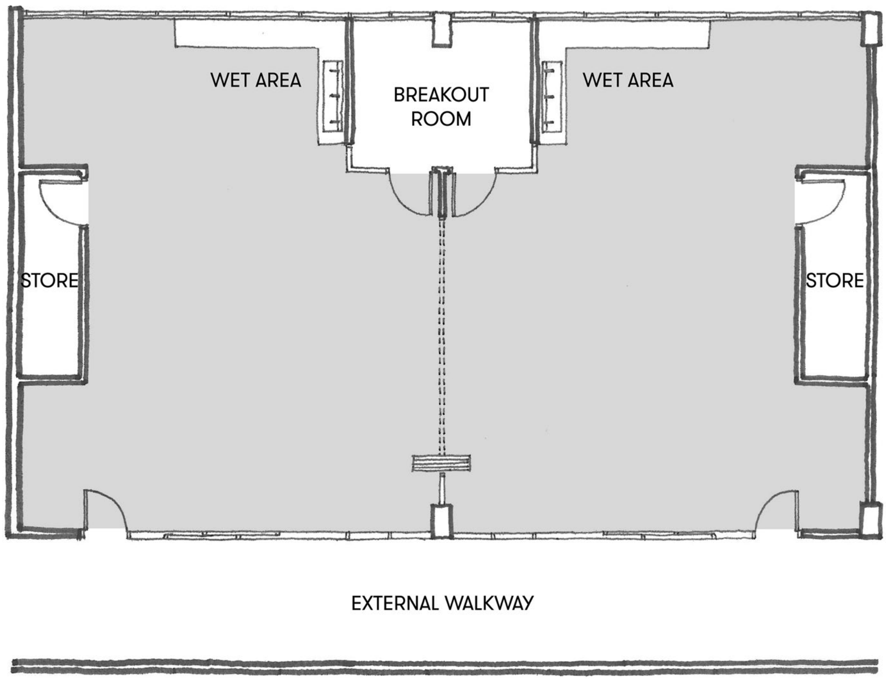

Fig. 8 Plan diagram of Site 3

- Mid-stage teacher (2–7 years); and
- Established teacher (7+ years).

At Site 5 (museum learning space) there were only two teachers who fulfilled these criteria, hence two additional teachers from local schools were sourced to participate via the Learning Environments Australasia professional network association, which includes a New Zealand chapter.

To ensure Architects were well-versed in learning space design, criteria for selection included five or more years of experience working on primary and secondary school building projects. Other desirable selection criteria included:

(a) Involvement in the design of the learning spaces at the case study sites (only relevant to ILE sites 3-5); and
(b) Membership to Learning Environments Australasia (a4le.org.au).

Data collection

At each site, the teachers/educators and architects were invited to participate in an individual interview. These were conducted within the chosen learning spaces (profiled above) whilst not occupied by students. Initially, participants were asked

Fig. 9 Site 3 view towards walkway

Fig. 10 Site 3 view towards breakout room

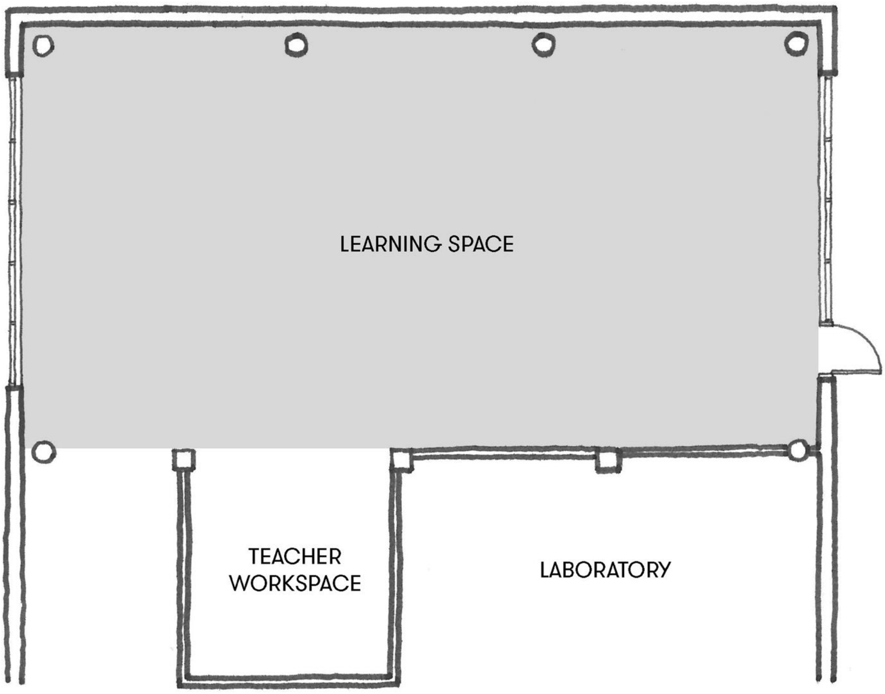

Fig. 11 Plan diagram of Site 4

to describe a) how the space enabled learning activities and b) how the space constrained learning activities. Each participant was given an iPad to photograph the spatial features they perceived to afford learning activities—or not—and their responses were audio recorded. Subsequently, all participants were asked whether any of the features they described specifically supported the following approaches to teaching and learning:

(a) deep learning;
(b) collaborative learning;
(c) team teaching; and
(d) interdisciplinary learning.

Subsequent semi-structured interviews were also conducted with participants over following days in a more formal setting. They were asked (a) to identify additional affordances that could support deep learning that may not have been mentioned during the on-site interview, and (b) to rank a range of affordances for deep learning that had been identified following preliminary analysis of the on-site interviews. The questions asked during the initial on-site interviews and subsequent semi-structured interviews are outlined in Table 3.

Fig. 12 Site 4 learning space

Fig. 13 Site 4 view towards teachers' workspace and laboratory (beyond glazing)

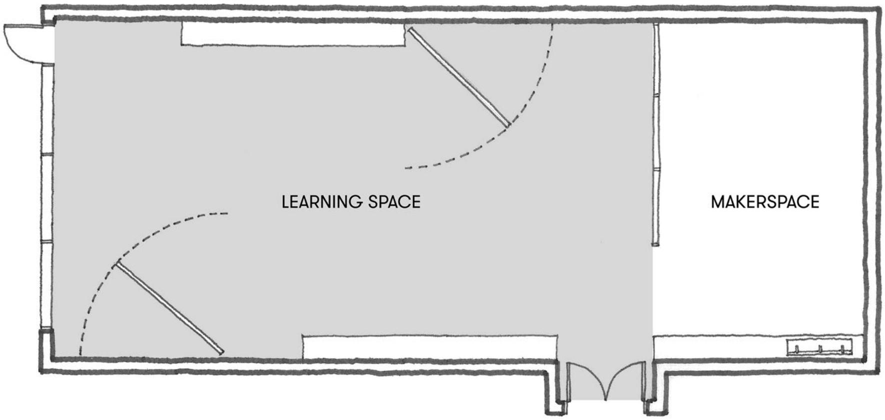

Fig. 14 Plan diagram of Site 5

Fig. 15 Site 5 learning space

Data analysis

All interviews were audio recorded and transcribed. Transcriptions were coded in NVivo using a thematic analysis approach adapted from Braun and Clarke (2006). References to different types of affordances were noted and highlighted. Based on initial coding, data were reduced into themes, defined and named. A series of tables

Fig. 16 Site 5 view towards Makerspace

Table 2 Teacher participants

	Site 1	Site 2	Site 3	Site 4	Site 5
Early-stage (0–2 years)		1	1		1
Mid-stage (2–7 years)	2	1	1	3	2
Established (7+ years)	2	2	2	1	1
Total no. of teachers/site	4	4	4	4	4

and graphs were developed to represent the data. Subsequent model building produced two outputs: (1) a taxonomy of participant-identified affordances, and (2) categories, or groupings, of closely related affordances. The third data source, participant photographs, was used to record the affordances described by participants.

Table 3 Interview questions

On-site interview questions	
1	How can this space be used for learning activities?
2	Of the aspects you described, which do you think best support student deep learning?
3	Of the aspects you described, which do you think best support collaborative learning activities?
4	How do you think this space supports team teaching?
5	How do you think this space supports interdisciplinary learning?
6	How do you think this space constrains learning activities in any way?
Semi-structured interview questions	
1	Can you think of any other elements of the physical environment (either at this school or elsewhere) that you didn't see (or mention) in our on-site observation/interview which you think also support student deep learning?
2	Would you consider there to be a hierarchy of importance of these elements in relation to student deep learning?

Findings and discussion

Categories of affordances

The analysis of interviews with educators and architects from across the multiple case study sites identified three major themes associated with learning environment affordances:

(1) Spaces;
(2) Objects; and
(3) People

Within these thematic groups, 'spaces' refers to spatial qualities with distinguishable 'zones', such as smaller defined areas, large group areas, teacher work area or outdoor learning spaces. It also includes 'finishes and fixtures', such as writeable wall surfaces, retractable walls or curtains, and different types of floor surfaces (timber, carpet, etc.). The thematic grouping of 'objects' refers to more discrete elements such as 'furniture' for sitting, working or storing things, and 'digital technologies', such as computers, tablets and projection screens. The 'people' category refers to other teachers and students, identified by educator participants as affording a variety of teaching and learning opportunities (for details see Table 6 in Appendix).

Higher-level 'parent' affordances were also identified. These typically included clusters of 'nested' affordances (Gaver 1991) that integrated spaces, objects and people. For example, a parent affordance might comprise spaces, such as 'large group areas', 'separable smaller spaces' or 'walls that can be opened and closed', objects, such as 'moveable seating and work surfaces' and 'tablet devices', as well as people, such as peers and teachers. These socio-spatial settings were found to comprise a range of 'nested'—or entangled—affordances from across the three thematic groups such that produced 'a range of different settings to enable different ways to work' or 'spaces that can be changed or used in different ways to suit a range of learning activities'.

General perceptions of educators and architects

The number of affordances perceived by educators and architects varied quite significantly (refer Fig. 17). Architects perceived fewer affordances than educators across all sites. As a group, architects tended to identify higher-order 'parent' affordances, such as different integrated settings, more so than 'nested' affordances, such as wall surfaces that might enable standing collaboration or open floor space that might afford gathering large or small groups. Architect A at Site 1 summarised their perceptions of the learning environment as follows:

> It's pretty typical of most of the classrooms I see. It's an absolutely traditional size and shape. It's a prefab type building. It's got some hard floor for wet areas, the rest of it is soft floor, a bit of technology, a projector. The layout is absolutely standard. (Architect A, Site 1).

By contrast, educators more frequently perceived both 'parent' and 'nested' affordances, exemplifying their more detailed experience of the human actions common to these learning environments. This greater variety of *affordances for learning* was illustrated by Teacher 1 at Site 1 (the same site as described by the architect above):

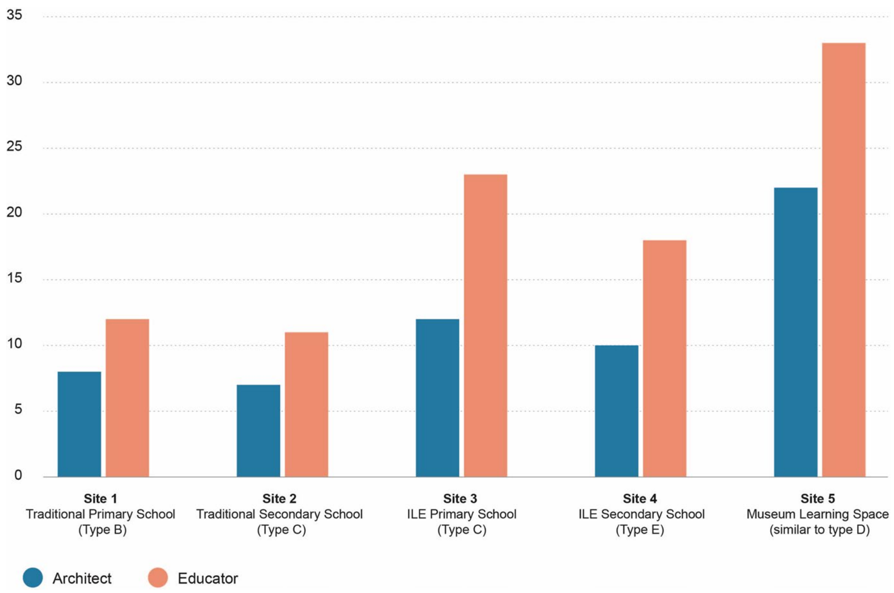

Fig. 17 Number of affordances perceived by architects and educators at the case study sites

> There's spots for kids to be facing each other and working … there's options for independent learning spaces where they can maybe close themselves off from any distractions … there's different levels for being on their knees or at a desk or down on somewhere comfy … you've got current learning walls with student input … there's obviously no name tags on any of the chairs so it's quite flexible where the kids can choose where to sit and that can obviously change from moment to moment or from day to day so they've got choice in where they work. (Teacher 1, Site 1)

Findings of this nature align with those of Koutamanis (2006), who suggested that architects are commonly less successful at sharply defining functions within the built environment due to the complexity of human activities that are better known to inhabitants.

With respect to supporting learning activities more generally, architects rated natural light, ventilation, air temperature and acoustics as the most important (baseline) affordances for learning. And whilst teachers also valued environmental comfort, most perceived settings where students could gather, gain access to resources, and settings that could be reconfigured for multiple uses, as most important in affording learning. Table 4 outlines the hierarchy of spatial qualities that were found to enable and constrain student deep learning.

These varied perceptions are interesting in the context of findings reported by Barrett et al. (2015). They quantified the impact of light, temperature and air quality on students' learning and found that these environmental aspects accounted for 49% of the factors that influence learning outcomes. The differing professional perspectives of architects and educators also highlighted the relative influence that these groups may have on different types of affordances, with architects more keenly aware of how buildings can be designed with good indoor environmental quality (natural light, air quality, temperature and acoustics) and educators more focussed on enacting their influence through managing students' social organisation and the provision of resources.

These findings also concur with those of Cleveland (2011), who identified the size and scale of learning spaces, varied learning settings, effective circulation, furniture, technology, storage, display, acoustics, light and visual connection as key design considerations for ILEs.

A number of educators rated the presence of other students as the most important affordance for students' deep learning, along with access to settings for collaborative activities in groups of varied sizes. Most educators identified open floor space as valuable, enabling both large and small groups to gather for varied activities. Unencumbered floor area was also seen to enable flexible furniture arrangements and promote teacher movement between student groups.

With respect to features of the environments that might constrain learning, the two professional groups were generally in agreement. Both perceived the relatively small floor area of traditional classrooms as constraining collaborative teaching and learning activities and identified poor acoustics as detracting from the learning experience. Interestingly, whilst architects rated good acoustics as a fundamental affordance for learning, educators did not specify acoustics as a necessary (baseline)

Table 4 Hierarchy of spatial qualities enabling and constraining student deep learning

	Enablers		Constraints	
	Architects	Educators	Architects	Educators
most important	Natural light, ventilation and air temperature Sound absorption A range of different settings Spaces that can be changed or used in different ways Seating and horizontal work surfaces	Places where groups can get together Digital resources Spaces that can be changed or used in different ways	Size of (traditional) learning spaces Lack of sound absorption	Size of (traditional) learning spaces Lack of sound absorption
more important		Larger (than traditional) learning spaces. Table height horizontal round flat surface Smaller defined areas Outdoor spaces Natural light, ventilation and air temperature	Not having connected spaces Lack of, or ineffective digital resources	Lack of smaller defined areas Having only one writeable/ projection surface
important			Lack of accessible resources Lack of smaller defined areas Lack of diversity in furniture Having only one writeable/ projection surface	Lack of diversity in furniture

affordance for learning in general, only mentioning it in relation to group work settings.

Again, this may be explained by the different professional practices and experiences of architects and educators. When discussing the constraints related to students' and teachers' ability to hear clearly, architects referred to the importance of building design and surface treatments in providing a comfortable acoustic environment. By contrast, educators did not use the term 'acoustics', but talked about 'noise'. Many described the need to adjust to the sound generated by students when participating in collaborative group activities, as well as the need to update their teaching practices to better integrate periods of direct instruction around other forms of activity. Furthermore, they highlighted the need to commonly allow students to wear headphones to block out unwanted noise when working independently.

Affordances relative to spatial typology

A clear distinction emerged from the analysis in relation to the numbers of affordances perceived within learning spaces of different typologies. Overall, participants perceived more affordances within ILEs than traditional classrooms, indicating that more opportunities were afforded for learning activities in ILEs (refer Fig. 17). This variation in perceived affordances between spaces of different typologies reflected both the physical features of the spaces as well as the practices (actions) known to take place.

With respect to the more traditional learning spaces found at Site 1 (primary—Type B) and Site 2 (secondary—Type C, but effectively operating as Type B due to permanent closure of the retractable wall), the shared common areas (breakout spaces) immediately adjacent to the classrooms were perceived favourably by educators for affording a range of teaching and learning opportunities not afforded within the classrooms.

For example, the covered timber deck at Site 1 was seen to be a highly collaborative learning environment, extending the types of teaching and learning activities that were possible within the surrounding classrooms. Educators commented that they regularly integrated lessons across the triple-classroom cluster, including the shared timber deck and nearby outdoor areas, as part of their teaching practice. They acknowledged that whilst the separated spaces constrained ease of connection between cohorts of students and teachers, their philosophical position on the effectiveness of team-teaching 'forced them' to maximise the opportunities afforded by their spaces, allowing walls to seem more porous than may have been perceived by others.

Teachers at Site 2 were unaware why the retractable walls were permanently closed, considering it a constraint—particularly as adjacent classes were often taught the same thing at the same time. One teacher felt that the walls were not opened due to a perceived risk of 'losing control' of the students in their classes and a lack of time being made available to prepare adequately to teach collaboratively. They commented as follows:

> To team teach, to open up a space requires a lot of preparation on behalf of the teachers. So, given that everyone is so busy I don't think that that is a huge

consideration even though it could potentially lead to better engagement if two classes are combined or the learning space was bigger. (Teacher A, Site 2)

The more numerous affordances identified in the ILE spaces found at Site 3 (primary—Type C), Site 4 (secondary—Type E) and Site 5 (museum—Type D) were found to emerge from a combination of:

- larger spaces;
- more numerous well-defined zones within larger spaces;
- varied furniture, aiding the definition and differentiation of learning settings;
- the capacity to change and/or reconfigure spaces to meet varied requirements; and
- access to a range of digital resources/technologies.

Furniture was by far the largest family of affordances identified by participants. This thematic 'parent group' included:

- mobile furniture, affording the ability to reconfigure spaces for different activities;
- circular tables (both sitting and kneeling heights), affording enhanced collaboration;
- standing tables or joinery designed to afford working whilst standing up;
- whiteboard surfaces on tables, walls and storage units, affording sharing, testing and brainstorming;
- stackable cushions, affording sitting (or lying) on the floor in different arrangements; and
- accessible storage for learning resources, affording ready access for students and teachers.

Digital resources/technologies at the museum space were particularly evident to participants. These included access to Wi-Fi, mobile devices, green screens and virtual reality resources—all technologies that have been identified by others as bringing additional capabilities (affordances) to the learning environment (Lomas and Oblinger 2006).

Affordances relative to teaching and learning approaches

The affordances perceived by educators and architects in support of deep learning, collaborative learning, team teaching and interdisciplinary learning can be seen in Table 5. Both educators and architects felt that having a range of learning settings supportive of varied activities was of high importance across all teaching and learning approaches. Similarly, both groups felt that larger spaces that enabled teachers to work together were important for team teaching. Interdisciplinary learning was seen to be afforded by areas suitable for wet and/or messy activities, including access to digital resources and spaces able to be easily reconfigured to be used in different ways.

Table 5 Taxonomy of affordances perceived by educators and architects relative to teaching and learning approaches

	Affordance		Feature/Element	Student Deep Learning		Collaborative Learning		Interdisciplinary Learning		Team Teaching	
	Spatial properties	Action Possibility		Educator	Architect	Educator	Architect	Educator	Architect	Educator	Architect
	General										
space	A range of different settings	Different ways for students to work	Zones, seating, tables, booths, breakout areas, wet areas, makerspaces, floor	most important	most important	most important	most important	most important	most important	most important	more important
space	Places where groups can get together	Ability to collaborate	Circular tables, booths, floor	most important	most important						
space	Spaces that can be changed/used in different ways	Ability to change space/ practice through co-location and merging of activies	Multi-use and flexible spaces defined through mobile furniture or joinery, moveable walls or doors					most important	most important		
space	Spatial openness and vista	Visibility of students and teachers within a space	Larger spaces, higher ceilings, no obstructions, glazed walls/screens			important				important	more important
space	Connected spaces	Ability for teachers and students to connect	Open and physically connected spaces								more important
	Zones										
space	Larger (than traditional) learning spaces	Ability for more teachers and students (than in a typical class size) to work together	(At least) twice as large as a traditional classroom (to allow a minimum of two classes to learn together)					more important	most important	most important	most important
space	Outdoor spaces co-located to internal spaces	Ability to extend learning activities to the outdoors	Outdoor decks, terraces adjacent to indoor learning spaces					more important			
space	Sink and durable floor covering	Ability for messy activities such as art (exploring, making, doing, experimenting)	Makerspaces, wet areas with sink and durable floor covering, outdoor learning spaces					most important	most important		
space	Open floor space	Ability to gather large groups, or space for smaller groups to work	Open space on floor for students to gather and/ or work			most important					
space	Space for teachers to work together	Ability for teachers to collaborate and plan programs	Shared teacher workspace							more important	more important
	Finishes/Fixtures										
space	More than one vertical writing/ projecting surface	Ability to teach to different groups in same space, or change point of focus	Multiple whiteboards and/or projection/digital screens							important	
space	Display space	Ability to display learning protocols and/or student work	Hanging display or vertical surface for pinboard, magnetic panels, or to tape up work	more important							
	Furniture										
object	Seating and horizontal work surfaces	Ability to work sitting down or standing up	Desks, tables, benches, seats, stools	most important	most important		most important				
object	Horizontal, round, flat surface for seated users to work facing each other	Ability to collaborate	Circular tables and seats/stools	more important			important				
object	Moveable seating and work surfaces	Ability to change furniture settings	Mobile furniture: tables, chairs, ottomans, cushions, etc				most important		important		
object	Centralised storage areas	Ability for teachers and students to easily access commonly located resources	Visible or mobile storage drawers or shelves				more important		more important		important
	Digital Technology										
object	Digital resources	Ability to collaborate virtually, and/or to access information online	Projector, LCD screen, laptops, iPads, BYOD, digital touch tables, green screen, VR, Cloud, WIFI	most important	most important	more important	most important	more important	most important		
	People										
people	Other students	Discussing ideas and working together	Other students	most important				more important			

	most important	*more important*	*important*
Educator	●	◉	○
Architect	●	◉	○

Whilst some participants felt that both traditional and ILE spaces could support a range of learning settings and teaching approaches, traditional spaces were not perceived to readily afford team teaching or interdisciplinary learning. ILEs characterised by larger spaces, more numerous learning settings, openness that allowed visibility and movement, and dedicated teacher spaces were seen to better support team teaching.

Conclusion

By adopting Gibson's ecological approach to perception as a lens through which to study *affordances for learning,* we hoped to open up a conversation about how best to advance the *action possibilities* for deep learning.

The principal aim of the study was to gain insights into the types of affordances people read in learning spaces. This was achieved and a brief taxonomy of affordances for deep learning as perceived by educators and architects was presented (see Table 5). This brief taxonomy may be considered a 'stepping-off' position from which to add further detail and insight into the complex 'entanglements' of space, people, and objects that intermingle to become meaningful and valuable learning environments.

This study suggests that the actualisation (or use) of affordances is influenced not only by the qualities, or features, of the physical environment, but also by the complex practices, activities and behaviours of teachers and students, as informed by their school culture and past experiences.

We see great potential in promoting an affordance perspective on learning environments. This is likely to involve developing an expanded taxonomy of affordances that can be used as a tool to support dialogue between those designing school buildings and interiors (architects) and those inhabiting them (students and teachers). Adopting an affordance perspective, which identifies relationships between qualities of the environment and action possibilities, is likely to provide clarity around the anticipated uses of spatial affordances for learning activities. It may also promote productive design innovation, as suggested by Koutamanis (2006).

Whilst this study identified commonalities between the perceptions of educators and architects with respect to *affordances for learning*, significant differences were also highlighted. The study revealed that although architects are generally responsible for designing the physical environments of schools, educators perceive more detailed affordances than architects. We attribute this recognition of additional detail to educators' deeper insights into the actions associated with teaching and learning practices, activities and behaviours. This finding further highlights the importance of architects engaging with teachers/educators, students and other users of learning spaces to ensure that designs enable the types of *action possibilities* that are desired and required within new learning spaces.

Furthermore, there is a need to better understand how teachers/educators might learn to recognise and take advantage of various affordances for teaching and learning. To this end, we see the further development of a taxonomy of *affordances for learning* as an effective tool for teachers to use when exploring the 'enabling' and 'constraining' elements present in the learning spaces they inhabit—supporting their awareness of what actions may be possible towards promoting deep learning in their students, amidst an 'entanglement' of space, people and objects.

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Appendix

Table 6 Affordances perceived by educators and architects at case study sites

	Affordance		
	Spatial qualities	**Action possibility**	**Feature/element**
Space	**General**		
	A range of different settings	Different ways for students to work	Zones, furniture and surfaces
	Multi-use spaces that can be changed or used in different ways	Ability to adapt spaces to suit learning activities	Flexible spaces defined by moveable walls, mobile or agile furniture
	Spatial openness and vista	Visibility of students and teachers within a space	Higher ceilings, larger spaces, glazed screens
	Uncrowdedness/space to move	Ability for teachers to easily move around to different groups of students	Adequate space between furniture
	Natural light, ventilation, air temperature	Environmental comfort	Suitable floorplate depths, glazed facades, openable windows
	Zones		
	Smaller defined area	Small group, individual and independent work	Alcoves, recesses, nooks, booths
	Separable smaller space	Quiet individual activities, or small group activity	Breakout room with acoustic separation
	Large group area	Gathering large group for explicit teaching	Area to fit large group (either seated or on floor)
	Outdoor learning spaces	Ability to extend learning activities to the outdoors	Outdoor decks or terraces adjacent to indoor spaces
	Spaces with a sink, durable floor covering	Ability for messy activities (making, doing, experimenting) including art and science	Wet area, Makerspace, Laboratory
	Open floor space	Gathering large groups, or smaller group work	Area of open floor space for large or small groups
	Space for teachers to work together	Ability for teachers to collaborate and plan lessons	Teacher collaboration workzones
	Finishes/fixtures		
	Empty wall space (or pin board)	Display of learning protocols and/or student work	Vertical surface for pinboard and/or magnetic panels
	Wall that can be opened or closed	Ability to connect or separate spaces	Sliding, retractable or pivoting wall
	Writeable wall surface	A primary focal point to display information	Whiteboard or whiteboard wall surface
	More than one vertical writing and/or projecting surface	Ability to change point of focus or for multiple groups to have different points of focus in same space	Multiple whiteboards and/or digital screens located around space
	Writeable glazed surface	A writeable surface, definition between zones whilst maintaining visibility throughout the space.	Glazed screen
	Large circular floor graphic	Demarcating specific activities or gathering groups of students	Floor markings defined by carpet or paint
	Retractable curtain	Making a space darker, and connecting or separating spaces	Curtain or blinds

Table 6 (continued)

	Affordance		
	Spatial qualities	**Action possibility**	**Feature/element**
Object	**Furniture**		
	Horizontal sitting and working surfaces	Working sitting down, on tall stools or standing up	Desks/tables, high tables, benches, seats, bar stools
	Table height horizontal surface for 4-6 users	Ability to collaborate	Group table seating four to six people
	Table height horizontal, round, flat surface	Facing other students for collaborative activities	Circular table
	Table height horizontal writeable surface	Freedom for students to test ideas	Whiteboard table
	Table height individual work surface	Independent work	Single desks or bench facing perimeter wall
	Standing height horizontal surface	Working standing up	High table or bench top, mobile storage unit
	Low table	Working seated on floor	Low table e.g. coffee table height
	Low soft/comfortable seating	Working in a comfortable setting	Couch, beanbags, cushions, seating pads
	Stepped horizontal surfaces	Explicit teaching to a group, or independent individual or small group work	Tiered seating
	Moveable seating and work surfaces	Ability to easily change furniture settings to suit learning activities	Lightweight tables and chairs on castors or glides, ottomans, beanbags, cushions, seating pads
	Pivoting standing height horizontal surface	Ability to change between independent or group standing setting	Pivot bench
	Open shelves	Ability for students to access learning resources	Open shelves at accessible height for students
	Mobile resources storage	Ability to move learning resources where required	Mobile resources trolley
	Digital technology		
	Device to project content to large screen	Sharing content	Projector, digital LCD screen
	Virtual workspace	Virtual collaboration	Cloud, WIFI
	PCs	Use of internet and computer software	Fixed computers and laptops
	Mobile large digital screen	Ability to move presentation screen where required	Computer on Wheels (COW)
	Retractable green screen	Ability to use as a background for filming	Green screen on retractable roll
	Digital touch tables	Collaboratively researching and sharing information	Digital touch tables
	3D printers	Ability to print 3D objects	3D printers
	Tablet devices	A mobile digital workspace	iPads
	Virtual Reality (VR) zone	Ability to explore ideas using VR technology	Zone defined for VR activities
People	**People**		
	Students	Working together and discussing ideas	Other students
	Teachers	Ability to support students in their learning	Teacher facilitators

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