Making the Space for Learning

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Learning unfolds within and across spaces, whether within school classrooms, across small outdoor tables, or on quiet library couches. Such spaces contain various elements that we use and experience. We find furniture to relax or focus on. We interact with objects, materials, and tools to assist our thinking and expression. We look for surfaces, lighting, temperature, colors, and acoustics to create a sense of safety and calm. When thoughtfully assembled, spaces and their elements can provide affordances for learning—offering architectures that support encountering new ideas, extending knowledge, practicing skills, and getting feedback. To what degree are the spaces in which we learn designed *with learning in mind*? This white paper aims to examine what is known about the qualities of spaces that support learning and offer guiding principles for designers of learning spaces to consider.

Linking Learning Outcomes & Spaces

Work in the past decade has examined the relationship between the qualities of space and various learning outcomes such as standardized literacy and mathematics scores. An array of studies suggest linkages between space typologies and student achievement through methods of qualitative interviews and surveys with teachers and learners, quantitative longitudinal regression analysis, and observations of classrooms (Kariippanon et al., 2020; Talbert & Mor-Avi, 2019; Vroman et al., 2012). While these veins of work have important methodological differences, several general and overlapping findings are useful for designers and educators.

First, and perhaps the most obvious, is that effective learning spaces are designed with attention to basic conditions for physical safety

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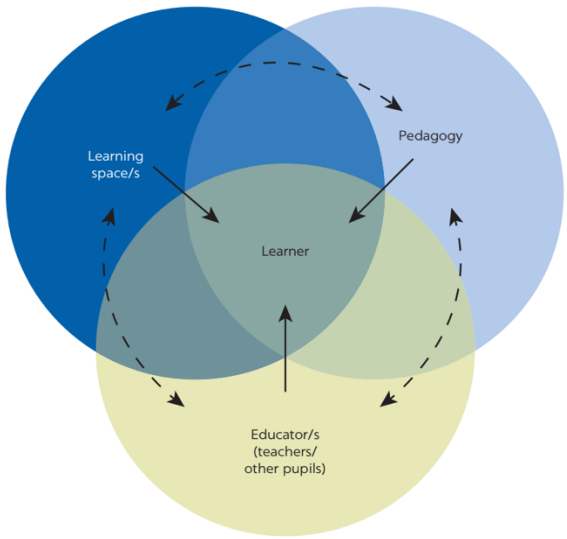
and habitability. Buildings must be structurally sound. Rooms should provide good air and light quality. Settings should have suitable acoustics and comfortable temperatures, as well as adequate furnishings, such as chairs and tables, and not be overcrowded. Spaces should provide access to clean water, be sanitarily maintained, and have access to electricity. Research has shown that spaces lacking attention to such basic conditions contribute to lower student learning outcomes (Barrett et al., 2019; Uline & Tschannen-Moran, 2008).

Second, spaces that support positive learning outcomes are designed for optimal stimulation. Variations in colors and architectural elements provide visual complexity (Cox, 2018; Tanner, 2008) and varied materials can produce different sensations of touch and feel (Davies et al., 2013). The experiential levels of visual, auditory, tactile, and other stimuli must not flood or distract learners. Conversely, a lack of stimuli can risk disengagement or boredom. Optimal stimulation is the goal: not too much that overwhelms and distracts, but enough to arouse and enliven learners' experience (Fisher et al., 2014).

Finally, research suggests that spaces designed for learner connection lead to increases in various learning outcomes. Learner connections can take several forms. Spaces can support connections to *self* by enabling feelings of ownership and belonging in learners (Beckers et al., 2016). Spaces engender connections to *others* by offering views to see peers in other settings, visibly sharing work, assembling a mix of large and small configurations, and organizing school life in clustered neighborhoods (Tanner, 2009). And spaces create connections to *surroundings* through ease of movement, ample interior views, and views of the outdoors (Barrett et al., 2017). Designs with these types of learner connections have demonstrated a variety of positive impacts on academic learning outcomes.

In sum, existing studies suggest these spatial qualities—spaces that are *physically safe and habitable*, have *optimal stimulation*, and foster *learner connection*—are linked to increases in academic achievement measured by various testing outcomes. While space plays a significant role, researchers also caution designers not to take an overly deterministic view: the teachers' pedagogical choices within spaces are equally, if not more, impactful on student learning outcomes (Barrett et al., 2019; Imms & Byers, 2017; Young et al., 2019). Therefore, as Figure 1 suggests, designers must bear in mind how pedagogical experiences unfold within spaces.



Source: Barrett et al. 2015.

Figure 1. Learning interactions between teachers, spaces, and pedagogy

In that spirit, this white paper goes a step further by reminding designers that learning is more than what is evaluated in standardized tests or achievement scores. Designing spaces with affordances for learning must consider learning as both a process and an outcome. That is, spaces for learning must not only support *what* is learned but *how* learning happens.

Linking Learning Practices & Spaces

How learning happens is evidenced by the quality of learning practices. Learning practices

are processes learners engage in that build attitudes, knowledge, and skills. Research has long investigated a range of socio-cognitive learning processes of individuals, dyads, and groups. Such studies reveal the important activities that support learning, including how and why learners pay attention (Bandura, 1977), how learners flexibly think with and transfer knowledge (Perkins, 1993), and how learners give and receive feedback (Webb & Palincsar, 1996). Looking across this work, processes can be loosely grouped into types of learning practices, including but not limited to learning practices of *noticing, wondering,* and *helping*.

Noticing is a core learning practice with processes that focus learners' attention through slowing down for close observation, looking, listening, thinking, and feeling (Tishman, 2018). Practices of noticing often lead learners to practices of wondering, in which they are curiously asking questions, creatively exploring, and actively experimenting (Clapp, 2017; Ritchhart et al., 2011). As learners confront uncertainty and doubt, they often turn to others for advice, ideas, and support. Practices of helping include learners asking for and offering input, feedback, and guidance (Aleven et al., 2003; Calarco, 2011; Webb et al., 2006). These three categories are not offered as discrete or exhaustive. Rather, they aim to give designers a provisional purchase on core and interrelated learning processes from which research-based design principles can be derived.

There is curiously scant research in school contexts that link spatial qualities and affordances to such learning practices. Therefore, over the course of a year, the authors identified and read over one hundred research studies from fields ranging from urban design, museum education, cognitive science, health care, architecture, and therapeutic counseling. Studies were summarized, discussed, and coded according to learning practices, research methods, and key findings. Through iterative cycles of sensemaking, the authors distilled the following research-based qualities of space, objects, and materials that support learning practices of noticing, wondering, and helping.

Contrasting

Gestalt psychology, a foundational school of thought for modern visual design, suggests that people interpret objects with the "simplest and most complete perceptual solution possible under the conditions given" (Dresp-Langley, 2015). When spaces, objects, and materials conflict with expected perceptual patterns, they create affordances for noticing, curiosity, and exploration. Whether an art exhibit sparks opportunities for a surprise or a mixed-use neighborhood design fosters novel community interactions, environments with contrasting elements can encourage behaviors and relationships that foster several learning practices. This section examines various environments where designers and researchers have explored linkages between contrasting design elements to evoke practices of noticing, wondering, and helping.

Figure 2. Temporary mirror exhibits in plazas

Incongruity

When objects in one's environment are perceived as out-of-place or surprising, it creates incongruity between expectations and reality (Paletta & Tsotsos, 2008). Objects and spaces that exhibit incongruity create unexpectedness, triggering attention and slowed movement and perception. For example, creating temporary installations in community

spaces that change over time can increase the usage, lingering, and interactions between community members. Schlickman and Domlesky (2019) stationed temporary mirror installations in urban plazas and observed the behaviors of passersby over several days before, during, and after the intervention. People lingered around these mirrors, taking pictures of themselves and the respective cityscape. Similarly, Nikolopoulou et al. (2016) found that "mirrors as [environmental] interventions hold attention and heighten self-awareness," noting that, "the greatest effect occurs when interventions are unexpected." Likewise, an urban design study found that including new landmarks, trees, and local storefronts on extended streets slowed traffic speed in villages (Hamilton-Baillie & Mitchell, 2020). Intentional moments of incongruity in spaces can be a useful tool in encouraging individuals to slow down and notice their surroundings with deeper awareness.

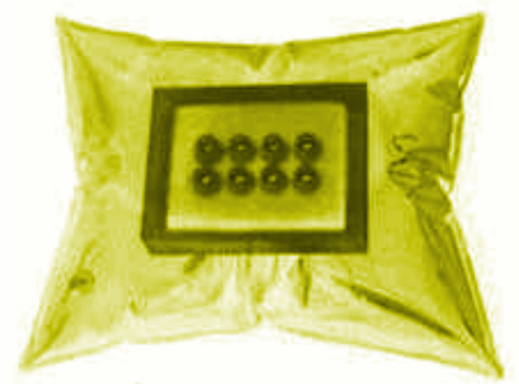


Figure 3. The Pillow by Tony Dunne and Fiona Raby

Additionally, ambiguous objects, or objects with unclear meanings or uses, can stimulate curiosity and exploration. Ambiguity creates unexpectedness, eliciting awareness and attention. It invites users to actively speculate and consider the different meanings and uses of objects (Montambeau, 2018).

In their piece "The Pillow," design researchers Dunne and Raby delve into the concept of ambiguous objects. The Pillow is an inflated, plastic brick embedded with a digital display. The display responds to, both acoustically and visually, electromagnetic waves from various digital devices in its vicinity (e.g. radios, cellphones, etc.). The disparity of the visuals and sounds emitted necessitates that users cognitively complete an idea of what the object is and how it is used, ultimately inciting curiosity and engagement (Gaver et al., 2003). Likewise, in a study of children's interactions with recycled and discarded materials, Guerra and Zuccoli (2012) suggest that the ambiguity of unfinished materials positively impacts children's sense of wonder and creativity. Such materials enable the formation of novel connections between information, thoughts, and objects. Studies also posit that children's interactions with "open-ended objects" (e.g. clay, Froebelian wooden blocks, etc.) can spark and sustain curiosity, exploration, and creativity as learners construct new meanings for the objects (Cortés Loyola et al., 2020; Davies et al., 2013).

On a larger scale, Jelic et al. (2020) observed that designing non-standardized and open-ended play spaces presents challenges that nurture children's curiosity and sense of wonder as they explore their environs. Open-ended objects and spaces that are incongruent with their surroundings afford opportunities for users and learners to lead their learning by exploring personal and intimate creations of meaning and uses.

Sense-scaping

By engaging a variety of human senses, including touch, smell, sound, taste, movement, and bodily awareness, individuals can experience instances of heightened awareness and contemplation. Schlickman and Domelesky (2019) note that plazas designed with soft surface materials and exposed to sunlight create a warm environment that encourages slow movement and lounging. Similarly, Hamilton-Baillie and Mitchell's (2020) study found that drivers tend to drive slower when they experience different physical sensations,

such as vibrations or sounds produced by subtle bumps and variations in the pavement.

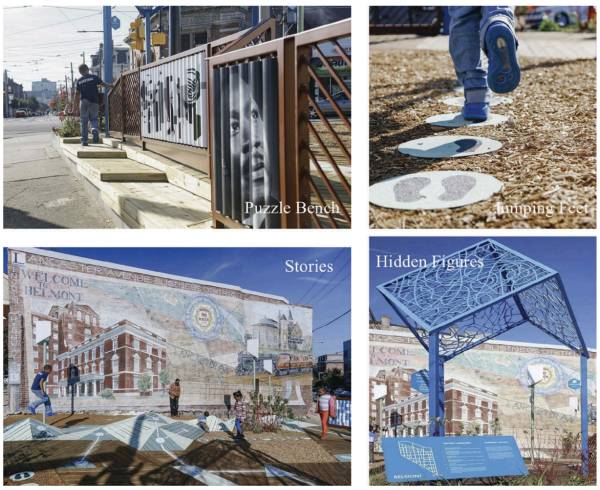


Figure 4. Photos of Urban Thinkscapes

In a series of interventions called Urban Thinkspaces (Figure 4), researchers designed puzzles and movable parts at bus stops and parks to stimulate spatial skills and proprioception, or bodily awareness, to promote exploration and curiosity. These sensory-based interventions resulted in increased conversations and interactions between caregivers and children (Hassinger-Das et al., 2020).

Furthermore, diverse and sensory-rich materials are effective in stimulating attention, curiosity, and exploration among young learners (Penfold, 2019). Cox (2018) coined the phrase "sensescape" to describe the range of stimuli in an environment and their role in supporting different learning tasks. As Cox succinctly explains, "The importance of the sensory aspect of this learning landscape reminds us that the body is central to learning." Incorporating sensory variation in an environment creates various affordances for learning practices such as noticing and wondering. However, it is essential to maintain a balance of sensory stimulation to ensure an appropriate learning space. Jelic et al. (2020) reference the work of Dutch architect Aldo van Eyck to depict how the purposeful absence of stimulation allows children to freely use their imagination and explore various uses of the space. Van Eyck's playgrounds, aptly named "Tools for Imagination," are adorned with abstract forms and playful sculptures that encourage children to imagine new interactions with their surroundings. When designing spaces, objects, and materials for learning, it is important to implement a deliberate level of sensorial stimulation experienced by learners.

Spotlighting

In a learning environment, objects and tools can also aid in focusing and "spotlight" learners' attention. Spotlighting refers to the ability of a space, material, or object to enable a narrow line of attention. Spotlights can be predetermined for learners, or they can provide options for where and how they direct their focus.

Figure 5. A dyad exploring dioramas with flashlights

At the Field Museum in Chicago, researchers found that the use of prompted conversational cards that focused the attention of caregivers and children often led to elaborative discussions about curious objects, nonverbal engagement with the exhibits, and associative statements from the caregiver between exhibits (Jant et al., 2014). A similar study at the Carnegie Museum of Natural History (Figure 5) found that families who explored dioramas with flashlights in dimly lit settings were more likely to establish joint attention and engage in educational conversations about the objects than in standard, well-lit environments (Povis & Crowley, 2015). In a more conventional setting,

Hassinger-Das et al. (2018) used cleverly designed signage in local supermarkets to encourage conversations between children and caregivers in low socio-economic neighborhoods. The signs included questions such as, “Where does the milk come from?” or “What’s your favorite vegetable?”. This intervention resulted in a notable increase in caregiver-child language interactions in which adults used more descriptive language and children asked significantly more questions.

The quality of light in a space can also influence the ability to focus on oneself and others. For instance, a study on counseling spaces revealed that dim lighting evoked feelings of pleasantness and relaxation in participants, resulting in greater self-disclosure (Miwa & Hanyu, 2006). Conversely, bright lights and resistant surfaces were found to increase “feelings of non-control over their environments” (Liddicoat, 2016). Properly designed lighting can lead to internal redirection, allowing individuals in a space to be more comfortable with self-disclosure and seeking help.

These findings demonstrate that, unsurprisingly, learning environments intentionally designed to spotlight can encourage learners to notice purposeful objects and ponder upon curious ideas.

Varying

In addition to sensorial and tactile interventions, there are also advantages to employing contrast within the broader context of communities. For instance, communities that incorporate walkable paths and mixed-use buildings have been found to promote higher levels of trust, social engagement, and political participation among residents (Leyden, 2003). Unlike neighborhoods with homogenous forms and functions, neighborhoods with varying uses promote a sense of responsibility to a resident's own community. These mixed-use neighborhoods were seen to “[increase] individual calm, community trust and [decrease] perceived danger in public space” (Zumelzu & Herrmann-Lunecke, 2021). Spaces with high use variance were also observed to elevate perceived social support and diminish social angst. Neighborhoods designed with qualities of contrast, through the incorporation of diversity and variation, can set the scene for learners to slow down, notice their environments, and bolster practices of communal help.

Flowing

Restricted movement or sedentary behavior in students has been associated with reduced engagement and focus among early adolescents (Kariippanon et al., 2020). Moreover, the ability to move and the quality of movement can support learners noticing, exploration, and curiosity (Leyden, 2003; Proulx et al., 2016). For example, spaces, objects, and materials with winding and non-linear pathways prompt participants to slow down and explore their surroundings (Hamilton-Baillie & Mitchell, 2020; Schlickman & Domlesky, 2019). What follows are several ways in which designers integrate a sense of flow, offering learners the freedom to reconfigure, control, manipulate, and adapt their environment in ways that inspire creativity and moments of wonder, leading to novel discoveries.

Curving

Studies in urban design reveal how the layout of pathways can have a significant impact on the pace of human activity and interaction. Hamilton-Baillie & Mitchell (2020) found that drivers adjust their speed based on the formal characteristics of the road, such as its width and curvature. Narrow or curved roads that obscured the horizon resulted in slower driving speeds. Additionally, the researchers observed that when drivers slow down, they become more aware of the environment and pay closer attention to their surroundings. The design of a pathway, whether it is a highway or a hallway,

can influence where and how people redirect their attention.

On a more personal scale, studies of interior design have shown that the shape of furniture can have a psychological impact on people. Dazkir & Read (2012) state that curvilinear furniture tends to elicit feelings of comfort, calmness, and peacefulness more than rectilinear forms. This suggests that incorporating organic curves and shapes into learning spaces could create the psychological conditions that support help-seeking and help-giving behaviors. Designers should consider incorporating organic curves and shapes into spaces intended for help-seeking, noticing, and wondering, to influence how learners move through the given space.

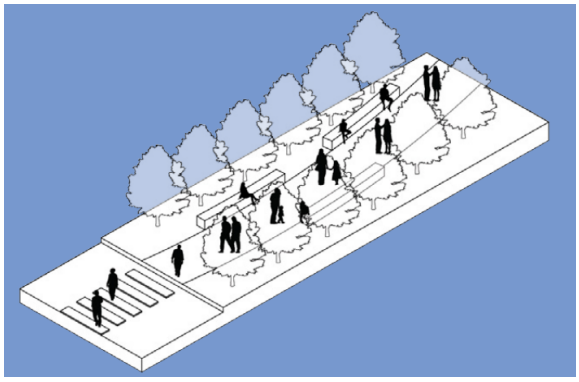


Figure 6. Diagram of "pit-stopping"

Pausing

Pathways for movement can be designed to encourage individuals to slow down, pause, and notice. For example, plazas designed with features that encourage "pit-stopping," such as extended sidewalks and adjacent pathways, can result in pedestrians slowing down, lingering, and gathering spontaneously (Schlickman & Domlesky, 2019). On the other hand, plaza designs that have no obstructions, such as the "downstream" and "channelization" interventions, tend to attract larger and faster-moving crowds of people.

Figure 7. Pathway layouts for two international museums: (a) global vs. (b) sequential.

Indoor spatial studies suggest similar findings. Museums often aim to elicit slow-paced experiences and promote exploration. Tzortzi (2014) suggests that museum layouts vary in how they guide their occupants, differing in global sequencing and local experiences, vastly affecting how visitors move through exhibits. Within museums, global sequences can range from linear to exploratory movement. Highly linear global sequencing—shown in Figure 7a with a main hallway and discrete branches—resulted in a higher proportion of spaces visited but with less lingering and thematic connectedness. In contrast, less linearity, characterized by multiple pathways between exhibits (Figure 7b), encouraged more movement and exploration across different exhibits.

Collectively, these findings suggest that designing pathways as "pauseways" can foster behaviors where users shift their pace, slow down, and explore their surroundings.

Moving

While curved paths and pauseways promote practices of slowing down, noticing, and helping practices, other design choices that encourage movement and spatial familiarity can enhance learners' creativity. Studies show that physical movement can stimulate various creative outcomes. (Fleury et al., 2020; Leung et al.,

2012; Oppezzo & Schwartz, 2014). According to Leung et al. (2012), physical movement can improve performance in both divergent-thinking and convergent-thinking tasks, as moving between spaces without constraints can break down mental barriers that restrict creative cognition. In another study, Fleury et al. (2020) demonstrate the benefits of “the visual perceptual component of movement” through virtual reality, suggesting that even perceptual movement, not just physical, can increase creative outcomes.

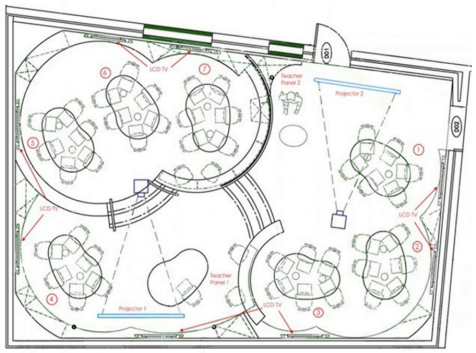


Figure 8. Active Learning Environment

These findings have prompted designers and researchers to develop Active Learning Environments (ALEs) as a response to the passive, inactive learning that commonly occurs in many classrooms (Talbert & Mor-Avi, 2019). ALEs (Figure 8) have demonstrated positive effects on outcomes such as student achievement, engagement, autonomy, creativity, and noticing (Charteris, 2019; Davies et al., 2013; Kariippanon et al., 2020; Talbert & Mor-Avi, 2019). These learning environments frequently feature movable furniture that can be reconfigured to suit the space or occupant’s needs. Many of these spaces lack a defined front or back, serving as polycentric rooms that offer greater freedom of movement. In the aforementioned study on playgrounds by Jelic et al. (2020), the researchers concluded that “the availability of moveable play equipment supports creativity and diversity of play behaviors.”

In addition, pliable objects and materials like water, sand, wood, rocks, and vegetation provide students with the opportunity to "manipulate, adapt, construct, design, develop, and relocate equipment that develops their social and collaborative skills." The ability to modify one's surroundings is essential for individuals to feel in control of their learning and space.

Local familiarity is another aspect of space that promotes movement. Studies have demonstrated that residents in walkable, mixed-use neighborhoods tend to have greater trust in others, greater social involvement, and greater political participation (Leyden, 2003). These neighborhoods foster an environment in which individuals can easily and comfortably navigate their surroundings, becoming familiar with their local context. This sense of familiarity and movement can lead to increased help-seeking and help-giving behaviors, as well as promote overall positive feelings of social connectedness and support. Studies conducted by Proulx et al. (2016) indicate that familiarity with one's neighborhood and the ability to move freely through it promote allocentrism—an attentional focus on other people. Specifically, Proulx and colleagues suggest that having unrestricted movement within a neighborhood over time allows individuals to experience multiple pathways and perspectives, leading to the acquisition of allocentric knowledge. In contrast, disorderly neighborhood spaces or constrained local movement can result in a lack of familiarity and encourage egocentric behaviors, which in turn limits opportunities for both help-seeking and help-giving (Mou et al., 2004).

Closeness

Although contrast and flow can enhance learning practices through surprise and movement, closeness and connectedness are also important qualities for creating social conditions that promote help-seeking,

observation, and curiosity. Spaces that evoke feelings of closeness and connectedness foster relationships and a sense of inclusion within one's environment. In the following section, we will explore several ways in which designers can cultivate a sense of closeness through visibility, density, and a sense of belonging.

Visibility

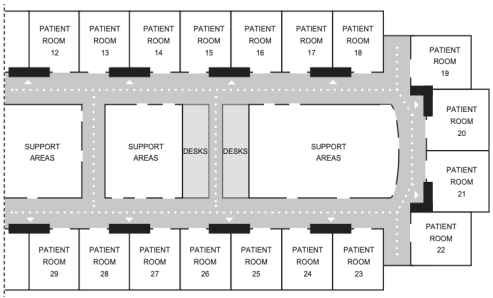


Figure 9. Healthcare clinic floorplan

The ability to see and make eye contact with others fosters opportunities for forming social connections. Studies indicate that a learner's sense of belonging to a group or community predicts their academic help-seeking behaviors (Dueñas et al., 2021; Won et al., 2021). Additionally, at the urban level, features such as front porches that allow for visibility from a building's exterior inward or having a front door instead of a side or back entrance are positively linked to perceived social support in a neighborhood (Brown, 2009; Spokane et al., 2007). Landmarks, which aid in spatial recognition, also help individuals navigate an area more easily (Mou et al., 2004). In short, elements that facilitate feelings of connectedness encourage social support and interpersonal communication. Conversely, studies suggest that a lack of invitations, such as closed curtains on front-facing windows, can lead to reduced opportunities for visibility and social support (Brown, 2009). However, it is important to note that, although visibility enables awareness of others, a loss of control over personal exposure can result in discomfort.

The relationship between awareness, visibility, and help-seeking has also been thoroughly explored in the healthcare domain (Figure 9). Within healthcare clinics, open spaces, as opposed to enclosed, pod-like spaces, facilitated a higher frequency of unplanned and spontaneous instances of help-seeking among nursing staff (Real et al., 2017). According to Pati et al. (2016), enclosed pod-like spaces hinder communication among medical staff and patients, reducing their "capacity to extend or seek help due to a lack of awareness." Taking these findings into account, a study on classroom seating arrangements found that the same holds for children's question-asking. Placing students in a semicircular seating arrangement with unobstructed eye contact yielded a greater number of questions asked, in contrast to the row-and-column seating arrangements (Marx et al., 1999).

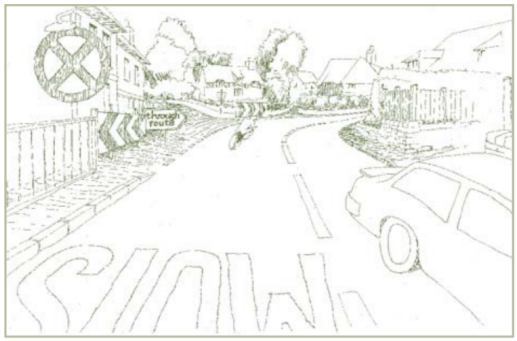


Figure 10. Sketch of a winding street path

Hamilton-Baillie and Mitchell's (2020) research extends beyond enclosed spaces to describe the effect of visibility in an urban environment. When drivers have an unobstructed view of the horizon, they tend to drive at a faster speed. When their line of sight is occluded by a winding path (Figure 10) or redirected to their surroundings, they are more likely to slow down and notice smaller details in their environment. Schlickman & Domlesky (2019) also studied the impact of visibility on plazas by incorporating spaces for performances and audiences. This design intervention resulted in most occupants, particularly teenagers, feeling comfortable in "entertainer" spaces because they could both observe their surroundings and be seen by others. By utilizing varying heights and ground

levels, the design meets the needs of the occupants.

Compactness

The proximity between individuals is also an important factor in fostering closeness. Research suggests that high levels of density can be detrimental to social support and learning behaviors, particularly concerning seeking help. Spaces with higher densities have been linked to lower levels of support-seeking behavior, lower perceived support, and reduced support provision. Researchers suggest that this may be due to individuals feeling a lack of control or becoming overstimulated, leading to social withdrawal (Evans & Lepore, 1993).

The compactness of a community can facilitate socialization. Like varying neighborhoods, compact neighborhoods may offer a variety of spaces, like bars, restaurants, and coffee shops, as well as shorter distances to the city center, which encourages social interaction and support. Mouratidis (2018) addresses this phenomenon and explains that “even though compact-city residents may not even know the people living in the same apartment block, they do have more close relationships with which they socialize more frequently, and they receive more emotional and functional support as compared with residents of low-density suburbs.” As a result, compact neighborhoods allow people to maintain their existing relationships, which enhances their social support, and generates opportunities to develop new friendships and acquaintances, ultimately contributing to their overall social well-being. In the context of classrooms, Imms & Byers (2017) (Figure 11) illustrate how many schools are experimenting with neighborhood-like designs that leverage the affordances of compactness. The establishment and maintenance of relationships can enhance people's ability to seek and provide social support.

Figure 11. Compact learning space typologies

Inclusivity

While visibility and density reveal interpersonal and urban conditions, at the community level, promoting a sense of inclusivity is crucial in fostering help-seeking behaviors. When students are involved in the co-design of learning spaces, they feel a sense of ownership and belonging, which enables them to more comfortably rely on their peers for support and feedback, fostering closer relationships (Levy & Adjapong, 2020; Szatek, 2020).

Explicit invitations for help-seeking can also promote inclusivity by challenging students’ “perceptions of the reactive and remedial nature of 'support’ and guidance” and dismantling the negative social connotations of help-seeking (Pillai, 2010). Spatially, inclusivity is manifested in “democratic classrooms.” Tannebaum and Tannebaum (2019) state that, democratic classrooms are emotionally supportive environments where students “can feel confident in their belief system and free to seek assistance from those around them.” Moreover, among students, classrooms with more comfortable peer relations demonstrated more help-seeking behaviors (Ryan et al., 2001). Implementing such spaces may involve showcasing student artwork or incorporating vibrant and colorful elements (Fedorenko, 2014; Milkie & Warner, 2011, as cited in Tannebaum & Tannebaum, 2019). Designing spaces for inclusivity seeks to foster connections among

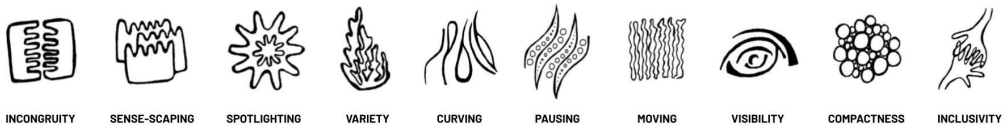
people and ultimately promote help-seeking and help-giving behaviors.

Conclusion

The research studies presented suggest three qualities of space, objects, and materials that support learning practices of noticing, wondering, and helping. The findings suggest that designs featuring qualities of contrasting, flowing, and closeness offer affordances for how learners learn. This paper is intended to provide design opportunities for designers to consider in learning spaces; from implementing curvilinear furniture forms to promoting comfort and help-seeking behaviors.

Qualities of Materials, Objects, and Spaces

LEARNING PRACTICES	Contrasting	Flowing	Closenesss
NOTICING	How are elements out of place, juxtaposed, or surprising?	In what ways do pathways support learners' awareness of their broader surroundings?	How are different views and vantage points encouraging learners to slow down?
	How are elements stimulating various senses for learners?	How are pathways encouraging learners to slow down, gather, and linger?	
	How are learners enabled to choose where to focus their attention?	In what ways are learners engaging in self-directed, flexible movement?	
WONDERING	How are ambiguous elements supporting users to explore meaning and uses?	In what ways do pathways enable nonlinear exploration?	How are different heights providing moments of personal and environmental awareness?
	How does stimulation of various senses encourage exploration?	How do elements promote rediscovery and new ways to move through an environment?	How are spaces and elements co-designed in ways that ignite learners' exploration?
	How are questions, signs or prompts initiating reflective conversations?	How polycentric is the space?	How is learners' thinking and learning displayed and shared?
HELPING	How is low lighting used to induce feelings of self-disclosure?	How does the curving of elements provide comfort?	How does access to interactions promote helping behavior?
	How varied and heterogeneous is the environment?	How are familiar elements promoting movement?	How do elements create a sense of comfort and closeness among learners?
	How is space designed for multiple uses and social support?	How are related elements evoking familiarity within the space?	How do co-designed spaces support learners' belonging and inclusivity?



To do so, designers could incorporate contrasting textures of materials to create multisensory experiences and create varying levels of visibility to influence how learners connect and feel connected. Moreover, the table above offers a reflective tool that operationalizes key findings into questions to consider when developing designs to support learning practices.

While this tool attempts to integrate key ideas from the research into action, a keen reader might wonder whether some qualities inherently relate more to one learning practice than others. For example, studies suggest that qualities of contrast create conditions that tend to support practices of noticing. Designs that emphasize qualities of flowing and movement seem well suited to create affordances for practices of wondering. And help-seeking practices may be fostered by designing for qualities of closeness. While this may feel conceptually true, just as the learning practices should not be viewed as fully discrete categories, we encourage readers to consider the interrelationships between the qualities and the practices. Further applied research needs to be done to explore the connectivity and conceptual clarity between qualities and practices.

Beyond the formal qualities of objects, materials, and space, the various studies cited in this paper raise the importance of considering the social-cultural context of design interventions. Though many interventions highlight the formal qualities of an object or space, such as the curvilinearity of furniture or paths, all interventions ultimately aim to change or support interactions among people. Therefore, socio-cultural issues such as power, identity, and values need to be understood and critically considered. Interventions that seek to create active learning environments, compact neighborhoods, and democratic classrooms need to take into consideration participants' cultural values to be effective. In other words, while the qualities of contrasting, closeness, and flowing occur in the formal, material, and environmental dimensions, designers also understand the sociocultural dimension of the design.

Additionally, while the authors reviewed over a hundred articles for this white paper, some key and important studies were likely missed. For example, the literature review was limited to peer-reviewed articles in English. Key search terms for research studies were derived from phrases and concepts related to noticing, wondering, and helping learning practices. Peer-reviewed research journals were targeted, but not dissertations, books, or other resources. These and other choices we made may have led to oversights in finding and distilling additional studies that could have shaped the types of qualities we found.

Designers and educators who are interested in creating environments that support learning should focus, not just on how spaces, objects, and materials lead to traditionally measured learning outcomes, but also on how the environment supports specific learning practices. Some qualities that support traditional learning outcomes, such as optimal stimulation and learner connection, seem connected to qualities that support learning practices, such as contrast and closeness. However, this paper offers a more nuanced view into specific sub-qualities, such as incongruity and sensory variance, that research suggests supporting practices of noticing, wondering, and helping. Environments for learning should be deliberately designed for how learning happens, in all its social complexity.

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