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Belonging in the ecotone: a case study from a STEM higher education context

Luke McCrone

Introduction

We live and learn in a physical world which has immense impact on how we behave, feel, interact and relate. Personal, social, institutional and political factors shape the power and agency we feel in any given 'space'. To better understand belonging, we might study these spaces and develop methods for understanding the meaning people make of them.

This chapter introduces a mixture of traditional, redesigned, timetabled and non-timetabled learning space case studies, and draws upon my experiences representing, researching and partnering with students at a science, technology, engineering and mathematics (STEM), research-intensive university. These findings comprise my doctoral research, which investigated undergraduate student engagement with transitions between formal, timetabled and informal, non-timetabled learning. Studying these transitional spaces aided the identification and understanding of spaces in which students feel they have a sense of ownership in their learning, and of how this sense of ownership can support a sense of belonging.

Applying these empirical findings in practice informed a series of student partnership-driven projects which converted informal departmental areas (adjacent to lecture theatres) into functional transitional spaces. One such transitional space was evaluated before and after the renovation, in conjunction with its adjacent redesigned lecture theatre, to investigate how transforming each physical space supported the institution's strategic move to student-centred, discovery-based

learning. Reflecting on these institutional case studies and on my student representation experience as Deputy President (Education) in the student union, I explore the implications of partnering with students in the space (re)design process for their sense of ownership and belonging, including in the redesigned spaces. I adopt socio-spatial theories to acknowledge the significance of space as a social product that shapes social activity, whilst later introducing an ecological concept that provides an alternative, critical way of conceptualising sense of belonging in learning space. I argue that belonging between spaces, processes and disciplines requires increasing attention in a complex and evolving higher education ecosystem.

The chapter focus is inspired by literature which increasingly acknowledges that students' sense of belonging is linked to positive academic outcomes (Osterman, 2000), higher student engagement (Furrer & Skinner, 2003), well-being (Allen et al., 2018) and ownership of learning (du Toit-Brits, 2022). Whilst belonging to university is multidimensional, Ahn and Davis (2020) found 'surroundings' to be one of four important domains of belonging, which is defined as students' 'living space, and geographical and cultural location' (p. 1). Ecological metaphors can reveal tensions between spaces and potentially empower an increasingly diverse group of learners, including students who – intentionally or unintentionally – do not belong (see also Kandiko Howson & Kingsbury, Chapter 1 in this volume).

The focus is also influenced by a growing recognition that didactic transmission lecturing is a less effective pedagogical approach than more student-centred, discovery-based learning in STEM fields (Freeman et al., 2014; see also Ohmori et al., Chapter 12 in this volume). With hybridisation increasing the ubiquity of learning (Deed & Alterator, 2017), most students own or have access to personal devices like phones and laptops and thereby have a greater perceived ownership of their formal and informal learning (Wut et al., 2022). Students therefore increasingly find themselves operating at the boundary of spaces, in a state of transition and tension.

As this tide of change continues to sweep us away from traditional conceptions of learning as a classroom-bound phenomenon towards more holistic conceptions of the student experience, the question of belonging has been brought into focus. Hybrid learning poses challenges and opportunities for designers, educators and students, and creates a need to rethink and redesign university campuses for improved belonging, well-being and learning. However, our understanding of the role of the physical university in supporting the development of belonging remains limited and requires further attention (Temple, 2018).

Background and context

My anecdotal and empirical experiences as an undergraduate student in the geosciences, as Deputy President (Education) in Imperial College Union, and most recently as a PhD student who explored student engagement with learning spaces (McCrone, 2021), have given me a unique insight into the evolving institutional context. This collective experience has afforded me direct exposure to a variety of learning spaces, disciplinary contexts and committees in the institution, which have shaped my ontological positioning.

The institution's main campus is located in an urban part of London and is highly international; 60 per cent of the students are from outside the UK. Its ongoing commitment to a Learning and Teaching Strategy, which I was involved in co-creating as a student representative, aims to make the university more student-centred, evidence-based, inclusive, diverse, outward-looking and technology-enhanced (Imperial College London, 2017). These strategic aspirations arguably require a careful evaluation and development of educational infrastructure such as campus spaces and timetables to better reflect the changing needs of the learner and society. Whilst the institution has invested in the maintenance and modernisation of this infrastructure, a joined-up dialogue between space practitioners and those engaging with and improving education has arguably been lacking (Carnell, 2017). The fragmented constitution of research-intensive universities can make this joined-up dialogue even more difficult (Brew, 2010).

The anecdotes introduced in this chapter represent unique case studies in which I employed my experiences and research findings to partner with students, educators and design practitioners to redesign campus learning spaces. The role and impact of these learning spaces on student sense of belonging are explored, as are the ways in which students were engaged in the participatory processes.

The case for 'space'

'Space' is not merely a neutral physical container, it is socio-political, imbued with functional and symbolic messages which indicate how people should behave and interact (Temple, 2019). Hence, whilst different individuals experience the same space differently, shared physical, cognitive and social spaces influence an individual's behaviours, feelings and ways of thinking (see also Kandiko Howson & Kingsbury,

Chapter 1 in this volume). In our striving for a stronger sense of belonging, space should therefore be at the centre of our purview. Furthermore, with the average cost of UK education space nearing £200 per square metre, and with the ongoing maintenance of this physical capital approaching £3 billion annually – only exceeded by staff budgets (Temple, 2018) – it is in the sector’s best interest to garner knowledge about the impact of space on social activity to inform future investments.

This chapter assumes that space is a social product which shapes social relations and practice (Lefebvre, 1991), and that space is relational with an inherent power-geometry dictated by economic, political and cultural influences and resources (Massey, 2005). By focusing on people’s ‘use of space and the meanings they associate with different spaces’ (Samura, 2018, p. 19), we can better decode their experience and sense of belonging. This chapter looks closely at the interplay between what Sennett (2019) calls the *cit * and *ville*, the former describing social life and the latter the physical location and form of a place. Temple (2019) argues that once the infrastructural *ville* elements ‘become ends in themselves, rather than a means towards supporting some wider, broadly agreed, social purpose’ (p. 224), they become unsatisfactory for their users, whatever their architectural merits. The relationship between people and spaces, and their sense of ownership in those spaces, can therefore influence their sense of belonging.

Introducing ecotones

Having adopted these socio-spatial theories in the institutional case studies, this chapter presents an ecological way of conceiving learning space – popularised by Barnett and Jackson (2019) in their book *Ecologies for Learning and Practice: Emerging ideas, sightings, and possibilities* – to provide an alternative, critical way of understanding student sense of belonging in space.

The question of where students belong is arguably a question of space and place. This question was historically shaped by a teacher-centred learning paradigm and the absence of the internet and ubiquitous learning. With students’ belonging in an increasingly hybrid world, the learning spaces they engage with are increasingly transitional, contested and flexible. The way we conceptualise learning space is therefore changing from binary divides like ‘formal’ and ‘informal’ (Middleton, 2019) to metaphors which can more aptly capture both these defined learning spaces and the spaces and tensions in between.

'Ecotones' are ecological zones 'where two distinct ecosystems overlap or grade into one another' (Pendleton-Jullian, 2019, p. 112). The word 'ecotone' etymologically means 'ecologies in tension', and, like estuaries in the natural world, they are zones of tension between tidal (e.g., classroom space) and river (e.g., informal space) forces in which a more diverse group of species (students) can potentially thrive. Furthermore, ecotones are spaces at the edge which can reinforce, challenge and develop territorialised ideologies and identities, transforming the adjoining core spaces by feeding changes back into the entire ecosystem. Belonging in the ecotone between spaces, processes and disciplines can promise new ways of thinking and richer flows of knowledge than being at the core, given 'progress is made at the interface' (Epstein, 2021, p. 279). This chapter introduces the ecotone concept as a flexible metaphor, in a similar way to Pendleton-Jullian (2019), who explored innovative educational environments, to conceptualise the transitional space and tensions between timetabled and non-timetabled learning, between different pedagogical spaces, and between the design and use of those spaces.

(Re)designing space for belonging

Our efforts to redesign space in the future will likely centre on bringing people together to think and interact in non-traditional ways. This is because the world is changing, and so too are the problems we face in STEM and society. It is abundantly clear from Covid-19, for example, that an interdisciplinary approach is needed for addressing complex real-world issues (Moradian et al., 2021). Developing spaces with flexible power-geometries (Massey, 2005) in which students can think inside and outside the traditional bounds of their discipline is therefore increasingly needed. Whilst on the one hand formal disciplinary spaces like classrooms and labs can develop disciplinary belonging, on the other they can stifle creativity and collaboration across disciplines (Becher & Trowler, 2001).

Contemplating the implication of these changes for belonging encourages us to abstract implicit assumptions about learning space. For instance, to what extent do alterations made to formal, timetabled spaces like classrooms lead to desired changes in learning behaviour (Imms & Kvan, 2021)? How do these changes influence the development of disciplinary belonging? Which dilemmas exist between the enhancement of this disciplinary belonging and that of interdisciplinary collaboration

when we are designing learning spaces? How will these questions remain relevant as our theoretical and physical conceptions of learning space develop into metaphors which more aptly capture the complexity of hybrid, discovery-based learning?

Since space is socially constructed and people's interactions are affected by space, changes made to space inevitably lead to changes in people's intent and interactions (Samura, 2018). However, since architectural space is not necessarily deterministic by virtue of its inbuilt intentionality, we fundamentally have agency in how we choose to act within space (Oolbekink-Marchand et al., 2017). This chapter argues that, whilst redesigning space can shift what Ravelli and Stenglin (2008) call the 'social distance', that is, a participant's physical position and perceived power relative to other interactants, the sense of ownership which teachers and students have in a space influences how empowered they feel within it. I explored these transitions in and relationships between space and behaviour in more detail in my doctoral thesis (McCrone, 2021).

The learning space case studies in this chapter demonstrate how ownership can arise incidentally, such as when students find themselves in more flexible in-between spaces in which they can direct their own learning, or more explicitly when users shape the design of space to suit their own and others' needs. Burke et al. (2016) argued that the objectives of redesigning a learning space will only be fully realised if the users of that space support the pedagogical principles informing it. Exploring student engagement with these transitional spaces, both as users of space and as agents in shaping that space, has assisted a unique understanding of the conditions for belonging.

Transforming the lecture theatre

Traditional learning spaces like raked lecture theatres crystallise patterns of behaviour in which the teacher is in control and the students listen (Finkelstein et al., 2016; Imms & Kvan, 2021). Whilst this in-person timetabled teaching is an increasingly rare opportunity for student cohorts to engage with shared ways of thinking, the 'sage on the stage' approach in which teachers transmit knowledge is being supplemented with 'guide on the side' approaches, in which students discover things for themselves with teacher guidance (Jones, 2006). The evolving role of teachers and students is changing how they interact and perceive one another, changing the type of belonging and identity which is possible.

Amid this pedagogical transition, formal learning spaces must become more flexible in their design to accommodate both traditional and interactive pedagogical approaches (Lam et al., 2019). The relationship between this design and pedagogical flexibility was directly investigated through the pre-renovation exploration, the redesign and the post-renovation evaluation of a raked lecture theatre (see Figure 13.1) in the Department of Physics at Imperial College London during the doctoral research. The intent of the redesign was to retain the original rake and transmission function of the space, whilst converting the row-by-row seating into fixed connect-booth seating with accessible walkways and enhanced audio-visual technology. Each booth could accommodate up to five students, so that group-based learning was more easily achievable.

The doctoral research showed that both teachers and students found it easier to transition between segments of transmission teaching and group-directed learning activities than in the pre-renovation space. The new design provided teachers, particularly those who had pre-existing intent to use alternative pedagogies, with more pedagogical options and agency (see also Horsburgh, Chapter 11 in this volume). Furthermore, reconfiguration of furniture from row-by-row seating to shared booths enabled students to form small distinct learning groups in which they



Figure 13.1 Photograph of refurbished raked lecture theatre showing connect-booth seating converted from original row-by-row seating. Photograph by Thomas Angus, Imperial College London. © Luke McCrone.

could share their learning; interestingly, this was the case during both transmission-based and interactive instances of teaching. Student sense of belonging transitioned from feeling like an individual member of a cohort, to belonging to a learning group with which they could share the challenges inherent to learning. These peer-to-peer relationships prevailed beyond the timetabled session, providing students with more opportunity and agency to work through misunderstanding and its associated emotion, both inside and outside their formal learning (see also Ohmori et al., [Chapter 12](#) in this volume).

Despite challenges with cooperation and team management when they were being required to solve task-problems in booth groups, students developed a shared ownership of their learning, and underwent transitions in perception and behaviour and in their expectation of that learning. This shared ownership of learning resulted in a sense of ownership of the space, evident from the increased use of the space for independent and collaborative study during non-timetabled periods. Hence, whilst the overall capacity of the renovated space was reduced in comparison to its row-by-row configuration, the potential 'transitional space' for both teachers and students was broadened.

The implications of this broader transitional space and heightened ownership, arising from a change in space design and pedagogical intent, for student sense of belonging provide fertile ground for further research. However, concepts that can aptly frame the transitions and tensions inherent in the (re)design and use of innovative learning spaces in STEM higher education are arguably lacking. This is particularly important as the institution in the case study (among others in the sector) strategically 'share' learning spaces like the transformed lecture theatre in [Figure 13.1](#) between departments.

Thinking about this lecture theatre as an ecotone helped the institution to find a balance between supporting the development of disciplinary belonging in the Department of Physics (for example by retaining chalkboard writing surfaces for physics notation) and accommodating potential for interdisciplinary usage and collaboration. Furthermore, the ecotone metaphor allowed me to be more holistic in looking at the informal spaces adjacent to and connected to the lecture theatre, which led to the redesign of one such informal space (explored in the next section) to support transitions into and out of timetabled learning. Having this broader awareness of learning space beyond the formal, timetabled space is important given the increase in hybrid learning, and the transitions students navigate between virtual and physical learning.

Developing the spaces in between

Students now have greater agency about how they choose to engage with hybrid learning and the physical and virtual spaces available to them. This is shifting the perceived significance and utility of formal learning spaces like lecture theatres – which are timetabled and institutionally controlled – in relation to informal learning spaces which students colonise of their own accord. Understanding and nurturing the spaces in between is of growing importance as discovery-based learning and research play a greater role in shaping the higher education experience (Carnell, 2017).

In addition to my proactive involvement in the redesign and evaluation of the lecture theatre in [Figure 13.1](#), I partnered with students and staff to redesign the informal learning space adjacent to that lecture theatre (see also Kinchin et al., [Chapter 17](#) in this volume). This action was motivated by my doctoral research findings, which discovered the potential of these fringe informal learning spaces for supporting transition and discovery-based learning. Because of its position adjacent to the lecture theatre, the pre-renovation informal space was unfurnished and mainly used as a method of ingress to and egress from surrounding spaces. Nonetheless, my observations established that there were subtle changes in student behaviour as they transitioned between this space and the lecture theatre. This raised the question of whether the lecture theatre and the adjacent space could be treated as distinct entities between which students transitioned, or whether these physical and temporal spaces blended into one another (when considered in the context of the timetable) to result in a separate transitional space. This question was able to be conceptualised and addressed using the ecotone metaphor. The informal space possessed potential for the formation of departmental and cross-cohort community as students transitioned into and out of timetabled learning in the lecture theatre.

Through the addition of suitable furniture like sofas, high tables and chairs (see [Figure 13.2](#)), the space's altered affordance allowed students to develop a greater sense of ownership in the periods just before and after lectures, as well as during lunchtime and other non-timetabled periods. The addition of writing surfaces (in this case chalkboards) physically and conceptually extended the physics lecture space, so that teachers and students could transition questions and interactions at the end of the timetabled session into a space more permissible of informal, discovery-based discussion. The ambiguous designation of this transitional space also allowed students to colonise it for independent study and collaborative learning not directly associated with timetabled learning.



Figure 13.2 Photograph of refurbished informal learning space adjacent to the lecture theatre in [Figure 13.1](#), entered through the door on the right, showing a variety of furniture types and writing surfaces. Photograph by Luke McCrone, Imperial College London. © Luke McCrone.

The transformation of both the lecture theatre and the adjacent transitional space, in tandem with the broader strategic context, led to changes in how students perceived not only the spaces, but their peers and teachers. Students went from describing their teachers as ‘guardians of credit’ in the pre-renovation context to ‘approachable helpers’ in the new spaces. This transition seemed to be due to the negotiation of a more co-constructive relationship between students, their peers and their teachers, which was found to impact how they interacted outside of the timetabled sessions, that is, when approaching teachers with questions. These lasting changes in cohort culture impacted student sense of belonging to the department, supported transitions into online group work during Covid-19, and more broadly contributed to the strategically desired transition to discovery-based learning.

Repeated transitions into and out of any space – including spaces with more neutral designation, expectation and power-geometry like the redesigned transitional space – can lead to increased familiarity, trust, safety and other preconditions for belonging. These shared familiar

spaces, which can range from departmental spaces to hall-of-residence kitchens, provide students with a collective purpose such as timetabled learning or eating, and can broaden the potential space for community and belonging. Developing underutilised foyers and corridors, which act as 'both buffer space and physical link' (Nassar & Hosam, 2014, p. 8306), has been proved to increase student ownership of and belonging to their department and discipline. The extent to which the contrasting power-geometry and tension between these transitional spaces and their connecting 'oppressive' lecture theatre (Freire, 2020) can empower students to regain a sense of ownership and agency in their learning is worthy of further investigation. The involvement of students as partners in the redesign of these transitional spaces deepened their sense of ownership and worth in the spaces and departmental community, a relationship which is equally worthy of further investigation.

Partnership: creating space ownership

My own belonging to the institution shifted when I was given the opportunity to contribute meaningfully to improving the student experience in representation roles like Deputy President (Education). This involved me collecting authentic student voice to inform and shape institutional strategy and practice, which shaped my belonging and even my decision to transition from a STEM discipline into the educational research community. However, even with an elected representation title, I at times found it difficult to enact change and was only successful in doing so when provided with the right tools and opportunities. Furthermore, whilst I felt comfortable participating in these formalised representation structures, the same cannot be said for all students. This has prompted an ongoing reflection about how students might be engaged productively and sensitively in shaping their learning experience.

I later partnered with undergraduate students and staff under the institution's StudentShapers partnership programme to convert an underutilised departmental area into the transitional learning space in [Figure 13.1](#) (see [Streule et al., 2022](#)). This research-informed, participatory-design approach involved student partners using mixed methods like surveys and sandpit-style focus groups ([Casanova et al., 2018](#)) to consult their peer user groups to reimagine the spatial design. An open call for student partner applications was made to the department to ensure inclusive selection of the design team. As a doctoral researcher with experience of social science methods, the pre-renovation space and its transitional potential, I acted as what Norman (2010) calls a

'translational designer' by bridging the gap between research and practice. Students were engaged meaningfully, from the conceptualisation of space designs up to the implementation of those designs when products were selected from furniture suppliers. The depth of this involvement gave users a greater stake in the learning environment, both directly, for the student partners, and less directly for consulted staff and student groups.

Perhaps more interestingly, the participatory approach impacted how the space was later perceived and colonised. Whilst changing the physical space had intentionally changed its affordance (Gibson, 1977), the partners and the consulted user group also reflected on their preconceptions of the space and what Pantidi (2013) calls their 'legibility'. The participatory approach impacted their sense of ownership of and behaviour within the space, as well as their sense of belonging in the space and in the department.

Several researchers have theorised similarly in other contexts, including Temple (2019), who uses common-pool resource (CPR) theory to argue that the collective management of tangible and intangible resources, like physical and social space, can maximise sustainable output and help to create 'place' in universities. Likewise, Lefebvre's (1991, p. 33) 'conceptual triad' distinguishes between 'conceived' space, which is formally determined by conceptual design, 'lived' space, which relates to the meaning assigned to space as influenced by symbolic messages and cultural values, and 'perceived' space, which links the two former categories and is revealed through the daily use of space. Temple (2019) argues that, if we are to create place, as many spaces in the university should be moved from the conceived to the perceived category as possible through a greater understanding of which spaces in the institution are valued by staff and students.

Participatory approaches to space redesign arguably transform students from being users of an institutionally conceived space to designers with agency over the physical form and social capital of that space; this changes the meaning students make of those spaces. The participatory approach allowed several other departments to redesign their learning spaces in a way that was more effective, both educationally and in terms of cost, than traditional approaches. The literature does, however, lack theories and terminology which conceptualise this transition in student role and sense of ownership (Martens et al., 2019). The ecotone metaphor may help to conceptualise this tension and transitional space between design and usage, in a similar way to Lefebvre's (1991) conceptual triad, to explore how students' participation in shaping their own learning environment impacts their sense of belonging in and ownership of that environment.

Ecological metaphors for space and belonging

The ecotone metaphor has been introduced to help with conceptualising and understanding some of the learning spaces introduced in this chapter. For example, the transitions between the transformed, timetabled lecture theatre and the adjacent informal, non-timetabled space gave rise to a separate ecotone space in which students were less constrained by expectation or code of conduct. Within these ecotones exist tensions between opposing forces, between old and new behaviours and ways of thinking, and between existing and potential identities (see also Kandiko Howson & Kingsbury, [Chapter 1](#) in this volume). The flexible power-geometry of these fringe ecotones offers new situations and possibilities for students and teachers to manage these tensions.

The ecotone metaphor has helped to reveal the potential of the transformed lecture theatre, firstly via the introduction of connected seating booths which might be thought of as ‘micro-ecotones’ between student groups and teachers, and secondly by understanding the transitions and tensions in power and ownership between different interactants. Using this metaphor helped me to understand how the lecture theatre redesign had broadened the potential ecotone for transitions in behaviour, ownership and different ways of belonging, compared to the pre-renovation space. It also encouraged a redefinition of the classroom from a demarcated lecture theatre to an ecological zone, which includes the fringe informal spaces and potential ecotones in between; this conceptualisation has had powerful implications for design and practice ([McCrone, 2021](#)).

Thinking ecologically about space and belonging can help us to think more holistically about where students learn and belong ([Barnett & Jackson, 2019](#)). Ecotones are a versatile ecological metaphor which can be used to conceptualise not only the space between formal and informal learning, but those between teacher and student, between physical and virtual learning, between liminality and understanding, and between disciplines. Pendleton-Jullian ([2019](#)), for instance, used the concepts of ecotones, elasticity and agency for designing environments of innovation. This application may extend to how we understand the space and opportunity between management (conceived space) and user (perceived space) in the context of the student partnership redesign work. Involving students as end users in the redesign process provides them with more agency in shaping the ecotone and their sense of belonging in the subsequent renovated space. Furthermore, the ecotone metaphor could be applied to campus-scale design and planning in more holistic

thinking about student belonging in ‘distal’ living spaces like halls of residence, ‘proximal’ learning spaces like lecture theatres, and the spaces in between.

As students unpredictably colonise new learning spaces as hybrid learning increases, we need to develop methods which more aptly capture how exactly spaces are being used and perceived (McCrone & Kingsbury, 2023). This development will allow us to identify and develop ecotones like informal transitional spaces, in which a diverse group of students can thrive and shape their own conditions for belonging.

Conclusion

If we are to create a strong sense of belonging and support discovery-based learning, we must understand how ownership of space can be transitioned to students in ways that enable them to freely enact different ways of thinking and interacting. This chapter has introduced case studies, firstly to argue that transitional spaces like foyers and corridors at the fringe of lecture theatres possess flexible power-geometries within which students can engage in this learning interaction. Secondly, I have argued that the involvement of users in the redesign of these spaces can support a deeper sense of ownership and agency in those spaces. For student partners to reap these benefits, however, they must feel valued in the redesign process and be equipped with methods and tools which allow them to reimagine the spaces effectively; a translational designer who has researched the spaces can help to guide student partners towards a purposeful design.

The complex relationships between space, ownership and belonging are requiring us to rethink the traditional socio-spatial theories alluded to in this chapter. Ecotones are ecological zones at the boundary of two ecosystems (learning spaces) which provide a useful metaphor for this evolving complexity, given that they can capture the transitions and tensions between the lecture theatre and adjacent informal space, as well as the transitional space between those who design space and those who use it. Ecotones might also help us to identify and design not only spaces which enhance disciplinary belonging, like the transformed lecture theatre, but also spaces in between that promote interdisciplinary collaboration, innovation and new ideas from the interaction of different perspectives and approaches.

The dilemma between disciplinary belonging and interdisciplinary collaboration requires us to find a balance by looking at the ecotones

between formal, disciplinary spaces in which students and teachers have a shared agency to discover new ideas and possibilities. Furthermore, these ecological metaphors and holistic conceptions of learning space might help us to incorporate flexibility, connectivity and inclusivity into an increasingly hybrid learning experience. However, as hybrid, discovery-based learning poses challenges and opportunities for designers, educators and students, we must think carefully about which spaces students are learning in, and how these spaces can support the formation of belonging. This is particularly important in the STEM higher education context.

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References

- Ahn, M. Y. & Davis, H. H. (2020). Four domains of students' sense of belonging to university. *Studies in Higher Education*, 45(3), 622–34. <https://doi.org/10.1080/03075079.2018.1564902>.
- Allen, K., Kern, M. L., Vella-Brodrick, D., Hattie, J. & Waters, L. (2018). What schools need to know about fostering school belonging: A meta-analysis. *Educational Psychology Review*, 30(1), 1–34. <https://link.springer.com/article/10.1007/s10648-016-9389-8>.
- Barnett, R. & Jackson, N. (eds). (2019). *Ecologies for Learning and Practice: Emerging ideas, sightings, and possibilities*. Abingdon: Routledge.
- Becher, T. & Trowler, P. (2001). *Academic Tribes and Territories: Intellectual enquiry and the cultures of disciplines*, 2nd edn. Milton Keynes: McGraw-Hill Education.
- Brew, A. (2010). Imperatives and challenges in integrating teaching and research. *Higher Education Research & Development*, 29(2), 139–50. <https://doi.org/10.1080/07294360903552451>.
- Burke, P. J., Crozier, G. & Misiaszek, L. I. (2016). *Changing Pedagogical Spaces in Higher Education: Diversity, inequalities and misrecognition*. Abingdon: Routledge.
- Carnell, B. (2017). Connecting physical university spaces with research-based education strategy. *Journal of Learning Spaces*, 6(2), 1–12.
- Casanova, D., Di Napoli, R. & Leijon, M. (2018). Which space? Whose space? An experience in involving students and teachers in space design. *Teaching in Higher Education*, 23(4), 488–503. <https://doi.org/10.1080/13562517.2017.1414785>.
- Deed, C. & Alterator, S. (2017). Informal learning spaces and their impact on learning in higher education: Framing new narratives of participation. *Journal of Learning Spaces*, 6(3), 54–8.
- du Toit-Brits, C. (2022). Exploring the importance of a sense of belonging for a sense of ownership in learning. *South African Journal of Higher Education*, 36(5), 58–76. <http://dx.doi.org/10.20853/36-5-4345>.

- Epstein, D. (2021). *Range: Why generalists triumph in a specialized world*. New York: Riverhead Books.
- Finkelstein, A., Ferris, J., Weston, C. & Winer, L. (2016). Research-informed principles for (re) designing teaching and learning spaces. *Journal of Learning Spaces*, 5(1).
- Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafo, N., Jordt, H. & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, 111(23), 8410–15. <https://doi.org/10.1073/pnas.1319030111>.
- Freire, P. (2020). Pedagogy of the oppressed. In J. Beck, C. Jenks, N. Keddie & M. F. D. Young (eds), *Toward a Sociology of Education*, pp. 374–86. Abingdon: Routledge.
- Furrer, C. & Skinner, E. (2003). Sense of relatedness as a factor in children's academic engagement and performance. *Journal of Educational Psychology*, 95(1), 148–62. <https://doi.org/10.1037/0022-0663.95.1.148>.
- Gibson, J. J. (1977). The theory of affordances. In R. Shaw & J. Bransford (eds), *Perceiving, Acting, and Knowing: Toward an ecological psychology*, pp. 67–82. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Imms, W. & Kvan, T. (eds) (2021). *Teacher Transition into Innovative Learning Environments: A global perspective*. Singapore: Springer.
- Imperial College London (2017). Innovative teaching for world class learning: Learning and teaching strategy. <https://web.archive.org/web/20220520111847/https://www.imperial.ac.uk/learning-and-teaching-strategy/>. Accessed 30 December 2023.
- Jones, A. N. (2006). From the sage on the stage to the guide on the side: The challenge for educators today. *ABAC Journal*, 26(1), 1–18.
- Lam, E. W. M., Chan, D. W. M. & Wong, I. (2019). The architecture of built pedagogy for active learning: A case study of a university campus in Hong Kong. *Buildings*, 9(11), art. no. 230, 1–13. <https://doi.org/10.3390/buildings9110230>.
- Lefebvre, H. (1991). *The Production of Space*, trans. D. Nicholson-Smith. Oxford: Blackwell Publishing.
- Martens, S. E., Meeuwissen, S. N. E., Dolmans, D. H. J. M., Bovill, C. & Könings, K. D. (2019). Student participation in the design of learning and teaching: Disentangling the terminology and approaches. *Medical Teacher*, 41(10), 1203–5. <https://doi.org/10.1080/0142159X.2019.1615610>.
- Massey, D. (2005). *For Space*. London: SAGE Publications.
- McCrone, L. (2021). Transitional space in active learning: Perspectives from an undergraduate STEM education context. PhD thesis, Imperial College London.
- McCrone, L. & Kingsbury, M. (2023). Combining worlds: A mixed method for understanding learning spaces. *International Journal of Qualitative Methods*, 22. <https://doi.org/10.1177/16094069231173781>.
- Middleton, A. (2019). *Reimagining Spaces for Learning in Higher Education*. London: Bloomsbury Academic.
- Moradian, N., Moallemian, M., Delavari, F., Sedikides, C., Camargo, C. A., Jr, Torres, P. J., ... & Rezaei, N. (2021). Interdisciplinary approaches to COVID-19. In N. Rezaei (ed.), *Coronavirus Disease – COVID-19*, pp. 923–36. Cham: Springer.
- Nassar, U. A. & El-Samaty, H. S. (2014). Transition space in higher-education buildings as an efficient 'behavior setting' model. *International Journal of Innovative Research in Science, Engineering and Technology*, 3(1), 8304–19.
- Norman, D. A. (2010). The research–practice gap: The need for translational developers. *Interactions*, 17(4), 9–12. <https://doi.org/10.1145/1806491.1806494>.
- Oolbekkink-Marchand, H. W., Hadar, L. L., Smith, K., Helleve, I. & Ulvik, M. (2017). Teachers' perceived professional space and their agency. *Teaching and Teacher Education*, 62, 37–46. <https://doi.org/10.1016/j.tate.2016.11.005>.
- Osterman, K. F. (2000). Students' need for belonging in the school community. *Review of Educational Research*, 70(3), 323–67. <https://doi.org/10.3102/00346543070003323>.
- Pantidi, N. (2013). An ethnographic study of everyday interactions in innovative learning spaces. PhD thesis, Open University.
- Pendleton-Jullian, A. (2019). Education and innovation ecotones. In R. Barnett & N. Jackson (eds), *Ecologies for Learning and Practice: Emerging ideas, sightings*, pp. 112–28. Abingdon: Routledge.

- Ravelli, L. J. & Stenglin, M. (2008). Feeling space: Interpersonal communication and spatial semiotics. In G. Antos & E. Ventola (eds), *Handbook of Interpersonal Communication*, pp. 355–93. Berlin: Walter de Gruyter.
- Samura, M. (2018). Understanding campus spaces to improve student belonging. *About Campus*, 23(2), 19–23. <https://doi.org/10.1177/1086482218785887>.
- Sennett, R. (2018). *Building and Dwelling: Ethics for the city*. New York: Farrar, Straus and Giroux.
- Streule, M., McCrone, L., Andrew, Y. & Walker, C. (2022). Engaging with students as partners in education-space design. *International Journal for Students as Partners*, 6(2), 79–90. <https://doi.org/10.15173/ijsap.v6i2.5024>.
- Temple, P. (2018). Space, place and institutional effectiveness in higher education. *Policy Reviews in Higher Education*, 2(2), 133–50. <https://doi.org/10.1080/23322969.2018.1442243>.
- Temple, P. (2019). University spaces: Creating cité and place. *London Review of Education*, 17(2), 223–35. <http://dx.doi.org/10.18546/LRE.17.2.09>.
- Wut, T. M., Xu, J., Lee, S. W. & Lee, D. (2022). University student readiness and its effect on intention to participate in the flipped classroom setting of hybrid learning. *Education Sciences*, 12(7), art. no. 442, 1–15. <https://doi.org/10.3390/educsci12070442>.

