Making the Space for Learning

Paula Garza Gonzalez
Daniel Noh
Daniel Wilson

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 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 the 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.

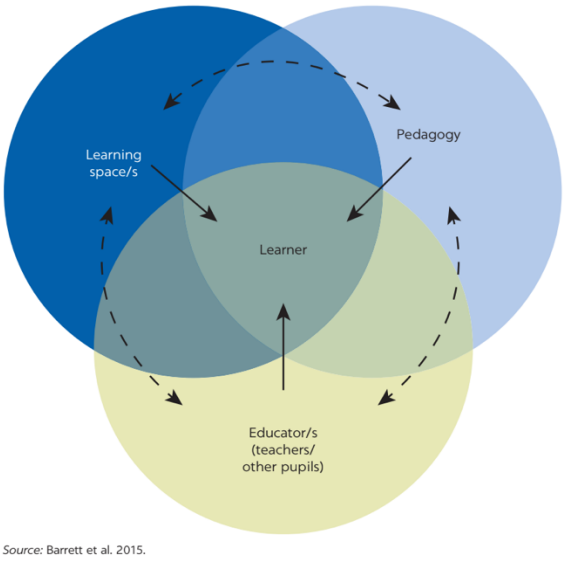
First, and perhaps the most obvious, is that effective learning spaces are designed with

attention to basic conditions for physical safety 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 positively increase 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: 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 suggest, designers must bear in mind how pedagogical experiences unfold within spaces.



Source: Barrett et al. 2015.

Figure 1. Learning Interactions: Teacher, 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, which 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 they 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 provisional purchases 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. Below are various ways designers and researchers have explored linkages between contrasting design elements and 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 the

slowing down of movement and perception. For example, creating temporary installations in community spaces that change over time can increase community member use, lingering, and interactions. As shown in Figure 2, researchers 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. From their observations, 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, a study of traffic in villages found that the inclusion of new landmarks, trees, and local storefronts on extended streets slowed traffic speed (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 heightened awareness.

Additionally, ambiguous objects, or objects with unclear meanings or uses, can stimulate curiosity and exploration. Ambiguity also creates unexpectedness, eliciting awareness and attention. In addition, however, it also invites users to actively speculate and consider the meaning and uses of the object (Montambeau, 2018). For example, imprecise displays, such as "The Pillow" in Figure 3,

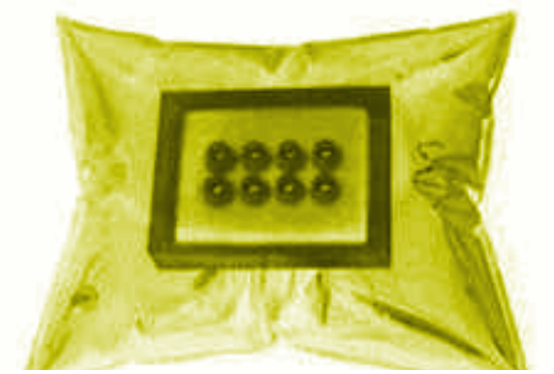


Figure 3

require users to cognitively complete the image, resulting in curiosity, engagement, and feelings of aesthetically pleasing outcomes (Gaver et al., 2003). Additionally, in a study of children's interactions using recycled or discarded materials, Guerra and Zuccoli (2012) suggest that the ambiguity of unfinished materials has a positive impact on their sense of wonder and creativity. Such materials enable the generation of novel and original connections between information, thoughts, and objects. Therefore, studies of children's interactions with "open-ended objects" (e.g. clay, Froebelian wooden blocks, etc.) show that these objects spark and sustain curiosity, exploration, and creativity as meanings are constructed (Cortés Loyola et al., 2020; Davies et al., 2013). Not only can objects be open-ended, but spaces too. Researchers (Jelic et al., 2020) have also discovered that designing open-ended and non-standardized play spaces introduces challenges that nurture children's curiosity and sense of wonder as they explore their environment. Open-ended objects and play spaces afford opportunities for users and learners to notice, wonder and lead their learning through personal creations of meaning and exploration of uses.

Sense-scaping

Research suggests that tapping into the range of human senses – including touch, smell, sound, taste, movement, and bodily awareness – elicits pausing and noticing. For example, Schlickman and Domelesky (2019) note how warmth from the sunlight and soft materials encourages slowing down and lounging in plazas. Similarly, drivers reduce their traveling speeds when they feel or hear different sensations, such as vibrations or sounds from variations in the pavement or subtle bumps (Hamilton-Baillie & Mitchell, 2020). In a series of interventions called Urban Thinkscapes depicted in Figure 4, researchers designed puzzles to stimulate spatial skills at bus stops and movable parts on park benches to promote exploration and curiosity. These sensory interventions led to more exploratory

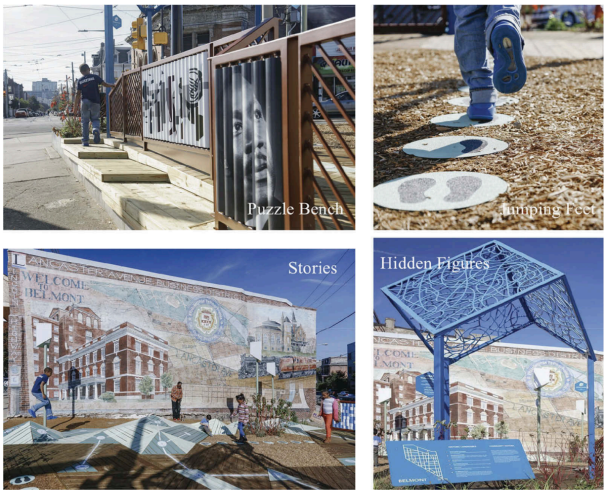


Figure 5

conversations and interactions between caregivers and children (Hassinger-Das et al., 2020).

Furthermore, diverse and sensory-rich materials encourage attention, curiosity, and exploration in young learners. (Penfold, 2019). Cox (2018) coined the phrase "sensescape" to describe the range of stimuli in an environment and the designed role they play in supporting different learning tasks. As Cox succinctly puts it, "the importance of the sensory aspect of this learning landscape reminds us that the body is central to learning." Designing sensory variation in an environment creates various affordances for learning practices of noticing and wondering. However, a balance of sensory stimulation is important for adequate learning space. Examples of spaces on the less stimulating side of the spectrum are the works of Dutch architect Aldo van Eyck. Researchers Jelic et al. (2020) use the architect's work to explain how a lack of stimulation gives children the freedom to use their imagination and explore the different uses of the space. Aldo van Eyck names these playgrounds as "Tools for Imagination" with this simple goal in mind. Therefore, when designing for learning practices such as noticing and wondering, it is important to balance sensory stimulation that is experienced in the spaces, objects, or materials.

Spotlighting

Objects and tools in a space can also support where and how learners focus and "spotlight" attention. Spotlighting refers to a quality of a space, materials, or objects that enable a narrowing of focus and attention. It can be singularly predetermined for learners or offer choices of where and how they focus.

In a study done at the Field Museum in Chicago, researchers found that the use of conversational cards with prompts that focused the attention of caregivers and children was positively correlated to elaborative talk about objects, nonverbal engagement with the exhibits, and associative statements from the caregiver between exhibits (Jant et al., 2014). A study at the Carnegie Museum of Natural History (see Figure 5) found that families who explored dioramas with flashlights in dimly lit settings were more likely to establish joint attention and engage in learning-talk about the objects than in standard well-lit environments (Povis & Crowley, 2015). Similarly, in a study of adult-child interactions in supermarkets, Hassinger-Das et al. (2018) used cleverly designed signage to start 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 33% increase in caregiver-child language interactions in which adults used more descriptive language and children asked significantly more questions. These studies illustrate how objects and

Figure 4

materials with spotlighting qualities create a focus for practices of noticing and wondering.

The lighting quality of spaces can also create conditions for focusing on the self and helping others. A study on counseling spaces found that dim lighting resulted in feelings of pleasantness and relaxation in participants, which led to a more self-disclosure (Miwa & Hanyu, 2006). Conversely, spaces with bright lights and resistant surfaces are seen to increase "feelings of non-control over their environments" (Liddicoat, 2016). Therefore, the appropriate usage of lighting can lead to an internal redirection, where occupants of an environment are more capable of self-disclosure, which has been noted to lead to help-seeking practices.

Varying

Beyond sensorial and tactile interventions, contrast at the larger environment level is evidenced through a diversity of forms and functions that support help-seeking practices within communities. For example, increased levels of trust, social involvement, and political participation are found in residents who live in walkable, mixed-use neighborhoods (Leyden, 2003). In contrast to neighborhoods that feature homogenous forms and functions, mixed-use designs feature a high variation of buildings and uses. These types of neighborhoods also promote a sense of responsibility for people's communities, "increasing individual calm, community trust and decreasing perceived danger in public space" (Zumelzu & Herrmann-Lunecke, 2021). In the same study, Zumelzu and Hermann-Lunecke also found that high mixed uses of spaces are correlated with greater levels of perceived social support and lower angst levels. Therefore, neighborhoods designed with qualities of contrast feature diversity and variation which in turn creates the conditions for slowing down, noticing, and pro-social practices of helping.

Flowing

The second quality of environments that support learning practices we have observed is flow. 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 the movement can support learners to notice, explore and be curious (Leyden, 2003; Proulx et al., 2016). For example, spaces, objects, and materials with winding and non-linear pathways enable participants to slow down and explore (Hamilton-Baillie & Mitchell, 2020; Schlickman & Domlesky, 2019). What follows are several ways in which designers provide a sense of flow that offers 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

Research in urban design reveals how to direct versus circuitous pathways affect the pace of human activity and interaction. Hamilton-Baillie & Mitchell's (2020) research revealed how drivers choose their speed based on the formal characteristics of a road. If the road was narrow or had curves, in which they could not see the horizon, drivers were more likely to slow down. They also observed that when drivers slow down, they become more aware of their surroundings and pay closer attention to the environment. The curved design of a pathway, whether it be a highway or a hallway, affects how and where people redirect their attention.

On a more personal scale, studies of elements of interior design suggest that sharp edges or right angles inhibit a sense of comfort. Dazkir and Read (2012) found that curvilinear furniture elicited more feelings of comfort, calmness, and peacefulness than rectilinear forms. Such findings suggest that curvilinear forms may create the psychological conditions that support learning practices of help-seeking and -giving.

Within classrooms, feeling comfort with peers is correlated with help-seeking behaviors among students (Ryan et al., 2001). When creating spaces for help-seeking, noticing, and wondering designers incorporate organic curves and shapes that influence how learners flow through the given space.

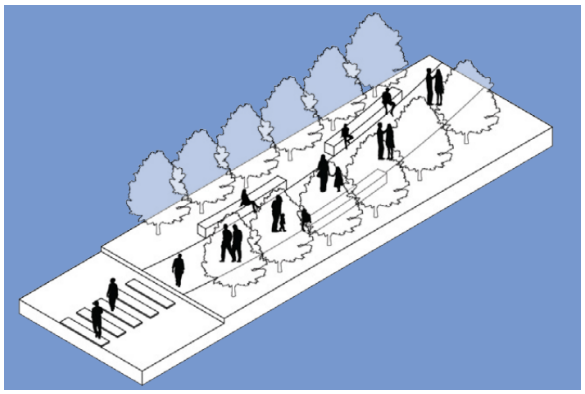


Figure 6

Pausing

Like Curving, research also suggests how pathways for movement can be designed to encourage slowing down, noticing, and exploring. Plazas designed for "pit-stopping" (Figure 6) incorporated sidewalks and extended adjacent pathways, resultingin the slowing down, lingering, and impromptu gathering of pedestrians (Schlickman & Domlesky, 2019). In contrast, other plaza designs such as the "downstream" and the "channelization" design interventions, which lack obstructions in the path, attracted larger and faster-paced flows of people.

Indoor environment research suggests 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 vary from linear to exploratory movement. Highly linear global sequencing – depicted in the bottom figure with the main hallway and discreet, disconnected branches – resulted in a higher proportion of spaces visited but with less lingering and thematic connectedness. Less linearity, in which there are multiple routes between and among exhibits, encourages more movement and exploration among various exhibits.

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

Taken together, these findings suggest how designing pathways as pauseways encourages practices in which users shift their pace, slow down, and explore.

Moving

While curving and pauseways support slowing down, noticing, and helping practices, other design choices that trigger movement and spatial familiarity can also ignite creativity in learners. Experiencing physical movement has been shown to stimulate a variety of creativity outcomes (Fleury et al., 2020; Leung et al., 2012; Oppezzo & Schwartz, 2014). Leung et al. (2012) explain that physical movement can improve performance on both divergent-thinking and convergent-thinking tasks, positing that moving from space to space without constraints breaks mental barriers that restrict creative cognition. In another study, Fleury et al. (2020) isolate "the visual perceptual component of movement through the use of virtual reality" suggesting that even perceptual

movement, not just physical, boosts creative outcomes.

Such findings have led designers and researchers to create Active Learning Environments (ALEs) to change the passive, inactive learning that occurs in many classrooms (Talbert & Mor-Avi, 2019). ALEs such as those pictured in Figure 8 have been shown to improve outcomes such as student

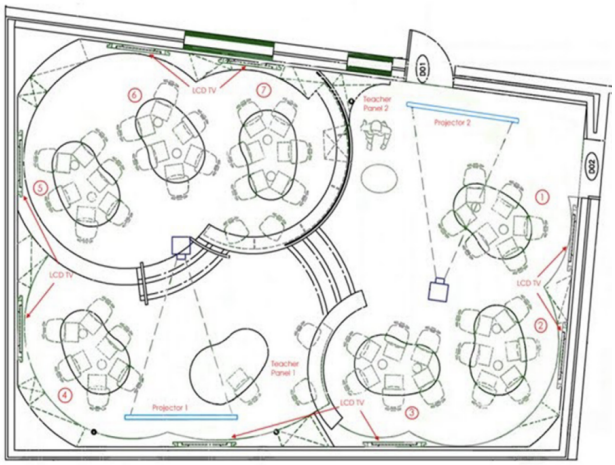


Figure 8

achievement, noticing, engagement, autonomy, and creativity (Charteris, 2019; Davies et al., 2013; Kariippanon et al., 2020; Talbert & Mor-Avi, 2019). ALEs often include moveable furniture that can be reconfigured depending on the need of the space or people. Additionally, many of these spaces do not have a front or back, working as polycentric rooms, allowing more freedom for occupants to move throughout the space. Another previously mentioned study that examined playgrounds concluded that "the availability of moveable play equipment supports creativity and diversity of play behaviors" (Jelic et al., 2020). Moreover, malleable objects and materials, such as water, sand, wood, rocks, and vegetation opened the possibility for students to "manipulate, adapt, construct, design, develop, and relocate equipment that develops their social and collaborative skills." Being able to modify one's environment is crucial for people to feel agency over their learning and space.

An additional quality of space that encourages movement is local familiarity. Trust in others, social involvement, and political participation have been positively correlated with residents living in walkable, mixed-use neighborhoods (Leyden, 2003). Such neighborhoods enable members to have familiarity with, and the ability to comfortably flow through, one's local context. Such local familiarity and movement create the conditions for help-seeking and -giving practices based on overall positive feelings of social connectedness and support. For example, studies by Proulx et al. (2016) reveal that neighborhood familiarity and movement foster allocentrism, or attention centered on other people, stating that "having unrestricted movement in the space over time allows for the experience of multiple paths and perspectives as well for gaining allocentric knowledge." Conversely, disorderly neighborhood spaces or constrained local movement to contribute a lack of familiarity and egocentric behaviors, resulting in fewer opportunities for both help-seeking and help-giving (Mou et al., 2004).

Closeness

While qualities of contrast and flowing stimulate learning practices through surprise and movement, qualities of closeness create visible connectedness and proximal encounters with others and one's environment. Spaces with qualities of closeness create the social conditions for relationships that are conducive to seeking help, noticing, and wondering. What follows are several ways in which designers create closeness through creating visibility, density, and a sense of belonging.

Visibility

Social awareness and visibility, which include seeing others and making eye contact, enable opportunities for forming social closeness. Studies suggest that learners' sense of belonging to the group or student community predicts academic help-seeking behaviors

(Dueñas et al., 2021; Won et al., 2021). Moreover, at the urban level, features on front entrances such as porches, which promote visibility from a building's exterior inward, or even having a front door, rather than a side or back entrance, were positively associated with perceived social support in a neighborhood (Brown, 2009; Spokane et al., 2007). The presence of landmarks, which promote spatial recognition, enables individuals to navigate around areas with greater ease (Mou et al., 2004). Simply put, elements that create invitations to feel connected encourage social support and interpersonal communication. In contrast, studies suggest the lack of invitations (e.g., closing the curtains on front-facing windows) can result in reduced opportunities for visibility and social support (Brown, 2009). An important caveat: although visibility enables awareness of others, losing control of personal exposure leads to feelings of discomfort.

The relationship between awareness, visibility, and help-seeking has also been studied extensively in the context of healthcare (see Figure 9). In health clinics, open spaces, as opposed to contained, pod-like spaces, supported more frequent and spontaneous instances of help-seeking between nurses (Real et al., 2017). Pati et al. (2016) suggest that enclosed pod-like spaces hinder the communication between both medical staff and patients, deterring their "ability to extend or seek help because of the lack of awareness." With these studies under consideration, a study on classroom seating arrangements observed that the same is true for children's question-asking. Seating students in a semicircular seating arrangement with unobstructed eye contact had a positive effect on the number of questions asked, in comparison with row-and-column seating arrangements (Marx et al., 1999).

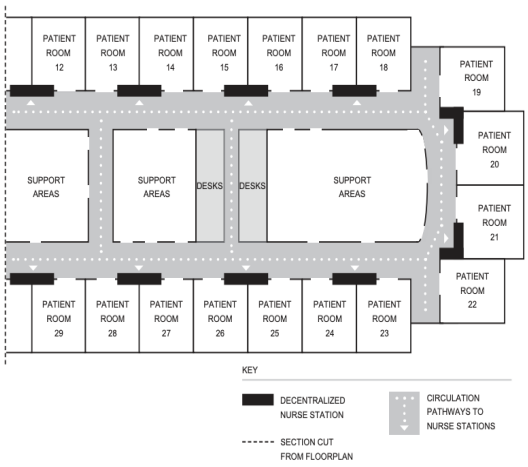


Figure 10

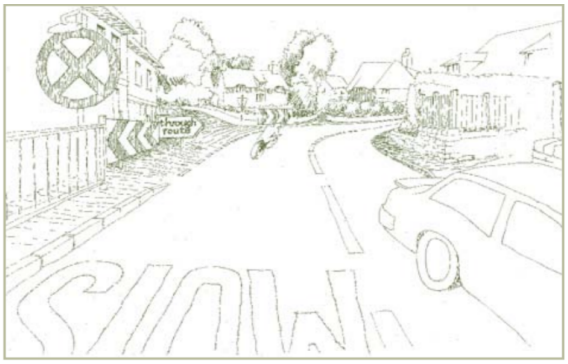


Figure 9

Beyond enclosed spaces, Hamilton-Baillie and Mitchell (2020) discuss how qualities of visibility impact a driver's speed. When a driver's sight is directed towards a visible horizon, they are more likely to drive fast. However, if their visibility is constrained by a winding path (see Figure 10), which hides the horizon from view, or their view is redirected to their surroundings then they are more likely to slow down and notice details in their environment. Schlickman & Domlesky (2019) also describe the impact of creating visibility via performance and audience spaces in plazas. In this plaza schema, most users, especially teenagers, felt comfortable using "entertainer" spaces because they wanted to both be seen by and observe their surroundings. Consequently, through different heights and ground staggering, the occupants' needs were met.

Compactness

Qualities of closeness also include the compactness of people in a space. Research suggests that density is detrimental to social

support and learning practices, particularly help-seeking. Spaces with higher levels of density are correlated with lower levels of support seeking, perceived support, and support provision, perhaps due to the result of social withdrawal when people feel that they have no control or are overstimulated (Evans & Lepore, 1993).

However, socialization may be facilitated by the compactness of a neighborhood. Like the quality of variation, compact neighborhoods are likely to offer a range of spaces, like bars, restaurants, and coffee shops, as well as shorter distances to the city center, which enables interaction and social support. Mouratidis (2018) describes 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." Therefore, not only do compact neighborhoods allow people to sustain their previously formed closed relationships, which leads to stronger social support, but they also increase the opportunity to make new friends and acquaintances, positively contributing to their overall social well-being. Consequently, the creation and sustenance of relationships increase people's ability to seek social support and provide help. As seen in Figure 11 (Imms & Byers, 2017),

Figure 11

many schools are increasingly experimenting with various neighborhood-like designs that leverage the affordances of compactness.

Inclusivity

While visibility and density speak to interpersonal and urban conditions, at a community level, a sense of inclusivity is critical in encouraging help-seeking behaviors. When learning spaces are co-designed with students, the students feel a sense of ownership and belongingness that enables them to comfortably rely on peers for support and feedback, feeling closer to one another (Levy & Adjapong, 2020; Szatek, 2020).

Inclusivity can also be encouraged by explicit help-seeking invitations. This may challenge "some students' perceptions of the reactive and remedial nature of 'support' and guidance" and dismantle the negative social connotations of seeking help (Pillai, 2010). Spatially, inclusivity is manifested in "democratic classrooms." Tannebaum and Tannebaum (2019) state that democratic classrooms are emotionally supportive spaces where students "can feel confident in their belief system and free to seek assistance from those around them." These environments may be designed by hanging student artwork on the wall or even providing a bright and colorful classroom (Fedorenko, 2014; Milkie & Warner, 2011, as cited in Tannebaum and Tannebaum 2019). Therefore, designing a space for inclusivity aims to bring people closer together, which eventually leads to help-seeking and -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 with qualities of contrasting, flowing, and closeness create 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. 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 below offers a reflective tool that operationalizes key findings into questions to consider when developing designs to support learning practices.

Qualities of Materials, Objects, and Space

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 to among learners?
	How is space designed for multiple uses and social support?	How are related elements evoking familiarity within the space?	How does co-designing support learners' belonging and inclusivity?

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. While 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, environmental dimension, designers also understand the socio-cultural dimension of the design.

Additionally, while we 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.

In sum, designers and educators 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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