I N C L U S I V E

A Human Centered Approach to Accessible Architectural Design

by
Jenny Liu

Submitted to the Department of Architecture
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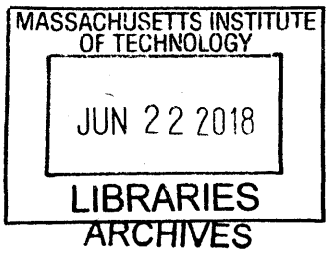

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Abstract

Architecture is about creating spaces for people to live their best lives, yet architecture can be disconnected from the people most directly impacted by its work. According to a survey in 2015, only 2.6% of non-architects feel that the profession does an excellent job of understanding the needs and desires of those living and working in our buildings. As such, occupants suffer spaces that are uncomfortable and sometimes unusable; in particular, people with disabilities are often restricted to certain spaces because most places are designed without any consideration of their needs..

Universal design, a new concept in architecture, asks how can we design in a way that makes life easier, healthier, and friendlier for all by putting people with disabilities on an equal playing field with other types of users. Universal design draws from accessibility standards and design principles to create environments that can be used by as many as possible without specialized design accommodations. Integrating accessibility and universal design principles in architecture could enrich our understanding of a space and add a new layer of spatial experience for everyone.

The purpose of this thesis is to investigate what makes spaces inclusive and usable for those with disabilities, how we can design for a broader population, and whether we should embrace universal design ideas. This thesis will use a review of the history and current practices of universal and accessible design and precedent studies to inform a design process focused on understanding the users and their experiences in order to maximize usability. Then, this thesis will apply this knowledge by assessing the MIT Stratton Student Center and the Ray and Maria Stata Center using observations and surveys to find the gap between their designs and universal design principles. This analysis will provide findings and recommendations of how universal design can be better incorporated in public spaces on MIT's campus.

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and my mom and brother, for the support from far away.

Contents

prologue

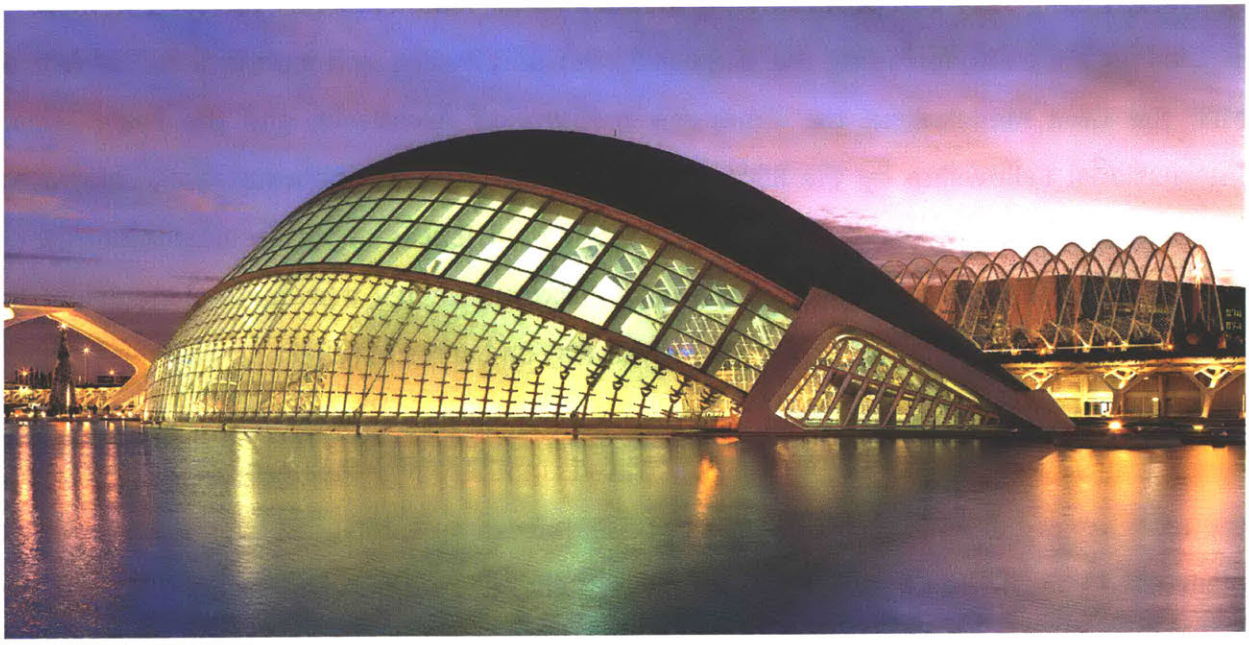
The Disconnected Architect

"Architectural discourse has gradually become incoherent with the social and ethical needs of the contemporary city."

— Sophia Bannert

To admirers, **Santiago Calatrava** creates delicate yet powerful sculptural buildings, and his devotion to form is masterful. He often conceives his buildings first as sculptures, thinking "of sculpture as a pure plastic art while architecture is a plastic art which is submitted to function, taking into consideration the human scale." Calatrava has received numerous awards for his work, including the Eugene McDermott Award by the Council for the Arts of MIT, the Gold Medal from the American Institute of Architects, and the Fazlur Khan International Fellowship by the SOM Foundation. In Valencia, Spain however, Calatrava's works became controversial. The City of Arts and Sciences — an entertainment-based cultural and architectural complex including a performance hall, a bridge, a planetarium, an opera house, a science museum, a covered walkway and acres of reflecting pools — has cost three times its original budget of 300 million euros and over 10 years of construction. The complex has garnered complaints that Calatrava is indifferent to the needs of his clients and the usability of his buildings. The opera house, for example, includes over 150 seats with obstructed views. The science museum was initially built without fire escapes or elevators for the disabled. And this disregard for the inhabitant experience has appeared over and over again in Calatrava's work.

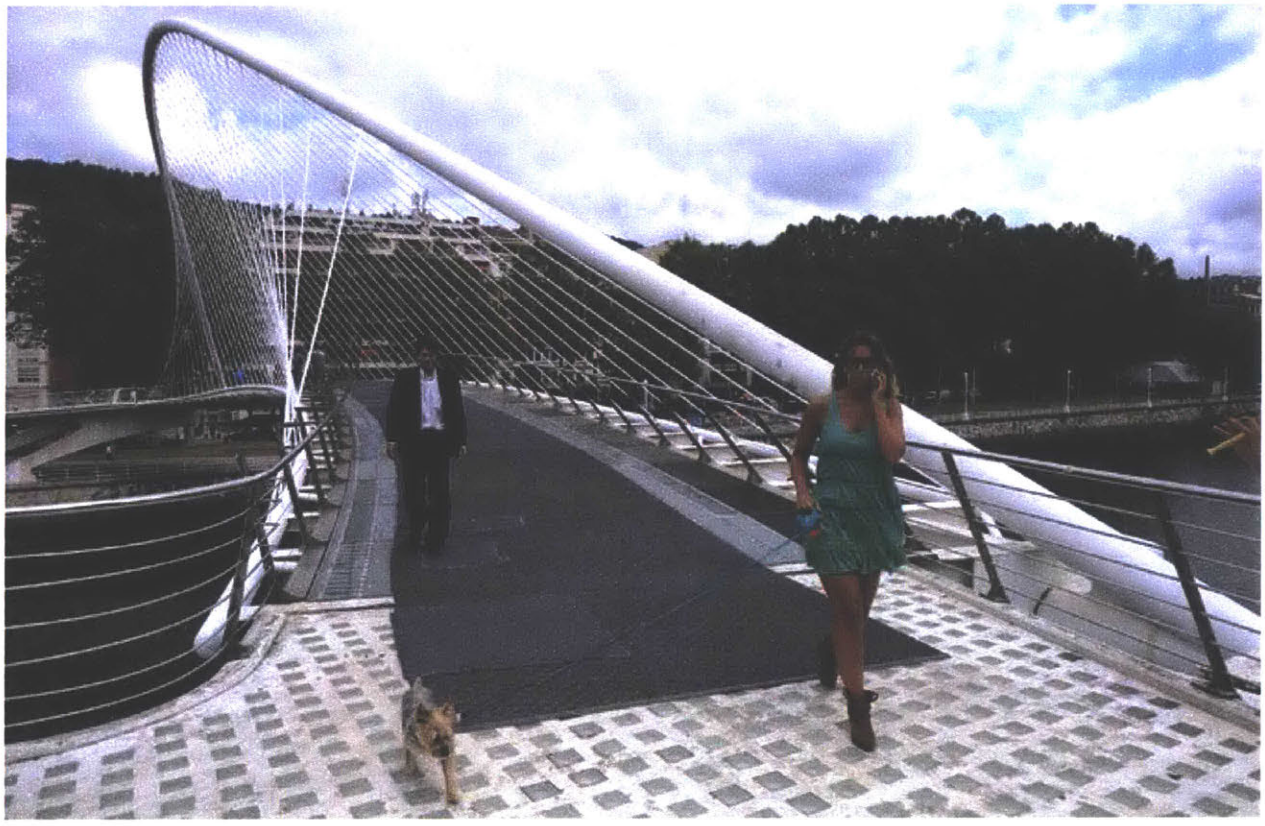
Workers fix leaking windows in the science museum



City of Arts and Sciences L'Hemisfèric (Cinema, planteterium, laserium)

In Bilbao, Calatrava designed Zubizuri, a footbridge with a glass tile surface to be lighted from below, freeing the space of lampposts. But in a city with a lot of rain and snow, pedestrians kept falling on the slippery surface. Over 50 citizens have injured themselves, sometimes breaking legs or hips, on the bridge since it opened in 1997, and the glass bricks frequently crack and need to be replaced. In 2011, the city resorted to laying a huge black rubber carpet across the bridge.

"What you see over and over again is that rather than searching for functionality or customer satisfaction, he aims for singularity," says Jesús Cañada Merino, the president of Bilbao's architects' association. "The problem is that Calatrava is above and beyond the client.



Zubizuri Footbridge, Bilbao

Architecture should be about creating spaces for people to live their best lives, yet it is often disconnected from the people most directly impacted by its work. Students are trained in school using highly theoretical projects, rarely interacting with real people or communities. In addition, the profession praises those who focus on the innovative aesthetics of buildings, rather than their societal impact and usability. Calatrava's buildings offer an extreme, but important, version of how architecture sometimes ignores not only the user, but also the realistic conditions of public spaces, such as weather. By treating architecture as art not to be disturbed by practicality, the architect fails to provide the public with accessible architecture and has perhaps created art, rather than architecture.

Meanwhile, non-architects are sometimes intimidated by architects, afraid to speak out and be labeled as ignorant of "good design" and "professional excellence". However, only 2.6% of non-architects feel that the profession does an excellent job of understanding the needs and desires of present and potential building occupants, indicating that there may be a serious disconnect between designer and user (Outram, 2015). Whether people feel comfortable in the building, if they can find the entrance and exit, and how the building compares with its surroundings, are all issues that architects should consider. By questioning and understanding the human experience of built space from the user's perspective, architects can develop their empathetic design sensibilities and a more human centered way of thinking.

This thesis asks the question: what makes spaces inclusive and usable for those with disabilities? First, a study of sensory design in architecture and a review of the history and current practices of universal and accessible design will inform a design process focused on understanding the users and their experiences in order to maximize usability. The three steps of this design process are followed to understand the senses, open a dialogue, and assess the space.

1. **Understand the senses:** When designing for accessibility, the designer must first thoroughly understand how each of the senses interacts with architecture.

2. **Open a dialogue:** The architect can never be fully knowledgeable about what their users want in a space, and how they will use it. By establishing communication between the designer and the user, the designer can learn about the users' needs in the built environment, leading to more a informed design.
3. **Assess the space:** After initial designs educated by open communication between the designer and the users, the space can then be evaluated and adapted. Since no design is ever fully finished, universal design is an ongoing and iterative process.

This process notes that trade-offs are inevitable in design and that some choices will require changes or elimination of other elements that could enhance the user experience. Then, several precedents focused on those with disabilities will illustrate how architects currently approach accessible design. The final section of this thesis will assess the MIT Stratton Student Center and the Ray and Maria Stata Center, using this process with both my own experience and those with disabilities on campus. This assessment will highlight how we can better incorporate universal design, concluding this thesis with next steps.

one

Literature

Understand the Senses

"We can better plan, design, and manage the environment for and with people if we know how they image the world."

— Kevin Lynch

In everyday life we experience physical objects and spaces around us, including our own bodies, through our senses. Our body can be separated between the physical body, or 'Körper', as the physical system of bones and organs, and the living body, 'Leib', as we use it in everyday life. Our engagement with our environment comes not only from the physical encounter, but our spatiotemporal relations with the world (Husserl, 1962). Multisensorial architecture has the ability to facilitate a sense of integration and belonging, adding meaningful layers to one's spatiotemporal experience of architecture.

Sight is a multi-layered experience, conveying meaning and inspiring awe through form, color, light, and movement. Often described as "visual poetry", architectural designs create an interplay with the environment and its inhabitants. The sense of sight dominates modern architectural discourse, often to the detriment of our other senses in an authentic architectural experience. (Pallasmaa, 2005) That is not, however, to diminish the importance of visual consideration in design. Our vision has a large influence on bodily rhythms — the amount of sunlight in a space signals to the body the time of day — as well as wayfinding — reading our surroundings can help us ground ourselves within an otherwise confusing space.

We **hear** sounds that surround and envelop our bodies, connecting us to the world around us. Sound waves, atoms that vibrate and move through air, communicate with our ears, influencing our experience of a space. Although often overlooked, proper acoustic design is vital for comfortable and beautiful spaces. The materials in a space can cause music to reverberate, conversation to echo, and noise to be unbearable.

Touch is a primal sense, bringing us closer to the spaces around us. The mutual exchange between the physical environment and body allows a relationship to develop between the two. The tactile experience allows us to understand and gain a deeper appreciation of the built environment. Tangible things, or 'real' things, can link us to the present and the past. Touch can also be a powerful tool when the other senses are unavailable, in navigation and mapping.

Smell has a unique way of connecting us to both the present and the past. The memories we carry of places, experiences, and people can be brought back by the smells that surround us. Our sense of smell is closely connected to the limbic system of the brain, where emotion is processed. As such, nostalgia plays a vital role in our individual perception of smell, making it an organic and uncontrolled sensory experience. Smells can not only affect our emotion, but subtly influence our thoughts and behavior.

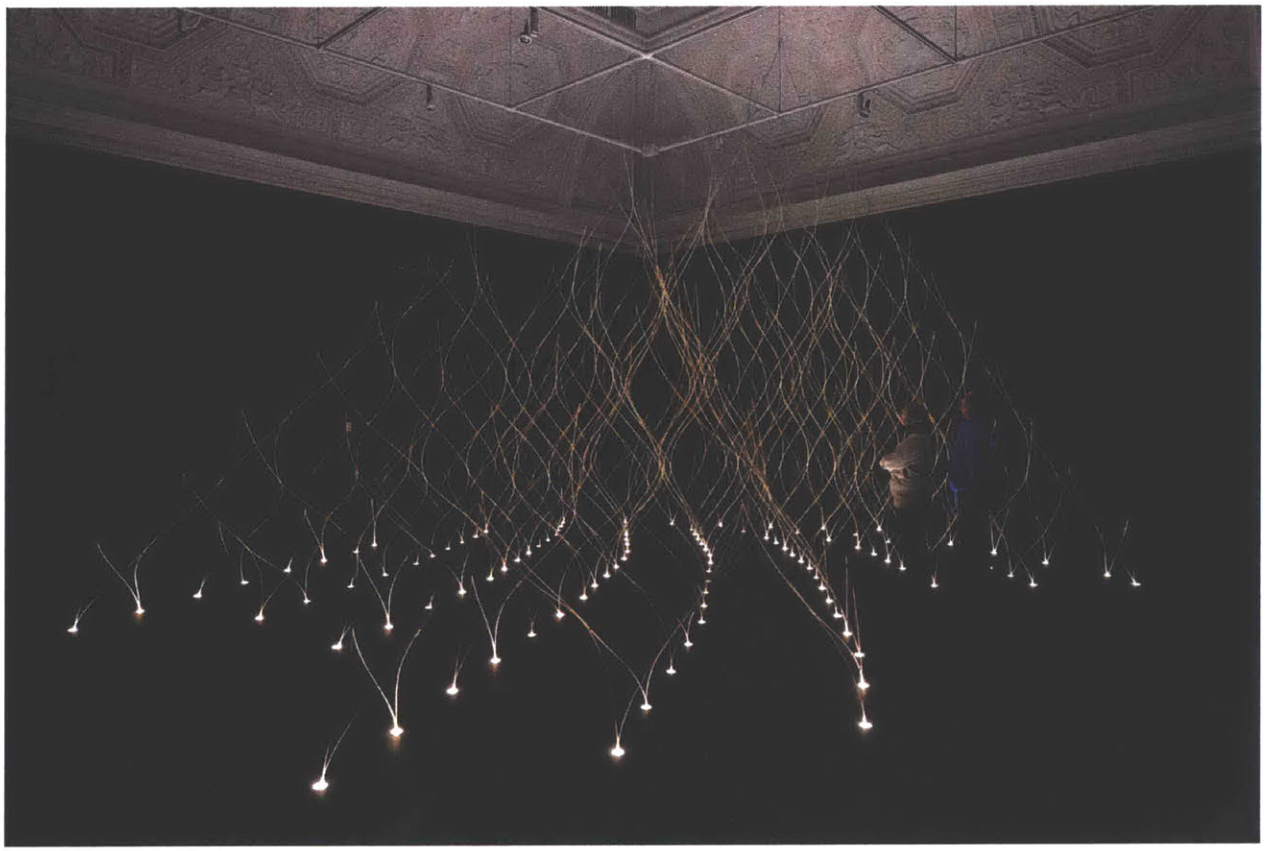
Taste, upon first thought, has little to do with architecture. Yet the experience of a building can translate to all our primal senses, including taste. "There is a subtle transference between tactile and taste experiences. Vision becomes transferred to taste as well; certain colours and delicate details evoke oral sensations. A delicately coloured polished stone surface is subliminally sensed by the tongue. Our sensory experience of the world originates in the interior sensation of the mouth, and the world tends to return to its oral origins. The most archaic origin of architectural space is in the cavity of the mouth." (Pallasmaa, 2005)

By creating architecture that interacts with each of our senses, we can create a more whole and well rounded experience, which is not reliant on solely the visual sense. This in turn helps to include everyone in a full architectural experience, regardless of ability. To further understand how architects approach sensory architecture, I looked at several design precedents focused on a sense other than sight.

Sensing Spaces: Architecture Reimagined

Sensing Spaces: Architecture Reimagined, an exhibition at the Royal Academy of Arts in 2014, was designed to reawaken our sensibilities to the spaces around us – bringing to the fore the functional and experiential qualities of architecture. Using the essential elements of architecture such as space, proportion, light and materials, overlaid with cultural context and visitor interaction, the exhibition challenges our perception of architectural elements.

Kengo Kuma created two installations for the exhibition, a pair of delicate structures made of Japanese bamboo. The bamboo was chosen because of its flexibility and ability to absorb and slowly release scent. The freestanding pavilion and cave structures evoke powerful memories for the architect and visitors, using Cyprus and tatami infused bamboo and sinuous, winding forms.



Sensing Spaces, Kengo Kuma

Li Xiaodong created a sequential experience of visiting the Academy, or a choreographed one way route with coppiced timber and acrylic floors. The route opens into a zen garden. The installation draws inspiration from traditional Chinese architecture such as the Forbidden City, which is laid out as a sequence of spaces rather than a collection of buildings. Li also draws on the Chinese philosophy of focusing on the intangible rather than the tangible in order to create a satisfying physical experience.

Sensing Spaces, Li Xiaodong

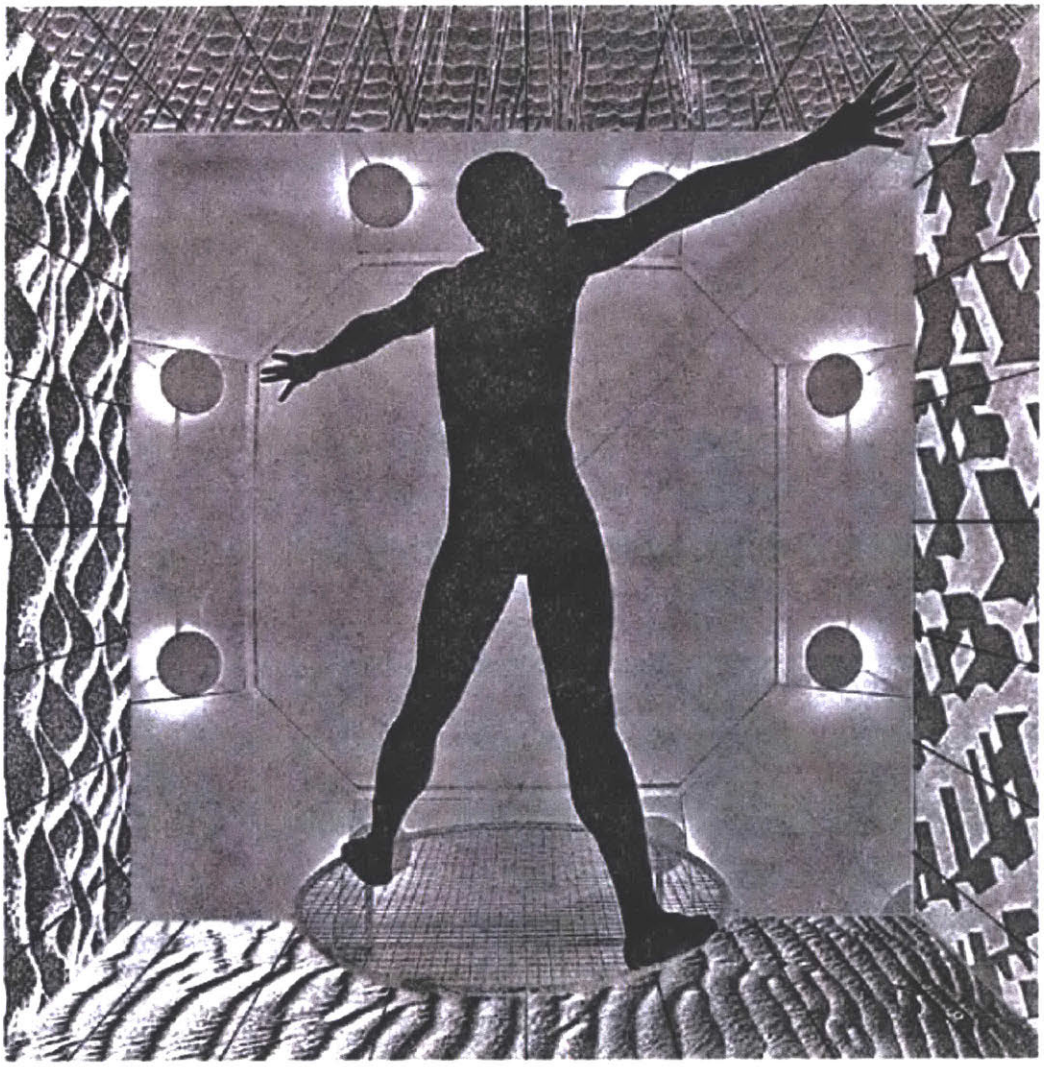
The Art of the Scent

The Art of the Scent is the first major museum exhibition to focus on smell. The 2013 exhibition at the Museum of Art and Design in New York, designed by Diller Scofidio + Renfro (DSR), celebrates the history of scent from 1889 to 2012 as an artistic medium. The 12 fragrances exhibited included famous scents such as Ernest Beaux's modernist Chanel No.5 and the Postmodern Drakkar Noir by Pierre Wargnye. The exhibition also challenged the reflexive emotional response to smell, and the difficulty in conveying a critical analysis of scent design. DSR used the term "immaterial architecture" to describe the ephemerality and atmospheric effect of their designs, emphasizing the ephemeral purity of scents.

The Art of the Scent, Diller Scofidio + Renfro

Glass House 2001

Glass House 2001, a conceptual project designed by Penezić and Rogina Architects, questioned the materiality of glass and the nature of non-visual architecture. The installation featured audio-tactile glass elements that could be regulated by water and air, designed for a blind person's experience. In engaging in dialogue with blind people and utilizing multisensory aspects of materials, Glass House sought to create an environment that is responsive to its surroundings and its users.



Glass House 2001, Penezic and Rogina Architects

one

Literature

Open a Dialogue

> "For where client and architect do not communicate freely and accurately, the architect cannot easily discover the real purpose of his building and his design must suffer."
>
> — Humphry Osmond

There are places — where we work, play, and live — that make us feel unhappy, unhealthy, or uninspired. Many public spaces in the contemporary world were built by architects who rarely take the time to understand how people unlike them experience their designs. How can these places be better designed with us in mind?

Because "architects did not merely disagree with laypersons about the aesthetic qualities of buildings, they were unable to predict how laypersons would assess buildings, even when they were explicitly asked to do so", establishing a dialogue between the two is necessary for good design. This disagreement in assessment between architects and laypersons can be attributed to cognitive differences in the two populations related to building preference.

A solution "is a broader form of architectural education or socialization that stresses both the creative extension of the great aesthetic trends and a better understanding of public taste." (Gifford, 2002) As such, the people who live in the places we build are invaluable ambassadors for design and should be included in architectural discourse. Creating an open dialogue between the architect and those being designed for is the first step towards creating an understanding of our needs and wants. Building upon this type of research can allow for empathetic and fulfilling designs that truly serve the needs of the ones using them.

Participatory Design

Participatory design is an approach to design that actively involves stakeholders and users in the design process to ensure the result meets their needs and is usable, by focusing on processes and procedures of design. The term is used in a variety of fields (e.g. software, graphic design, product development), as a way of creating environments that are more responsive and appropriate to their inhabitants' and users' cultural, emotional, and practical needs. Although participatory design is not yet seen as an integral step in the architectural design process, it allows for input from the inhabitants of a building, which can identify badly designed spaces early in the process. Several methods of participatory design exist, such as interviews and design workshops.

Placemaking

The MIT Department of Urban Studies and Planning explores the evolution of the urban planning and design of public places toward a process called "placemaking." Placemaking is a method to transform communities by creating and revitalizing open, public spaces around the needs and desires of the community. The research revealed that placemaking is relevant and powerful in enhancing quality of life and supporting collaborations that connect people and support local action. Susan Silberberg, lead researcher on the MIT team, explained, "Placemaking puts power back in the hands of the people. The most successful placemaking initiatives transcend the 'place' to forefront the 'making,' and the benefits for community can be substantial and long-lasting."

The relationship between places and communities is cyclical, mutually influencing and influenced by each other. Places grow out of the needs and actions of their communities, and in turn shape the way these communities behave and grow. This creates a cycle of placemaking that supports the creation of infrastructure necessary for healthy societies. Furthermore, the iterative and interactive process creates multiple opportunities for the engagement of community members.

Blindness/City: The Local Making of Multisensorial Public Spaces

Working with the Workgroup Accessibility in Leuven (a group of disabled people given a platform by the city), Patrick J. Devlieger explores the dialogue between blind people and their city, as well as how a city's public spaces can become more multisensorial. Devlieger facilitated dialogue between the able-bodied and the disabled and its many forms and interpretations, shaped by personal, social, and other factors.

One project consisted of a workshop between architecture students and the blind. The workshop focused on engaging in a dialogue to understand the spaces of the city from both perspectives in order to complete the task: the students were tasked with transforming a visual map of a city square into a tactile map using information gained from the blind people. The workshop led to an increased awareness on both sides about their challenges and experiences. In particular, the use of specific materials can create interesting spaces. Mindful dialogue and multisensorial knowledge can ultimately provide further possibilities for design.

Starbucks

With over 23,000 distinct coffee shops, Starbucks is one of the largest fast food corporations in the world. Everything in each store is planned and designed with strong influence from its customers and cultural context. To create so many stores that feel connected yet unique, Starbucks interviewed hundreds of coffee drinkers, seeking what it was that they wanted out of a coffee shop. The consensus had nothing to do with coffee.

Consumers actually sought a place of relaxation, a place of belonging (Bernson, 2015). This discovery informed every aspect of the coffee shop's design, from its cups to interior decorations. For example, Starbucks intentionally formed their own coffee lingo, using the terms "tall," "grande," and "venti" as the size options. Once their customers learned the lingo, other coffee houses, where you must choose from a small, medium, or large, would make them feel uncomfortable and out of place. Starbucks also incorporated round tables in their shops, to promote a sense of inclusion and belonging. In listening to their customers, Starbucks built a successful design based on an open dialogue.

Starbucks Coffeehouse

one

Literature

Assess the Space

"A design isn't finished until someone is using it."

— Brenda Laurel

How can we evaluate how well a space responds to its inhabitants' multisensory needs? It can be assessed in regard to the different senses, both quantitatively and qualitatively. This then helps designers to better iterate and understand the strengths and weaknesses of their designs, and ultimately fulfill the needs and goals of its inhabitants. Assessing the space both before and after its construction can be a valuable tool for designers to grow and improve.

The Understanding Architecture Surveys, an informal study conducted in 2015, used online questionnaires to gather data and thoughts from both professional architects and those who have worked with an architect. 1047 architects and 198 others responded to the survey. It found that 27% of architects who answered the survey have never performed a post-occupancy evaluation, and 40% perform them, but don't formally capture the findings. However, only 1.8% of architects who answered the survey said it wasn't relevant to the practice of architecture.

The disconnect between the perceived importance and the number of evaluations actually performed is indicative of an important issue in the profession and the design process. The top ways that architects understand user needs, according to the survey, are their own intuition/experience and one-on-one conversations. Therefore, interpersonal communication between the occupants and the architect can provide valuable insight, illuminate the needs and desires of the occupants, and inform future adaptations and designs to better serve its users.

Post Occupancy Evaluation

A post occupancy evaluation (POE) is a research method used to improve the ways that building can support productivity and wellbeing. Originating in Scotland and the United States in the 1960s, a POE can be defined as "the process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time" (Preiser, 1988). Specifically, the evaluation can account for building quality, inform designs for new buildings and alterations, and troubleshoot user problems.

Most involve feedback from the occupants using questionnaires, interviews, or focus groups. Environmental and sustainability monitoring, such as temperature, noise levels, lighting levels, indoor air quality, energy consumption, waste levels, and water usage, may also be used.

A Multisensory Evaluation of Space

Vienna's University of Applied Arts conducted a study to investigate the haptic and olfactory qualities of a typical Viennese café. Seven cafés, depicting the core characteristics of Vienna coffeehouses were selected and analyzed. The research focused on answering the following:

"How did the materials in Vienna cafés feel to the touch? How did the choice of material affect the atmosphere? What are the typical characteristics of a Viennese coffeehouse?

What is the olfactory impression of a Viennese café? How would one brand a Viennese coffeehouse?"

Café Ritter interior

Each café was examined for its atmosphere, olfactory impressions, visuals, acoustics, and provided with suggestions. For example, Café Ritter was described as such:

Atmosphere: Casual, time stands still for contemplation; café for everyone; people feel comfortable here; warm and soft lighting; Gemütlichkeit

Olfactory: Strong cigarette smell; food aroma

Haptic/visual: Real materials (wood, leather, stone); high, stucco ceilings; run down feeling

Suggestions: More pleasant if noise level were reduced, better lighting for reading

After studying the selected cafés, the researchers could not find one that perfectly fit the archetypal Viennese coffeehouse. However, several aspects of a Viennese coffeehouse were determined to be a tarnished look, sleepy, slow motion atmosphere, and similar sounds (murmur of people, reading, playing cards, talking). This qualitative method of sensory spatial evaluation can be useful in pinpointing the feel of a place and how well it serves its purpose. In addition, quantitative measures of sound, material tactility, and scent strength can add another layer to our understanding of how a space impacts its occupants. Using various methods of assessing the space after it has been built, we can gain insight into how a space responds to its users needs and actions in reality. This can then inform any adjustments to the space, as well as new designs in the future.

two

Design For All

"Universal design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design."

— Ron Mace

Architecture is thought of as a primarily visual practice; we care about the beauty of the space or place and how it looks or appears in contrast to the space it inhabits. Yet this approach often overlooks other senses and other user experiences. This can be clearly seen when we consider the experiences of people with disabilities who are often restricted to certain spaces within buildings, because their needs are not given consideration in design. If architecture is hyper focused on the visual experience of a building, places may be designed without adequate consideration to the needs of the elderly, the physically challenged, and/or non-sighted individual — people for whom other senses may be dominant . Specifically, the other senses — sound, touch, smell, taste — are relegated to coincidental occurrences rather than designed experiences.

The inherent multisensory qualities of a building, including its materials and layout, can both contribute to or detract from the building's impact and usability. Well-designed buildings are not just a matter of taste or aesthetics, but a space that understands and responds to its users and environment. Integrating accessibility in architectural design can enrich an architect's understanding of how a building may be used by many different types of users, adding a new layer of spatial experience for everyone. By dedicating more architectural practices to exploring multisensory user experiences, more diverse and universal forms of design can be created.

It is important to differentiate between accessible and universal design. Accessibility is a process in which those with disabilities are considered specifically. In contrast, universal design is a broader term that seeks to design for as broad a population as possible without specialized design. Both play a key role in more usable spaces for the disabled population.

Accessibility — History of Accessible Design in the United States

The first nationally recognized accessible design standard was the American National Standards Institute (ANSI) A117.1 Accessible and Usable Buildings and Facilities, released in 1961. This standard was based upon research done by the University of Illinois and funded by the Easter Seals Research Foundation. Since then, accessibility laws like the Architectural Barriers Act (1968) Section 504 of The Rehabilitation Act of 1973, the Fair Housing Act Amendments (1988), and the Americans with Disabilities Act (1990) have established minimum requirements that protect people with disabilities from discrimination in the built environment. The timeline below outlines the progress of accessible design standards in the United States.

1968 **Architectural Barriers Act**

Requires that facilities designed, constructed, altered, or leased with certain federal funds (e.g. U.S. post offices, national parks, federal office buildings,

U.S. courthouses, federal prisons, public schools, public housing, mass transit systems) be accessible to persons with disabilities.

1973 **Rehabilitation Act**

Prohibits discrimination on the basis of disability in programs conducted by federal agencies, in programs receiving federal financial assistance, in federal employment, and in the employment practices of federal contractors.

1988 **Fair Housing Amendments Act**

Requires adaptable features in certain covered multi-family dwellings with 4 or more units.

1990 **Americans with Disabilities Act**

Prohibits discrimination on the basis of disability and establishes design requirements for the construction or alteration of facilities required to be accessible. Covers facilities in the private sector (places of public accommodation and commercial facilities) and the public sector (state and local government facilities).

1991 **ADA Standards for Accessible Design**

Contains accessibility scoping and technical requirements implementing the Americans with Disabilities Act of 1990.

Due to the strict rules and regulations of accessibility in architecture, architects may focus on solely achieving the minimum standard as an afterthought, or something to be tacked on to their design. This approach fails to embrace the possibilities of universal design, because the needs of those with disabilities are not fully incorporated into the design process. Though the national accessibility requirements are a major step in reducing inequality in the built environment, architecture could be much more accessible than the minimum requirements of the law call for.

Universal Design

Universal design, or inclusive design, is "a process that enables and empowers a diverse population by improving human performance, health and wellness, and social participation" (Steinfeld and Maisel, 2012). In short, universal design is a design process that incorporates the needs of all users and strives to create designs that make life easier, healthier, and friendlier for all. Universal design is a relatively new concept that helps develop a better quality of life for a wide range of individuals and may be able to reduce the stigma of being disabled by putting people with disabilities on an equal playing field. For example, an architect might design the building to include only ramps that accomodate all users, rather than designing a separate ramp for the disabled. The goals and practices of universal design may also help people become more self-reliant and socially engaged.

Principles of Universal Design

The "Principles of Universal Design" were developed by the Center on Universal Design at NC State University in the 1990s. Accompanied by a set of guidelines for each principle, they were a valuable tool for clarifying universal design for early adopters, and are still widely used today. Here are the seven overarching guidelines:

1. **Equitable Use**

   The design is useful and marketable to people with diverse abilities. It provides the same means of use for all users, identical when possible and equivalent when not. It avoids segregating or stigmatizing users. The design is appealing to all users.

2. **Flexibility in Use**

   The design accommodates a wide range of individual preferences and abilities. It provides choice in the method of use, accommodates right or left handed access and use, facilitates the user's accuracy, and provides adaptability to the user's pace.

3. **Simple and Intuitive**

   Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level. It eliminates unnecessary complexity, and is consistent with user expectations and intuition.

4. **Perceptible Information**

   The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities. It uses different modes (pictorial, verbal, tactile) for redundant presentation of essential information, and maximizes "legibility" of essential information. It provides compatibility with a variety of techniques or devices used by people with sensory limitations.

5. **Tolerance for Error**

   The design minimizes hazards and the adverse consequences of accidental or unintended actions. It arranges elements to minimize errors, provides warnings when necessary, and provides fail safe features.

6. **Low Physical Effort**

   The design can be used efficiently and comfortably and with a minimum of fatigue. It allows user to maintain a neutral body position, minimizes repetitive actions and sustained physical effort.

7. **Size and Space for Approach and Use**

   Appropriate size and space is provided for approach, reach, and use, regardless of user's body size, posture, or mobility. It provides a clear line of sight to important elements for any seated or standing user and makes reaching to all components comfortable for any seated or standing user. It provides adequate space for the use of assistive devices or personal assistance.

Eight Goals of Universal Design

To update the seven guiding principles, the eight goals of universal design were recently developed to clarify the concept of universal design, incorporate human performance, health and wellness, and address contextual and cultural issues. In developing countries, universal design is often perceived as idealistic, expensive, or an imposition of Western values. Therefore it is important that universal design strategies also address cultural values associated with social, economic, and physical context. The eight goals are as follows:

1. **Body fit:** Accommodating a wide a range of body sizes and abilities
2. **Comfort:** Keeping demands within desirable limits of body function
3. **Awareness:** Ensuring that critical information for use is easily perceived

4. **Understanding:** Making methods of operation and use intuitive, clear, and unambiguous
5. **Wellness:** Contributing to health promotion, avoidance of disease, and prevention of injury
6. **Social integration:** Treating all groups with dignity and respect
7. **Personalization:** Incorporating opportunities for choice and the expression of individual preferences
8. **Cultural appropriateness:** Respecting and reinforcing cultural values and the social, economic and environmental context of any design project

Universal design can be incorporated into traditional design methodology using participatory methods. Though nothing can ever be fully usable by every person, the practice of creating architecture can benefit from universal design thinking.

three

Precedent Studies

"“Architecture can be empowering only if architects develop empathy.”"

— Raymond Lifchez

To understand how architects currently approach accessible design, I reviewed several projects focused specifically on those with disabilities. The projects I selected are the Hazelwood School in Glasgow, Scotland, Gallaudet University's Living and Learning Residence in Washington D.C., and Selis Manor in New York. These precedents represent one extreme of design, with aspects focused on the building's intended occupant and not the general population. However, many aspects of these designs are not only helpful for those with disabilities, but can be helpful for everyone. Each study looks at both the final design and the design process. Common in each example are the communication between the architect and client, as well as an understanding of a multisensory architectural experience.

Hazelwood School

Hazelwood School, located in Glasgow, Scotland, is a school for children who are blind and deaf, or dual sensory impaired. The architectural organization of the school presented a unique challenge, as many of the school's children are physically handicapped and all have a degree of cognitive impairment. Gordon Murray + Alan Dunlop Architects were tasked with the goal of designing a building that maximized safety and ease of spatial navigation for students. To understand the difficulties and specifics of their users, the architects held workshops, meetings, and seminars with client groups to inform the design.

The design, for example, avoids long dark corridors, maximized natural light, and incorporated visual, sound and tactile clues. The school has a winding plan to create strong internal circulation and blend indoors and outdoors. Since ease of navigation and orientation through the building was critical for the students, the concept of a trail rail that also doubles as storage was developed. The wall is clad in cork, which has warmth and haptic qualities and provides signifiers or messages along the route to confirm the children's location within the school. Classrooms lie along the northern quiet, edge of the site, overlooking play spaces.

Hazelwood School interior, Gordon Murray + Alan Dunlop Architects

The school steps and curves around the existing beech trees to create a sequence of safe, landscaped teaching gardens. Eight foot tall storage boxes create a solid wall that reduces external visual distraction, which is a significant cause of loss of concentration levels in some visually impaired students according to teachers. The intentionality behind the materials, form, circulation, and color provide a rich and meaningful experience for the students.

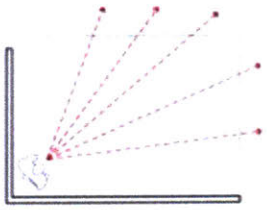
Hazelwood School demonstrates that although the architect may not be aware of their building occupants' experiences, participatory methods and collaborative design can

provide insight and contribute to a more informed design. The architectural elements used in Hazelwood for navigation, lighting, and multisensory features are key takeaways. Each element of the school was designed with the students in mind, ensuring a safe and productive learning environment. Since its completion, Hazelwood School has been labeled a success by its students and teachers.

Hazelwood School interior, Gordon Murray + Alan Dunlop Architects

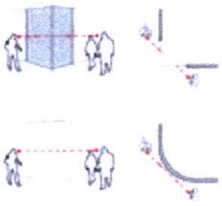
DeafSpace and Gallaudet University Living and Learning Residence

Established in 1864, Gallaudet University is the only liberal arts university in the world dedicated to the education of deaf and hard-of-hearing individuals. As such, one of Gallaudet's aims is to create a space tailored to deaf, cognitive, linguistic and cultural ways-of-being. In 2005, architect Hansel Bauman established the DeafSpace Project (DSP) in conjunction with the ASL Deaf Studies Department at Gallaudet University. Over the next five years, the DSP developed the DeafSpace Guidelines, over 150 DeafSpace architectural design elements that address the five major touch points between deaf experiences and the built environment: space and proximity, sensory reach, mobility and proximity, light and color, and acoustics. Interwoven are the ideas of community building, visual language, the promotion of personal safety, and well-being. The purpose of this project was to celebrate deaf and hard of hearing culture, as well as develop a unique design language aimed towards the deaf population. Many of the principles of DeafSpace overlap and complement universal design, and can be extended to benefit the general population.



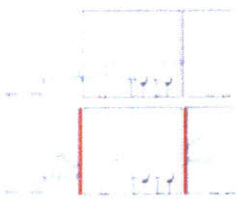
Sensory Reach: Deaf people "read" the activities in their surroundings using visual and tactile cues such as the movement of shadows, vibrations, and subtle shifts in the expression/position of others. Many aspects of the built environment can be designed to facilitate spatial awareness, orientation and wayfinding.

Space and Proximity: Deaf individuals stand at a distance where they can see facial expression and full dimension of the signer's "signing space." This basic dimension of the space between people impacts the basic layout of furnishings and building spaces.



Mobility and Proximity: While walking together in conversation, signers will tend to maintain a wide distance for clear visual communication. The proper design of circulation and gathering spaces enable signers to move through space uninterrupted.

Light and Color: Poor lighting conditions such as glare, shadow patterns, backlighting interrupt visual communication and can cause eye fatigue. Proper lighting and architectural elements used to control daylight should provide soft, diffuse lighting. Color should also be used to contrast skin tone to highlight sign language and promote wayfinding.



Acoustics: Many deaf individuals use hearing aids or cochlear implants to enhance sound. Reverberation caused by sound waves reflected by hard building surfaces can be distracting or even be painful for individuals using assistive devices. Spaces should be designed to reduce reverberation and sources of background noise using absorptive materials and careful acoustic design.

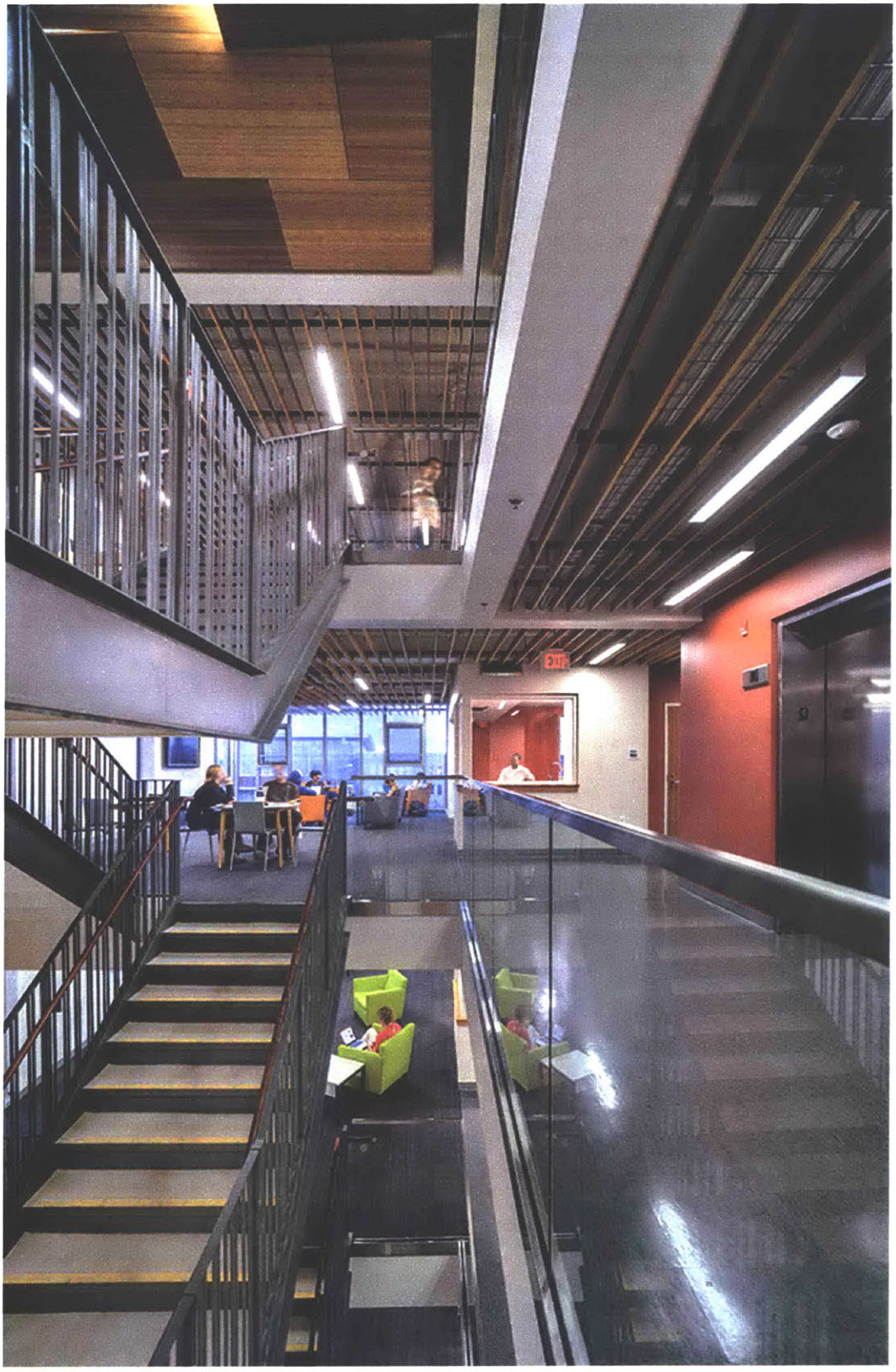
Living and Learning Residence Hall interior, Gallaudet University

Designed by LTL Architects, Quinn Evans Architects, and Sigal Construction in 2012, the Living and Learning Residence Hall (LLRH6) is a residential and educational center at Gallaudet University. "At its heart, LLRH6 expresses the unique deaf ways of being. The building was designed to facilitate both planned and spontaneous forms of communication. We created the environment in a way that fosters interaction and self-expression," said Hansel Bauman. LLRH6 was designed using an "Integrated Design/Build" process — a process that brings together architects, builders, and university stakeholders much sooner and more collaboratively than a traditional design method. Between August and October 2010, a group of more than 30 Gallaudet students, faculty, and staff met periodically with the architects to collaborate on various design options for the new residence hall and incorporate the principles of DeafSpace.

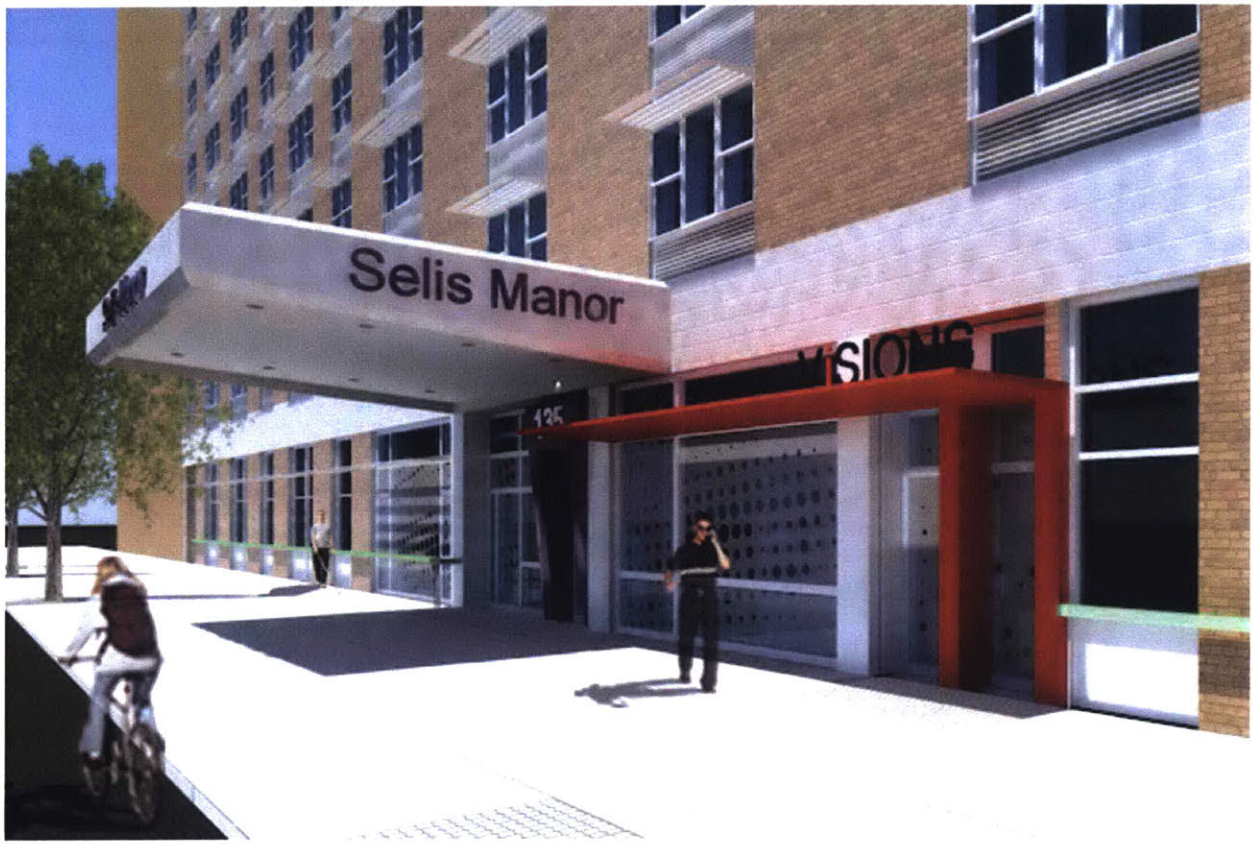
The design weaves together the Victorian Gothic styles of the historic areas of campus and the more modern styles that surround the site. Wood is used throughout the project to

create a warm, home-like feel. Gallaudet chose to change the current separation between the residential and academic components of the campus by expanding the program to include public gathering spaces and in locating the hall directly on the center of campus known as the mall. The building is comprised of four floors, accommodating 173 residents, four faculty and one graduate advisor. Large gathering spaces and academic spaces are located on the ground floor facing toward the mall. The main social space is a terraced room that steps down with the site to provide multiple small group study areas or a single room with good sightlines for a large gathering for movie night or lectures. The room is welcoming with built-in wood seating and a high ceiling and an expanse of windows that allow clear visual connection to the main campus mall. In addition, the ground floor houses classrooms, offices, and a collaboration studio.

Gallaudet University, in creating DeafSpace, has developed a unique design language focused on the deaf and hard of hearing experience. Although these design principles are tailored to the deaf population, many of them can be extended to benefit the general population. Because the elements of DeafSpace increase usability for not only the deaf population, they can be considered elements of universal design. For example, diffuse natural lighting, gently sloped ramps, and increased spatial visibility are welcomed regardless of the user's ability. We can see many of these principles exemplified on Gallaudet's campus.



Living and Learning Residence Hall interior, Gallaudet University



Selis Manor

Selis Manor is the first government-funded residence for the vision-impaired and disabled in New York City, opened in 1980. In 2014, its first building upgrades were designed by Magnusson Architecture and Planning, with consult from Chris Downey. Chris Downey, AIA, is an architect, planner and consultant who lost all sight in 2008. He draws upon his experience as an architect to help design teams create enriching environments for both the visually impaired and the sighte. By better integrating of critical tools for the blind, such as way-finding and access to information, using more thorough consideration of tactility, touch, smell, temperature, sound, and new technologies, Downey facilitates clarity in the design process and end product.

The 14-story building is located at 135 West 23rd Street in Manhattan, containing 205 units, a roof terrace, courtyard, bowling alley, fitness center, computer center, library, and

auditorium. During the redesign, all of the public spaces were upgraded and a new entrance was added. Each of the apartments received new fixtures and finishes; the previously separate kitchens were connected to the living areas of the residential units for better flow and circulation. Voice-controlled thermostats that allow tenants to control the temperature of their apartments were also installed.

Previously, there only existed one entrance for 250 residents and VISIONS, a non-profit that provides services such as meals and classes for over 500 people each day. This led to congestion in the ground floor. To solve this, a secured residents-only entrance was added. Furthermore, an open staircase and elevator was added between the first floor and the service activities in the cellar.

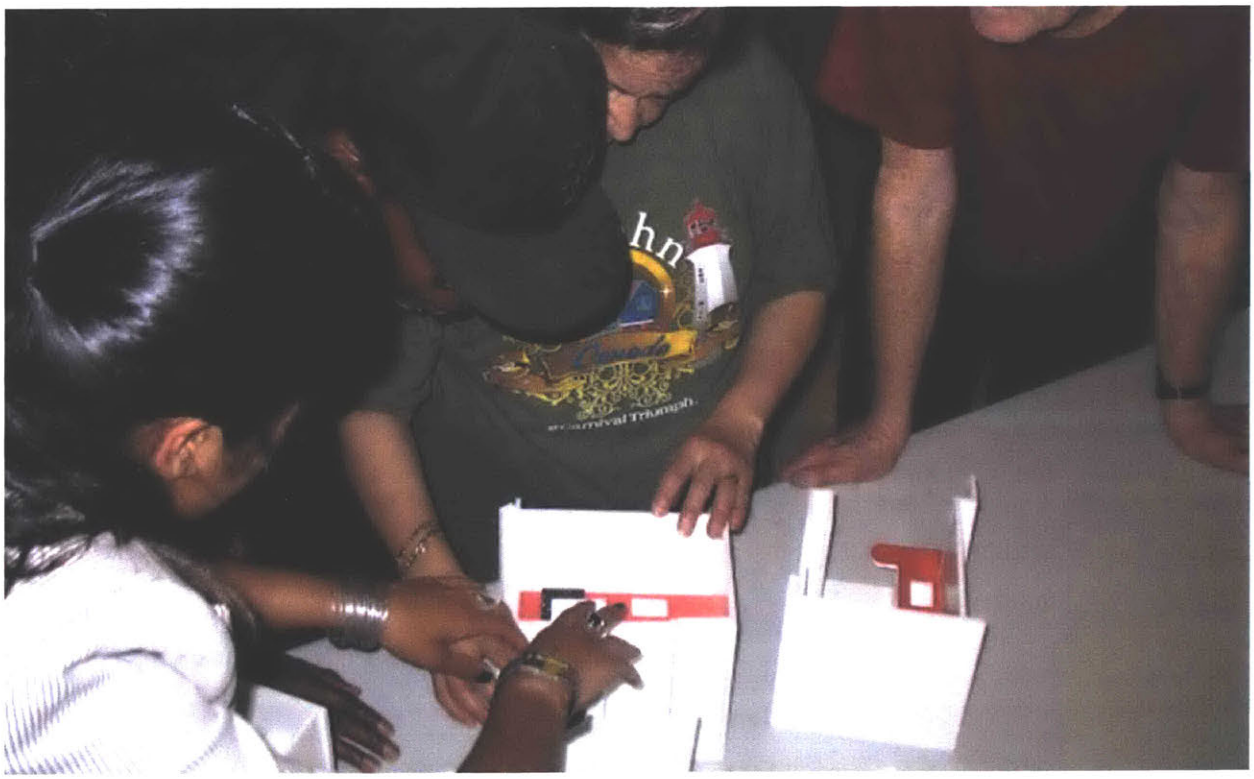
Rendering of Selis Manor redesign, Magnusson Architecture and Planning

Scored terrazzo flooring was placed to help residents navigate within the building. A path along the floor guides residents toward elevators and indicates stair landings. A guardrail

along the south façade of the building includes Braille inserts describing the history of the residence that lead toward the entrance.

Since many of the residents lived in the building since its opening, the architects wanted their input and understanding of the changes. During the design phase of the project, touchable models of the new apartment layouts were created as 3D aides to help the residents understand the changes. Using the models as a guide, the designers were able to easily communicate their ideas and engaged the residents in the process, incorporating the residents' suggestions into the renovations.

The design methods utilized in the redesign of Selis Manor illustrates the ever ongoing and improving process of architectural design. After the initial building was completed, the designers looked to the residents for their input on improvements. By asking for and incorporating user feedback, the architects could more accurately assess the necessary changes.



Touchable models of redesign, Magnusson Architecture and Planning

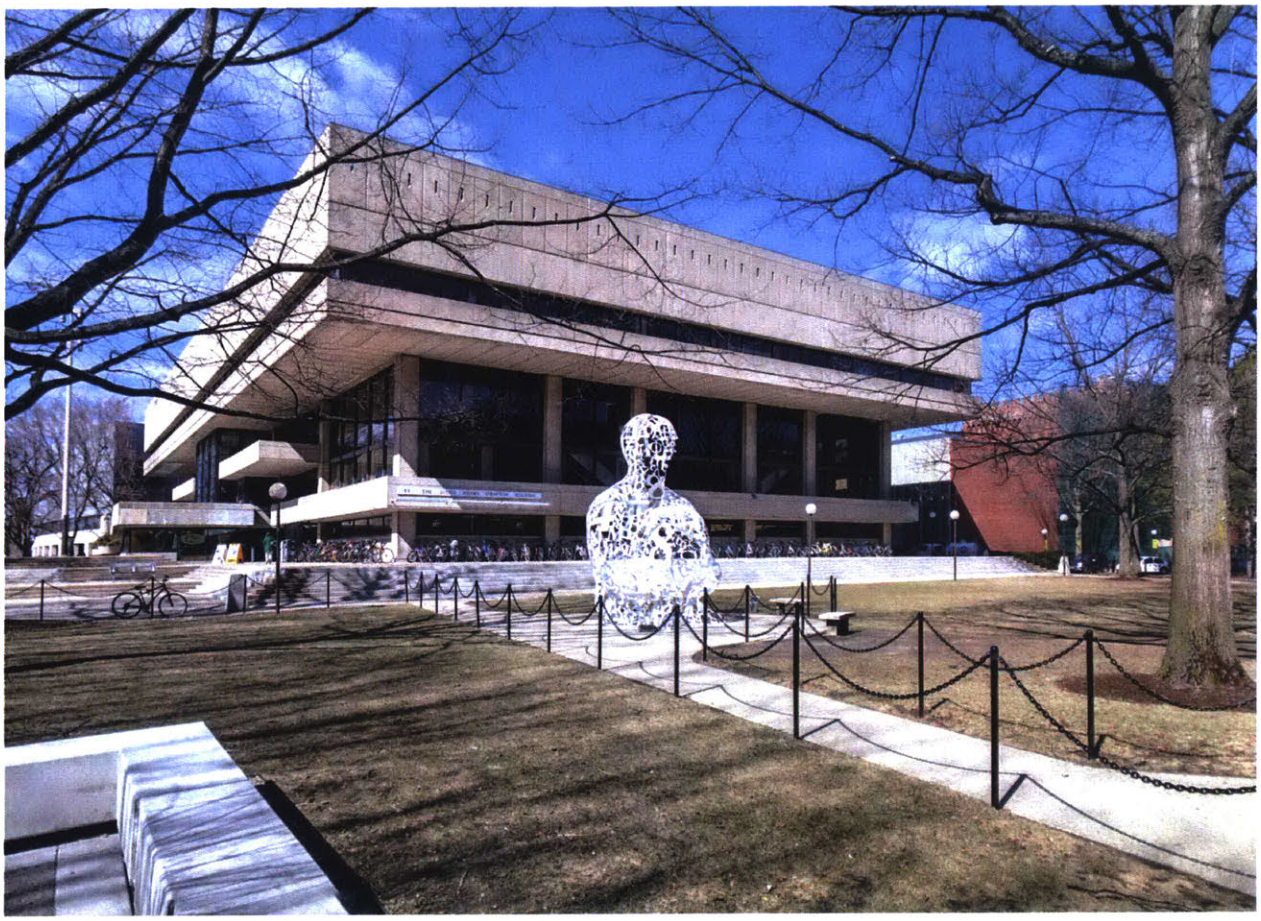
four

Spaces at MIT

"The room is there for the human being – not the human being for the room."

— El Lissitzky

Massachusetts Institute of Technology, founded in 1861, is a private university serving both undergraduate and graduate schools. The school campus is located on the Charles River in Cambridge, Massachusetts. The campus houses several buildings designed by notable architects, including the Ray and Maria Stata Center by Frank Gehry, the Cecil and Ida Green Building by I.M. Pei, and Kresge Auditorium by Eero Saarinen. For the purpose of this thesis, I focused on the Stratton Student Center and the Ray and Maria Stata Center, as they are largely utilized by the public and by the MIT community for many purposes. I explored the buildings through the different senses and speak with MIT staff and students with disabilities in order to assess the spaces.



The Stratton Student Center

Designed by Eduardo Catalano in 1963, the Stratton Student Center is a centrally located space for students at the Massachusetts Institute of Technology to gather, study, dine, do errands, and relax. The Student Center, or "the Stud" as it is colloquially known among students, is located at 84 Massachusetts Avenue and open 24 hours per day, seven days per week. The building is comprised of 5 floors containing offices and lounges, dining venues, group study spaces and a computer lab, an art gallery, an MIT Coop bookstore, a dry cleaner, a salon, an optical shop, banks, a supermarket, and a post office. Though created for all of MIT to congregate and use, the center's lack of universally designed spaces leave much to be desired, especially for those with disabilities.

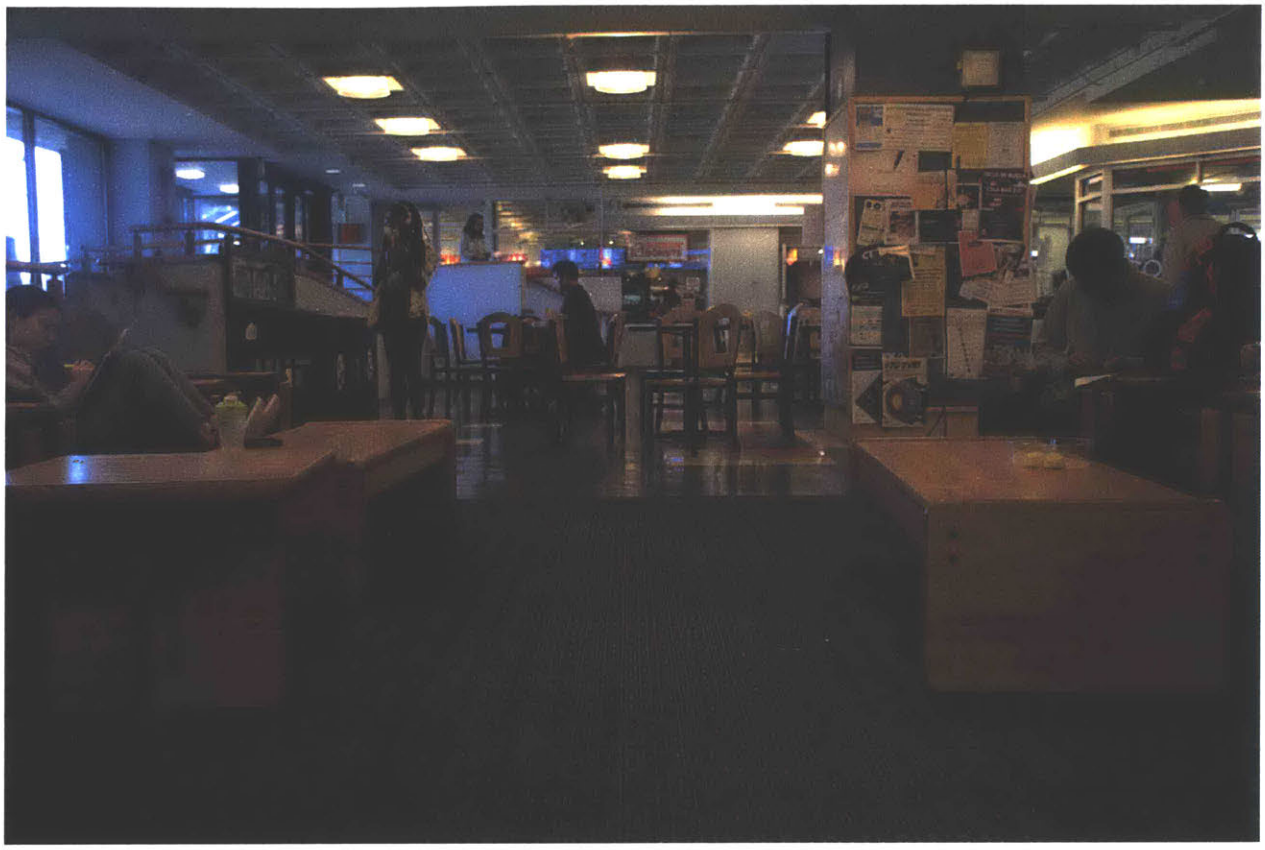
The Ray and Maria Stata Center

The Ray and Maria Stata Center, more commonly referred to as "Stata" or "the Stata Center," is an academic complex designed by architect Frank Gehry in 2004. The ground floor contains a cafeteria, lounge and study spaces, lecture halls, and a childcare center. In addition, a wide main passage called the "Student Street" runs through the length of the building, often cited as a more spacious contrast or substitute for MIT's "infinite corridor." Above the fourth floor, the building splits into two distinct structures: the Gates Tower and the Dreyfoos Tower. The upper floors contain research labs and offices of the Computer Science and Artificial Intelligence Laboratory (CSAIL), the Laboratory for Information and Decision Systems (LIDS), as well as the Department of Linguistics and Philosophy. Costing $300 million dollars, Stata Center has been fixed multiple times since its opening, and has gathered criticism for its design.

The Student Center and the Senses

When experiencing the Student Center, each sense is stimulated by different aspects of the space and the facilities. To get a sense of the multisensorial spatial experience, I conducted a sensory walk of the building's first and second floors, as well as the outdoor areas.

Sight: The ground floor has a distinct lack of natural lighting. Because the first floor rests below ground level and there is a large cantilevered roof, the windows do not provide much light. The ceilings in the first floor are relatively low, which can provide either a cozy or claustrophobic feeling. The central area of the first floor is occupied by a large, diagonal, double staircase to the second and third floors. The other facilities are around the edges of the floor, surrounding the staircase. Two elevators are on either side of the staircase, 30 feet apart and facing each other.



Hearing: The floors are linoleum or vinyl, which makes for a squeaky surface especially on the many rainy and snowy days in Cambridge. There is low to medium background murmuring from the people occupying the lounge space. There are also sporadic mechanical noises from the different food preparation services on the first and second floors. The noise level is not uncomfortably loud for me, and provides a good working atmosphere. There is little to no echo, and the ceiling is designed to absorb sound.

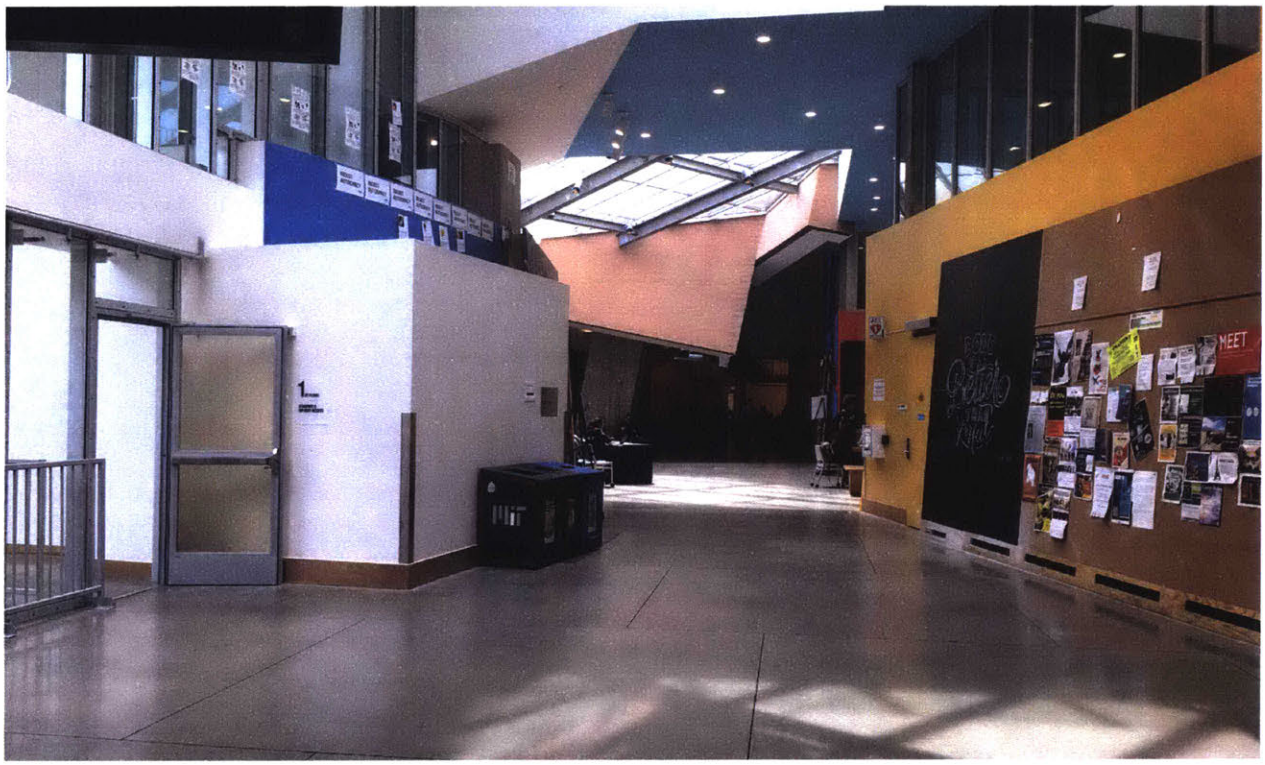
Touch: The first floor contains ample railing along the staircases and ramps, cold to the touch. The flooring is smooth and squeaky linoleum, changing to carpet for the lounge spaces. Several ramps on the first and second floors have tactile elements to grip the shoes better. The temperature inside is comfortable, providing a good difference to the outside heat or cold. There is a variety of seating options, including couches, benches, and chairs. The walls are smooth, with the occasional cork board for informational flyers.

Smell: The first floor smells mainly of Anna's Taqueria, the casual burrito restaurant that dominates the front of the first floor. The smell permeates through the lounge area. As I move towards the back of the Student Center, the food smell fades and is replaced by a stale scent, combined with cleaning chemicals.

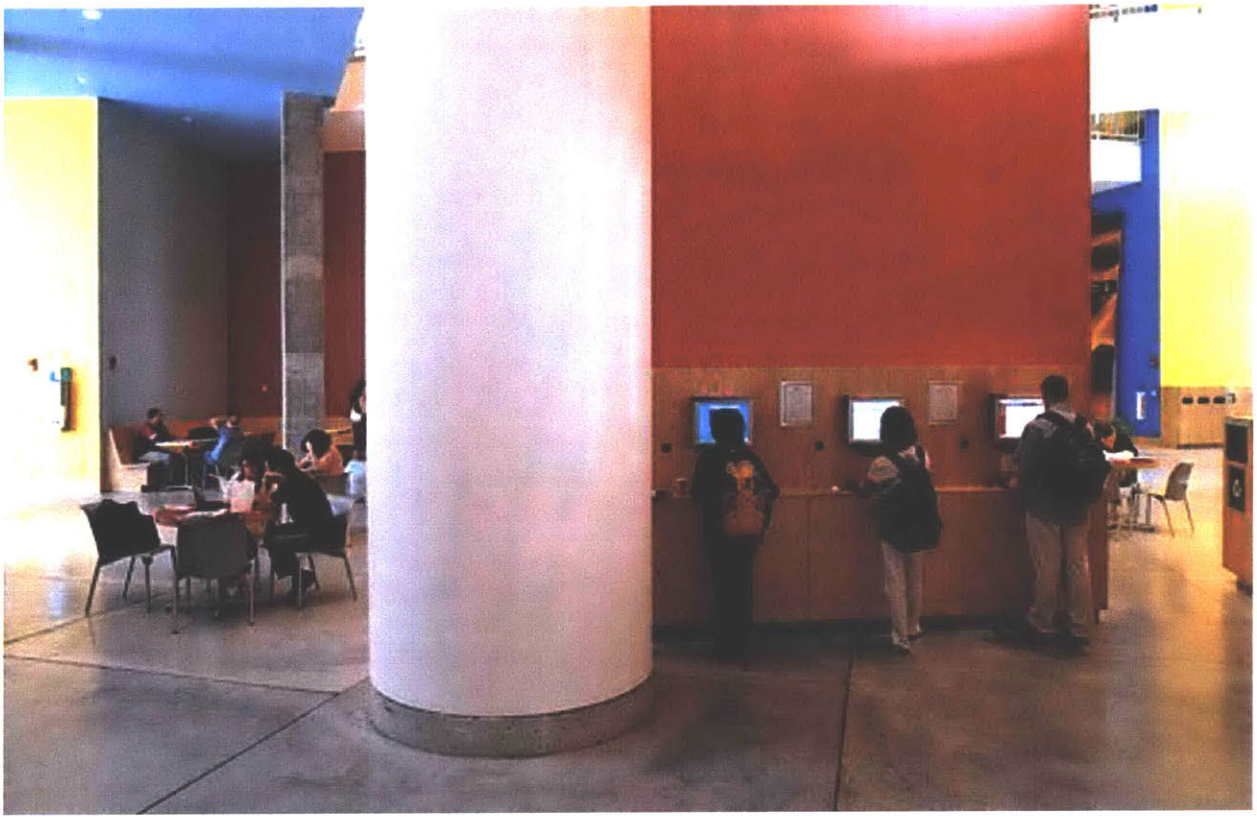
Taste: The first and second floors contain various food vendors, displaying their food and emitting smells. My sense of taste, closely linked to the sense of smell and sight, is triggered by these visual displays and scents.

The Stata Center and the Senses

When experiencing Stata, I am inundated with sensory experience. The building is a sprawling complex with a variety of materials, colors, and spaces. This sensory walk will cover the public spaces on the ground floor of Stata, including the cafeteria and Student Street areas.



Sight: Coming in front of the Collier Memorial on the east side of the building, I can see several doors at the entrance. The angles inside and out are very irregular, and somewhat disorienting. The entrance hall is well lit from the transparent doors and large windows. However, as I move into the building, there are spots with natural light from the skylights, and spots without. The Student Street is an interesting space to walk through, with many offshoots for seating and lecture halls. There are several large poles in the middle of the "street", which block my view through the hallway. The ceiling is high on the first floor, giving a spacious feel. The walls are painted bright red, yellow, and blue, and there are also corkboards with flyers and large chalkboards in the hallway.



Hearing: During the daytime, Stata is very crowded with student and tourist activity. The ground floor is relatively loud with the bustle of talking and footsteps. As I stand in one spot, I can hear the echoes of students nearby, working on a group project. The metal chairs have tennis balls attached to the feet to prevent the unpleasant scraping noise on the ground. A delivery worker wheels a cart inside, and the wheels roll loudly on the concrete ground. Near the cafeteria, there is the low hum of mechanical equipment, perhaps refrigerators. Food preparation sounds also echo throughout the area.

Touch: Stata is a warm environment, with smooth, colored walls and built in wooden seating. The space is composed of a variety of materials, with concrete floors, metal finishing, cork boards and chalkboards on the wall, and wooden and metal furniture that are cool to the touch.

Smell: Inside Stata, the cafeteria area is permeated with the smell of baked goods. As I move away from the cafeteria, the smell fades into a neutral, concrete scent. The scent is not unpleasant

Taste: In Stata, the Forbes Family Cafe is a prominent facility and provides food for students and staff during the day. As a student, I have used this cafe many times for coffee, baked goods, and lunch. The smells emitted by the food and food preparation triggers my sense of taste

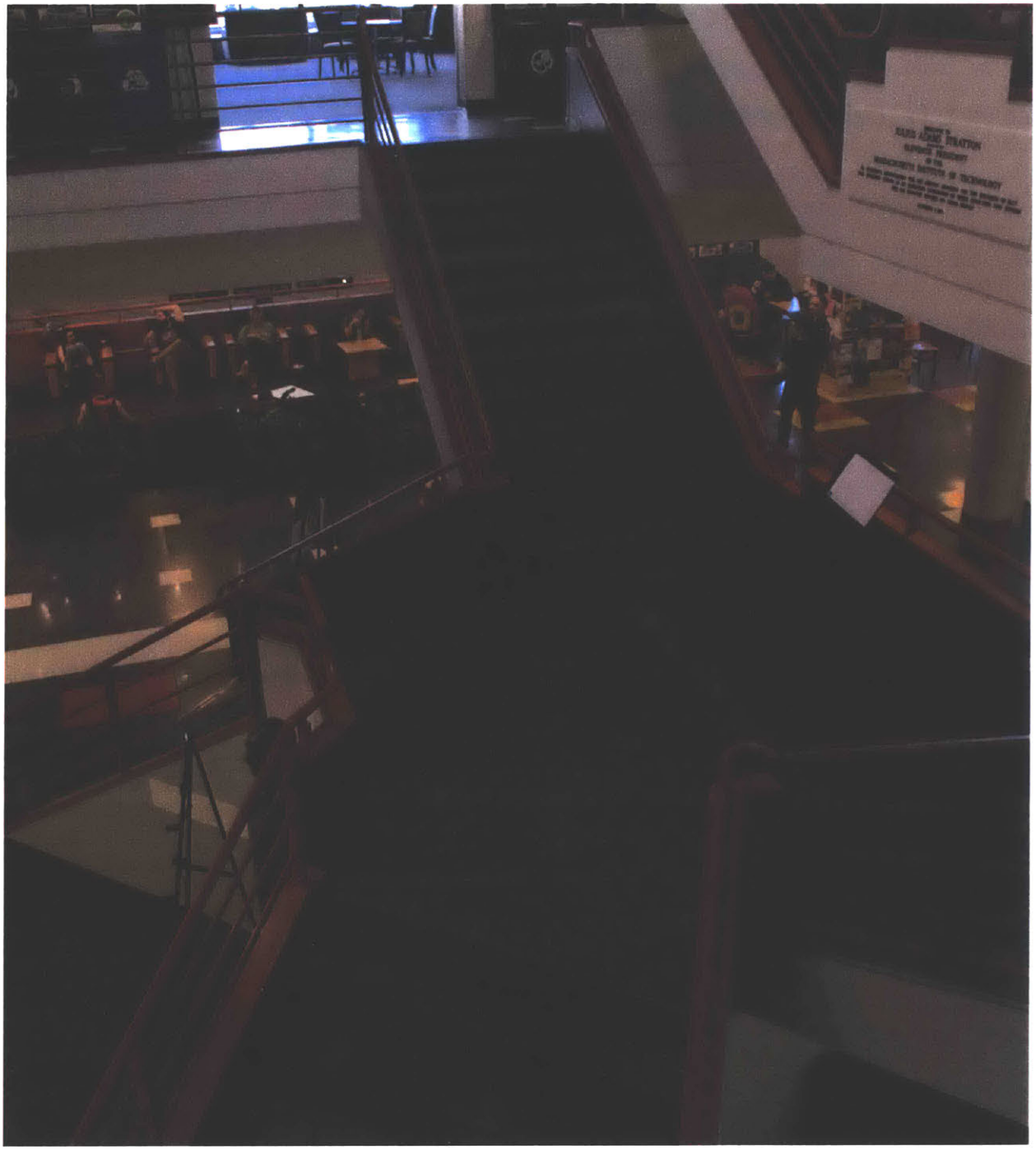
Assessing the Student Center

To gauge the usability of the Student Center by those with disabilities, I gathered the thoughts of several staff who work in the Student Center. Each participant self identified as having either vision loss, hearing loss, or a mobility impairment. From the survey, several key components of the Student Center emerged as areas for potential improvement to allow for a more universal design.

Layout and Circulation

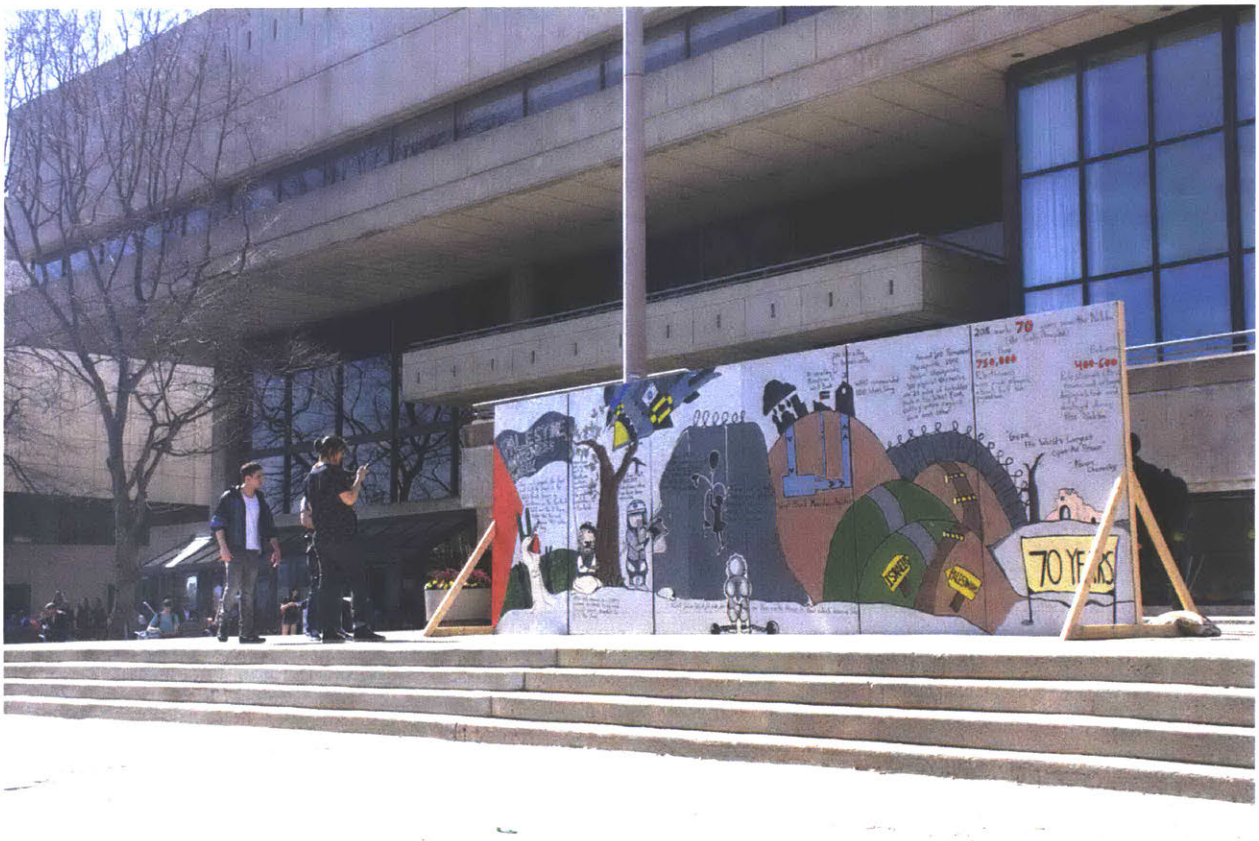
The Student Center provides an inefficient and potentially dangerous flow for those with limited mobility and sight. Many tripping hazards, as well as a confusing layout, are barriers to the student center being an accessible building. The first floor has no clear walking path, and contains poles in the middle of the space that obstruct walking. Having more direct and clear pathways for walking was suggested by those with low vision. In addition to physical obstruction, the poles also obstruct the visual space, which is not ideal for the deaf and hard of hearing.

There exist three stairways within the Student Center: the central staircase and two side staircase shafts. The central staircase is angled diagonally across the floor plan, making navigation difficult. Several participants were unaware of the side staircases, which can be more efficient and easier to use.



The elevators in the Student Center, while vital for universal design, are not placed ideally for efficiency. Because the elevators are not placed together, users typically must watch out for both sides to see which elevator will arrive first.

The outdoor area of the Student Center is also inefficient, due to the choice of flooring and stairs. The entire area is elevated with several levels of steps, and a roundabout ramp to get to the front doors. The Student Center also includes an elevated plaza for public events, and an outdoor staircase for access to the second floor. The plaza is elevated with stairs, making it very difficult to access for those with limited mobility. In addition, the ground of the outside seating area is covered with loose rocks. This can be potentially dangerous for those with low vision or limited mobility.



Amenities

The participants are generally satisfied with the provided facilities and amenities in the student center, citing that the banks, food services, and work spaces are the most important. In the Student Center, there are a variety of spaces to work individually or meet in a group, ranging from the first and second floor lounges to the private rooms on the fifth floor. One participant indicated that they would prefer work spaces to be better lit, or have adjustable lighting, as well as better noise controlled.

There are no restrooms on the first floor of the Student Center. The most accessible restrooms from the first floor are located in the basement, or on the second floor. The restrooms are generally cramped, and do not all have automatic doors.

Acoustics and Lighting

The Student Center is generally full of sounds from occupants and the facilities inside. One participant with hearing loss indicated that it is difficult to hear and communicate with others while inside the student center.

Several participants noted that there is not enough natural lighting in the Student Center, especially in the first two floors. A general "lack of light" was noted, and lighting improvements and adjustable lighting in the meeting rooms were suggested.


Assessing the Stata Center

Layout and Circulation

The Stata Center is complicated to navigate due to its organically shaped pathways. There are many hazards, such as columns, stairs, and tables on the ground floor that are not properly indicated. Stata's many entrances and diagonally shaped hallways present a challenge to use and find one's way inside the building. In addition, the organization of the space is inefficient, with two separate towers in the upper floors. There are several elevators in the building, but each of them only serves one tower.

In one of fourth-floor seminar rooms next to the faculty lounge, the creatively-slanted walls and wall panels induce vertigo in those who step inside. The reason behind this is that the walls fool the eyes into thinking the floor is tilted, which conflicts with the information from the inner ear. In order to prevent vertigo, MIT resorted to putting in several large vertical objects like rolled-up rugs and coverings for the wall.

Amenities

Of the amenities in Stata Center, the most important and frequently used were indicated to be the Forbes Family Cafe, the lecture halls and classrooms, and the study spaces. The restroom on the first floor is equipped with large stalls, automatic doors, and lowered countertops that allow for ease of use and navigation.

Acoustics and Lighting

Within the Stata Center, the lighting is inconsistent throughout the first floor. Skylights are interspersed throughout the Student Street, and some spots are much brighter with harsher lighting, while other spots are dark. The ground floor's materials and layout is also very conducive to echoes, making it relatively loud and busy to work in.

Outdoor Amphitheater

Stata Center contains an outdoor amphitheater on the east side of the structure, providing public seating during lunch on warmer days, as well as an outdoor performance space. However, the amphitheater is dotted with several trees that obscure the pathway and the visual sightline to the stage while seated. In 2007, MIT filed a lawsuit against Frank Gehry and Skanska USA Building Inc., the construction company that built the Stata Center. In the lawsuit, MIT specifically cited "design and construction failures" on the Stata Center project which resulted in "masonry cracking" and "poor drainage" at the outdoor amphitheater, "persistent leaks," "sliding ice and snow from the building," and "mold growth." (Dey, 2007)

Next Steps

MIT's Stratton Student Center and Stata Center are both public hubs of student activity on campus, and should be designed with all types of users in mind. Although the Student Center was designed in 1963, prior to the accessibility movement, Stata Center is much more recent. As such, the design of Stata clearly ignores key accessibility and universal design principles. We can work towards a more inclusive campus by embracing universal design and carefully assessing current and potential public spaces on campus. Though many aspects would require an entire redesign to incorporate universal design principles, there are many that are easier to implement. Lighting and acoustic design, for example, can be changed to provide a more natural and comfortable space for people to work in. Walkways can be cleared of obstructions such as tables and chairs, and better communicated to low vision individuals. Other aspects that are lacking, such as the layout and circulation of the buildings, can be improved in subsequent designs of campus spaces. Drawing upon the precedent of Selis Manor, we can see that it is also possible to implement a redesign and upgrade of a building, while still preserving its original form and function.

To further explore how spaces on campus can be more inclusive, a wider survey of students and staff at MIT can gauge usability of public spaces on campus and identify universally designed spaces. After identifying spaces that fit universal design principles and those that could use improvements, a participatory redesign of these public space layouts can ensure user input in the spaces they use. By becoming more aware of the user's perspective and the relationship between the building and the user, we can design smarter and more empathetic spaces.

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Conclusion

"We shape our buildings, and afterward, they shape us."

— Winston Churchill

Multisensorial architecture has the ability to facilitate a sense of integration and belonging, adding meaningful layers to one's spatiotemporal experience of architecture. In addition to the five senses, our interaction with architecture can encompass the senses of pressure, balance, rhythm, movement, warmth, life, and more. When adopting universal design principles, the architect is asked to consider, understand and incorporate multiple senses into the user's experience. By understanding how the human senses work and interact with the built environment, an architect can become more aware of how a building will impact its occupants from all dimensions. Multisensorial architecture is architecture that gives consideration to the disabled population, involving a richer involvement of all the senses.

As designers, we hold a responsibility to the public. Rather than being compelled by the artistic form, our designs should be driven by a commitment to usable spaces that inspire joy in its inhabitants. Through an understanding of rich, multisensorial architecture, we can more fully utilize our senses to their potential and create authentic experiences. By listening and responding to our users, we can better accommodate for their needs and desires. Using an iterative process to design, we can learn to adapt and change our buildings and our ideas. Good design is thoughtful design, and is deserved by everyone.

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