UNLOCKING SPACE POTENTIAL

Aligning the Power of People, Practice, and Place in Middle School Learning Settings

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WHAT'S INSIDE:

UNLOCKING SPACE POTENTIAL

Aligning the Power of People, Practice, and Place in Middle School Learning Settings

This isn't just a paper — it's an invitation to think differently about learners, spaces, and the systems that connect them. However you move — skimming, scanning, or diving in — you're welcome here.

Learning has changed, but school spaces haven't kept up, especially for middle schoolers navigating big transitions. This project began with a simple question: How can learning environments better reflect the needs of young adolescents and the people who support them?

Abstract: School building design lags behind advancements in pedagogy, adolescent development research, and evolving societal needs, particularly at the "middle school" level. This research, supported by the One Workplace research grant, addresses the need to align physical space with current educational practices. Through an interdisciplinary approach, four key concepts are explored: space and pedagogy alignment, spatial roles, space signals, and critical spatial tools. Findings reveal a pervasive communication gap between designers, educators, and learners regarding their spatial experiences. Extrapolating on affordance theory, a practical spatial framework is conceived to bridge the experience and language gap and facilitate change.

Phase one outcomes include a toolbox designed to foster spatial competency, agency, and alignment. Future research will refine these tools through co-design workshops with learners and educators.

THE BIG IDEA

When designers, educators, and learners come together, it's usually with a common goal: to create a school that best serves its users.

As designers working with schools, we want to know: What must be true to design a beautifully functional and profoundly innovative middle school that is genuinely responsive to the unknown demands of the future, while empowering educators and learner today?

Through our research we learned simple, yet powerful insights::

- **Inertia is a compelling force.** If you want to make real, enduring change you need alignment between three spheres of influence: people, practices, and place.
- **The ability to clearly communicate and listen is key.** How ideas are exchanged, tested, modified, and incorporated requires language alignment between learners, educators, and designers. As facilitators of the building design process, architects and designers are responsible for ensuring that everybody understands and comprehends both the questions and the answers as they relate to architectural design.
- **We need a simple, practical communication toolbox.** For designers to better uncover, in real time, the challenges that are perceived to have the greatest impact on learners and educators, the toolbox will enable designers to better communicate and then manipulate the physical world in service of the school's design and layout.

On the surface these findings may seem anything but ground-breaking.

Over the last few decades, inclusive and engaging design practices have been inviting diverse voices into the process in ways that were previously rare. These practices are moving the needle, but are falling short - we are now using the same words to point to challenges and solutions and yet don't see obvious changes in actualized designs. **Why, then, do we keep hearing that the building is getting in the way? Why, then, do designers imagine a future that looks nothing like the present or the past... but continue designing schools that are fundamentally unchanged from previous decades?**

People are the complex expressions of their lived experiences and education. With our toolbox we will be able to understand how our individuality – whether a designer, educator, or learner – can help us see ourselves, each other, and our physical world more clearly, as well as the steps we can take together to start designing, constructing, and learning in buildings we deserve, for the future we imagine.

A ONE-PAGE SNAPSHOT

The design and planning of school buildings has not radically changed since the inception of the one-room schoolhouse or the comprehensive school building of the early 20th century. Schools are still structured by age-based student groupings and designed with subject-based classrooms for adolescent learners. In contrast, there have been significant advancements in pedagogy[A] leading to new teaching practices informed by learning science and research on adolescent development. Rapid shifts affecting societal norms, economics, and technology apply constant pressure on schools to respond and adapt. Design professionals working with school communities are frequently told that school buildings do not support current learner-centric education models and the goal of preparing learners for success in an uncertain world. This is acutely felt at the "middle school" level. **The goal of this research is to advance the design and use of learning settings in the US for early adolescents, aged 11-15, to directly support emerging education models within the next 10-years.**

Supported by the **One Workplace ONEder Research Grant**, this study employs an integrated approach drawing insights from neuroscience, education, and design. It highlights key findings contextualizing the people, practices, and places (3Ps) that reinforce traditional teaching models and school buildings, as well as emerging ideas seeking to disrupt them. **Drawing on practical experience designing schools, a literature review, and guidance of an advisory team, the study identified critical research questions and provides strategies to address them.**

Research has reinforced a pervasive disconnect between how learners, educators, and designers experience and therefore communicate about space. Identifying and then understanding this experience and language gap are necessary first steps to answering the critical research questions.

Building on foundational efforts of those who previously addressed this challenge, this research hypothesizes that a **practical spatial framework** is essential to **bridge the experience and language gap** to facilitate purposeful change. Aligning people, practice, and place through affordances can evolve the design of learning settings. By making affordances practical and approachable across various roles operating within a school ecosystem, meaningful change to align learning settings with pedagogy can begin. A designer's focus is primarily spatial. A spatial framework is a way to hyper-focus on "place" by providing shared language and tools to understand space signals and make intentional changes to learning settings.

Phase One outcomes include an improved understanding of the influence of physical space on learner-centric education models utilizing a spatial framework consisting of a setting toolbox and questionnaire. This framework is intended to generate spatial competency, agency and alignment between educators, learners, and designers. Future research will refine these tools, further exploring the interplay of people, practice, and place, through co-design processes centering learners and educators. This work contributes to both education and design communities by providing practical tools that empower all members of a school ecosystem to "see" and "shape" settings in service of evolving educational practices.

A Pedagogy is the theory and practice of teaching. It encompasses learning principles, as well as approaches, methods, strategies, and techniques educators use to facilitate learning and ensure students acquire and apply knowledge effectively. It involves an understanding of how students develop and learn as well as the design of instructional activities.

How can learning settings better align with learner-centric education models?

What does space signal to different spatial roles?

What are the critical spatial tools for achieving 3P alignment?

CRITICAL RESEARCH QUESTIONS

This research uses historical context to examine relevant traditional pedagogical models, legacy school design and planning approaches, and the complexity of people, practices, and place – the 3Ps – influencing school buildings today.

Architecture is reflective of the time and culture in which it is built; school buildings are no exception. **There is a long history connecting building design to pedagogical models that mirror larger social norms and economic cycles.** Buildings constructed during these cycles reflect inherited design thinking. Experiences from childhood often anchor adults' perceptions of what schools should look and feel like today, shaping expectations based on outdated models rather than an understanding of evolving educational needs. Design professionals are a taught to look backwards referencing legacy designs as **"industry best practices."** [6]

The investment in time and resources required to build a school has limited the ability of communities to take significant risks when designing a new school or significantly renovating an existing school. [69] Compounding this challenge, planning models like formal and assigned teaching stations, utilization, and space allocation per student, as well as subject-based space types like general 'classrooms', 'science labs', 'art studios', and even the more modern 'makerspace' [65] tether designers, educators, and learners in traditional teacher-centric design solutions and pedagogical models. [6]

This combination of **teacher-centric and subject-based** is frequently called the **'Factory Model.'** It has its origins in the 'Common School' dating back to the late 19th and early 20th century. At the time of its inception, the 'Common School' and subsequent 'Factory Model' was a revolutionary idea. It had a novel goal of providing 'publicly funded, compulsory, education' [B] that could equip all students with the skills needed to be contributing members of society. Intended to be accessible to children of all socioeconomic backgrounds, these schools were meant to serve the "common good" through standardized curriculum that ensured consistency, and therefore conformity, in education across different communities, while also promoting the professionalization of teaching. However, the skills and competencies that students need to be successful contributors have dramatically shifted in our current world. [43, 85] **The artifacts of the traditional model are insufficient to meet the needs of the coming decade.**

To drive big ideas forward, we have to understand what we've inherited.

IMAGE Students in a 'common school' classroom, Seattle, Washington (c. 1890-1920) Photo accessed via Wikipedia from University of Washington: Special Collections

B This RSA Animate was adapted from a talk given at the RSA by Sir Ken Robinson, world-renowned education and creativity expert and recipient. Robinson, K. (2010, October 14). Changing education paradigms [Video]. RSA Animate. https://www.youtube.com/watch?v=zDZFcDGpL4U

UNDERSTANDING THE FACTORY MODEL: TEACHER-CENTRIC AND SUBJECT-BASED

The focus of a **f**actory model is **efficiency, uniformity, and compliance**.[4,19] Mastery of curriculum-driven goals is measured against standardized content and assessments. A teacher-centric approach creates a **rigid hierarchy** between administrator, teacher, and student which shapes the relationships and interactions between them. It prioritizes **order, discipline, and clear expectations**. To that end, spaces within this model are limited to the subject matter that is prescribed for that space; teachers, rooms, lessons, and ways of thinking (Scientific, Socratic, Creative) are defined by subject.

Within this model, administrators are responsible for determining pedagogy used to facilitate learning. They select curriculum, set benchmarks, and approve instruction methods that **emphasize standardized compliance**. The teacher serves as the primary authority and decision-maker in the learning process. The role of the teacher is to deliver content, guide planned instruction and maintain control of the classroom. Lessons are designed with **limited flexibility** to ensure alignment with prescribed standards and benchmarks. Instruction is teacher-directed, often lecture-based, and reliant on traditional teaching strategies and techniques like textbooks, papers, tests, and worksheets. Students are passive recipients of knowledge. They are expected to **follow structured lessons with prescriptive information** as outlined by the teacher, and linear, sequential courses as defined by the administration.

A school building designed for this model is equally rigid, efficient, and hierarchical. [66] It requires highly efficient utilization[C] of rooms and prescribes clear room types and grouping size. All spaces within the building fall under the ownership of the administrators or teachers. Classrooms are primarily the domain of the teacher.

School administrations responding to demands for responsibility and accountability default to parity[D]. **They use similar buildings within their district, or adjacent districts as a baseline to define the scope of new building projects.** This parity anchor is in tension with the commonly stated goals of modern school administrators who desire buildings that support evolving education models that foster innovation and instill a love of learning. Administrators, in the form of operational leadership, tend to prefer standardization between buildings. **This is a simple measure to ensure each community has the same resources. Any differences between buildings, even if they are in direct response to specific needs, may be problematic, as they can be presumed to be biased or preferential.** By providing strict alignment, districts can assure all communities that there is consistency, a marker of the teacher-centric education model.

Pedagogy is a layered system that connects belief to action

At its core is an educator's approach—the foundational view of how learning happens. Built on that are methods (structured plans), strategies (purposeful choices), and techniques (specific actions).

C Utilization is the percentage of time a teaching station is actively used for instruction and defines the efficiency of space use relative to availability.

D Parity is the condition of being equal or equivalent, often referenced in discussions of sameness, fairness, equality, or balance between two or more entities.

THE PARITY ANCHOR: EXISTING FACILITIES, DESIGNER EXPECTTIONS, AND 'LESSONS-LEARNED'

In addition to creating parity with existing facilities, designers are **challenged to design enduring buildings** that have at least a '50-year' life.[6] Capital construction is a significant, community-funded, financial investment. **Limited available funding to support initial construction and ongoing maintenance require design decisions perceived as durable and timeless.** The standard solicitation process for selecting design teams also favors design firms with significant experience and expertise in school design

This makes it difficult to disrupt the status quo, limits new ideas and reinforce designer bias in what makes a 'good' school.[6, 37, 51, 53] These parameters limit a designer's ability to innovate in the design process, master planning, educational specifications, space planning, material selection, and broader systems applications, resulting in marginal improvements within the understood system. [42] An example of this is the current trend of "using data to drive" sustainable design recommendations by measuring carbon impacts or citing the positive benefits of improved IAQ and biophilia. [1,3] While these do improve some measures of space, they do not challenge current planning models, nor do they take into consideration changes to curriculum. **The design and construction of a school has not fundamentally shifted from early reference manuals [2, 23] prescribing program types, quantities, adjacencies, and space quality measures from mechanical air changes to acceptable acoustic reverberation.**

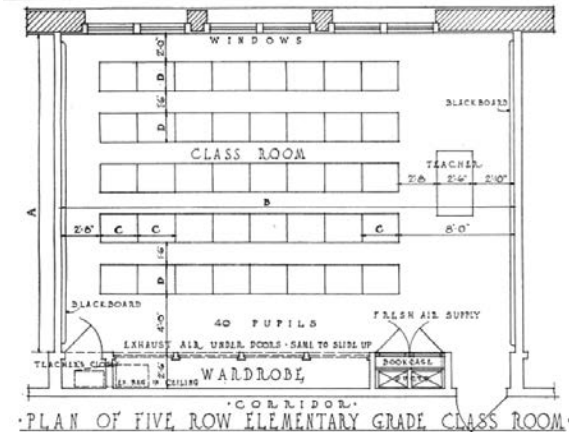
Yet, history and practice has made "middle school" ambiguous as a term and in physical definition. While there are many unique design parameters for designing primary, secondary, and higher education facilities, there are few such parameters identified for this adolescent age group.[13, 46] Regional differences categorize the grades for "middle school" learners differently, ranging from 5th through 9th grades. Grades can be incorporated into primary schools (PK-8), as stand-alone "middle schools" (5-8, 6-8, or 7-9), or as part of secondary schools[6-12]. **Adolescents at the "middle school" level are the forgotten middle of learning at a critical point in their individual and educational development.**[49]

'Lessons-learned' disadvantage non-traditional or alternative models in a disproportionate way. **Non-traditional approaches that 'fail' are raised as examples for why radical change cannot work and reinforcement of the status-quo.** Alternatively, less-conventional approaches like public/private partnerships that succeed are often flagged as unique, non-transferable outliers.

Current, unique and successful examples of 16 alternative approaches are described in the World Economic Forum's Schools of the Future report.[85] They are intended to "provide inspiring examples" of learning "taking place outside of traditional school walls" with the hope to "drive transformational change in education." (WORLD ECONOMIC FORUM, P.13)

As an example, the open-plan movement is frequently cited as a failure. Social upheavals in the 1960s and 70s inspired experimental school designs emphasizing open, student-centered learning spaces that sought to foster collaboration. Despite progressive layouts and innovation in the physical environment, like movable partitions, shared areas, and multipurpose rooms, these often struggled due to a lack of technological and acoustic support, entrenched behavior expectations, standardized curricula and limited options to meet diverse cultural and educational needs.[6] However, influential ideas from that movement remain relevant today and have seen a revival in the student-centered pedagogy.

Open-plan experimentation 'failed', not because it was inherently flawed, but because the day-to-day behaviors of people, the operational structures that guided them, and the qualities and resources of the physical spaces were not aligned.



PLAN OF FIVE ROW ELEMENTARY GRADE CLASS ROOM

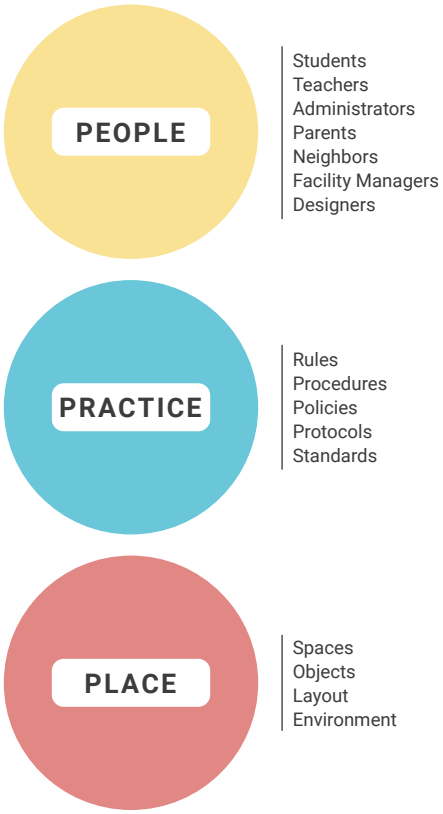
TABLE OF SIZES & MEASUREMENTS OF SCHOOL DESKS

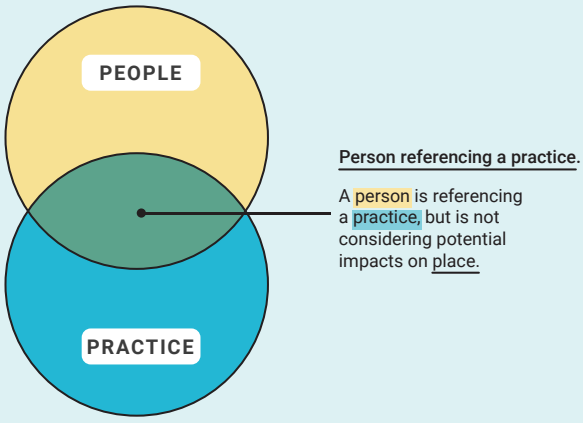
GRADES	I II III	IV V VI	VII VIII
WIDTH OF ROOM A	19'-6"	20'-9"	22'-0"
LENGTH OF ROOM B	27'-4"	30'-0"	31'-4"
DISTANCE BACK TO BACK C	2'-1"	2'-5"	2'-7"
DISTANCE ACROSS D	1'-6"	1'-9"	2'-0"
SIZE OF DESK	12" × 18"	15" × 21"	16" × 24"
HEIGHT OF DESK	21" TO 24"	23" TO 28"	26" TO 31"
AREA REQUIRED FOR GRADES	532.93 SQ.FT.	622.5 SQ.FT.	689.26 SQ.FT.
AREA PER PERSON	12.98 " "	15.18 " "	16.81 " "

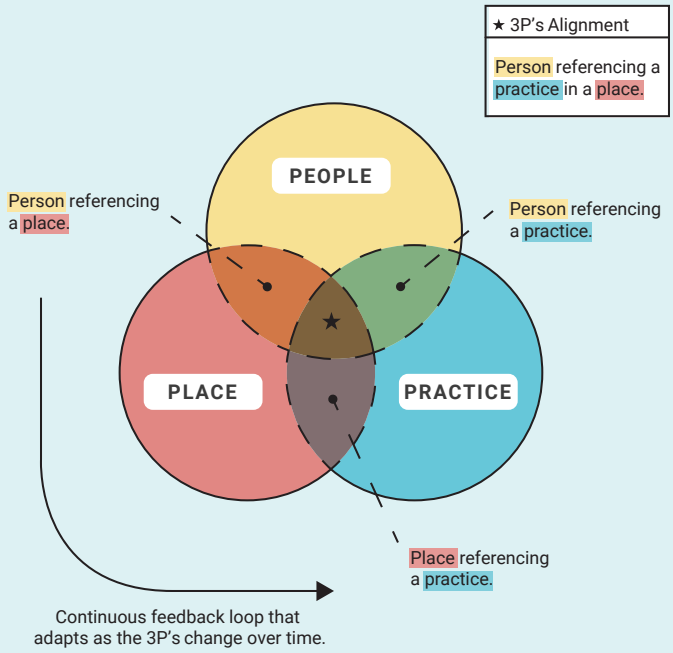
IMAGE Plan of standard elementary classroom and desk sizes, *School Architecture: Principles and Practices*, John Joseph Donovan, 1921 -1920)

THE 3PS: SCHOOL BUILDINGS AS THE INTERSECTION OF PEOPLE, PRACTICE, AND PLACE

As the brief history of formal education shows, **schools are complex, multifaceted** organizations. **They are prime examples of the intersection of people, practices, and place (3Ps).** These 3Ps are shaped by both **tangible** (physical environment) and **intangible pressures** (cultural norms, practices, and regulations). They exist in a continuous feedback loop – where people, practices and place are perceived and adjusted over time in attempts to align. When alignment occurs, significant changes in all three become possible. This was the case for the "factory-model" and what we seek to redefine for our time. **If any of the three are not optimally aligned, the power of inertia limits change as was the case for the "open-plan classroom" concept.**



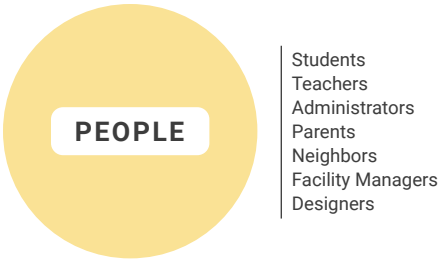




ONE DEGREE OF INTERACTION [NOT ALIGNED] ⟷ [ALIGNED] **THREE DEGREES OF INTERACTION**

As children cross the threshold into adolescence, they enter a period of rapid, yet unpredictable development. The changes they are experiencing biologically, physically, and psychologically occur at different rates, making it difficult for adolescents to make sense of their own identities and for adults to act in a manner that is matched or responsive to their needs (Bishop & Harrison, 2021). This is most consequential in middle school.

STUCK IN THE MIDDLE



People influence actions, interactions, and routines within a school ecosystem. People are conceptualized as both **individuals and groups**. They include students, teachers, administrators, parents, neighbors, facility managers, and designers. **People are characterized by their individual values, experiences, preferences, abilities, skills, and needs.** Individuals that share overlapping characteristics make groups. Early adolescents face the added complexity of puberty. This is discussed in more detail in the section on adolescent development.

Most people share common, inertia provoking, psychological phenomena. These include loss aversion[E], cognitive dissonance[F], and the Dunning-Kruger effect[G]. The ways in which these phenomena are recognized or addressed are both deeply personal and rooted in societal norms. Educators' and Designers' professional expertise can hinder them from seeking new information and inhibit their willingness to update previous knowledge when presented with new information.

The "return to the basics" movement exemplifies a systemic response to these human psychological phenomena. Emerging partly from the perceived failure of experimental approaches like the open-plan classroom model and partly as a reaction to changing social values, the movement emphasized a renewed focus on foundational skills like literacy and numeracy, reflecting a strengthened societal preference for structure and traditional academic competencies in the face of uncertainty and change.

E Loss aversion is a psychological principle where individuals tend to prefer avoiding losses over acquiring equivalent gains, meaning the pain of losing is felt more strongly than the satisfaction of gaining

F Cognitive dissonance is the mental discomfort experienced when a person holds conflicting beliefs, values, or attitudes, or when their actions contradict their beliefs.

G Dunning-Kruger effect is cognitive bias where individuals with low ability or knowledge in a specific area overestimate their competence, while those with high ability often underestimate their own expertise.

Rules
Procedures
Policies
Protocols
Standards

Practices are the rules, procedures, policies, and protocols that guide how schools and design firms operate. The **practices and underlying theories** that inform how schools teach are pedagogy. School manuals, mission and vision statements, continuous improvement plans[H], student safety measures, emergency preparedness plans, educational specifications[I], and classroom assignment[J] models are direct examples of school-based practices. These lay the foundation for the organizational culture and norms of the school which in turn shapes how spaces are used and influence behavioral expectations within them. Design standards, codes, regulations, graphic conventions, and stakeholder engagements are practices relevant to design professionals and district capital project departments. This is an important concept to acknowledge as both sets of institutional practices come into play throughout the school design process which influences designers and the school-based community.

Practices are structures created by people; they are made in attempts to meet current perceived needs. Structures change over time. Changes are built on existing structures, and they are, to varying degrees, reflective of the people who conceive of and perpetuate them. Consequently, they are multi-layered and intersecting responsive to broad social, economic, and political influence as well are smaller-scale regional values. School practices are unique because they simultaneously integrate the large and granular dimensions of district, grade-level, and classroom dynamics into the individual school.

…teachers are often expected to accept the new physical framework and adjust their practices with little or no training and support. Students, families and other community members can find themselves in similar circumstances. In addition, specific professional learning must be provided to those responsible for the delivery of education, within ILEs [innovative learning environments] – teachers, teacher aides and leaders – to establish the ways of working in these spaces as the new norm for education.

INCLUDING STUDENTS WITH DISABILITIES IN INNOVATIVE LEARNING ENVIRONMENTS: A MODEL FOR INCLUSIVE PRACTICES

Introduced by Chris Bradbeer (2021) there are three broad categories of structures to consider when modifying or developing new practices for a school building – heritage, novel and modified.[8] **Heritage structures are common structures that existed before and carry-over through time and space into the new building.** Typical examples may include grading systems based on letter grades, standardized testing schedules, subject-specific classrooms, and fixed school hours. **Novel structures are structures that did not previously exist.** These include the introduction of student-driven projects with external mentors or community partners, virtual reality spaces for collaborative exploration, co-teaching models with multiple instructors present simultaneously, and unassigned classroom areas. The previously discussed open plan schools were examples of this.

Modified structures are structures that existed beforehand but require some level of modification. Block scheduling where traditional periods are extended for deeper engagement, shared teacher spaces replacing individual offices to promote collaboration, or behavioral management systems evolving into restorative justice practices are examples of modified structures. Modified structures are sometimes described as Innovative Learning Environments (ILEs) [7, 8, 10, 17, 25, 27, 34, 38, 39, 44, 58, 88], Non-Traditional Learning Spaces (NTLS)/ Informal Learning Spaces/Shared Learning Spaces [5, 13, 26], Active Learning Classrooms (ALCs) [72, 73, 74]. Attempting to change any structure is inherently challenging, particularly those that are heritage since more has been built upon them.

Page, Anderson and Charter is, in their paper *Including Students with Disabilities in Innovative Learning Environments*, touch on the challenges of shifting to an ILE for teachers, students and families. Noting that this frequently occurs without providing "stakeholder understanding of the rationale behind ILE's…opportunities to understand the philosophy behind the learning and teaching approaches" [58] and "specific professional learning" [58] to "establish the ways of working in these spaces." [58]

H A continuous school improvement plan is a structured, ongoing process for assessing school performance, identifying areas for growth, implementing targeted changes, and evaluating results to enhance student outcomes and achieve educational goals.

I Educational specifications are guidelines defining the spatial, functional, and design requirements of a school facility, aligning the physical environment with the educational goals, programs, and activities. They are often established at a district-wide level by operational leadership to create consistency and then modified to a site-specific iteration through a community engagement process.

J Classroom assignments give teachers ownership and stability in their spaces, fostering personalization, but can also lead to inefficiencies in utilization, reduced collaboration between teachers, and resource inequities.

During past decades, the 'stability' of traditionally designed schools, where classrooms predominated as well-understood physical and social structures, meant that designers and educators were able to occupy a comfortable 'middle ground', where both envisaged pedagogies based on teacher-focused instruction and associated spatial arrangements. However, in more recent years, there has been an increasing appetite to enable a wider range of pedagogical approaches than considered possible within traditional classrooms. As architects are not trained educators, nor teachers instructed on how to manipulate the physical environment to support their practices (Newton 2009), such 'disruption' has called into question assumed relationships between space and educational practice and demanded further inquiry into how designers and educators can work together to develop new socio-spatial arrangements.

THE AFFORDANCES OF INNOVATIVE LEARNING ENVIRONMENTS FOR DEEP LEARNING

PLACE

Spaces
Objects
Layout
Environment

Place is the tangible and sensory school environment. This includes **physical design and layout** of the school building, and the **spaces and objects** within it. This is the element that designers (architecture and interior design, landscape, graphic design, engineers) can significantly impact. Place, being physical, is materially connected to the practices and limitations of heritage structures. **Physical objects, while easy to identify, require tremendous energy (both mentally and physically) to change.** The existing stock of school buildings represents a significant investment of resources. As mentioned in the previous section on parity, they are difficult to see beyond or abandon.

Foundational works such as *The Third Teacher: 79 Ways You Can Use Design to Transform Teaching and Learning, Language of School Design: Design Patterns for 21st Century Schools, and Planning Learning Spaces: A Practical Guide for Architects, Designers, and School Leaders*, as well as knowledge emerging from the Learning Environments Applied Research Network (sites.research.unimelb.edu.au/learn-network), have established various frameworks for considering how a school building impacts learning.

They have provided critical lenses and insights through which contemporary research and design practice, including this study, continue to build. While these resources articulate the perspective of architects and innovative educators advocating for change, there remains gaps to driving change and accelerating forward momentum. This study focuses on alignment of 3Ps as a critical first step to meaningful change.

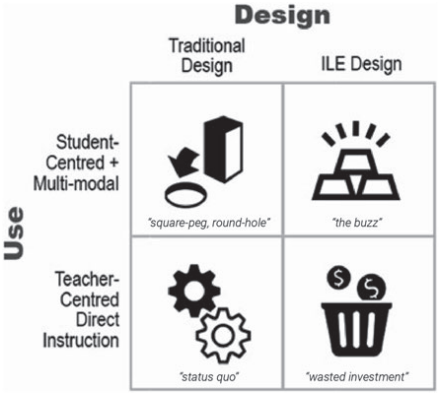


IMAGE Matrix of alignment and misalignment between the design and use of schools. Originally published in *Teacher Transitions Into Innovative Learning Environments: A Global Perspective*, in Racheal French's article School Change: Emerging Findings of How to Achieve the "Buzz".

Place change alone won't shift how learning happens - it's a three part lock with people and practice.

Individual changing space accessible from shared locker area
Image: Lincoln High School, Seattle Public Schools, Photos By Art Ross

CRITICAL INSIGHT

HISTORICAL CONTEXT AND THE 3PS

Traditional teacher-centric models are still prevalent in the people, practices, and places that make schools. There has been significant research on people and practice but place lags. This is particularly true at the “middle school” level. Research on people-practice-place interactions in school buildings is an emerging area of focus. There is currently a gap between research and application as it is difficult to isolate influencing variables.

Change requires alignment across the 3Ps. Successful place change will not work without support from people and alignment with practices. A frequent area of misalignment is lack of adequate professional development and appropriate change management support for educators.

The Innovative Learning Environments and Teacher Change (ILETC) project in Australia underscores this challenge, highlighting the importance of helping teachers tap into the untapped potential of place to improve student outcomes.

Tools to assist educators to adapt their existing teaching practices were identified as essential in new buildings grounded in a student-centered education model. Efforts like these are necessary to co-create shared understanding of spatial intent and provide proper training and support for how to use new spaces or existing spaces differently.

SIDE QUEST: At Lincoln High School, **rethinking spaces to get ready for PE and Athletics** highlighted the need to align people, practices, and place. Lasting change required more than **new locker room spaces — it depended on shifting routines, roles, and shared understanding** between educators, students, and families.

LOOKING BACK

MOMENTS THAT MOVED US FORWARD

Over centuries, the education system has evolved alongside societal norms and economic cycles. In colonial America, education was informal, sectarian, and exclusionary, serving primarily privileged groups and reinforcing social hierarchies. The early 1800s brought early public schools and the one-room schoolhouse, emphasizing basic skills and student learning based on ability, where moving forward was demonstrated by knowledge mastery. By the late 19th century, calls for edu**cation reform standardized schooling, introducing grade levels and efficiency-focused buildings,** yet segregation and inequities between urban and rural communities remained deeply embedded.

The industrial era of the **early 20th century reshaped schools into "factory models," reflecting the workforce demands** of a growing urban society. As populations surged during the Baby Boom, **school construction expanded rapidly, prioritizing efficiency and uniformity**. Social movements in the 1960s and 70s sparked experiments with open and collaborative designs, but systemic barriers and limited resources hindered lasting change.

In recent decades, the focus shifted toward **inclusion, sustainability, and adaptability**. Accessibility laws, technology integration, and culturally responsive practices have pushed design forward, though disparities in resources and opportunities persist. **Beginning in the late 1990's was the shift toward '21st-century learning.' This persists today with an emphasis on 21st-century skills, well-being, and interdisciplinary learning which underscores the need for schools that are flexible, equitable, and future-focused.** Education 4.0 or the 'fourth industrial revolution' [54,85] promises to be a period of economic change driven by technological advancements and globalization.

1600

Informal Colonial Agrarian Education

Rural society with small, agrarian communities.
Limited access to education.

1800

One Room Schoolhouses

Simple, rectangular building (wood or brick) with large windows, a central stove, and minimal furnishings.
Classroom arrangement based on ability. All children in sight of teacher's desk, minimizing opportunity for wrongdoing.

1825

1850

1875

Multiple One-Room Classrooms Grouped Together

Grade groupings implemented with 'Common School' state-wide system of professional teachers.

A "revolutionary idea" of the 19th century: public, standardized, compulsory education

1900

Factory Model Created

Standardized utilitarian spaces for as many students as possible.
Structural advancements make big-box spaces possible.

1925

Urban School Standardization

>Massive population growth and shift toward urban settings.
>Rapid industrialization results in need for vocational training.

Rise of progressive education leads to comprehensive and standardized school.

1950

Factory Model Evolves

Shift to quicker and cheaper construction methods.
Sprawling layouts with multiple wings; modern materials like steel and glass.

Criticism of traditional teaching methods leads to 'open school' and experimental buildings.

1975

'Open School' and Experimental Buildings

Large open teaching areas with several teachers.
Reaction and return to classrooms due to misalignment in space/pedagogy.

2000

21st Century Education Environments

Ecosystem of connected learning and teaching spaces.
Focus on college prep and skill-building for knowledge based economy.

21st-century skills-based curriculum pivots from content acquisition and rote memorization.

2020

Global Pandemic Disrupts In-Person Learning

2035

'The Future'

Influence of well-being and belonging.
Focus on equity to address long-standing disparities.

SECTION 03: RESEARCH INSIGHTS
A few big ideas from others that helped shape our path

LITERATURE REVIEW

RESEARCH AND INSIGHTS INTO ADOLESCENT DEVELOPMENT, CURRENT PEDAGOGICAL MODELS, AND AFFORDANCE THEORY.

IMAGE Lakeridge Middle School, Lake Oswego School District
Photo By Art Ross

Introducing adolescents to new ideas, activities, and possibilities is what teachers and schools are supposed to do anyway. Providing explorative learning experiences is a way of fulfilling this task through a pedagogical approach that stimulates adolescents to connect what they are taught in school to who they are and want to be.

THE ROLE OF SCHOOL IN ADOLESCENTS' IDENTITY DEVELOPMENT

In contrast to the design and planning of school buildings, there have been significant research advances to human understanding of adolescent development.

This section focuses on early adolescents and highlights key insights relevant to the design of spaces serving these learners. This includes brain development, identity formation, and physical changes. For the purposes of this study, the focus is on understanding learners aged 11-15, which loosely corresponds to the previously mentioned "middle school" years.

ADOLESCENT DEVELOPMENT: UNDERSTANDING CRITICAL, RELEVANT DEVELOPMENTS

Brain development in early adolescence is marked by significant structural changes of the prefrontal cortex affecting the process of learning through neural pathways. Structural change and cognitive maturation happen in stages. During early adolescence, the Prefrontal Cortex experiences a significant stage of maturation. This is marked by novel abilities and heightened reward sensitivity. Meta-cognition and "higher order" thinking provide new ways of learning as well as complex problem solving. Budding emotional processing, self-regulation, and impulse control usher in new ways of interacting with self and others. Motivated risk-taking offers a new way of experiencing physical and social worlds.

Neuroplasticity, neural pruning, and neural strengthening are key concepts influencing how we learn. For the early adolescent brain, providing both broad and repeated exposure to ideas and experiences is particularly important. Neuroplasticity refers to the highly adaptable nature of the brain and its agile responses to different stimuli – this creates pathways. Neural pruning and strengthening are the process of refining, eliminating, and strengthening those pathways.

IMAGE Wy'east Middle School, Vancouver Public Schools
Photo By Benjamin Benschneider

> **Identity development is an important task in adolescence. Adolescents are supposed to be concerned with developing educational and professional goals while shaping an image of who they are and want to be. Previous research indicates that a relatively clear and stable identity makes people more resilient, reflective, and autonomous in the pursuit of important life decisions, while promoting a sense of competence.**

THE ROLE OF SCHOOL IN ADOLESCENTS' IDENTITY DEVELOPMENT

Identify formation in early adolescence is marked by a break from primarily familial influence. Peers and adults, like teachers and coaches, hold greater influence. Adolescents have a heightened awareness of social hierarchies and desire for social approval. They also have a malleable identity, shaped and re-shaped through exposure and experience. This is expressed in superficial changes like fashion or music preferences, to more foundational ones like associations of community and competency.

Physical changes are directly tied to hormonal fluctuations triggering a cascade of physical, cognitive, and emotional changes. The physical body of a "middle schooler" is difficult to neatly categorize compared to other aged cohorts. Puberty and rapid growth affect each child at a different rate causing growth spurts and drastically different body sizes in the same class and grade. These growing and changing bodies also come with increased demand for sleep and physical movement. School-based practices, like loss of recess, early school hours, and defining when and where food is consumed directly intersect with these physical changes. Place, too, is intersecting through the use (or lack) of lighting that supports sleep/wake cycles, furniture that offers ways to wiggle/fidget, and with facilities for students to safely and easily respond to biological and hygiene needs.

To build for the fourth revolution, we must leave the legacy of the 'factory model' behind.

> According to one estimate, by 2022 alone, everyone will on average need an extra 101 days of learning to keep pace with the changing world of work. While traditional education systems have been designed to decrease learning with age, a new system must emerge whereby people engage in lifelong learning to navigate future job disruptions. To realize this vision, a love of learning must be instilled in children from a young age.
>
> SCHOOLS OF THE FUTURE: DEFINING NEW MODELS OF EDUCATION FOR THE FOURTH INDUSTRIAL REVOLUTION

THE EDUCATIONAL EVOLUTION: KEY DRIVERS CHANGING PEDAGOGY AND THE RISE OF "LEARNER-CENTRIC"

As deeper understanding of adolescent development became available, so did research on the science of learning. Pedagogical developments, like the ones of the 'factory model' schools, are a product of their time. **They reflect changing cultural norms and expectations, while harboring optimism and uncertainty about the future.** While there are various names for the current pedagogical era, for the purposes of this paper, we will refer to it as the **'learner-centric'** model. This learner-centric model expands on the previous goal to equip students with skills required to be contributing members of society. It does so by recognizing the need for global competency, lifelong learning, and durable skills necessary in an uncertain, rapidly changing world.

The learner-centric model is an approach that balances two core ideas: meaningful learning experiences (what drives engagement) and supportive learning environments (who makes it stick) to acquire the knowledge and skills to flourish.

Cultural Snapshot and Future Projections

Changing cultural norms, global influences, and regional trends are reshaping how and why educators are preparing learners for the future. **The variables most frequently referenced include: the changing nature of work and skill demand, advances in technology and artificial intelligence, the rise of social justice movements, increased demand for climate action, and a focus on holistic health and wellness.** This is sometimes referred to as the "fourth industrial revolution" or "Education 4.0." [54,85]

As adolescent learners transition to adulthood, learning is also seen as an **ongoing, continual need** to keep pace with an evolving world. Middle level education is a critical point to influence and construct that desire in learners as they are a critical stage in adolescent development. [49]

Current language casts the future as rapidly changing in every sphere -- physically, culturally, economically, technologically. **The picture painted of the future is complex – imagined to be both unpredictable and improved.**

In practice words like volatile, uncertain, and ambiguous are intermixed with resilient, interconnected, sustainable, and innovative. However, this positive potential is laced with warning; **students must be properly equipped in mindset, skills, and competencies** for this better future to become a reality.

MEANINGFUL LEARNING EXPERIENCES
- > Relevance to student lives and goals
- > Challenge that deepens thinking
- > Agency in how learning happens

SUPPORTIVE LEARNING ENVIRONMENT
- > Belonging through strong relationships
- > Collaboration between peers and educators
- > Guidance with trust, feedback, and care

Within the context of middle school, this means that students are primed to emotionally invest in school and the relationships that can be formed within the learning environment, especially if students are provided opportunities for choice in what they learn and how they demonstrate what they know.

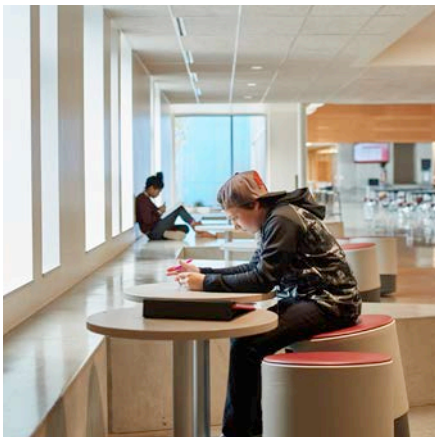
STUCK IN THE MIDDLE: EXAMINING THE IMPACT OF THE LEARNING ENVIRONMENT ON ADOLESCENT MOTIVATION

Learner-centric Education Model

The macro factors of culture change, future uncertainty, and advancements to learning science have set the foundation for the learner-centric model envisioned in schools around the world today. A learner-centric model offers **research backed understanding of how learning happens and what learners currently need to be successful** in the near future. This new, learner-centric model is intended to **disrupt the teacher-centric models** of the past.

In contrast to the "factory-model," **students are at the center** of their own learning. In this learner-centric model, **personalization, relevance, and challenge are primary motivators** where learners and educators work together in a less hierarchical way. Curriculum and teaching methods emphasize **flexibility and relevance** which empowers students to connect their learning to real-world contexts and future goals. Learners have agency and take an active role in **setting goals, choosing pathways, and pursuing interests** that matter to them. Educators act as **guides and facilitators** who support self-directed learning by providing tools, scaffolding, and feedback tailored to individual needs. There remains applications for traditional teaching methods like lectures and worksheets; however, these are not the primary methods utilized.

Learner-centric models of learning and teaching ask **educators to work together across disciplines** to help learners make connections between subjects and applications. This is a closer approximation to how collaboration and innovation happens in the real world. The idea of real-world relevancy gave momentum to the concepts behind "hands-on learning", "project-based learning" and "active-learning". This also correlates to practice changes within schools like more block classes, flexible scheduling, and cross-disciplinary or co-teaching to support these new learning experiences.



Learning is understood to be an experience, not merely a task. Thus, learning experiences, not "lessons," are designed to honor student voice while ensuring mastery of essential skills and knowledge. Through "project-based" learning, adaptive technologies, like AI-driven tutoring systems and self-paced learning platforms, and co-creation of learning plans, learning is personalized to work with diverse backgrounds. **The learner-centric model considers each learner's various needs, strengths, interests, and culture to make knowledge and skill acquisition relevant, challenging, and inclusive.** (85)

A building to support this type of learning and teaching, must indicate that is different that the rigid structures of the past. To support dynamic learning, it must facilitate experimentation, independent focus, collaborative group work and community socialization. **A school building designed for this model has variety to support difference.** As Sailer notes, "In this system pupils have more autonomy and choice; teaching is integrated and collaborative; subject areas dissolve, and teaching units become fluid… [subject areas] cease to have fixed references. Social spaces can be used for a variety of purposes and filled in a number of different ways." (66)

The previously mentioned ILEs, NTLS and ALCs are examples of these in practice. A variety of space sizes and levels of openness invites connections between settings and people. Scheduled and unscheduled areas allow for different levels of formality when sharing ideas or building partnerships beyond the school walls.

IMAGE Roosevelt Middle School, Eugene School District
Photo By Benjamin Benschneider

WHAT DRIVES ENGAGEMENT

MEANINGFUL LEARNING EXPERIENCES

Learning science made clear the **direct connection between learning and engagement**. [4, 82] People, regardless of age, learn when they are engaged. If learners do not feel what they are exposed to is relevant, they disengage. **Engagement occurs when individuals perceive the information as meaningful. To be meaningful, it must be both interesting and relevant.** For adolescents, Verhoeven, Poorthuis and Volman state that they must "recognize themselves in the learning material and content" and this occurs through "in-breadth, in-depth and reflective explorative learning experiences". [82] Therefore, educators strive to create meaningful learning experiences. **Students have agency to learn what is required through lenses they care about and show mastery through self-directed methods.** There is not a prescribed, uniform, or standard way to prove competency.

This does not mean a meaningful learning experience is structureless, nor that educators relinquish responsibility for managing the learning setting. There is a **balance between agency, self-management, and structured learning** to empower students without leaving them directionless. Autonomy without support can lead to disengagement or frustration, while excessive structure limits exploration and ownership of learning. **Meaningful and effective learning experiences provide scaffolding – offering choice and flexibility that ensures progress, accountability, and a sense of purpose.**

An illustration of what a learning experience looks like in this new model could be described as follows: a student chooses a topic they are curious about, like sustainable gardening, and develops a project to plant locally harvested seeds in the school's garden beds where they are responsible for tending to the seeds. The show of competence is a podcast to share their understanding of photosynthesis and growth cycles with students across the school. To get there, their educator is offering targeted, actionable feedback to help the learner refine their work and achieve their learning goals through effective coaching. The student is using basic skills, like reading and writing, while creating connections across disciplines and learning to use relevant tools and technology.

WHO MAKES IT STICK

SUPPORTIVE LEARNING ENVIRONMENT

Students thrive in environments where they feel **safe, included, and valued; belonging is foundational** to their ability to connect with peers and teachers, express themselves, and fully engage in learning. [82] **This coincides with critical developments at this age, when students develop their sense of self, are primed to take risks, and seek approval from peers.**

School culture and practices reinforce belonging by emphasizing shared values, celebrating diversity, and creating opportunities for collaboration and connection. **Educators cultivate supportive learning environments by fostering strong social relationships, promoting inclusivity, and prioritizing social-emotional learning (SEL) to help students develop empathy, resilience, and self-awareness.** Examples include advisory programs, restorative practices, peer mentoring, and inclusive extracurricular activities. Exposure to new activities and groups, like those found in extracurricular settings, is foundational to core identity development and future interests. [82] These practices foster an environment where every individual feels they matter and can find or create community.

When considering place impacts, supportive learning environments offer and allow learner choice and create appropriately stimulating (not distracting) sensory spaces. To reinforce community, common settings include areas for display of student work (rotating or permanent), a variety of space scales and types, assigned and open informal meeting areas, visual connections into spaces, communal eating and food preparation areas, and gender inclusive or non-gendered spaces.

How can learning settings better align with learner-centric education models?

CRITICAL RESEARCH QUESTION

To name the gap is a first step - it invites a path toward shared meaning.

> It is also necessary to agree on an internationally shared understanding of what an innovative learning environment is. Working against this notion is the primarily culturally specific nature of education at the school level. Every nation—and indeed many provinces and states of those nations—have their own specific educational approaches, nomenclature and agreed standards. It is thus difficult for a project such as this to use an agreed terminology for ILE's.
>
> CO-CREATING INNOVATIVE LEARNING ENVIRONMENTS: LEARN'S DECADE OF DISCOVERY

CRITICAL INSIGHT

EXPERIENCE AND LANGUAGE GAP

Designers and educators – and in many instances, researchers, have assigned different meanings to the same words. This critical insight highlights a disconnect in language usage and lived experiences. A "learning environment" can be considered and discussed from either a socio-cultural or physical lens. **Designers default to physical interpretation of words while educators default to socio-cultural ones.** Both literature and dialogue reflect each group's default conceptual assumptions for the word "environment" and similarly "space."

A purposefully designed learning environment from a **designer perspective** is where learning and teaching occur, shaped by spatial organization, materiality, and physical resources.

A learning environment from an **educator perspective** is a social and emotional ecosystem where learners and educators interact to enhance learning by fostering a sense of community, collaboration, and support.

For the purposes of this paper, and to help clarify language moving forward, "environment" will be used to refer to socio-cultural meanings and "setting" will refer to physical, place-based ones.

Additional words like **safe, welcoming, comfortable, belonging, supportive, inclusive, accessible, engaging, innovative, adaptable and flexible** also have ambiguous definitions and layered meaning reflecting the identity, role, and experience of the user and curator of space. Welcoming may recall warm colors and soft seating for some, while for another, it signifies cultural representation and emotional safety.

Using 'safe' as another example helps reinforce this point:

A **counselor** might think in terms of psychological security, while a school administrator may focus on visibility and supervision.

A **designer** might default to terms of building integrity to withstand a natural disaster or an active shooter.

A **student**, on the other hand, might associate safety with the ability to express themselves without fear.

People struggle to see beyond themselves (identity, roles, experience) and imprint themselves on place thereby limiting the potential for new practices. This is an example of the conceptual overlap of "people, practice, place" described earlier in this document.

Affordances emerge in the space between individual and setting.

For adolescents navigating rapid physical, cognitive, and social shifts, this relationship is fluid and formative. Designing with affordance theory means designing for change, perception, and possibility.

> **We naturally attach meanings to space, based on prior activities that have occurred there. Thus, when entering a space, we quickly surmise the kinds of social and interactional patterns with others, and with the artifacts present, that are permitted and encouraged. The environmental conditions evoke antecedent actions, activities and procedures that can be performed in that space… Space is never neutral. It whispers messages about what can and will happen here and, being attuned to the affordances and constraints, we are obliged to follow antecedent regularized forms of participation and action found in such a space.**

WHY SPACE MATTERS

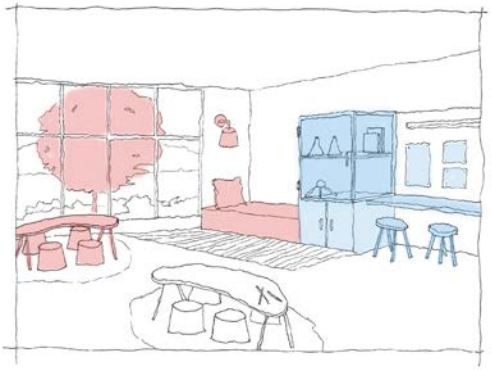
AFFORDANCE THEORY: SEEING POSSIBILITIES FOR INTERACTION

This study proposes to **build on affordance theory** as originally introduced by E.J. Gibson[30] **to help bridge the experience and language gap** common in designer/educator communications. Affordance theory offers language and insights for how the design of space and objects can influence the way people interact with them. While there are different definitions and among psychologists and designers, for the purposes of our paper we use the following definition. **Affordances are the possibilities for action provided to an individual by a physical setting, the perception of usefulness is relative to the individual's abilities and lived experiences.** The affordance is seen and actualized through the relationship between a setting and the individual perceiver. Critical to understand, is that for an affordance to exist, it is simultaneously relational (existing in interaction) and independent (inherent to the object and the individual).

Affordance theory takes into consideration physical, experiential, cognitive and socio-cultural variables about an individual as well as characteristics inherent in an object or setting. **An individual's lived experience, abilities, and identity shape how they perceive what is both possible and acceptable when interacting with a setting.** Young and Cleveland, also clarified that objects need "to be understood within a network of relations not only among different people, but also a 'constellation' of other objects drawn into a shared practice." [87] As an example, if two people were independently asked to enter identical rooms, and were provided the identical resources and spend 30-minutes "being creative," affordance theory would predict they would "see" different possible ways to do that and behave accordingly.

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

THE AFFORDANCES OF INNOVATIVE LEARNING ENVIRONMENTS FOR DEEP LEARNING: EDUCATORS' AND ARCHITECTS PERCEPTIONS



*A learner might perceive a **built-in bench area** as a safe, quieter space to emotionally regulate, read, or engage in self-directed inquiry. Helpful for those seeking autonomy or calm in a busy classroom setting.*

An educator may recognize it as an opportunity for differentiated engagement, such as one-on-one support, informal check-ins, or giving a learner space to self-soothe without fully leaving the learning environment.

A designer might see it as a spatial gesture that invites voluntary withdrawal, accommodating diverse neurodevelopmental and social-emotional needs. Its physical features—softness, enclosure, light—create cues that signal slower-paced interaction, in contrast to brighter task-focused or social zones.

Individual differences matter. Two people will perceive and interact with the same setting differently based on their background, abilities, and previous experiences. Affordances are therefore not entirely fixed. They are relational and depend on the individual, their context, and the setting itself. **Space is not neutral. It actively influences behavior and shapes how people interact with it. Design choices matter. By carefully considering affordances, designers can create spaces that are not only functional but also support the desired behaviors and experiences.**

This is relevant to the design of schools, because it links people, practices, and place, making explicit how human interaction, formal and informal protocols, and design choices shape behaviors of all building visitors and occupants. **Space is not neutral; it is an active participant in user experience, signaling how it can (or should) be used.**[28,61,76, 87, 88] Educators working toward a student-centric model infuse settings and objects with social and cultural expectations – enabling or constraining affordances for learners.

Adolescent cognitive and physical development offers additional significance to this idea. The changes undergoing the structure of their brains allow them to imagine new ways of perceiving and being as they learn, re-learn, and unlearn through experience. In addition, as their bodies grow and abilities change, it is directly connected to their ability to actualize an affordance.

As designers cultivate their aptitude with affordances, it can generate shared understandings between design professionals and building occupants, "aiding in the creation of spaces that are not only well-designed but also well-used in practice". (Young & Cleveland, 2022)

INSIGHTS:
LITERATURE REVIEW

EARLY ADOLESCENT DEVELOPMENT

Early adolescents undergo **rapid changes in the development of their brain, identity, and bodies**. While well-researched, insights into these developments are overlooked in traditional school design.

Creating learning environments that effectively support these early adolescents (ages 11-15) must incorporate these insights.

LEANER-CENTRIC PEDAGOGY

Pedagogical models are shifting from teacher-centered to learner-centered. A focus on **meaningful learning experiences and supportive learning environments** is the signature of this model. It links our current cultural snapshot and future projections in context with the 3Ps.

There is a **language gap between educator and designer** when describing the physical requirements of the learner-centric model. Lack of shared context leads to misunderstandings in the design process and misaligned built outcomes.

AFFORDANCE THEORY

Affordance theory emphasizes the dynamic and interconnected **relationship between people, their experiences, and the settings** they inhabit. This has particular relevance for school design, as it highlights the importance of creating spaces that are responsive.

An affordance-based approach to design is likely to help **generate shared understanding** between designers and users, so that spaces are designed to be aesthetically pleasing, useful and intuitive for users.

IMAGES Left: Lakeridge Middle School, Lake Oswego School District, Photo by Art Ross. Middle: Seattle Girls School, Photo By School. Right: Tumwater Middle School, Beaverton School District, Photo By Josh Partee.

SECTION 04: OUR DISCOVERIES
What we learned, what surprised us, and, what it might mean

The research goal is to advance the design and use of learning settings in the US for early adolescents, aged 11-15, to directly support emerging education models within the next 10-years. The literature review highlights an opportunity to practically apply affordance theory to bridge the experience and language gap underpinning misaligned learning settings. This work hypothesizes that a practical spatial framework with clearly defined spatial roles and tools will improve the alignment between learning settings and learner-centric pedagogy.

OUR HYPOTHESIS: A LEARNER-CENTERED SPATIAL FRAMEWORK

Making affordances practical and approachable across the various roles operating within a school ecosystem is the critical first step. **Understanding the learner centered 3Ps through the lens of affordance theory provides clearly defined spatial roles for educators, learners, and designers.** Each role has untapped capacities to learn the impact of affordances and identify space signals, to intentionally shape learning settings. A leaner-centered spatial framework will simplify the connection between affordances and the 3Ps by defining the common spatial tools (qualities and objects) of learning settings and a way for learners, educators, and designers to explicitly manipulate their space signals.

This provocative idea leads to the remaining research questions:

> What does space signal to different spatial roles?

> What are the critical spatial tools to prioritize for 3P alignment?

In exploring these questions, settings may not look radically different. However, how we think about settings changes how we use them, and how we use them, changes how we think about them.

This is the power of affordance.

IMAGE Lakeridge Middle School, Lake Oswego School District
Photo By Art Ross

What does space signal to different spatial roles?

What are the critical spatial tools to prioritize for 3P alignment?

CRITICAL RESEARCH QUESTIONS

> **Skills or knowledge about architecture, design or spatial behaviour are not a requirement for teachers who occupy flexible spaces, and though teaching is a spatial practice, understanding the influence of spaces and physical elements is not typically a part of the education to become a teacher. The established set of attitudes that characterises teachers' daily use of space is thus formed by the history of the profession and the buildings it has taken place in, not professional spatial understanding, reflections and discussions. The teachers' mindsets are the prerequisite for their actions and their repeated actions become the habits which dictates the way they set up and use the flexible spaces.**
>
> THE MOBILITY OF PEOPLE, NOT FURNITURE, LEADS TO COLLABORATION

CLARIFYING SPATIAL ROLES: EDUCATOR COMPETENCY, LEARNER AGENCY, DESIGNER ALIGNMENT

Spatial roles are the set of abilities, responsibilities, and perspectives that individuals within a school community bring to their interactions with the learning setting. There are three primary roles embodied by educators, learners, and designers. These roles are intertwined, directly affecting the degree to which responsibilities are fulfilled or abilities realized. The term "educator spatial competency" (10) came from Byers (2021) and was expanded upon for the other roles – student and designer.

Educator Spatial Competency is an educators' ability to effectively understand, utilize, and adapt the learning setting to optimize outcomes. They leverage their spatial awareness to create settings that support diverse learning needs and encourage engagement. It emphasizes the intentional connection between physical design, teaching practices, and behavioral outcomes. It requires recognizing the affordances of space and shaping practices to align with those possibilities.

Educator Spatial Competency ties directly to pedagogical approaches making educators facilitators of how space impacts learning. In project-based learning, "flexible" spaces with easily movable furniture, small group breakout areas, and learner accessible resources enable collaboration, hands-on exploration, and student-driven inquiry. In contrast, educators cognizant of trauma-informed teaching approaches could request a cozy corner with soft seating, calming elements like plants or soft colors, and sensory supports like dimmable lighting provides learners with a space to recharge and self-regulate.

Unlike learners, educators focus on adapting settings not just for their own needs but for the collective needs of the class. Skilled educators balance immediate classroom management strategies with long-term considerations for how settings impact learner growth and behavior. They recognize the iterative relationship between the 3P's and how they evolve based on teaching and learning goals. Educators guide and model effective use of space; teacher mindsets, in connection with the physical possibilities at hand (affordances of space), lead to spatial habits and teaching practices.

IMAGE Tumwater Middle School, Beaverton School District
Photo ByJosh Partree

> **Architects are commonly less successful at sharply defining functions within the built environment due to the complexity of human activities that are better known to inhabitants.**

THE AFFORDANCES OF INNOVATIVE LEARNING ENVIRONMENTS FOR DEEP LEARNING

Learner Spatial Agency is a learners' ability to navigate, interpret, and adapt to the learning setting in ways that support their individual learning needs, goals, and behaviors. It recognizes that learners are not passive occupants and encourages ownership and active participation in shaping how settings are experienced and utilized. Learner spatial agency is a supported process. It evolves with intentional guidance from educators and explicit design features introduced by the designer.

In a "flexible" learning setting, learners navigate and adapt the space around them to meet their needs –choosing soft seating for independent reading, standing counter for focus work on a computer, or round table with easy to move chairs for collaboration with a group. Educators model and reinforce agency in spatial decision-making, fostering a sense of ownership and active participation for the learner to shape their learning experience.

Student spatial agency shifts the focus to students' active engagement with the space, emphasizing empowerment and adaptability to meet their learning needs.

Designer Spatial Alignment is a designers' ability to create learning settings that align with the practices, needs, and goals of each unique school community. It requires an understanding of how learning and teaching happen in practice and focuses the designer on creating settings that afford behaviors that support current learning models. It highlights the importance of engaging with other spatial roles during the design process to ensure alignment. This requires designers to make simple connections between the 3Ps by offering common language and tangible examples.

Designer spatial alignment emphasizes the responsibility and intentionality required from designers to meet educational needs and create learner-centered settings. To create settings that clearly afford opportunities for agency and engagement, aligned with educational needs requires collaboration, empathy, and an understanding of how learning happens in practice.

A LEARNER-CENTERED SPATIAL FRAMEWORK

The learner-centric model balances two core ideas: meaningful learning experiences and supportive learning environments. It is intended to disrupt the teacher-centric models by recognizing rapid change and future-focused durable skills. A building designed to support this type of learning and teaching must indicate that it is different than the rigid structures of the past.

A designer's focus is primarily spatial. A **spatial framework** is a way to hyper-focus on "place" by providing shared language and tools to understand space signals and make intentional changes to a place. A **space signal** is a message communicated through the design, layout, or features of a physical setting. These influence how people understand and interact with the area around them. A space signal can be intentional or unintentional. **Indicators** are the dominant messages of multiple and cumulative space signals. The framework aims to make both indicators and signals clear and intentional.

Indicators of a learner-centered environment are tailored to educators and learners. For learners, spaces provide challenge, offer responsibility, and enable relationships. For educators, spaces must be responsive, intuitive, and facilitate safety.

Learner Critical Indicators

> A space that provides challenge is empowering

> A space that offers responsibility inspires growth through engagement

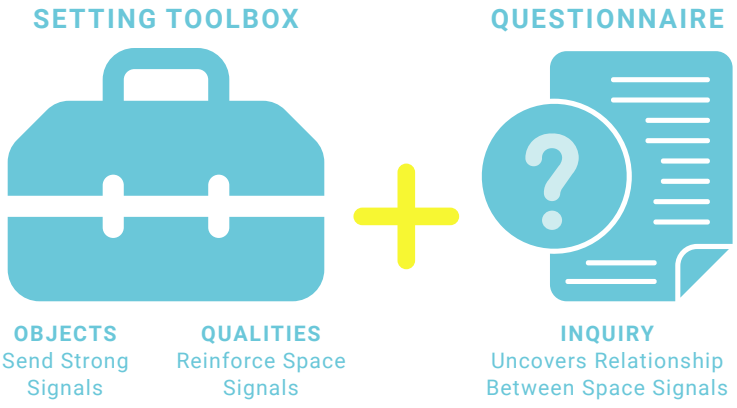
> A space that enables relationships promotes interpersonal interactions

Educator Critical Indicators

> A responsive space reacts to wants or needs

> An intuitive space is easy to use

> A space that facilities safety minimizes harm



A learner-centered spatial framework, consisting of a **setting toolbox and questionnaire**, can be used to align spatial roles with tools and enact learning setting changes. Within the setting **toolbox are common spatial tools comprised of qualities and objects** that create signals. A spatial role's ability to leverage the tool will determine its use and impact.

Spatial tools can be defined by many variables or scales. To help designers, educators, and learners find common language, the research intentionally defined and narrowed the variables. For the purposes of this study, **"small scale", single-factor variables** were used that would likely be understood by both early adolescents and adults. They are further defined below. Multifactorial variables on the building scale were not used. These would have included overall building layout and room adjacencies; both are important variables that are recommended be studied in future research efforts.

Building on commonly cited words in literature, resources like the taxonomy of space from the learning space toolkit (learningspacetoolkit.org), and feedback from the research advisory group, the toolbox identified on 29 common spatial tools. These tools make up our "setting toolbox" and they are divided into 14 qualities and 15 objects.

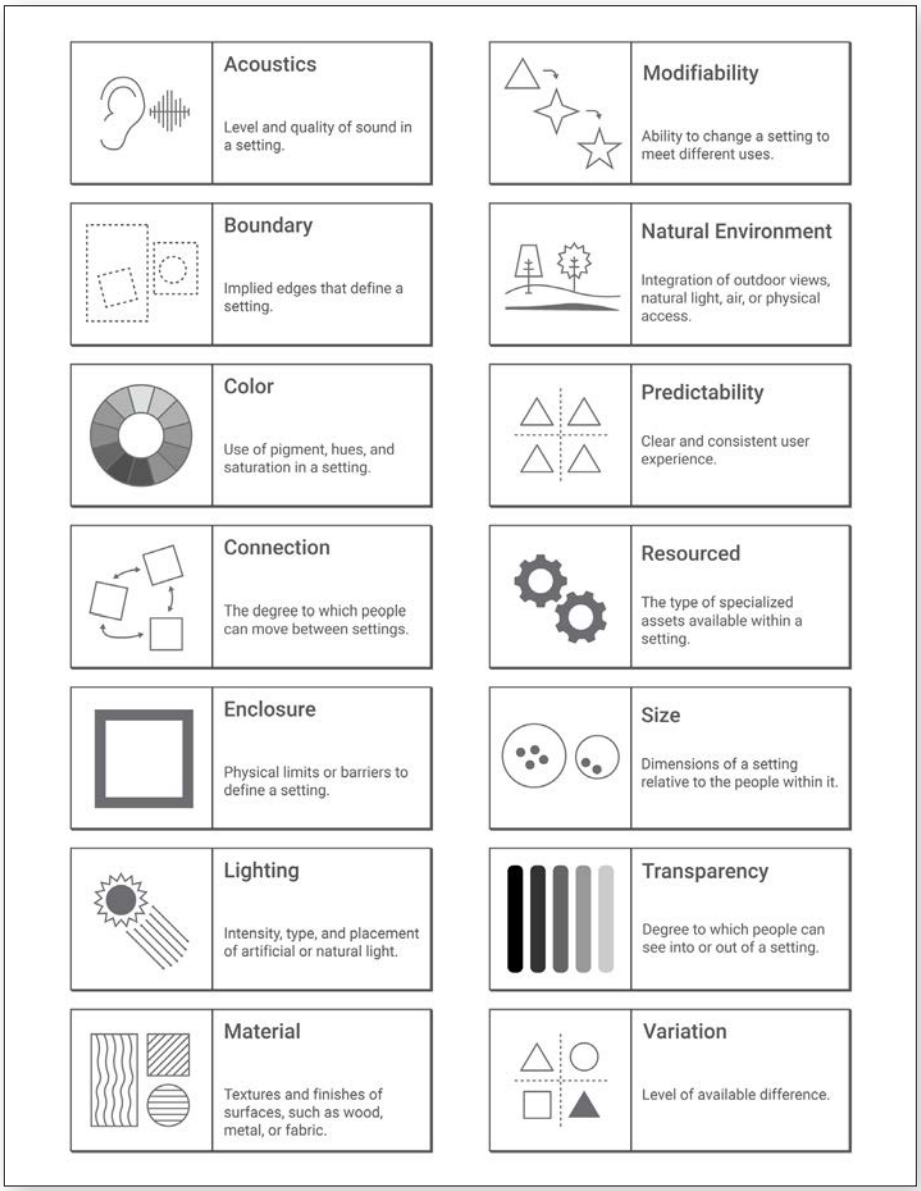
QUALITIES

TOOLBOX

SETTING QUALITIES

Qualities are **sensory attributes of a physical setting** embedded into its design and function. They shape the overall experience and usability of the setting. Qualities are foundational design tools that **send strong space signals**.

- **Acoustics:** Level and quality of sound in a setting
- **Boundary:** Implied edges that define a setting
- **Color:** Use of pigment, hues, and saturation in a setting
- **Connection:** The degree to which people can move between settings
- **Enclosure:** Physical limits or barriers to define a setting
- **Lighting:** Intensity, type, and placement of artificial or natural light
- **Material:** Textures and finishes of surfaces, such as wood, metal, or fabric
- **Modifiability:** Ability to change a setting to meet different uses
- **Natural Environment:** Integration of outdoor views, natural light, air, or physical access
- **Predictability:** Clear and consistent user experience
- **Resourced:** The type of specialized assets available within a setting
- **Size:** Dimensions of a setting relative to people within it
- **Transparency:** Degree to which people can see into or out of a setting
- **Variation:** Level of available difference



Worksheet developed for beta-test engagement session.

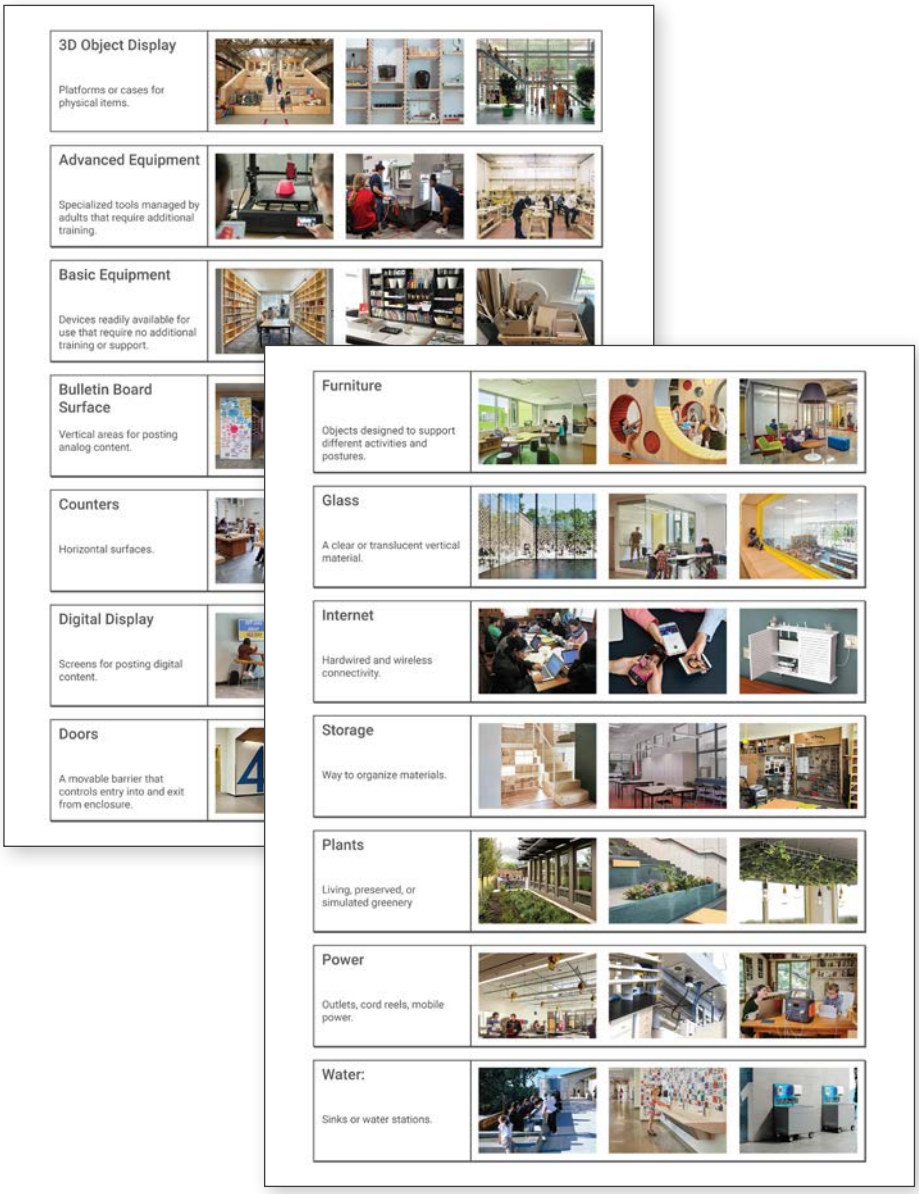
OBJECTS

TOOLBOX

SETTING OBJECTS

Objects are **tangible elements within a physical setting** that modify or enhance the qualities of a setting. They can be **fixed or mobile**. The objects in a setting serve practical purposes to directly support specific functions, activities, or interactions. They **reinforce space signals**.

- **3D Object Display:** Platforms or cases for physical items
- **Advanced Equipment:** Specialized tools managed by adults that require additional training
- **Basic Equipment:** Devices readily available for use that require no additional training or support
- **Bulletin Board Surface:** Vertical areas for posting analog content
- **Counters:** Horizontal surfaces
- **Digital Display:** Screens for posting digital content
- **Doors:** Movable barrier that controls entry into and exit from an enclosure
- **Furniture:** Objects designed to support different activities and postures
- **Glass:** Clear or translucent vertical material
- **Internet:** Hardwired and wireless connectivity
- **Storage:** Way to organize materials
- **Plants:** Living, preserved or simulated greenery
- **Power:** Outlets, cord reels, mobile power
- **Water:** Sinks or water stations
- **Whiteboard Surface:** Writable areas



Worksheet developed for beta-test engagement session.

TOOLBOX

QUESTIONNAIRE

The questionnaire is a tool to understand which space signals are perceived by the spatial roles through prompting responses of awareness, agreement, priority or frequency related to qualities and objects. Because indicators of a learner-centered environment are different for learners and educators there are complementary sets of questions.

There are three broad categories to the questions; demographic, role based, and indicator based.

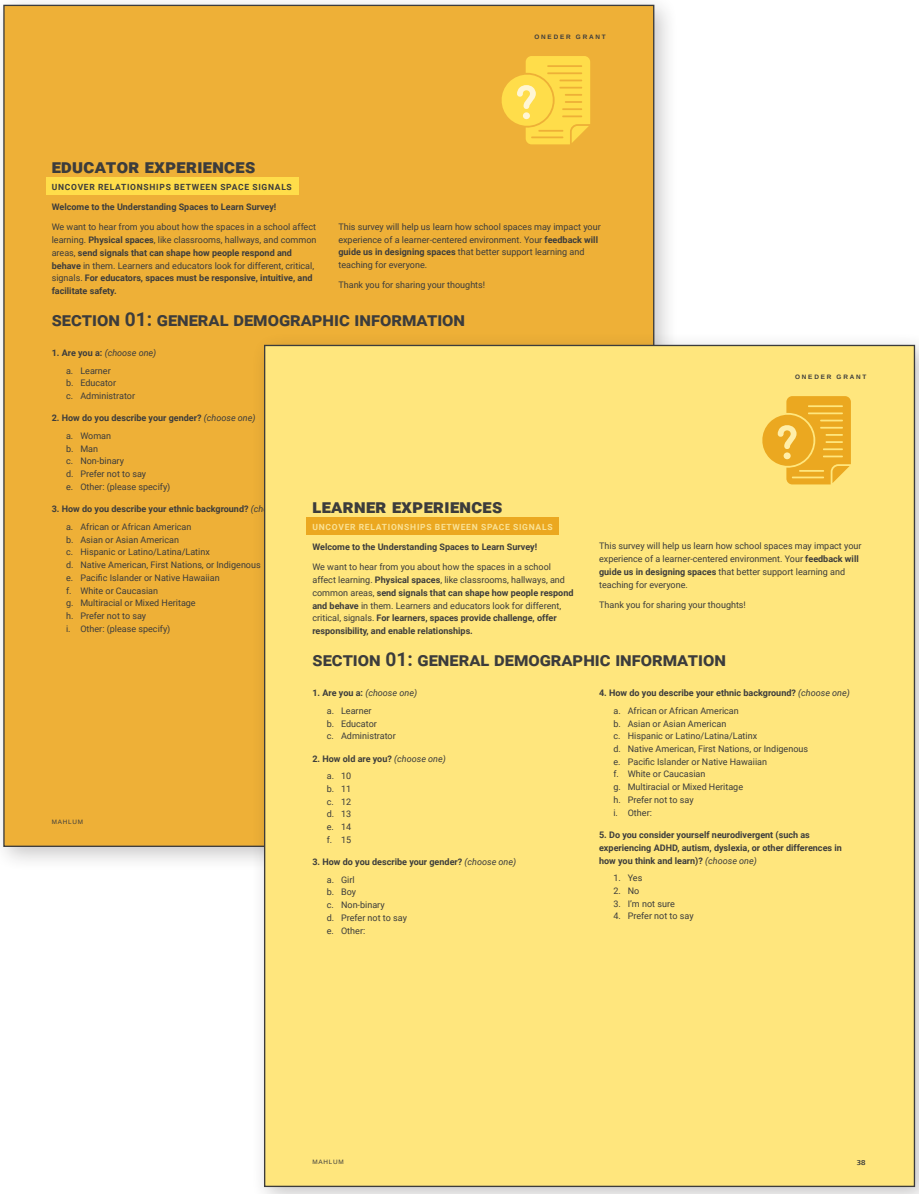
Demographic information on participants will provide context to their responses.

The remaining non-demographic questions are structured to uncover the relationship between role, signals, and desired indicator.

Role based questions will uncover their preferences and awareness of learner-centered settings.

Indicator questions focused on participants' perception of space signals to assess the importance of qualities and objects, as well as validate impact and identify signal conflicts as they relate to the prescribed, learner-centered indicators.

Responses will help pinpoint the significance of space signals to realizing indicators. Potential demographic or role-based differences in perception can also be tracked.



ONEDER GRANT

EDUCATOR EXPERIENCES

UNCOVER RELATIONSHIPS BETWEEN SPACE SIGNALS

Welcome to the Understanding Spaces to Learn Survey!

We want to hear from you about how the spaces in a school affect learning. **Physical spaces**, like classrooms, hallways, and common areas, **send signals that can shape how people respond and behave** in them. Learners and educators look for different, critical, signals. **For educators, spaces must be responsive, intuitive, and facilitate safety.**

This survey will help us learn how school spaces may impact your experience of a learner-centered environment. Your **feedback will guide us in designing spaces** that better support learning and teaching for everyone.

Thank you for sharing your thoughts!

SECTION 01: GENERAL DEMOGRAPHIC INFORMATION

1. Are you a: *(choose one)*

a. Learner
b. Educator
c. Administrator

2. How do you describe your gender? *(choose one)*

a. Woman
b. Man
c. Non-binary
d. Prefer not to say
e. Other: (please specify)

3. How do you describe your ethnic background? *(ch*

a. African or African American
b. Asian or Asian American
c. Hispanic or Latino/Latina/Latinx
d. Native American, First Nations, or Indigenous
e. Pacific Islander or Native Hawaiian
f. White or Caucasian
g. Multiracial or Mixed Heritage
h. Prefer not to say
i. Other: (please specify)

MAHLUM

ONEDER GRANT

LEARNER EXPERIENCES

UNCOVER RELATIONSHIPS BETWEEN SPACE SIGNALS

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We want to hear from you about how the spaces in a school affect learning. **Physical spaces**, like classrooms, hallways, and common areas, **send signals that can shape how people respond and behave** in them. Learners and educators look for different, critical, signals. **For learners, spaces provide challenge, offer responsibility, and enable relationships.**

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d. 13
e. 14
f. 15

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e. Pacific Islander or Native Hawaiian
f. White or Caucasian
g. Multiracial or Mixed Heritage
h. Prefer not to say
i. Other:

5. Do you consider yourself neurodivergent (such as experiencing ADHD, autism, dyslexia, or other differences in how you think and learn)? *(choose one)*

1. Yes
2. No
3. I'm not sure
4. Prefer not to say

MAHLUM 38

Questionnaire developed for beta-test engagement. See resource section for complete questionnaire.

SECTION 05: WHAT'S NEXT
Ideas to keep things moving, gratitude and helpful resources

PHASE ONE

RESEARCH OUTCOMES

This first phase of research has two primary outcomes:

First to **synthesize historical context, literature review insights, and design practice experience** into a clear hypothesis; Second to develop a **spatial framework** to test the hypothesis.

Schools are complex ecosystems with a long history of heritage and modified structures. **Understanding and alignment of 3Ps is a critical requirement for meaningful and sustainable change.** Key insights on adolescent development, learner-centric education, and affordance theory can be combined and clarified into spatial roles. **A critical experience and language gaps exist between spatial roles.** These insights provide designers with an improved definition of a learner-centric model and a deeper understanding of how physical settings can influence the adoption and efficacy of that model.

A spatial framework is developed to close the experience and language gap. It consists of a 'setting toolbox' and 'questionnaire' as a first attempt to generate spatial competency, agency and alignment between educators, learners and designers.

PHASE TWO

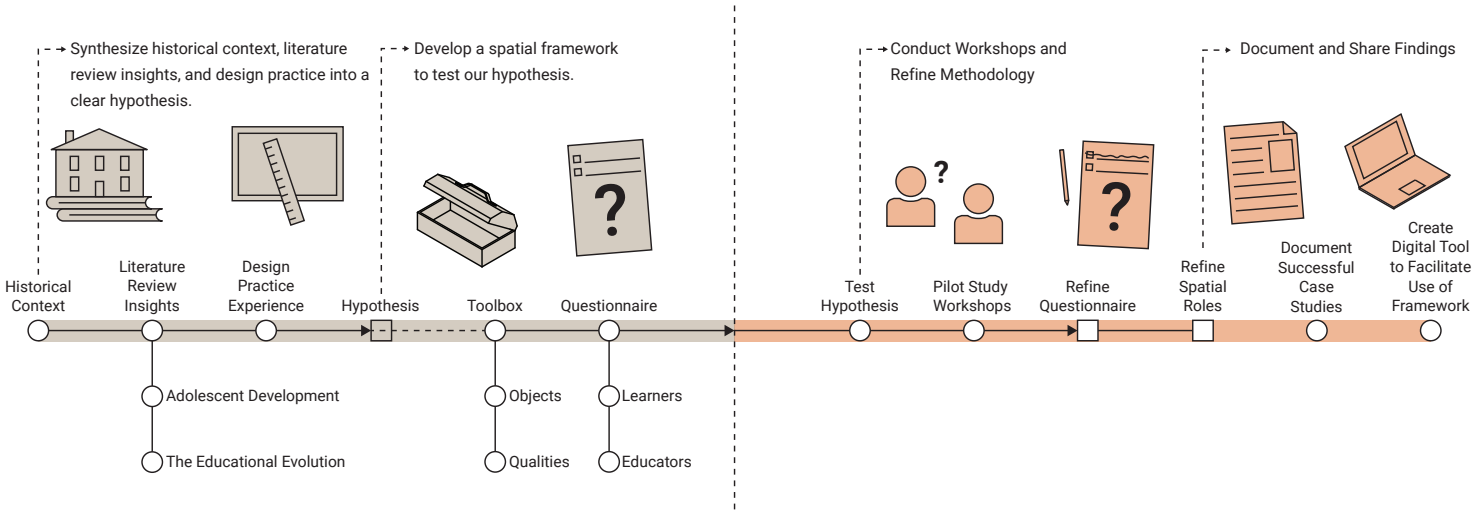
WHERE WE'RE HEADED

Future research will refine the spatial framework further **exploring the interplay of people, practice, and place** to advance school design. The primary focus of phase two will be to **test the hypothesis** and understand the significance of both the experience and language gap and the spatial roles as they relate to space signals.

The research team is preparing to **conduct pilot studies** in the form of workshops to affirm efficacy of the spatial framework through a co-design process with learners and educators. **The workshops will explore if the tools can be used to analyze existing learning settings and identify areas for improvement.**

Further refinements will be made to the questionnaire to **improve question clarity for intended audiences**. Data collected from the questionnaire as well as pilot workshops will be used to **refine the list of "Qualities" and "Objects"** with educators, learners, and designers.

Pending successful completion of pilot workshops, case studies could be documented that demonstrate how the framework can be applied to specific school design projects. A **digital tool** to facilitate the use of the framework and to support collaboration among educators, learners, and designers, is also under consideration.

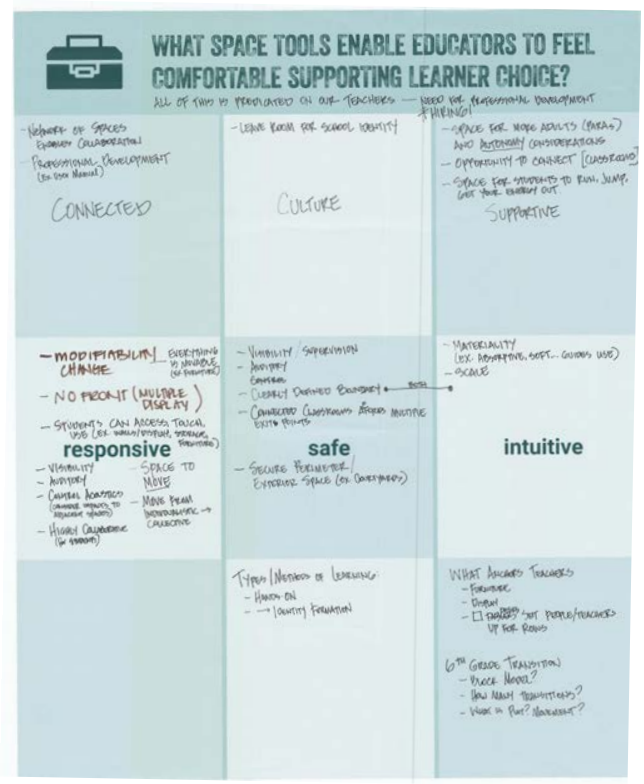


PHASE TWO

TESTING OUR HYPOTHESIS

Alongside development of the spatial framework in Phase One, the research team **tested a series of activities** to inform the early refinement of the “Qualities” and “Objects”. These are described below. Through Phase Two, the activities will continue to evolve into a **comprehensive workshop structure** intended to close the experience and language gap by engaging individuals in their spatial roles.

This work contributes to both education and design communities by providing **practical tools that empower** all members of a school ecosystem to “see” and “shape” learning settings in service of modern, evolving educational practices.



Educator activity sheet from workshop exploring indicators with the spatial toolkit.

[RE]IMAGINE A LEARNER-CENTRIC EDUCATION MODEL

Stop-Keep-Start is an activity where participants engage in a **structured reflection and ideation process to critically examine common educational practices** today with the intent to reflect on their understanding of a learner-centric model. The exercise challenges learners, educators, administrators, and community participants to shift their focus from traditional structures to intentional, learner-driven experiences. Participants are asked to consider what they may need to stop doing because it **hinders learner-centricity**, what they need to keep doing because it is **effective and supports student success**, and what they need to start doing to **foster bold thinking and innovation** in education.

EXPLORE CRITICAL INDICATORS AND SPACE SIGNALS FOR LEARNING

Activities and Space Signals is an activity that builds on Stop-Keep-Start, introducing **critical indicators and the space toolbox**. Participants are asked to identify specific learning activities that align with the identified critical indicators for learners and educators. Participants then engage with the space toolbox, articulating the **qualities and objects** that support these activities – separate from describing a setting – to **clarify priority space signals** in a learner-centric model.

CO-DEFINE SIGNALS AND LEARNING SETTINGS

Tuning Space Signals is an activity that integrates insights from ‘Stop-Keep-Start’ and ‘Activities and Space Signals’ through **manipulation of prioritized qualities and objects**. Participants utilize the qualities and objects from the space toolbox to create settings that signal a learner-centric model. They can modify ‘starter settings’ or create entirely new ones. This collaborative process is a form of **training that builds confidence for the spatial roles** engaged. Through this workshop, participants can **identify the direct relationship between signals and settings** and begin tuning them to find the desired results. It takes the leap from abstract ideation to concrete spatial planning.

RESEARCH METHODOLOGY AND GRANT SUPPORT

Mahlum Architects was awarded a **ONEder Grant** through the One Workplace grant program supporting research into how design influences human experience. Primary researchers were **Stacey Crumbaker and Claudia Saunders**, both practicing interior designers with Mahlum. While this study is grounded in academic research, it scaffolds on their practitioner expertise as both researchers focus on the PK-12 education market. The study builds on education and design theories, connecting the ways in which school-based learning is influenced by people, practice, and place.

Early insights helped refine the research questions and led to two phases of investigation. In Phase One, they convened an **Advisory Group** consisting of educators, designers, academics, industry researchers, and a futurist to provide **guidance, align goals with industry trends, and ensure relevance**. Advisors contributed best practices in methodology and ethics, while also advocating for specific focus within the research, and fostering connections within their communities.

Researchers completed a **comprehensive literature review of 85 sources** to synthesize existing findings on school buildings and spatial design, adolescent development, evolutions in pedagogy and learning science, and emerging trends in educational innovation. They looked to **uncover current trends and patterns** through influential studies, while **identifying contradictions and gaps** in existing research relevant to their primary questions.

Resources were gathered through online databases with searches focusing on the following:

- Current and future skills-based targets for engaged learning
- Adolescent developmental factors that influence learning capacity
- Factors that influence physical learning environments

Findings were integrated into the report and enriched by insights gained from applied field practice. During the development of the spatial toolbox, the research team engaged in, and continues to beta test, using exploratory trials of language, tools, and activities to refine the concept and asses its practicality and effectiveness in real-world applications.

Curious to learn more? Reach out and say hello!

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OUR APPRECIATION

This work didn't happen in a vacuum — and it's all the better for it.
With support from a One Workplace research grant, we teamed up with an incredible **Advisory Group** whose ideas and feedback helped shape where we went and how we got there. Their insights spanned everything from teaching models and future school trends to current challenges and research design.

Each Advisor brought their own lens, expertise, and curiosity to the mix—and what you'll find in these pages reflects that collaboration.

We're so grateful for the time, energy, and thoughtfulness you shared. Thank you for being part of this journey!

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GLOSSARY

FRAMING LANGUAGE

The terms in this glossary are not formal dictionary definitions — they're context-setters. These are words and ideas we use throughout the paper, and we want to **be clear about what we mean** when we use them. Language shapes understanding, and many of these terms (like "environment" or "affordance") carry layered meanings depending on your role, experience, or perspective.

This glossary is meant to surface those meanings and **create shared understanding, not prescribe one "correct" way** to define a term.

It's about clarity, not closure.

AFFORDANCE
Term coined in ecological psychology by James Gibson in 1977[30]. Affordances are the possibilities for action provided to an individual by a physical setting. Their perception and usefulness are relative to the individual's abilities and lived experiences as well as the inherent properties of setting.

COGNITIVE DISSONANCE
Mental discomfort experienced when a person holds conflicting beliefs, values, or attitudes, or when their actions contradict their beliefs.

CONTINUOUS IMPROVEMENT PLAN
Structured, ongoing process for assessing school performance, identifying areas for growth, implementing targeted changes, and evaluating results to enhance student outcomes and achieve educational goals.

COMMON SCHOOL
Championed by Horace Mann in the mid-19th century, common schools are a type of public school that emerged in the United States to provide free (publicly funded), universal, and non-sectarian education. Intended to be accessible to children of all socioeconomic backgrounds, these schools were meant to serve the "common good" through standardized curriculum that ensured consistency, and therefore conformity, in education across different communities.

CURRICULUM
Structured framework that defines intended content (knowledge, concepts, and skills), learning objectives, instructional methods, and assessment strategies designed to guide education.

DUNNING-KRUGER EFFECT
Cognitive bias where individuals with low ability or knowledge in a specific area overestimate their competence, while those with high ability often underestimate their own expertise.

EARLY ADOLESCENCE
Young people, typically between the ages of ten to fifteen years, experiencing the transitional periods from late childhood to adolescence and adulthood through rapid physical, cognitive, emotional, and social changes.

EDUCATIONAL SPECIFICATIONS
Guidelines defining the spatial, functional, and design requirements of a school facility, aligning the physical environment with the educational goals, programs, and activities; may be established at a district-wide level by operational leadership to create consistency and then modified for an individual school.

ENVIRONMENT
Physical spaces, places, and settings where people experience their daily lives, it includes the human-made structures and systems that support it.

> **Space:** A physical, three-dimensional area.

> **Place:** Space as influenced by personal experiences, cultural context, and design.

> **Setting:** Place where a specific set of interactions are intended to occur.

> Consider this example:
A cafeteria "space," is a large area where the school comes together. As a commons it becomes a "place" where the school gathers, and over time this creates a sense of connection and community. A "setting" could be a "quiet dining" area within or adjacent to the main commons where a learner who desires a less stimulating environment may choose to go.

INDICATOR
Dominant messages of multiple and cumulative space signals.

INSTRUCTION
Deliberate and structured process of guiding learners to acquire knowledge, develop skills, or achieve specific educational objectives.

LEARNING ENVIRONMENTS
Social and emotional ecosystem where learners and educators interact to enhance learning by fostering a sense of community, collaboration, and support.

LEARNING SETTINGS
Physical environment (see built environment) where learning and teaching occur, shaped by spatial organization, materiality, and physical resources.

LEARNER-CENTRIC
Education model that focuses on the needs, interests, and abilities of students, promoting active participation, personalized learning, and collaboration. Teachers serve as facilitators to support student-driven exploration and knowledge acquisition.

LOSS AVERSION
Psychological principle where individuals prefer avoiding losses over acquiring equivalent gains, meaning the pain of losing is felt more strongly than the satisfaction of gaining.

PARITY
Condition of being equal or equivalent, often referenced in discussions of sameness, fairness, equality, or balance between two or more entities.

PEDAGOGY
The theory and practice of teaching. It encompasses learning principles, as well as approaches, methods, strategies, and techniques educators use to facilitate learning and ensure students acquire and apply knowledge effectively. It involves an understanding of how students develop and learn as well as the design of instructional activities.

- **Learning Principle:** Foundational beliefs and frameworks that guide how learning and teaching occur; explain why learning happens in certain ways.
- **Approach:** Overarching philosophy or perspective that informs how teaching is conceptualized; defines the philosophical direction of teaching.
- **Method:** Structured systems used to deliver content and facilitate learning; specify the general system for teaching.
- **Strategy:** Specific plans or actions chosen to achieve learning objectives within a method; plan the specific approach within a method.
- **Technique:** Specific tools, activities, or practices used to implement strategies and methods; implement the practical tools or activities within a strategy.

3PS
A lens for understanding how schools function and evolve. This framework highlights the interconnected roles of individuals, systems, and environments.

- **People:** Individuals and groups within the school ecosystem, including students, educators, administrators, parents, and designers; they influence actions, interactions, and routines, reflecting both personal and collective dynamics.
- **Practice:** Rules, policies, and protocols that guide how schools and design firms operate; they shape organizational culture, pedagogy, space usage, and evolve to meet societal and institutional needs over time.
- **Place:** Tangible, sensory school environment, encompassing the physical design, layout, and objects within the building. “Spaces” and “settings” fall under the category of place.

MASTER PLANNING
Strategic process that outlines the long-term vision for the physical development and use of a campus.

SOCIO-SPATIAL
Interconnected relationship between social dynamics and the built environment.

SETTING TOOLBOX
Common tools within the spatial framework comprised of a questionnaire and spatial tools.

SPACE SIGNAL
Message communicated through the design, layout, or features of a physical setting/environment.

SPATIAL ROLE
Set of abilities, responsibilities, and perspectives that individuals bring to their interactions within a physical setting.

SPATIAL TOOLS
Qualities and objects within physical setting narrowed to “small scale” single-factor variables commonly understood by both early adolescents and adults.

QUALITIES
Sensory attributes of a physical setting embedded into its design and function; they shape the overall experience and usability of the setting.

OBJECTS
Tangible elements within a physical setting that modify or enhance the qualities of a setting; they can be fixed or mobile and serve practical purposes to directly support specific functions, activities, or interactions.

SPATIAL FRAMEWORK
A structured approach to organizing and understanding spaces, emphasizing sensory attributes, tangible elements, and functionality to support specific activities, interactions, and experiences.

LEARNER AGENCY
Capacity of a student to take ownership of their learning by actively participating in decisions about what, how, and why they learn; emphasizes autonomy, voice and choice, self-direction.

TEACHER-CENTRIC
Education model that prioritizes the teacher as the primary source of knowledge and authority, with a focus on direct instruction, structured content delivery, and student compliance, emphasizing standardized outcomes over individual learner needs or preferences.

TEACHING STATION
Scheduled instructional space used for teaching.

UTILIZATION
Percentage of time a teaching station is actively used for instruction and defines the efficiency of space use relative to availability.

LEARNER EXPERIENCES

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f. 15

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g. Multiracial or Mixed Heritage
h. Prefer not to say
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5. Do you consider yourself neurodivergent (such as experiencing ADHD, autism, dyslexia, or other differences in how you think and learn)? *(choose one)*

1. Yes
2. No
3. I'm not sure
4. Prefer not to say

SECTION 02: UNDERSTANDING OF A STUDENT'S ROLE OR EXPERIENCE IN A LEARNER-CENTERED ENVIRONMENT

6. What grade are you in? *(choose one)*

a. 5th
b. 6th
c. 7th
d. 8th
e. 9th

7. Do you enjoy school? *(choose one)*

a. Yes, I like it a lot
b. It's okay
c. Not really
d. I don't like it at all

8. What's your favorite thing about your classroom or school space? *(choose one)*

a. It's comfortable
b. It's fun
c. It's quiet
d. I can work with friends
e. It has cool tools or technology

9. How would you choose to learn new material? *(choose one)*

a. By listening
b. By doing hands-on activities or projects
c. By working with others
d. By working on my own
e. Other: (please specify)

10. What do you find most difficult about school? *(choose one)*

a. Keeping up with schoolwork
b. Making friends
c. Focusing in class
d. Feeling included
e. Other: (please specify)

11. How much do you agree with the following statements about your school? *(4-scale Likert)*
Very Effective – Effective – Ineffective – Very Ineffective

a. I can ask for what I need to help me learn.
b. I have choices in how I learn.
c. I feel safe at school.
d. I feel comfortable at school.
e. My classroom helps me do my best learning .
f. I can work by myself when I need to.
g. I can work with others when I need to.

12. Which of the following spaces do you think are important for how you need to learn?
(choose all that apply)

a. Spaces where you can work with friends.
b. Spaces where you can work independently.
c. Spaces that change easily.
d. Spaces where you feel safe.
e. Spaces where you feel comfortable.
f. Spaces with cool technology.
g. Spaces where you can go outside.

13. Do you feel like your classroom is set up to help you learn the way that works best for you? Why or why not? *(open)*

SECTION 03: PERCEPTIONS OF SPACE SIGNALS ON CRITICAL INDICATORS

14. Think about what makes a classroom push you to grow as a learner. Below are several statements about ideal room qualities. Please rank them in your order of importance.
1= MOST important 13 = LEAST important

1. It's easy to hear during lessons.
2. It's easy enter and exit the room.
3. The room has colors that help me stay focused.
4. I can go to another room to work in a different space if needed.
5. The lighting can be changed (brighter or dimmer).
6. Clean up after project work is easy.
7. The furniture can be moved around.
8. There are windows so I can see outside.
9. The room is organized in a way that's easy to understand.
10. The tools or materials I need for projects are easy to find.
11. There's enough space to move around without bumping into others.
12. I can see into the hallway and know what's happening outside the room.
13. There are different areas in the room I can use.

15. Here is a list of objects and features that may be in your classroom. When you're working on a tough problem, but you're excited to learn about it, which object and features are most helpful? *Choose up to three (3) that have the greatest POSITIVE impact on you.*

a. Display for looking at items.
b. Special tools that need adult help to use.
c. Tools and devices, like laptops, you can use on your own.
d. Spaces to pin-up and organize work.
e. Flat surfaces for hands-on tasks.
f. Screens to share or explore information.
g. Doors that let you create quiet.
h. Desks, chairs, or tables you can move.
i. Windows or clear areas to see outside or other spaces.
j. Wi-Fi or wired internet for research and collaboration.
k. Shelves or bins to organize materials.
l. Plants that make the space feel alive.
m. Outlets or chargers to keep devices powered.
n. Sinks or water stations for projects or staying refreshed.
o. Writable surfaces for sketching ideas and solving problems

16. Which objects and features in your classroom are most likely to it harder for you when you're working on that same problem? *Choose up to three (3) that have the greatest NEGATIVE impact on you.*

a. Displays that don't change
b. Special tools that aren't available when you need them.
c. Laptops or devices that don't work well.
d. Spaces that are messy or hard to use.
e. Surfaces that are too small or shaky.
f. Screens that don't work or are hard to see.
g. Doors that let in noise or distractions.
h. Desks or chairs that are hard to move.
i. Windows that are distracting.
j. Internet that is slow or doesn't work.
k. Shelves that are messy or hard to reach.
l. Plants that get in the way.
m. Outlets that aren't close or don't work.
n. Sinks that are hard to use or messy.
o. Writable boards that are too small or not clear.

17. In a classroom that helps you work on tough but interesting tasks; how often would you want to rearrange the furniture to fit in with what you're doing? *(choose one)*

a. Every class period
b. Every day
c. Once a week
d. Once a month
e. Only for special projects
f. Never

18. Think about how resources are managed in a classroom that pushes you to grow as a learner. What works best for your learning needs? *(choose one)*

a. All tools and resources are open access.
b. Digital resources are always accessible online, physical resources are accessible through your teacher.
c. All tools and resources are available when requested.
d. All tools and resources are available on a consistent schedule.
e. Spaces provide clear guidance on how and when to use tools & resources.

19. How can a classroom help you feel responsible for your learning? Below are several statements about ideal room qualities. Please rank them in your order of importance.
1 = MOST important 13 = LEAST important

1. I can hear clearly, so I know what's expected of me.
2. I can easily enter or leave the room.
3. The colors in the room help me feel calm.
4. I have the option to work in another space when I need to.
5. The lighting can be adjusted to make it easier for me to see what I'm doing.
6. It's easy to clean up and put things away after working on a project.
7. I can rearrange the furniture for the task I'm working on.
8. I can see outside, which helps me take a quick mental break and refocus.
9. The room is organized in a way that makes it easy to find what I need.
10. The tools and materials I need are easy to access.
11. There's enough space for me to move around without disturbing others.
12. I can see what's happening in the hallway or other nearby spaces without having to go into them.
13. There are different areas in the room, and I can choose a space that fits how I need to work.

20. Here is a list of objects and features in your classroom that could help you feel responsible for your learning. When you try to stay engaged with what you're working on, which ones have the greatest POSITIVE impact on you? *Choose up to three (3)*

a. Display for showing or organizing items.
b. Special tools for advanced projects.
c. Laptops or devices for independent work.
d. Spaces to share and organize ideas.
e. Surfaces for hands-on tasks.
f. Screens for sharing or exploring information.
g. Doors for controlling noise or distractions.
h. Desks or chairs you can move or adjust.
i. Windows for inspiration or connection.
j. Internet for research or collaboration.
k. Shelves for keeping materials organized.
l. Plants to connect to nature.
m. Outlets to keep devices powered.
n. Sinks for creative or messy projects.
o. Writable boards for active thinking.

21. Which objects and features make it harder for you to feel responsible and stay engaged with what you're working on?
Choose up to three (3) that have the greatest NEGATIVE impact on you.

a. Displays that are hard to use or not helpful.
b. Special tools that are difficult to access.
c. Laptops or devices that don't work well.
d. Spaces that are disorganized.
e. Surfaces that are too small or unstable.
f. Screens that are hard to see.
g. Doors that let in noise or distractions.
h. Desks or chairs that are uncomfortable.
i. Windows that are distracting.
j. Internet that is unreliable.
k. Shelves that are hard to reach.
l. Plants that are in the way.
m. Outlets that aren't close enough.
n. Sinks that are messy.
o. Writable boards that are too small.

22. How effective are the following features in helping you stay engaged in learning? *(4-scale Likert)*
Very Effective – Effective – Ineffective – Very Ineffective

a. Writable surfaces for brainstorming.
b. Furniture that can be rearranged for different tasks.
c. Outdoor spaces I can easily access.
d. Organized materials for the required task.
e. Dedicated group workspaces or furniture.

23. How often do you choose to use outdoor or natural spaces to learn? *(choose one)*

a. Daily
b. A few times a week
c. Weekly
d. Occasionally
e. Never

24. How can a classroom help you connect with others in a positive way? Below are several statements about ideal room qualities. Please rank them in your order of importance.
1 = MOST important 13 = LEAST important.

1. It's easy to hear, so I can listen to others and join discussions.
2. I can easily enter or leave the room without interrupting others.
3. The colors in the room make it feel soft and warm.
4. I can leave the room to work with someone in a quieter space.
5. The lighting can be adjusted to create a comfortable atmosphere for group work.
6. It's easy to clean up and reset the room after working with a group.
7. The furniture can be moved so groups or partners can be together.
8. I can see outside, which helps me feel calmer in group settings.
9. The room is organized in a way that helps us work together and find what we need.
10. The tools and materials we need are easy to find and share.
11. Our group can move around and work without feeling crowded.
12. I can see into the hallway and wave or talk to friends passing by.
13. There are different areas in the room for smaller groups or larger groups to work.

25. Here is a list of objects and features in your classroom that could help you feel connected to your peers. When you are trying to build relationships with others, which ones have the greatest POSITIVE impact on you? *Choose up to three (3) that have the greatest POSITIVE impact on you.*

a. Displays for showing items.
b. Special tools for group projects.
c. Laptops or devices for collaboration.
d. Bulletin boards to share ideas.
e. Large surfaces for group work.
f. Screens for presentations.
g. Doors for creating quiet or connecting spaces.
h. Flexible desks or chairs for group work.
i. Windows to see other spaces.
j. Wi-Fi for research and collaboration.
k. Shelves to organize materials.
l. Plants to make the space inviting.
m. Outlets to power devices.
n. Sinks for shared activities.
o. Writable boards for planning.

26. Which objects and features in your classroom make it harder to build relationships? *Choose up to three (3) that have the greatest NEGATIVE impact.*

a. Displays that are hard to use.
b. Special tools that aren't available.
c. Laptops or devices that don't work well.
d. Bulletin boards that are cluttered.
e. Surfaces that are too small.
f. Screens that are hard to see.
g. Doors that let in distractions.
h. Desks or chairs that are hard to move.
i. Windows that are distracting.
j. Wi-Fi that is slow.
k. Shelves that are messy.
l. Plants that get in the way.
m. Outlets that are too far.
n. Sinks that are hard to use.
o. Writable boards that are too small.

SECTION 04: CLOSE

27. Which of the following are MOST important to help you make friends with other students? *(choose up to two (2))*

a. Furniture that encourages group work during class
b. Spots where I can see students working in other areas
c. Quiet areas for one-on-one conversations OUTSIDE of class
d. Quiet areas for one-on-one conversations INSIDE of class
e. Informal spaces for relaxing and connecting outside of class
f. Displays where I can see work my classmates created
g. A quiet room where we can work together

28. How effective are the following features to help you connect with teachers? *(4-scale Likert)*
Very Effective – Effective – Ineffective – Very Ineffective

a. Open spaces to casually talk to a teacher.
b. Quiet spots for private talks with a teacher.
c. Windows or clear walls help me see a teacher.
d. Writable surfaces help me share ideas with a teacher
e. Movable desks make it easier for a teacher to sit next to me if I need help.
f. A quiet room helps me hear and talk to a teacher.

29. Imagine a classroom where you take the lead in your learning—setting goals, choosing what to work on, and exploring things that matter to you while working with your teacher. What would the space need to look like to help you learn this way? *(open)*

30. If you could add one thing to your classroom or school today to make it more relevant to what you care about, what would it be? *(open)*

EDUCATOR EXPERIENCES

UNCOVER RELATIONSHIPS BETWEEN SPACE SIGNALS

Welcome to the Understanding Spaces to Learn Survey!

We want to hear from you about how the spaces in a school affect learning. **Physical spaces**, like classrooms, hallways, and common areas, **send signals that can shape how people respond and behave** in them. Learners and educators look for different, critical, signals. **For educators, spaces must be responsive, intuitive, and facilitate safety.**

This survey will help us learn how school spaces may impact your experience of a learner-centered environment. Your **feedback will guide us in designing spaces** that better support learning and teaching for everyone.

Thank you for sharing your thoughts!

SECTION 01: GENERAL DEMOGRAPHIC INFORMATION

1. Are you a: *(choose one)*

a. Learner
b. Educator
c. Administrator

2. How do you describe your gender? *(choose one)*

a. Woman
b. Man
c. Non-binary
d. Prefer not to say
e. Other: (please specify)

3. How do you describe your ethnic background? *(choose one)*

a. African or African American
b. Asian or Asian American
c. Hispanic or Latino/Latina/Latinx
d. Native American, First Nations, or Indigenous
e. Pacific Islander or Native Hawaiian
f. White or Caucasian
g. Multiracial or Mixed Heritage
h. Prefer not to say
i. Other: (please specify)

SECTION 02: UNDERSTANDING OF A TEACHER'S ROLE OR EXPERIENCE IN A LEARNER-CENTERED ENVIRONMENT

4. Do you enjoy teaching? *(choose one)*

a. Yes, I like it a lot
b. It's okay
c. Not really
d. I don't like it at all

5. How many years have you been teaching? *(choose one)*

a. Less than a year
b. 1-2 years
c. 3-6 years
d. 7-14 years
e. More than 15 years

6. What grade level do you primarily teach this year? *(choose one)*

a. 5th
b. 6th
c. 7th
d. 8th
e. 9th
f. 10th
g. 11th
h. 12th

7. What subject(s) are you actively teaching this year?
(choose all that apply)

a. English / Language Arts
b. Math
c. Social Studies
d. Science
e. Learning Support (Special Education)
f. Physical Education
g. Visual and Performing Arts
h. Exploratory / Future Skills Class
i. Other:

8. What's your favorite thing about your teaching space?
(choose one)

a. It's comfortable for teaching.
b. It's inspiring for students.
c. It allows for focused work when needed.
d. It supports collaboration with students or colleagues.
e. It's equipped with useful tools or technology.

9. How would you define a learner-centered environment? *(open)*

10. What do you believe is your primary role as an educator in a learner-centered environment? *(choose up to two (2))*

a. Facilitating and guiding student learning.
b. Providing direct instruction and knowledge.
c. Creating opportunities for collaboration and problem-solving.
d. Supporting students in setting their own goals and pathways.
e. Ensuring students follow structured learning plans.
f. Other: (please specify)

11. How often do you provide students with choices in their learning process? *(choose one)*

a. Daily
b. A few times a week
c. Occasionally
d. Rarely
e. Never

12. How much do you agree with the following statements about your role? *(4-scale Likert)*
Completely Agree – Agree – Disagree– Completely Disagree

a. My role is to guide students toward their own learning goals.
b. My role is to ensure students meet specific learning objectives I set.
c. I provide clear structure and direction to help students stay on task.
d. I encourage students to take responsibility for their learning.
e. I adjust my teaching strategies to meet the needs of individual students.
f. My role is to deliver knowledge and ensure content is understood.
g. I help students collaborate and learn from one another.
h. I focus on balancing teacher-led and student-led activities in my classroom.

13. How do you balance teacher-led instruction with student-led learning in your classroom? *(choose one)*

a. Mostly teacher-led instruction
b. A mix, but more teacher-led
c. A mix, with equal emphasis
d. A mix, but more student-led
e. Mostly student-led learning

SECTION 03: PERCEPTION OF SPACE SIGNALS ON CRITICAL INDICATORS

14. Think about what makes a classroom respond to what you and your students need in the moment. Below are several statements about ideal room qualities. Please rank them in your order of importance.
1= MOST important 13 = LEAST important

1. It's easy for students to hear instructions and for me to manage classroom discussions.
2. Students can enter or leave the room smoothly without causing disruptions.
3. The colors in the room create a productive atmosphere for learning.
4. There's flexibility for students to step out of the room to work in alternative spaces.
5. The lighting can be adjusted to suit different activities or moods, like focused work or presentations.
6. The space is easy to clean and reset after hands-on activities or projects.
7. The furniture is moveable, so I can quickly adapt the layout for group work, individual tasks, or discussions.
8. Windows provide views nature that support mental health.
9. The room's organization supports smooth transitions between activities and helps students find what they need independently.
10. Tools and materials are accessible and visible, so students can use them without frequent reminders or interruptions.
11. During active lessons students can move around safely without crowding.
12. I can see into the hallway to monitor nearby activities or identify when students return to the room.
13. There are defined areas for different learning modes, like quiet reading, collaborative group work, or creative projects.

15. Below is a list of objects and features in a typical classroom. Which would help you create a physical space that is responsive to current teaching goals? *Choose up to three (3) that have the greatest POSITIVE impact..*

a. Displays for showing physical items
b. Special tools for different activities/projects
c. Laptops/devices for independent student use.
d. Bulletin boards
e. Large, flat surfaces
f. Large, digital screens
g. Doors for managing noise or transitions
h. Mobile desks/chairs
i. Windows to connect outside
j. Wi-Fi for online tools
k. Open shelves and bins
l. Plants
m. Power outlets
n. Sinks
o. Writable boards
p. Plants to create a calm space.

16. Which objects and features make it harder to meet current teaching goals? *Choose up to three (3) that have the greatest NEGATIVE impact.*

a. Displays that are hard to use
b. Lack of special tools
c. Broken student laptops/devices
d. Small or poorly placed bulletin boards
e. Surfaces that are small or unlevel
f. Screens that are hard to see
g. Doors that don't manage noise.
h. Heavy or fixed desks/chairs
i. Windows that are distracting
j. Unreliable Wi-Fi
k. Open shelves and bins
l. Plants
m. Inaccessible/ broken power outlets
n. Lack of sinks
o. Small or poorly placed writable boards

17. In a responsive learning setting, how frequently would you rearrange the furniture? *(choose one)*

a. Multiple times in a class
b. Daily
c. Weekly
d. Monthly
e. Rarely
f. Never

18. How available should resources be in a responsive teaching space for BOTH you and your students? *(choose one)*

a. Always easy for students and teachers to access.
b. Accessible for teachers but harder for students to access independently.
c. Accessible for students but harder for teachers to organize and manage.
d. Access to resources needs to depend on the task or activity.
e. Resources are better stored in another space.

19. What makes a classroom EASY TO USE for both you, and your students? Below are several statements about ideal room qualities. Please rank them in your order of importance.
(1= MOST important 13 = LEAST important)

a. It's easy for everyone to hear clearly during lessons and discussions.
b. Students can enter or leave the room smoothly, without needing extra instructions.
c. The room's colors support a productive learning atmosphere.
d. There are clear, simple options for students to step out and work in alternative spaces.
e. The lighting is straightforward to adjust for different activities, like group work or presentations.
f. The room is designed for easy cleanup and reset after projects or activities.
g. Furniture can be moved and rearranged quickly without needing extra effort or special tools.
h. Windows can be opened or closed without special tools or permissions.
i. The organization of the room makes it obvious where to find materials and tools without explanations.
j. Tools and resources are visible and accessible so students can use them independently.
k. Students can move freely within the room without needing constant adjustments to furniture.
l. I can stay engaged with the class and easily monitor what's happening in the hallway.
m. Different areas in the room naturally guide students toward quiet work, collaboration, or creativity.

20. Here is a list of objects and features in a typical classroom. Which are the easiest for you to use and help create a space that works smoothly for you and your students? *Choose up to three (3) that have the greatest POSITIVE impact.*

a. Displays for showing items.
b. Special tools for flexible activities.
c. Laptops/devices that are simple to use.
d. Bulletin boards that are easy to update.
e. Large surfaces for tasks.
f. Screens that are simple to operate.
g. Doors that work well for managing spaces.
h. Flexible desks/chairs that are easy to move.
i. Windows that connect to other spaces.
j. Wi-Fi that works reliably.
k. Shelves that keep materials organized.
l. Plants that enhance the space without effort.
m. Outlets that are convenient to use.
n. Sinks that are accessible and easy to clean.
o. Writable boards that are clear and simple to use.

21. Which objects and features make it difficult to create a space that works smoothly for you and your students? *Choose up to three (3) that have the greatest NEGATIVE impact.*

a. Displays that are hard to set up or use.
b. Special tools that are complicated or inaccessible.
c. Laptops/devices that don't work well or are confusing.
d. Bulletin boards that are hard to update.
e. Surfaces that are too small or awkward to use.
f. Screens that are complicated to operate.
g. Doors that don't function smoothly.
h. Desks/chairs that are heavy or hard to move.
i. Windows that are distracting or not useful.
j. Wi-Fi that is unreliable.
k. Shelves that are hard to reach.
l. Plants that require too much care or take up space.
m. Outlets that are hard to reach.
n. Sinks that are difficult to use or clean.
o. Writable boards that are too small or cluttered.

22. Rate the effectiveness of the following features in an intuitive learning setting. *(4-scale Likert)*
Very Effective – Effective – Ineffective – Very Ineffective

a. A fixed, primary display (like a mounted screen)
b. A movable, primary display (like screen on wheel or projector that can face different directions)
c. The display is easy for all students to see and use.
d. Tools for using the display (like cables or wireless systems) are reliable.

23. Prioritize the following features for an intuitive classroom. Please rank them in your order of priority.
1= HIGHEST priority 6 = LOWEST priority

1. Wide aisles between furniture for smooth movement.
2. Defined zones for specific activities.
3. Movable furniture for flexible layouts.
4. Clutter-free and organized open areas.
5. Direct pathways to key areas like exits or displays.
6. Visual cues to help guide movement and organization.

24. Below are several statements about ideal room qualities as they relate to safety. Consider how they help you prevent accidents or manage problems within the classroom. Please rank them in your order of importance.
1= MOST important 13 = LEAST important

a. It's easy for everyone to hear clearly, ensuring instructions and alerts are understood right away.
b. Students can enter and leave the room without crowding or confusion, making transitions smooth.
c. The room's colors create a calming environment that reduces stress and conflict.
d. There are spaces where students can go to step away or refocus in a supervised way.
e. The lighting is even and adjustable to prevent glare or dim areas.
f. The room is easy to clean and maintain, reducing clutter or messes.
g. The furniture is sturdy, easy to move, and can be arranged in a way that prevents tripping or tipping.
h. Windows provide natural light and views while maintaining privacy and physical security.
i. The room is organized so pathways are clear and students can navigate easily without obstacles.
j. Tools and materials are stored securely and accessed safely to prevent misuse or accidents.
k. Students can move around comfortably without bumping into each other or the furniture.
l. I can see into the hallway easily to monitor nearby activity.
m. Different areas in the room are set up to support calm, focused activities without creating conflict or distractions.

25. Which objects and features in your classroom help create a safe environment for you and your students? *Choose up to three (3) that have the greatest POSITIVE impact.*

a. Displays that hold items securely.
b. Special tools that are managed.
c. Laptops/devices that have controls.
d. Bulletin boards that are stable.
e. Surfaces that are sturdy.
f. Screens that are well-positioned.
g. Doors that control noise and access.
h. Desks/chairs that are stable and easy to move.
i. Windows that provide visibility.
j. Wi-Fi that is reliable.
k. Shelves that are organized and accessible.
l. Plants that are hazard-free.
m. Outlets that are accessible.
n. Sinks that well located.
o. Writable boards that are securely mounted.

26. Which objects and features in your classroom make it harder to create a safe and secure environment for you and your students? *Choose up to three that have the greatest negative impact.*

a. Displays that are unstable.
b. Special tools that are hard to manage.
c. Laptops/devices that are unreliable.
d. Bulletin boards that are cluttered.
e. Surfaces that are unsteady.
f. Screens that are poorly placed.
g. Doors that don't reduce noise.
h. Desks/chairs that are unstable or heavy.
i. Windows that are distracting.
j. Wi-Fi that is unreliable.
k. Shelves that are messy or unsafe.
l. Plants that get in the way.
m. Outlets that are inaccessible.
n. Sinks that are messy.
o. Writable boards that are too small or loose.

SECTION 04: CLOSE

27. When balancing monitoring students and maintaining a sense of safety, how important is a clear window between the room and shared space or hallway? *(choose one)*

a. Very important; I would always keep the windows uncovered to monitor and connect with students in shared spaces.
b. Important; I would keep the windows uncovered most of the time but might cover them occasionally for privacy.
c. Somewhat important; I would use transparency only in specific situations and prefer to cover the windows otherwise.
d. Not important; I would cover the windows to maintain classroom privacy and security but will still send students into the shared space.
e. Not important; I prefer no windows to maintain classroom privacy and security and do not plan to send students into the shared space.

28. What type of space would you provide for a student who needs a break to de-escalate?

a. A quiet, private area within the classroom.
b. A separate room or space outside the classroom.
c. An area that can be used for breaks and other needs.
d. An outdoor space.
e. I prefer not to provide a separate break space.

29. Consider how a primary learning setting (classroom or lab) interacts with an adjacent informal learning space (hallways, shared learning, outdoor space, commons, library, small group rooms, etc.) to foster a learner-centered environment. Rate your level of agreement. *(4-scale likert)*
Completely Agree – Agree – Disagree– Completely Disagree

a. Students can move easily between the spaces.
b. Spaces that can be rearranged feel cluttered.
c. Walls in the classroom help students focus.
d. Seeing into spaces may make students uncomfortable.
e. Informal spaces that can only accommodate up to 6-8 people feel too small.
f. Different designs help meet student needs.
g. Transparency helps with supervision.
h. Spaces that can open to expand and close to control work well for changing needs
i. Too much variety can overwhelm students.
j. Moving between spaces disrupts focus.
k. Informal spaces that can only accommodate 1-2 people are important to provide.
l. Walls in the classroom feel isolating.

30. Imagine a learning environment where students take the lead in their own learning, setting goals, choosing pathways, and pursuing meaningful interests, while working corroboratively with educators. What would the physical space look like to support this approach? *(open)*

31. If you could add one thing to your classroom or school to make it more learner-centered, what would it be? *(open)*

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This bibliography reflects the research, theory, and practice that informed our thinking. These sources span education, design, cognitive science, and more — each contributing to how we understand people, practice, and place.

Rather than an exhaustive list, this is a curated collection that supported the development of ideas and insights throughout the paper. It's about grounding, not just citing.

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