Chapter 7
Learning Spaces

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Abstract Sociocultural accounts of education emphasise that learning occurs in and through mediated interactions with the world; technology in education mediates those interactions, and commonly strives to create distinctive experiences centred upon particular spaces. Yet, until relatively recently, most analyses have typically underemphasised those spatial aspects of how technology in education functions—how tools come to be used in particular spaces, to intersect and challenge spatially embedded practices, and might thereby be designed "with space in mind". In this chapter, we set out some bases for a "spatial turn" in Technology Enhanced Learning (TEL) research. We argue that those of us working in the field need to better understand both technology and learning as spatial phenomena; that we must better conceptualise the design of technology and the spatial contexts of use; and that we should become more directly involved in designing and evaluating Learning Spaces themselves—thereby coming to view space as an integral part of the "technology" that might mediate learning. We emphasise the difficulties in conceiving how space and learning are related, and sketch six different models that view the development of spaces and learners as intertwined in increasingly complex ways. We conclude by considering some particular types of Learning Spaces and related issues such as apparent informality and flexibility; by considering pertinent directions in research on the design and evaluation of educational spaces; and by celebrating some of those strands of work within the TEL research field that do already strive to account for the spatial implications of technology.

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Introduction

Let us consider some particular educational settings. A primary school classroom has brightly-coloured furniture; it has been arranged so as to focus attention on an interactive whiteboard. A new secondary school building is organised around "learning corridors"; these are punctuated by display technologies that can be connected to learners' mobile devices. A university library—an "Information Commons"—provides food, drink, comfortable seating and computer terminals; it is a meeting place for students, where learning occurs within a bustling café atmosphere. A museum exhibition incorporates both projectors and interactive consoles; the ecology of information surfaces strives to create a reflective ambience, to encourage exploration while providing a coherent experience for visitors.

Those examples serve to illustrate how one important way that technology interacts with and re-shapes learning is by creating distinctive experiences that are centred upon particular spaces. Learning is neither immaterial nor non-corporeal. That is an apparently obvious point, but one that nonetheless eludes many analyses of sociality within TEL. In this chapter we argue that TEL researchers need to take something of a "spatial turn"—to better understand spatiality, to acknowledge spatial context when designing technology, and to increase our involvement with the design and evaluation of learning spaces themselves. Therefore, we suggest that 'Learning Spaces' can be seen both as an important, specific area of inquiry within TEL and as an underpinning way of enriching our accounts of *how learning happens*, so as to provide useful insight into how we might more sensitively design and evaluate technology. Let us begin by elaborating each of those priorities in turn.

Understanding Technology and Learning as Spatial

Those of us working in the TEL field would benefit from a better understanding of spatial concerns and practices and of how to evaluate educational uses of technology in material terms. We need to focus, for example, on how learners experience examples of TEL innovation as flesh and blood human beings. Some prominent points of focus for the TEL community—cloud-based services, learning analytics, particular applications for mobile devices, and so on—evoke visions of learning that may seem rather removed from those material concerns more readily associated with studying or designing co-present classroom interactions. Yet nearly all TEL tools will be experienced, via some interface, by particular learners within particular material settings. Better appreciating this fact is an important step towards gaining insight into why the experiences created by TEL projects may sometimes fall short of our aspirations.

Designing and Developing Technology for Use Within Space

TEL design projects would benefit greatly from better awareness of relevant spatial relationships. That means, for example, that designers should take into account how existing settings present design opportunities or constrain how a tool will be used; how technology might re-shape existing spatial practice; and how a tool itself might support users to change or adapt their own practices—even to go "against the grain" of dominant spatial norms. At present, TEL design processes most commonly attempt to engage with spatial issues where the model of learning renders the role of space obvious. For example, some mobile learning applications are designed to select the information that they provide to users based on what is known about the current task context and physical location—where information about the latter is derived from GPS or tagging data. Other TEL technologies are designed to be used in particular locations, such as within museum exhibitions. Accepting that *all* learning is spatial would impact how design processes are conceived more generally within the field.

Engaging with Learning Space Design

In our view there is a great need for researchers in the TEL field to engage directly in designing, implementing, evaluating and theorising Learning Spaces themselves. Technology-enabled learning spaces are a crucial resource for the re-shaping of learning. Those who identify with the TEL field should intervene directly within this area, while being aware of the interdisciplinary and institutional challenges that will arise when doing so. The remainder of the chapter will elaborate on that argument, and revisit those points more fully.

What follows is arranged into three sections. First, we examine a range of different models that suggest increasingly interdependent relationships between learning and space within the context of TEL. Second, we emphasise some key issues that are currently posed in the area of Learning Spaces. Third, we introduce four papers recommended as an introduction to the topic.

How Are Space and Learning Related?

Discussing the relationships between space and learning is important, though far from straightforward. Given widespread scepticism, it is perhaps important to establish first of all that empirical evidence does support increasingly confident claims in the literature that space has an 'impact' on learning, however that impact might be conceived. At the granular room level, for example, quasi-experimental research by Brooks (2011) finds a positive, and statistically significant, impact on learners' grade outcomes for a learning activity undertaken in a technology-rich

"Active Learning" space, when that context is compared with a more traditional classroom within the same university. The result of Brooks' research is particularly interesting because his quasi-experiential design controls for many of the differences in space *usage* that might otherwise be considered a likely explanation. At a less granular, campus level, Hajrasouliha and Ewing (2016) are similarly confident about the impact on student retention and attainment of what they call the "morphological measures" of campus design. In the compulsory education sector we can find similar claims. The approach of Barrett, Zhang, Moffat, and Kobbacy (2013), for example, distinguishes between different features related to design and usage within a multi-level model of classroom data from ten UK schools. Barrett et al. suggest that particular factors of space design and usage are particularly important for improving student learning outcomes: important design-related factors include natural lighting and carpet colour, while salient usage-related features include multiple 'zoning' within a room and ease of classroom re-configuration for teachers (p. 688).

Yet the more substantial issue of *how* and *why* the relationships between learning and space are manifest remains unclear; Learning Spaces, as a theoretical concept, remains underdeveloped and fragmented. In this section we sketch our own typology of theorised relations between educational spaces and educational activities. We illustrate each theory-type within the typology (hereafter, "view") by indicating links to prominent, particular theoretical perspectives and by providing pertinent examples of actual technological developments and TEL research projects. Furthermore, we show that each view links space with how students learn by emphasising a different object of investigative activity. As we proceed, the views that we consider increasingly serve to position the relationship between educational activities and space as more explicitly *dialectical*, by which we mean increasingly interpenetrated and dependent, as well as constantly developing (see Ollman, 2003). In each case, we also identify systemic points of focus that appear to be in contradiction, driving practitioners to make progress in order to overcome the contradictions they encounter. For brevity, we largely confine our scope to perspectives that can be identified within TEL and related work in Education and Human Computer Interaction (HCI) and do not dwell on the competing conceptual languages within fields such as Architecture and Philosophy.

(0) Space as "insignificant". Much work within TEL takes no systematic view of space. Viewing space as *insignificant* means ignoring spatial concerns entirely or engaging in opportunistic discussion only where spatial issues directly intrude into data—for example, where learners focus on some aspect of space during a focus group discussion. It has been suggested that researchers are not *prompted* to engage systematically with space because established theories of learning fail to engage satisfactorily with the issue. Neary et al. (2010) review four theories of learning and conclude in each case that spatial issues have been under-problematised. That is despite the fact that in many instances the vocabulary used within each particular theory is steeped in spatial metaphor, such as when discussing "surface learning", "threshold concepts" or "liminal spaces" (p. 11). Similarly, Boys (2011, pp. 37–39) provides a list of 28 learning theories and suggests that many fail to highlight spatial context. Yet there are signs that spatial issues are slowly being taken more

seriously within the TEL community. For example, Thomas (2010) discusses how our "inability to articulate where learning takes place" (p. 502), when analysing innovation in TEL, is to a great extent a problem of better understanding spatial and material concerns. The present chapter also contributes to that emerging discussion.

(1) Space as "impeding". Viewing space as *impeding* means understanding space as some set of *generalised* obstacles to desired actions or educational needs that must be overcome. Temple (2008), in the first of our selected papers, notes that students themselves rarely highlight the role of space within their learning experiences unless they have been irritated by some aspect of those spaces they have used. The *impeding* view suggests that "adequate" space meets a variety of basic needs and thus recedes to the periphery of users' attention. Correspondingly, if certain spatial criteria are met then learning can be provisioned with the opportunity to occur satisfactorily, though that opportunity may or may not be realised in practice (since that realisation is not seen as primarily spatial).

Within the literature, *impeding* views have been expressed in the form of *hierarchies* of needs that must be met. For example, Watson, Anderson, and Strachan-Davis (2007, p. 14) conceptualise users' needs within learning spaces as a Maslow Triangle diagram. Maslow (1943) posited a theory of human motivation based on a hierarchy of needs—in turn related to physiology, safety, love, esteem, and self-actualisation—where "higher" needs only come to dominate particular organisms once those lower in the hierarchy are satisfied. By analogy, Watson et al. suggest that learners' most basic need is for sufficient space, followed by an equitable internal environment, a suitable data communications infrastructure, flexible configuration, and a positive ambience.

We should say that the *impeding* view of space has considerable traction within educational policy. For example, the view that *inadequate* spaces impede learning was prominent in the large scale UK Government programme *Building Schools for the Future*, which ran from 2005–2010 (Woolner, 2010). The impeding view positions *standards* as the central object of investigation—standards that must take into account a range of constantly developing estates benchmarks and other legislative prerequisites while also seeking to support changing institutional aspirations. That relationship between pre-requisites and aspirations is usually conceived of in relatively blunt terms; in describing their hierarchy of needs, for example, Watson et al. suggest that the aspirations of learning are built "on top of" the pre-requisites they have identified (p. 15). We suggest that the bluntness of the impeding view does, if accepted uncritically, limit the potential for innovation by TEL practitioners. It has TEL researchers plausibly designing and evaluating technologies that meet particular needs, such as classroom control systems that place room configuration in the hands of learners, or digital displays used to create a particular "ambience". Yet, overall, the *impeding* view is imbued with a sense of space as relatively homogenous that can serve to restrict our ability to see the potential to shape learning positively through design.

(2) Space as "containing". The *containing* view suggests that spaces have particular properties and contents that support or restrict the practices of the people within them. Consequently, this view emphasises that spaces must be materially

configured so as to support those *scenarios* that are envisaged to occur within them. Consistent with this view, Jamieson, Fisher, Gilding, Taylor, and Trevitt (2000) discuss how seating arrangements in classrooms with computers may restrict learners' movement and constrain opportunities for group work. The implication is that spaces can be designed so as to support desired practice and, furthermore, that flexibility in design might allow a space to successfully support more varied practices. The physical relationship to learning that is described by the *containing* view echoes work on the ergonomics of learning environments, where "the design of educational technologies is best informed by an understanding of the actuality of learners' work" (Goodyear, 2008, p. 254). Yet, importantly, this *containing* view focusses on supporting *existing* practice, rather than inviting novel interactions or learners' exploration.

One important way in which the *containing* view differs from the *impeding* can be found in its increased particularity, a relatively closer focus on the actual properties of particular spaces rather than standards to be attained for spaces in general (or types of spaces). Yet, in common with the impeding view, the overriding concern of work of this type is that learners should be constrained in their (pre-)desired activity to the minimum extent possible. The notion that physical space might positively change learners' actions is not emphasised by this view; while the *containing* view does invoke some vision of affordances, it does so in a way that foregrounds the *closing down of possibilities for action,* rather than the perceptual models of affordance more prevalent in TEL. Much work on computer-mediated communication (CMC) implicitly adopts a *containing* view, particularly when the affordances for collaboration of video conferencing systems are recognised as different from those available in the physical world. A section of the paper by Jamieson et al. (2000), the second selected paper, rehearses these arguments in ways that recall HCI work on CMC that stretches back for several decades.

(3) Space as "stimulating". Physical space plays a role in *stimulating* our thinking in a number of ways. Spaces can be designed to invite reflection and exploration, particularly in situations where space itself is the object of our activity. Space is also a vehicle to externalise our thoughts. The *stimulating* view of space corresponds well with the perceptual, invitational nature of how educational affordances are understood within TEL. The object of investigation is *provision*, primarily because particular spatial elements are seen as *providing for* certain kinds of thinking and action, but also with reference to the intentions of designers to provide those underpinning elements. A range of other theoretical perspectives also inform work on how space stimulates learners. Models of spatial cognition are widely used in mobile HCI, to assist people to experience space vicariously or to support their exploration of space *in situ* (Mark & Freundschuh, 1995). The *exploration* of space is discussed within Architecture as invigorating, or even healing, due to the way our senses are stimulated (Pallasmaa, 2005, p. 41). At a micro scale, within the context of work on tangible technologies, it has been heavily emphasised that learners may undertake exploratory physical manipulation in ways that *precede* their development of verbalised understanding (e.g., O'Malley & Stanton Fraser, 2004). Technology and space may also combine to invite such exploratory action at larger scales, such as in technology-augmented museum exhibits (Wishart & Triggs, 2010).

Space can also make us aware of the presence of our own bodies, inviting us to engage in personal, exploratory narratives. The technology-focussed *Speckled Computing* project (Leach & Benyon, 2009) explicitly sets out to investigate how people might act to *forage* for information within augmented reality spaces; their project uses miniaturised, embedded devices to form wireless sensor networks that people *physically* navigate using their bodies, supported by a range of personal devices. The learning-focussed work of Ruchter, Klar, and Geiger (2010) shows how technology (a mobile guide) can encourage learners to explore an outdoor area with the aim of increasing their awareness of environmental issues. We are invited to reflect on our relationships to our environment, as human beings, and to explore the potential for new relationships.

(4) Space as "associative". The *associative* view of space analytically separates what is conceived of as objective, material space away from more subjective space (often referred to as "place"). It then theorises how those two constructs are inter-related, and suggests that the object of inquiry should be how learners might feel a particular "sense of place". The *associative* view of space suggests that *place* is constructed by learners in ways that are dependent on historical, cultural and social factors. Objective space remains understood as a "container" for things and people (echoing the *containing* view of space above), yet the precise nature of that container is suggested to be less important than how it is 'read' by learners. The canonical distinction used to illustrate the space-place dichotomy is that between *house* (a material space) and *home* (a place construct), a separation of meaning directly supported within the English language.

A range of *associative* formulations for place construction have been proposed but, for reasons of brevity, we will restrict ourselves to a particular example. Harrison and Tatar (2008) suggest that our experience of place depends on two phenomena. First, our experience depends on a complex "semantic tangle" of: *people*, (human beings in all their complexity, as opposed to the abstract profiling of "users"); *events*, or temporal phenomena and the constructed meaning of temporal experience; and *loci*, as used in lieu of the contested word "space" to mean that which exists to be recruited into meaning-making when humans do engage in place-construction. Second, our experience of place depends on the embodied physical experiences that underpin the development of our analogies, metaphors and abstractions. Harrison and Tatar argue that the *abstract* conceptions of place that technology designers utilise when undertaking development projects contrast unfavourably with the *embodied*, human conceptions of place held by the eventual users of the tools they are designing. Consequently, the outcomes achieved when using abstract, spatial design metaphors may be disappointing.

Designers of new Learning Spaces within the Higher Education sector frequently invoke a desire to create particular "places". For example, recognising learning as inherently social and frequently informal has stimulated interest in the creation of *third places*—places of conviviality that are neither workplace nor home (Oldenburg, 1999). That identification of third places underpins the interest within the Higher Education community in re-shaping University libraries into more social, Information Commons spaces.

Clearly, taking advantage of place metaphor when designing intertwined technologies and spaces can be a powerful way of leveraging the prior experiences and expertise of learners. Some learning space designers have suggested that place metaphors can be used directly as triggers for ideas within design processes. An example is the work of Watson (2007), who describes how particular spaces were designed using metaphors such as "the busy city", "the airport departure lounge" and "the domestic living room" (p. 261). Yet, equally clearly, relying on the invocation of senses of place is hardly a precise endeavour. Senses of place are influenced societally and historically, potentially carrying unanticipated or undesirable baggage; while the reading of place is also to a great extent individual, meaning that place cannot just be designed but only designed *for* (Ciolfi & Bannon, 2005). Furthermore, the very idea of space as defined by subjective, representational metaphor has attracted some controversy, since it takes for granted many of those productive and reproductive processes that act to control how space is understood and used (see Boys, 2011).

(5) Space as "constitutive". Human beings are materially a part of their surroundings, and the *constitutive* view of space problematises the boundaries separating "inner" from "outer". According to this view we ourselves constitute, and are constituted by, space. The object of investigation is the mutual *permeation* of the mind, the body, and the surrounding environment, with each of those terms requiring considerable clarification of their generally ascribed meanings.

Different theories of embodiment and distributed cognition provide mechanisms for conceiving how our mental processes are part of our immediate material surroundings. Distributed cognition, for example, proceeds from observations that human beings routinely *offload* their cognition onto accessible tools and onto other human beings (cognizers) (Dror & Harnad, 2008). The way that humans think – using both spatial metaphor and through the internalisation of initially external tools such as language – is a product of that offloading.

Importantly, distributed cognition suggests that our cognition is really *so* offloaded that defining boundaries between what is internal or external is challenging. We might say that we think *using* space, and operationalise those physical and mental actions so as to produce a psyche that is thoroughly and profoundly spatial. Dror and Harnad (2008) discuss the concepts of the "extended mind" and the "wide body", metaphors that attempt to capture some of the attendant implications. In a variety of ways, emerging technologies are playing a significant role in that extension of "cognition". Dror & Harnad suggest that the increasing information processing power and the "disappearing" nature of those technologies that surround us is affecting our brain development, organisation and capacity (p. 21). In doing so, they invoke the vocabulary of *ubiquitous computing*, whereby computing devices blend into the physical world, disappear into the periphery of our attention through familiarity, and move seamlessly back into the centre of our attention as we engage with the content they offer (e.g., O'Malley & Stanton Fraser, 2004. See also Chap. 8).

The TEL community has been active in taking advantage of developments in ubiquitous computing (UbiComp) to influence processes of learning. An example

is the work on "scriptable classrooms" by Kaplan and Dillenbourg (2010), the third selected paper. UbiComp is just one of a group of inter-related areas of work that focus on how computing devices are embedded in the fabric of the built environment, with others including the topics of tangible technology, augmented reality and ambient media (O'Malley & Stanton Fraser, 2004). The TEL community has also been involved in attempting to leverage those other possibilities—for example, by investigating how the ambient display of information in classrooms might extend cognition and interaction (e.g., Bligh & Sharples, 2010; Börner, Kalz, & Specht, 2011). The distinctive feature of the constitutive view is to emphasise how efforts of that kind should be viewed not as merely influential *on* cognition but as quite literally building aspects *of* cognition itself.

(6) Space as "socially constitutive". The *socially constitutive* view of space departs from a focus on individual learners and instead suggests that *community* should be the focus of our attention. The view privileges relations between the spatial and the social (including the interpersonal, but with heavy emphasis on the communal and the societal), rather than the individual, and proceeds from the notion that social space is a social *product*. Communities, institutions and societies act in ways that serve to reproduce themselves and in doing so, according to this view, they produce spatial forms, or repertoires, that act on our consciousness.

Within the Learning Spaces community the work of Jos Boys (2011) illustrates one prominent example of a *socially constitutive* view: one that is directed towards examining Higher Education spaces. Boys draws on the work of the Marxist philosopher Henri Lefebvre and on the Communities of Practice literature to argue for the importance of understanding, for specific contexts and locations, three intersecting aspects of Learning Spaces. Those may be summarised as: (i) *individual engagement and adaptation*, or how people understand, are affected by, and use their environment, thereby transforming it through their use; (ii) *community spatial routines*, or everyday social and spatial practices that affect and are understood by others within the community; and (iii) *design provision*, or how repertoires of design ideas have come to be established and how processes of innovation occur. Importantly, spatial design theories are seen as influencing the relationships between learning and space, by virtue of the power they exert over space production and because of how the theories themselves reciprocally develop as new kinds of space are produced. Thus spatial theories, such as the different "views" discussed in this chapter as well as the vocabulary of architects, themselves form part of the dialectical relationship between space and learning activities within particular communities.

Boys' work explicitly downplays views of space that she considers "metaphorical", which would seem to include those concepts such as "place" that are prominent within *associative* views of space. Instead, Boys focusses on the relationships between the activities of educationalists, architects and estates planners, and studies how learners use ecologies of spaces to traverse communities of practice within Higher Education settings. Boys' book provides a number of examples of technology-enhanced spaces, but usually with a focus on appropriate provision of tools rather than on the design of novel technologies.

Reflecting on the Typology

The different "views" of space we highlight here should not be understood as arising in isolation. Yet neither are the boundaries between them sharply defined. For example, the *associative* view of space seems to both react against and build upon the *containing* view; the loci that contribute the construction of place, according to that view, bear some similarity to *containing* space. In other cases, the views' discourses attempt to occupy the same territory and seem starkly opposed. Harrison and Tatar (2008), for example, suggest that "production models" of space (e.g., our *socially constitutive* view) are obstacles for design processes, because they chiefly draw attention to societal structures that sit outside designers' sphere of influence. Boys (2011), on the other hand, suggests that place metaphors (our *associative* view) can serve to restrict critical thinking about Learning Spaces. In our account, we ordered those views such that the relationship between space and learning was recognised as increasingly dialectical. This ordering is represented visually in Fig. 7.1, whichalso summarises the object of inquiry and systemic contradictions

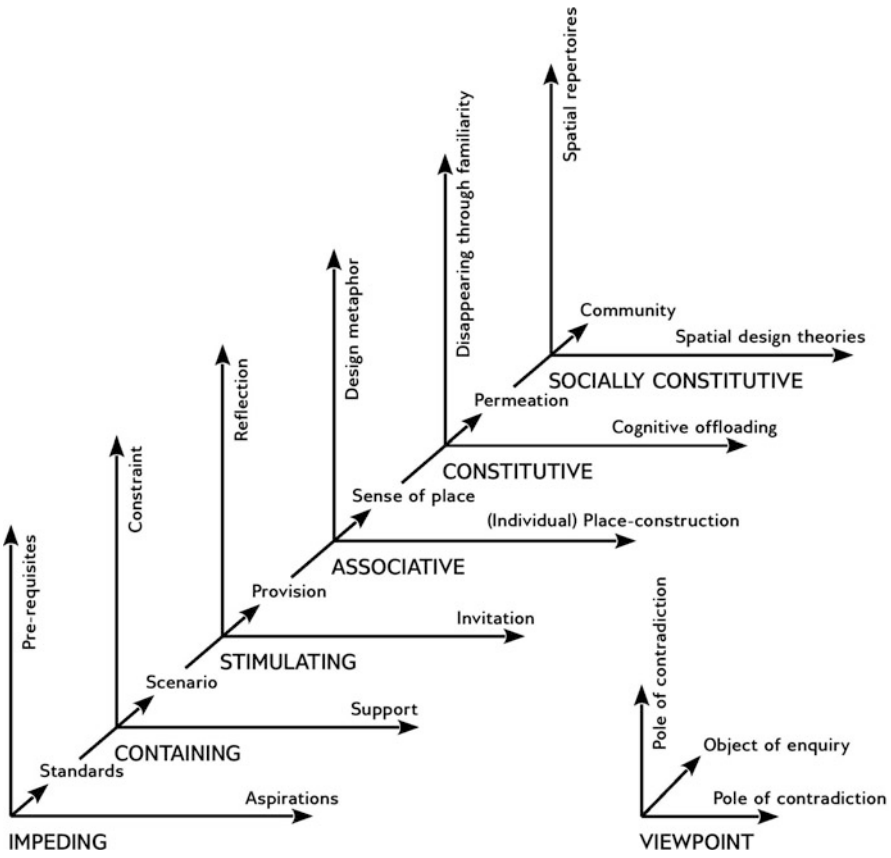

Fig. 7.1 An increasingly dialectical view of relationships between educational activities and space

described by each view. Our intention in doing so is *not* to produce another hierarchy wherein the issues posed at higher levels are only seen as relevant once accounts have been settled at lower ones. Instead, we wish to suggest that viewing space and learners as increasingly dialectically related means both accounting for increasingly complex mechanisms of mutual influence *and* re-problematising those that we might earlier have taken for granted. For example, the *containing* view is already imbued with a sense of particularity that requires a more situated vantage point than the *impeding* view, while also challenging the universal appropriateness of standards. The *socially constitutive* view, on the other hand, not only emphasises community and the use of theory—but also asks us to understand and challenge those productive processes that give control of standards and ownership of spaces to particular stakeholders, that act to define our place metaphors, and so on.

Nonetheless, the conceptual and disciplinary fragmentation of the Learning Spaces concept remains very real, and timely resolution of attendant debates is unlikely (and perhaps even undesirable). Thus, we hope that this relational mapping of different of views will prove useful to the TEL community, in lieu of providing a single, definitive model that cannot yet exist. We should emphasise, however, that those engaging in Learning Spaces work will not only need to contend with that dense tapestry of related yet competing theories; but also with a range of identifiable, more practical issues. We discuss some of those in the next section.

Significant Issues in Learning Spaces

Having mapped the different theoretical underpinnings used to connect space, learning and technology, in this section we briefly consider some significant, and interconnected, issues with which TEL researchers ought to engage.

"Types" of Learning Spaces

Whereas our typology, above, was theory-driven, here we wish to draw attention to how the literature categorises educational spaces themselves.

Learning Spaces research in compulsory education frequently engages with familiar school spaces. School classrooms provoke significant debate within the literature around issues such as colour, student ownership and relationships between seating areas and open "carpet space". There is a decades-long history of advocating *open plan* spaces, where several classes of learners are taught simultaneously (Woolner, 2010), though this concept has struggled to gain traction. At larger scales, the building and refurbishing of whole schools invites a focus on the potential of circulation routes and atria as spaces for informal learning.

Within Higher Education, the different architectural environments for learning have been categorised as group teaching/learning spaces, simulated environments,

immersive environments, peer-to-peer and social learning spaces, and learning clusters (AMA Alexi Marmot Associates & haa design, 2006). Locational *integration* of different services (including formal teaching areas, social environments, library and technical support services) in "learning clusters" is seen as particularly important within HE.

Outdoor spaces are an issue for researchers in both sectors, who argue that their potential is under-realised. Institutional space "types" will continue to raise issues for Learning Spaces researchers for the foreseeable future; yet, as we have already argued above, the challenge for TEL researchers is to perceive the opportunities within those spaces rather than perceiving only fixed configurations that restrict innovation.

Formality, Informality and Flexibility

Often discussed within the literature, the meaning of these concepts requires further careful examination. Informal learning is increasingly recognised as a very valuable practice, and one common response in the Learning Spaces community is to create specifically "informal" environments—perhaps based on *associative* assumptions that learners, prompted by particular furnishings such as café furniture or beanbags, will construct their own informal sense of place. Yet others (e.g., Boys, 2011) call for critical examination of how such spaces actually work. Sutherland and Sutherland (2010), for example, suggest that spaces can be formal, semi-formal, semi-informal, and informal, drawing those more precise distinctions based on how the learning purpose and the centrality of teacher orchestration within the space are rendered explicit.

Jamieson et al. (2000) also emphasises the distinction between the degree of formality of space and that of learners' practices when he suggests that spaces should *flexibly* support different activities—either concurrently within the same session, or across different sessions where, for example, rooms might be used informally by students when not booked for formal teaching. More broadly, Goodyear (2008) suggests that providing flexibility for learners at macro, meso or micro-*time*scales can take quite different forms. We would extend that point to space as well as time. Potentially, micro-spatial flexibility might refer to easily moved furniture or configurable lighting; meso-spatial flexibility to how clusters of co-located spaces support activity transitions where students move between differently configured areas; and macro-spatial flexibility to how institutions provide a range of appropriate spaces to support different forms of learning, making those available to learners and teachers through appropriate booking and drop-in systems.

Institutionality, Interdisciplinarity and Participative Design

Research work on Learning Spaces will often need to become involved more closely with institutional procedures, visions and politics than is the case for much TEL research. Support from institutional leaders will often be important if space designs are to be realised, ongoing support provided, and cost potentially shared between research teams and institutional budgets. Furthermore, it is likely that spatial designs will need to be developed in highly interdisciplinary ways that involve, as a minimum, TEL researchers collaborating with those from backgrounds in educational research, disciplinary teaching practice, architecture, estates management, IT support, and senior management, as well as students themselves.

A range of methods have been suggested in the literature to support such collaboration through participatory design. For example, Woolner (2010) considers participative design processes that include learners, teachers, parents and others. She advocates activities such as the "diamond-ranking" of photographs and the creation of paper maps representing "school days" as mechanisms to allow different stakeholders to articulate their experiences. The diamond ranking activity, for example, involves people collaboratively placing photographs of school spaces on a whiteboard to indicate preferences in relation to emerging criteria, prior to labelling the diagram so as to highlight more particular experiences (p. 61). The aim is to enable different participants—including young children—to come to a comparative understanding of various physical environments without recourse to professionalised terminology. Analogous approaches to participative design have also been documented in the literature on post-compulsory education; for an overview see Bligh (2014).

Evaluation

Processes that evaluate space are also subject to institutional pressures that may be unfamiliar to those within the TEL community. That may explain the "paucity of clear, replicable empirical studies" of school-sector Learning Spaces (Woolner, 2010, p. 17). Based on work in the University sector, Bligh and Pearshouse (2011) discuss how space evaluation is an essentially political act: one subject to tensions between the empirical possibilities for investigating space and institutional and cultural constraints. Spaces might be assessed on whether they (a) are in demand, (b) change learning outcomes, (c) satisfy their occupants, (d) enable specific learning scenarios to be enacted, (e) support desirable spatial activities, (f) fit into a wider ecology of provision, or (g) enhance an institution's brand. Bligh & Pearshouse suggest, however, that too few examples of learning space evaluation observe actual activity occurring in space.

One example of relevant work that does do so, combining structured observation with on-the-spot interviews and focus groups to examine space use, is that of Crook

and Mitchell (2012). Crook & Mitchell investigated students' activities within a University Library refurbished, along the lines of the Information Commons model, to include social spaces, a variety of collaborative technologies and a café. The ostensible aim of the refurbished space was to support intensive forms of collaboration, yet Crook and Mitchell observed students working productively in a variety of ways—including intensely collaborative problem solving, more intermittent exchanges, serendipitous encounters, and apparently solitary study. Importantly, students had specifically chosen to undertake their solitary work in the new space due to its "ambient sociality", notwithstanding that such activity was not congruent with the intentions of those who had commissioned the space. In general, learning space evaluations must avoid restricting their conclusions to fit institutional visions, yet they must not simply disregard the institutional context in an attempt to make their results appear more generalisable.

Accounting for Space in TEL

In our introduction, we suggested that studying Learning Spaces has an *underpinning* potential for the TEL field. Yet to realise such potential requires that theories and frameworks in other areas of TEL acknowledge spatial issues. Despite the fact that some theories in Education view space as *insignificant*, some work within TEL does acknowledge spatiality in ways that need to be celebrated and built upon. We focus here on four such examples.

In the arena of mobile learning, Vavoula and Sharples (2009) discuss how learners create *micro-sites for learning* out of the physical and social resources that have been made available around them. Physical settings for learning are suggested to vary in terms of their "vagueness", where classrooms are relatively conventional and static while the settings of personal mobile learning are less predictable.

Cook's (2010) concept of *Augmented Contexts for Development* also draws attention to the role of available physical resources for mobile learners. Cook focusses on design aspirations, suggesting that "designed contexts" can partly supplant the role of more knowledgeable people in a model that draws inspiration from Vygotsky's *Zone of Proximal Development* (ZPD).

Luckin (2010) also considers the role of the physical environment in a ZPD-inspired model. Luckin suggests that material space constitutes a *resource* within a learner's *Zone of Available Assistance*, from which their *Zone of Proximal Adjustment* is constructed in collaboration with more able partners.

Bielaczyc's (2006) *Social Infrastructure Framework*, on the other hand, adopts a collective, environmental vantage point rather than one focussing on a particular learner. One of Bielaczyc's four "dimensions" for successful social infrastructure is the *socio-techno-spatial relations dimension*, "the organization of physical space and cyberspace as they relate to the teacher and student interactions with technology-based tools" (p. 304). That difference of vantage point is important. Where focussing on mobile learning lends itself naturally to a focus on the personal

narratives of individual learners, engaging with Learning Spaces requires a focus on supporting different learners with different needs, concurrently and over time, or learners who are at different stages within their processes of learning.

In our view, work within TEL also needs to focus on how technology might undermine spatial conventions to benefit learning. For example, Bligh and Sharples (2010) document the design of Multi-Display Learning Spaces, where innovative display technologies challenge established, front-facing classroom design repertoires. The display space is used to create enabling juxtapositions of visual materials that support students' verbal contributions to small group teaching scenarios. Furthermore, work in TEL needs to better account for space when scripting learning, or creating repositories of re-useable learning scenarios. For example, Pérez-Sanagustín, Hernández-Leo, Nieves, and Blat (2010) suggest a space model for representing Learning Spaces within the scripting language IMS-LD, based on top-level constructs such as space types, dimensional areas, and electronic and non-electronic components. We must take care, however, to ensure that how we account for space retains a focus on the profound contingency of what is important in-the-moment. In other words, we should avoid the temptation to become wedded to particular representational models of space in ways that disregard the context of activity.

Four Papers

The four papers highlighted in this section were chosen because they offer different contributions that build further on those discussions that we have introduced here.

Learning spaces in higher education: an under-researched topic by Temple (2008) is a discussion of how space affects learning based on a funded literature review project. Several themes emerge from that work. Temple underlines how *space management* privileges particular forms of learning and argues that place construction has institutional underpinnings—where spaces are a microcosm of how an institution sees its own mission and identity. The paper also highlights how spaces enable the formation of communities, and critiques common assumptions about relationships between form and function. Next, Temple problematises relevant design approaches and the role of technology. An attendant note of caution permeates the paper. While that perhaps originates from the disciplinary reach and review-based nature of the work, the lack of methodologically sound work that Temple highlights, together with the rarity of rigorous institutional evaluation (Bligh & Pearshouse, 2011), is a real obstacle to progress and an area where TEL researchers can usefully contribute.

Place and Space in the Design of New Learning Environments by Jamieson et al. (2000) is a general introduction to Learning Spaces for an audience of Higher Education researchers. The paper provides guiding principles for Learning Spaces development and concrete examples of projects that complement our own, more theoretically targeted introductory comments. Jamieson et al. adopt what we would

term a broadly *associative* view of space, focussing on learners' sense of place and how designers might access those ideas. The paper successfully links the re-design of University campuses to emergent practices, including those of distance education. The authors court controversy by positioning teachers and academic researchers as forces of conservatism, while their occasional distinction of place as *electronic* space is now uncommon. The paper certainly poses more questions than answers—rather usefully for readers of the present book. One particularly timely question, at a time of rapid expansion in distance education, concerns those aspects of face-to-face interaction that are both essential and that cannot be rendered obsolete by distance education approaches.

Scriptable Classrooms by Kaplan and Dillenbourg (2010) explores how a range of UbiComp technologies can be used to support co-present learning activity. Desks with embedded LED displays, miniature projectors, embedded cameras, and distance and RFID sensors are used to support the scripted collaboration of learners. The aim is to support dynamic group formation, learners switching roles within groups, transitions between different activities (of individual, group or whole-class composition) and an aspiration of *bidirectionality*, in which information is both presented to and gathered from learners by the classroom systems. The paper foregrounds how roomware technologies can be used to support two prominent concerns within the TEL field: scripted collaboration, where learners' interactions are pedagogically guided by a set of instructions, and classroom orchestration, in which teachers' roles in managing and supporting activities happening around the space are recognised as crucial. The authors usefully draw together how such a varied set of technologies can form part of a classroom ecology. One unanswered question, particularly from what we have called the *socially constitutive* vantage point, concerns how such a complex synthesis of technology can become better embedded within practice—widely and longitudinally, culturally and institutionally—so that it can be appropriately supported and reproduced beyond its original research setting.

The NiCE Discussion Room by Haller et al. (2010) documents a design-based project with a twin-track focus on creating a collaborative space and designing particular technologies in a spatially-aware way. The NiCE Discussion Room contains attractive furniture along with tools designed to support large-scale digital sketching, the incorporation of paper, the streaming of content from laptops, environmental control through tangible devices, and communication and orchestration facilities. Haller et al. raise many important issues regarding the design of "roomware" to support co-located collaboration. Those include how people occupy and move through space when using a range of technologies, supporting concurrent task diversity, creating and sharing different forms of content, and connecting activities happening within the space to the outside world via users' own devices. Haller et al. document how their own design responds to those issues. From the perspective of studying learning, rather than HCI, we would have preferred to see an evaluation involving authentic users undertaking culturally embedded tasks rather than groups undertaking closely-bounded design problems. Nonetheless, Haller et al. usefully document how their users struggled to integrate their work after finishing breakout sessions, indicating that further design work (and accounting for

the conventions of practice) is still required. Other work presenting novel designs for technology or space exists in the literature (e.g., Bligh & Sharples, 2010; Kaplan & Dillenbourg, 2010; Wilson & Randall, 2012). Despite the fact that Haller et al.'s paper focusses more explicitly upon collaboration than learning, this paper is noteworthy because it involves designing a novel Learning Space and novel technology together.

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