ABSTRACT

Title of Thesis: SHAPING SOUND:
Engineering Adaptable Spaces

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Music and architecture share a unique series of connections, not only in their terminology, rational fundamentals, and creative potential, but also in their special public-facing role in society. These two realms provide opportunities to deeply connect with the people who encounter them and unify groups under shared experiences. However, many projects that have attempted to blend music and architecture simply use sound as a design driver for architectural form, much to the degree that this thesis had originally intended. Instead, what if the architecture of a space could adapt itself to the performances taking place, and allow artists or performers to be themselves without feeling the need to bend their styles to conform to the venue. What if the venue could change and conform to the artist? This thesis aims to explore that possibility, and investigate how architectural solutions could alter a space through dynamics and materiality to better optimize the variety of genres that would exist there, allowing music and sound to perform at its best no matter what qualities of space are needed.

SHAPING SOUND:
ENGINEERING ADAPTABLE SPACES

by

Nicholas Charles Majka

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Advisory Committee:
Professor Matthew Bell, Chair
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Table of Contents

List of Figures

Chapter 1: Music Fundamentals

What is Music?

The history of music and the way that musical scales came to be is interesting in that multiple cultures around the world were able to interpret the inherent mathematics behind musical vibrations and frequency almost independently from one another yet concluded similar findings for the fundamentals of sound. Ancient Eastern musicians, as one example, noticed the rhythmic harmonic connections between new notes when lengths of string were divided into thirds. The simple mathematical relationships between the first length of string and the newer length at one-third the previous created a harmonic overlap which was pleasing to the ear. This held true for the first five notes in the sequence: C, G, D, A, and E. However, when attempting the jump from E to B in a similar fashion to the previous notes, the musicians noticed that the sound did not harmonize with the C note, the first to be played in this sequence, leading them to leave off the B note and utilize a pentatonic scale – a scale with only five notes – with the notes that sounded pleasing with one another.

Western music followed similar roots but pursued a solution to the issue of the B note. Instead of viewing the C-B interval as an outlier, the musicians attempted to use that interval as the basis into which they would fit the rest of their musical scale. This interval became known as a semitone, and all notes with a larger interval would need to be given an intermediary note at the same interval as the semitone, eventually leading to the system of flats and sharps that we see used today. Along with some continued tweaking to the structure of the 12-note system, Western musicians used mathematics to construct what is known as the "chromatic scale," or tempered scale, to divide their musical scale into twelve equal parts, ensuring that the twelfth note in the sequence was the same as the first and that any composition could be played from any starting point and still function – such as playing a song in D Major that was originally written in A Major – a feat that the Oriental Scale could not execute. However, even with this brief introduction to the history of music, the connection to architecture still must be explored.

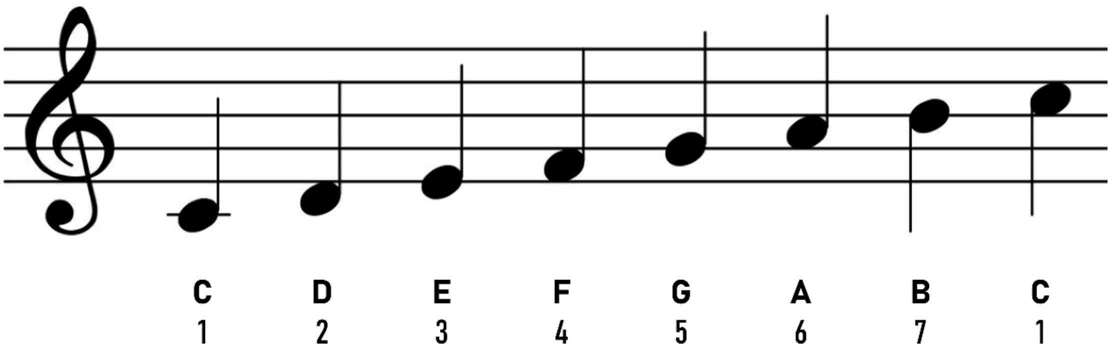


Figure 1: C Major scale. (Source: Nick Majka)

The art of music, the foundations on which it is built, and the role that it plays in society and history mirror closely that of architecture. From their creation to their appreciation by the public, these two forms of art are linked in every step and lend themselves to be blended in process and design. Much of the terminology used between the two fields are identical – often with many words being used in similar roles – and the process of creation and iteration shares many details. However, before the jump into form making and architectural design can take place, it is important to understand the essence of music; the core

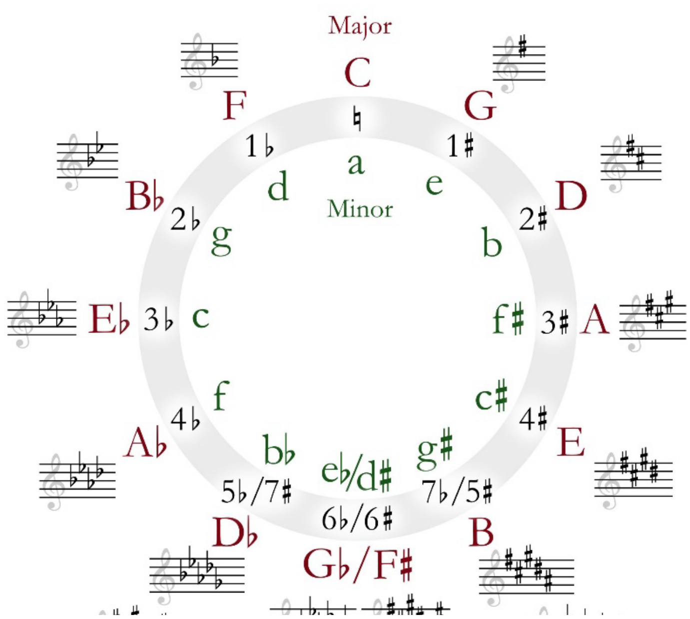


Figure 2: The Circle of Fifths, a graphical representation of the mathematical similarities and connections found through the Major and Minor chords.

of such an abstract and multi-faceted conceptual cloud from which this journey will begin.

The Language of Music

For all of the freedom and creativity that music provides the composer, the artist, and the listener, it is a form of art grounded in the absolute. Mathematics rules over the musical domain, and even the perception of correct tone and intervals is extrapolated from a relative mathematical scale. The key to fully grasping music theory is understanding the language of music; taking apart the foundational pieces of music, inspecting them, and having a full knowledge of how music is put together and deconstructed. Just like learning any language – and even architectural language – there are steps in the process, fundamentals at the start that are used to support more complex ideas later in the process. With that in mind, in order to get a grasp on music theory, we should start with the basics.

Fundamentally, sound is a wave. If one envisions a string fixed at both ends which is pulled and released, that string will oscillate to a waveform at a specific frequency; a certain number of oscillations per second, which is notated as Hertz (Hz). Affixing the string in the center – effectively dividing the string in two halves – and repeating the process to one side will create a waveform at twice the frequency – or double the Hertz – as the first trial. Looking at this through the lens of music, the frequency of that first trial would be associated to a note, and we could assume that that first string oscillated at 440Hz which would be the A note. The second trial, with the string length at half the first, would oscillate at 880Hz – still the A note, but at exactly one octave higher in pitch. Now, if we divide that original string into thirds instead, such as in the example of the ancient musicians above, we find that plucking that new string at 1/3 the original length produces a frequency three times higher than the A note at 440Hz. Effectively, just as the Eastern musicians discovered, this interval

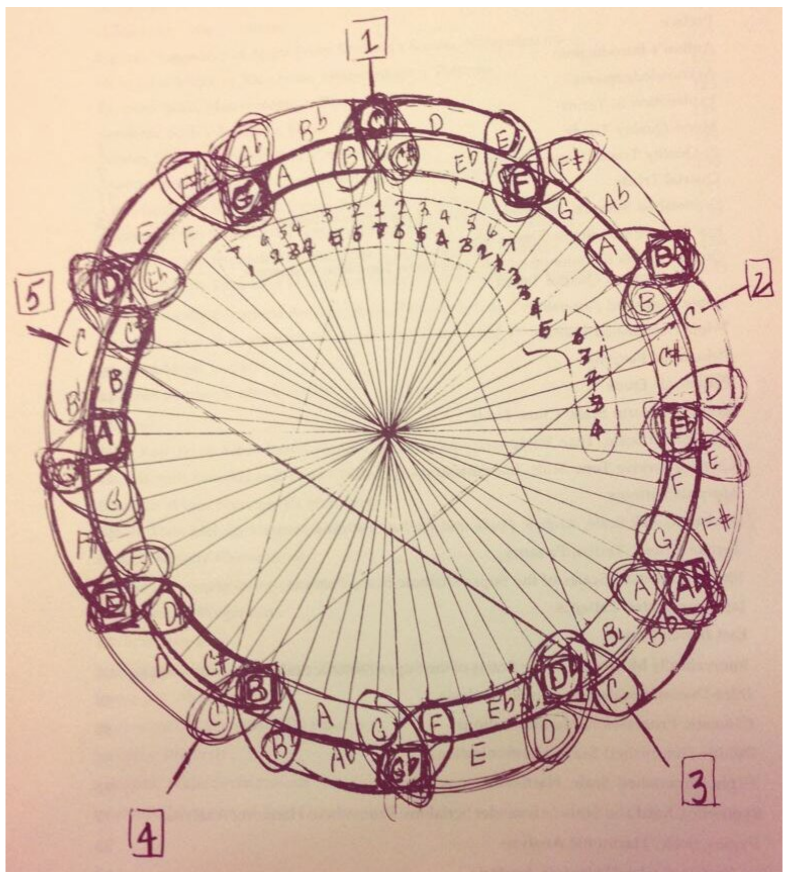


Figure 3: Mathematics of musical scales, depicted through a modified Circle of Fifths. (Source: John Coltrane)

leads to the E note at 1,320Hz. Even more interestingly, the same concept of octaves can be applied here, and we would find the E note closest to the original A note at 440Hz; dividing 1,320Hz by 2 gives us an E at a lower octave – 660Hz. All of this is important because of

Note	Frequency	Harmonic	Diagram of string
low low low A	$f = 55$ Hz	fundamental	
low low A	$f = 110$ Hz	second	1/2
low E	$f = 165$ Hz	third	1/3
low A	$f = 220$ Hz	fourth	1/4
middle $C^{\#}$	$f = 275$ Hz	fifth	1/5
middle E	$f = 330$ Hz	sixth	1/6
approx. middle G	$f = 385$ Hz	seventh	
middle A	$f = 440$ Hz	eighth	

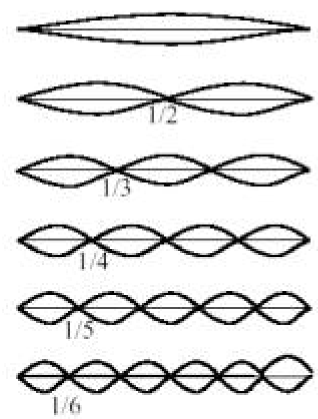


Figure 4: Illustration of frequency relationships through mathematical and visual examples (Source: famu.fsu.edu)

how our brains interpret music, and more specifically the intervals between notes. Musical notes that share simple fractional relationships are easier for our minds to decipher. Take the above notes for another example. The A and E notes at 440Hz and 660Hz, respectively share a simple ½ to 2/3 relationship. In the A Major scale, the interval from A to E – or from the first note to the fifth note in the scale – is a Perfect Fifth; a rock-solid interval that is extremely easy for our minds to rationalize. In contrast, the tritone – a notoriously unpleasant interval positioned between the Perfect Fourth and Perfect Fifth – shares a 32/45 fractional relationship from the starting tone. To get a bit more specific, the frequencies of notes that share simple fractional relationships will have their waveforms align much more frequently and regularly than notes that have more complex relationships. This makes it easier for our brains to find logic and reason between two adjacent sounds and to rationalize them.

By understanding the mathematical relationships between different notes, their fundamental frequencies, and having a general grasp on the fact that simple fractional relationships create pleasant intervals for our brains to process, the simple clarity of music begins to come into focus. Music is, by definition, the intervals between frequencies. It is relative mathematics. It is grounded in order and rationale yet allows for near limitless freedom and creativity of expression. Buried beneath the complexity and celebration of sound and songs, there is a clear and simple beauty to the foundation of music and music theory. It is within this simple complexity that we can begin to find our connection to the architectural world.

The Connection Between Music and Architecture

The importance of this prelude is to recognize that the magic of music is inherently tied to the logic of our minds. At the microscopic level, the math that lays the foundations and constructs the wonderful intricacies of music as it is known similarly helps to shape the built environment and the awe-inspiring forms we see all around. In a journal published in 2001 by ESCOM, Andrzej Rakowski says something wonderful.

"'Understanding a musical theme.' It means that someone had structured sounds making a theme and I, the listener, have to "understand" that construction, appreciate its perfection, recognize the constructive rules and in doing so have a pleasure - the pleasure of aesthetic perception. This is the core of it. This is what makes the difference between music and non-musical sounds, or sequences of sounds, or noise. Creating the construction, consciously or subconsciously recognizing that construction and having pleasure from that recognition:

creation and aesthetic perception. This is the main distinctive feature of music as an art dealing with sound. In more general terms it is also a feature of art as such."

"So, the first important factor that defines music is creation of a structure. The next, equally important, is conveying information about that structure to the receiver, in order that the second indispensable part of the aesthetic process might be accomplished. Does it necessarily mean that there must be a written score, a performer and a listener, capable of 'understanding a musical theme' and having aesthetic pleasure from that recognition? Of course not. Music is created for listeners, but it may perfectly exist without them. When the creative process in a composer's mind begins there is always a competent recipient, ready to accomplish the aesthetic process and to have pleasure from appreciating the uprising construction…" (p. 125-126)

Without much context, this excerpt could easily be used to argue similar points regarding the art of architectural form. The two fields share near identical roots and process elements, while having their products – outward facing expressions of the artists open for interpretation by the masses – align with equally compelling and powerful presence in society. It stands to reason that with such rampant similarities between the two, there should be a methodology to create architecture from music, and music from architecture. The Pythagoreans saw the innate connections between music and the mathematical proportions of creation, and it had been stated by 18th-Century writer Johann Wolfgang von Goethe that "music is liquid architecture and Architecture is frozen music. Really there is something in this; the tone of mind produced by architecture approaches the effect of music." They are simply two languages that are terribly alike, and one must only translate from one into the other.

Chapter 2: The Color of Sound

A Physical "Semitone"

Before exploring possible previous architectural projects that used sound and music as a design driver in creating the form or layout of a structure, it is important to study other avenues that have been taken for similar purposes. Particularly, art forms such as painting and sculpting can provide glimpses into the abstraction of music into a physical form that can be solely appreciated and not need to support a function or program like an architectural project would. In this way, we will be able to see examples of pure interpretations of music, with no other significant purposes than to be seen, appreciated, and gazed upon. This step halfway between the ethereal and invisible music, and the concrete and functional architecture can be seen as a critical "semitone" in the process; filling its role dutifully in order to provide a clearer and more complete picture in the greater scheme of the thesis.

Georgia O'Keeffe

Early 1900's New York teacher-turned-artist Georgia O'Keeffe explored the connections between her abstract paintings and emotional responses, leading to one of her first creations having a heavy connection to music. O'Keeffe strived to portray emotions that she simply could not put to words, and instead hoped to visualize through art. This project is particularly interesting, not only due to the vibrant colors contrasted by the sense of a void within the composition, but also because it was one of O'Keeffe's earliest explorations into the abstract style of painting. Although the artwork is not entirely derived from music, O'Keeffe believed that the feelings that she felt were similar to those expressed through music, and that similarly to how musicians can convey feelings that words cannot, so too could her paintings.

Figure 6: Georgia O'Keeffe's Green and Blue Music

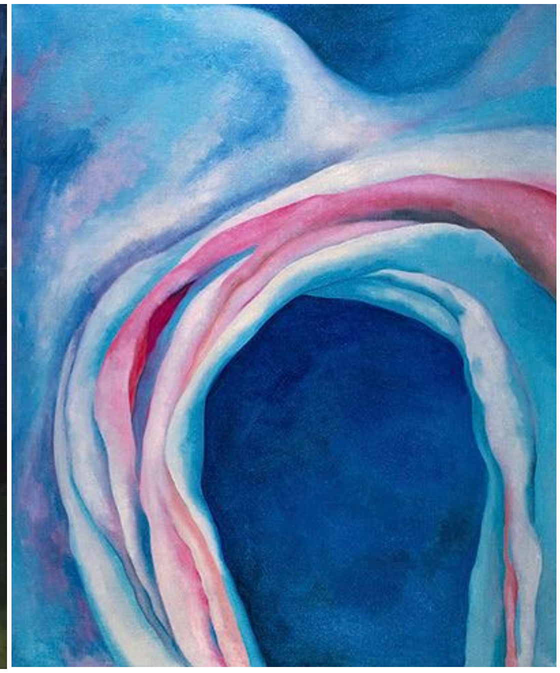


Figure 5: Georgia O'Keefee's Music, Pink, and Blue

The project was so influential, both outwardly and to O'Keeffe herself, that a second in the sequence was created; named Music, Pink, and Blue no.2. "I found that I could say things with color and shapes that I couldn't say in any other way – things that I had no words for."

O'Keeffe did not finish her abstraction of music into a visual form there. In 1920, she created a work titled *Green and Blue Music* which, unlike the previous Pink and Blue line, was intended to be a visual translation of music's tones and variance, allowing the change in edges and geometric forms to convey movement and rhythm. She stated that the intention behind this painting was for music "to be translated into something for the eye."

Wassily Kandinsky

Nearly the entirety of Kandinsky's portfolio finds its roots and influences deeply ingrained in that of music. From his Compositions and Improvisations – lines of work renowned for their impact and aptly-named after musical scores – to his more "primitive" woodcuts titled *Poems Without Words*, music is found through many, if not all, of his works. Kandinsky believed that the colors and shapes of art could be used to convey emotions, and a synesthete – one with synesthesia, or someone who experiences one of their senses through another – believed that he could accurately depict the color of emotions that were real to him, outwardly for others.

Figure 7: Wassily Kandinsky's Composition X

Composition X is said to be one of the greatest examples of Kandinsky's work relating to music, as well as had been claimed by Kandinsky himself that the work was his most complex and most complete up until that time. Engulfed in Surrealism at the time of its painting, Kandinsky utilized the dark background to allow the organic shapes in the foreground to stand out and dance, intentionally pointing the work toward the emotional peaks and valleys that are universally experienced. The work was so moving, it came to be heavily studied and dissected, with some critics arguing that Kandinsky had achieved a way of creating "chords of color" that could lay on top of one another and harmonize much like the notes in a musical chord. To prove this point, one of the critics, Bruno Haas, asked viewers of Kandinsky's art to cover portions of the canvas with their hands and watch as the relations between the newly revealed portions would give the context differing meanings, insinuating that each section had a part to play in the grander scheme, and while they could each stand alone as their own notes, together they played a greater "chord."

These observations of individual portions playing a role in their own right while contributing to the overall composition of the entire piece is a crucial consideration of what this thesis aims to explore. There are multiple scales to be viewed in an architectural development, and each individual element of this proposal should be uniquely influenced by musical terminology, emotional resonances, or acoustic responses. When critiqued piece by piece, each portion should have a concrete origin grounded in music and sound, but when viewed as a whole there should be a masterful interplay of the many parts as a complex unit, similarly to the works of Kandinsky where individual micro "notes" can stand on their own, but aid in the creation of a more complete macro "chord" that functions successfully as an effective soundscape and acoustically sound product.

Sculptural Pieces

There are many examples of sculptures that celebrate the life of a composer or musician in a fabulous way or provide some tactile response through tone of some form; all inspired by music. One such example is the Sibelius Monument in Sibelius Park, Helsinki,

Figure 8: Sibelius Monument located in Sibelius Park, Helsinki

which is comprised of over 600 hollow steel pipes meant to take a similar form of an organ, while the wave-like pattern overall is intended to mimic the wavelength of sound. Sibelius himself was a Finnish composer viewed as one of the last remaining masters of the grand Beethoven symphonic tradition, leading to his memorialization in this work of sculptural art.

In contrast to memorialization, there are examples of some sculptures being constructed as works of art in their own right. The Singing Ringing Tree in Burnley, Lancashire is a great work to study, as its sole intent was to decorate the landscape and take advantage of the winds – similarly to the aeolian harp, which gives it precedence – atop the hill that it sits upon. The piece is constructed from welded hollow steel piping that twists upwards to form the visage of a tree atop the hillside. The pipes which are not solely installed for structural security are tuned to be played by the wind, with some being constructed similarly to a recorder with holes along the side.


Figure 9: The Singing Ringing Tree located in Burnley, Lancashire

Chapter 3: Typology and Program

Program

The best medium through which to illustrate music in the built environment and in architectural form is through a musically programmed sequence of spaces. Creating a steady flow from exterior to interior of “softer” to more “hard” spaces – or public to more private – will also help to densify program elements that require sound buffering or near-silence to function correctly, such as practice and recording. Intermediary spaces – such as interior gathering, event, and education – can shield the most private zones from near-exterior and fully exposed performance, gathering, and public and private event elements. The smooth flow of programmatic density would allow the structure to mimic the “core” or “fundamental” spaces of music, illustrating the rational structure of sound at the epicenter of the project, from which all else would project outward. As spaces flow away from this center, structure and form are given room to breathe and express themselves, blending into the landscape and visually tying the structure into the context through the “limitless freedom” of music and art.

With the design intent of this thesis revolving around the essence of music, the emotive responses to sound, and the fundamental connection between musical expression and the spatial sequence and qualities of architecture, it seems intuitive to funnel the lessons learned through research into the construction of a music facility – more specifically a music education typology such as a Sound Lab. The project providing spaces for music education and practice, as well as sound recording would be key to illustrate the “essentials” of music production through both analog performance and digitally technology-driven methods.

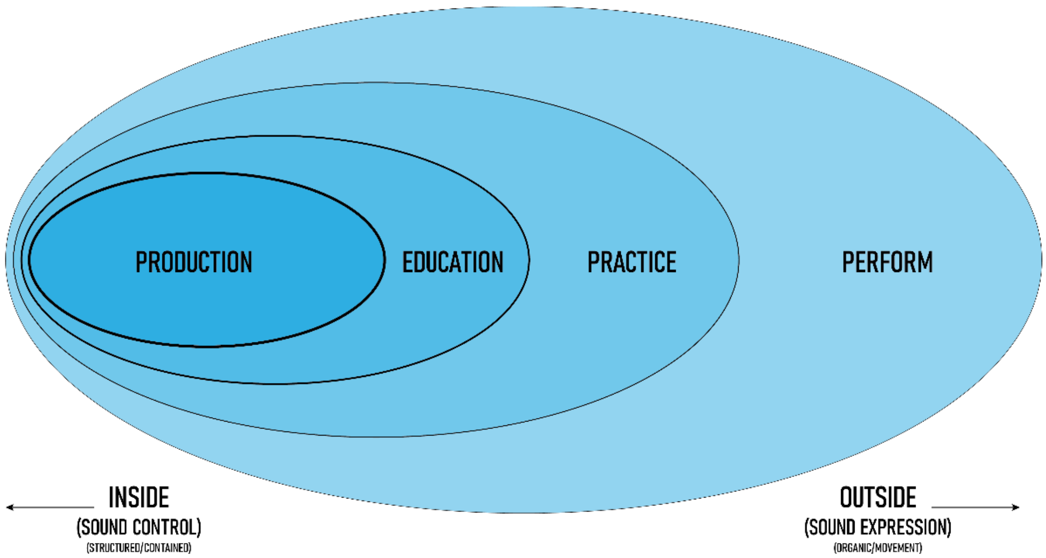


Figure 10: Diagram of interior to exterior program flow.

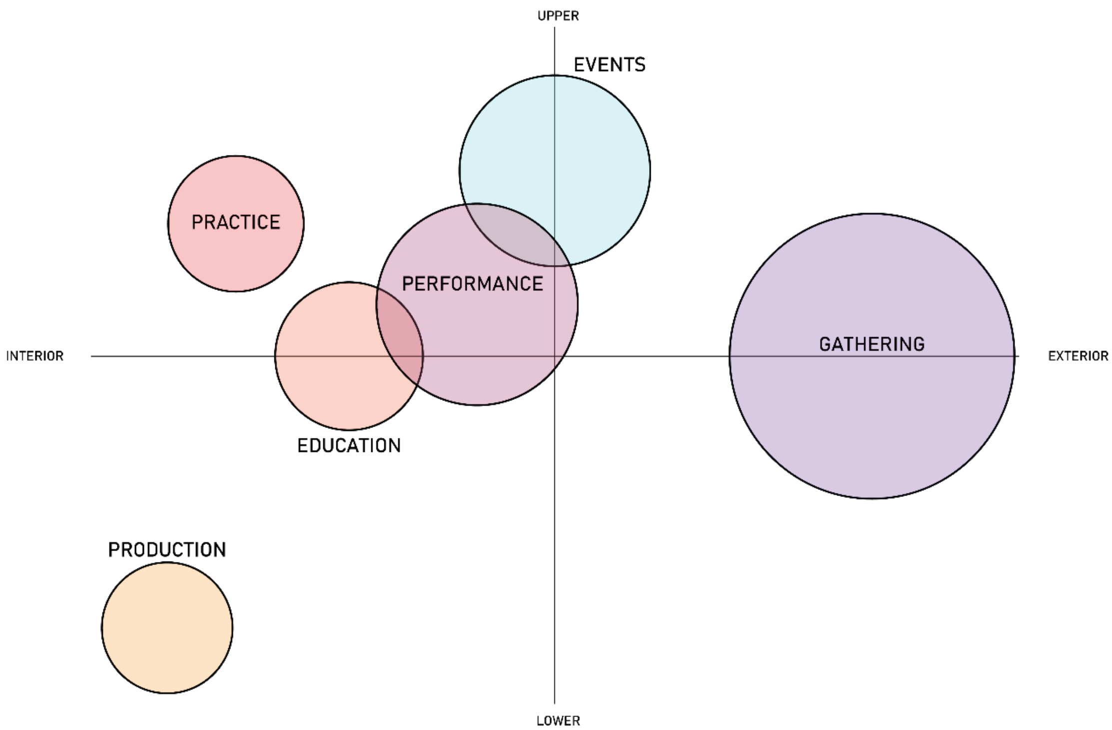


Figure 11: Matrix illustrating potential location needs of program elements.

The Duke Ellington School, Washington D.C.

RELEVANT PROGRAM

Building Systems	Square Footage
Restrooms	4,892 ft^2
Electric	2,539 ft^2
Mechanical Room	1,870 ft^2
Telephone	808 ft^2
TOTAL	10,109 ft^2

Administration	Square Footage
Office	2,294 ft^2
Storage	1,479 ft^2
Loading	986 ft^2
Security	730 ft^2
Break	605 ft^2
Meeting	390 ft^2
Overnight	366 ft^2
Bathroom	322 ft^2
Janitor	322 ft^2
Medical	277 ft^2
Mail	108 ft^2
TOTAL	7,879 ft^2

Theater + Backstage	Square Footage
Theater	10,873 ft^2
Changing Room	7,140 ft^2
Backstage	4,513 ft^2
Performance Hall	3,766 ft^2
Black Box Studio	2,404 ft^2
Storage	1,525 ft^2
Office	1,093 ft^2
Green Room	811 ft^2
Rehearsal / Library	305 ft^2
Meeting	172 ft^2
TOTAL	32,602 ft^2

Music Program	Square Footage
Rehearsal	11,347 ft^2
Music Study	6,856 ft^2
Storage	2,787 ft^2
Office	647 ft^2
Library	369 ft^2
Repair	123 ft^2
Misc.	103 ft^2
TOTAL	22,232 ft^2

Education	Square Footage
Classroom	21,492 ft^2
Office	1,745 ft^2
Workroom	495 ft^2
Meeting	190 ft^2
Medical	180 ft^2
Storage	92 ft^2
TOTAL	24,194 ft^2

Common Areas	Square Footage
Lobby / Gallery	4,063 ft^2
Terrace	1,285 ft^2
Storage	929 ft^2
Store	256 ft^2
TOTAL	6,533 ft^2

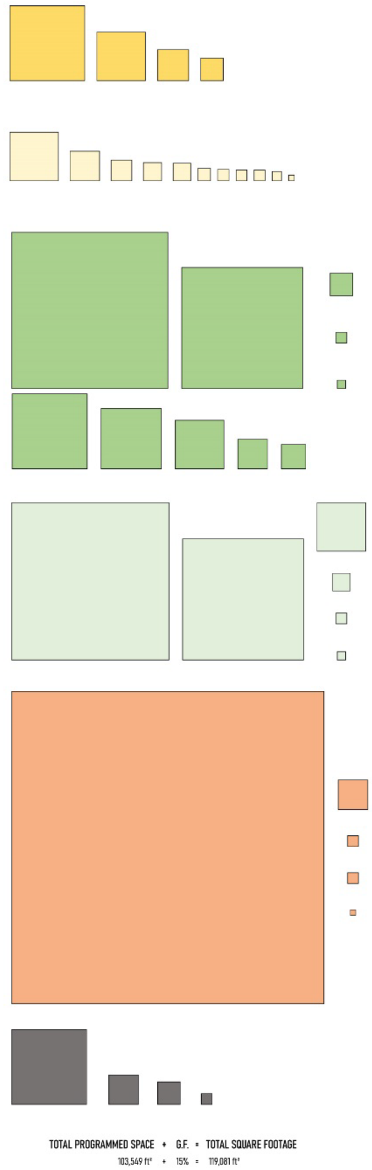


Figure 12: Breakdown of Duke Ellington School program. (Source: Nick Majka)

The Duke Ellington School – a state of the art institution built in 2014 – is an excellent precedent to study for this typology. Although much larger in scale than the proposal of this thesis, this project shows what can be done in a similar city environment with comparable constraints, while accomplishing all of the aspirational goals that are currently in the future plans for this thesis. The two main differences that the Duke Ellington case study presents – aside from its much greater size – is the incorporation of various satellite fields of study for its students, such as theater and show production, and the roots of the project being a full-scale Core and Shell revitalization. The infrastructure for the current Duke Ellington School was constructed in 1898 as Western High School, and would see multiple other renovation projects in its lifetime before being designated a Historic Landmark in 2003.

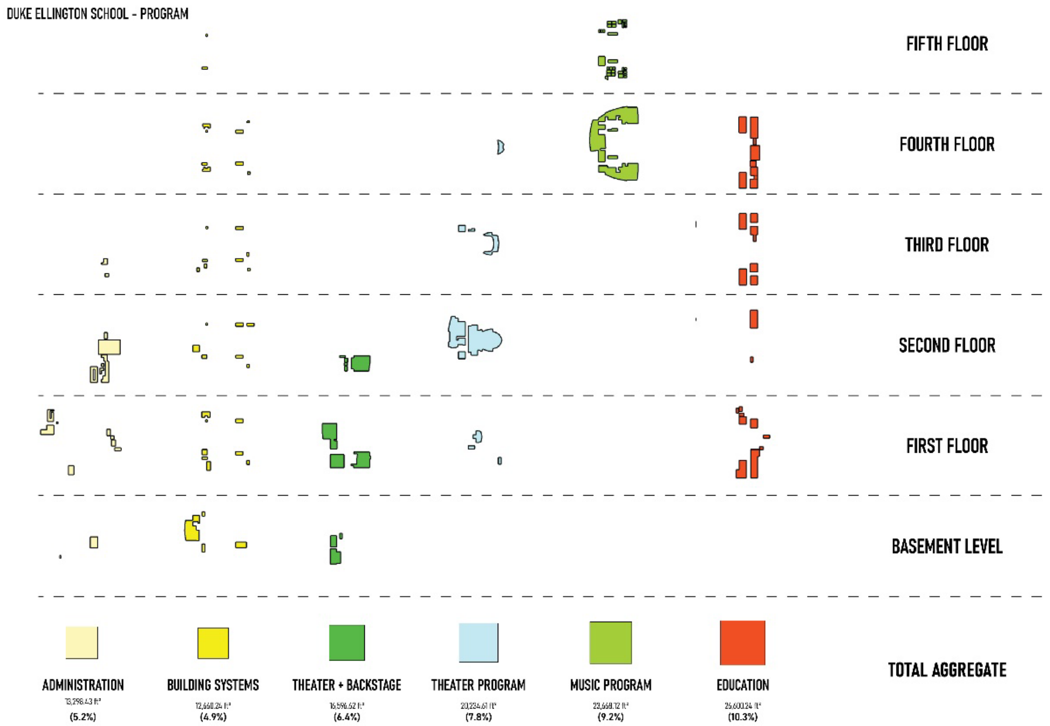


Figure 13: Diagram of Duke Ellington School program dispersion. (Source: Nick Majka)

These unique elements of the Duke Ellington School case study – the expansive educational program, and the existing site and infrastructure that was used to house the current iteration of the institution – do not distract from the excellent music-influenced design and deeply integrated music spaces throughout the project to provide a surplus of services for all branches of music education, practice, and production. Even through the disparity between proposed scale of this thesis project and the Duke Ellington School, this case study can provide a great glimpse into one successful solution to the problem of allocating spaces and how the hierarchy of program elements is constructed in a building of this typology. Namely, the most intriguing and relevant pieces of this program layout are the central performance theater near the main entry with an abundance of supplementary spaces along the edges for show production and set design and construction, along with the music practice and recording spaces being elevated from the ground floor.

Figure 14: Duke Ellington School exterior.

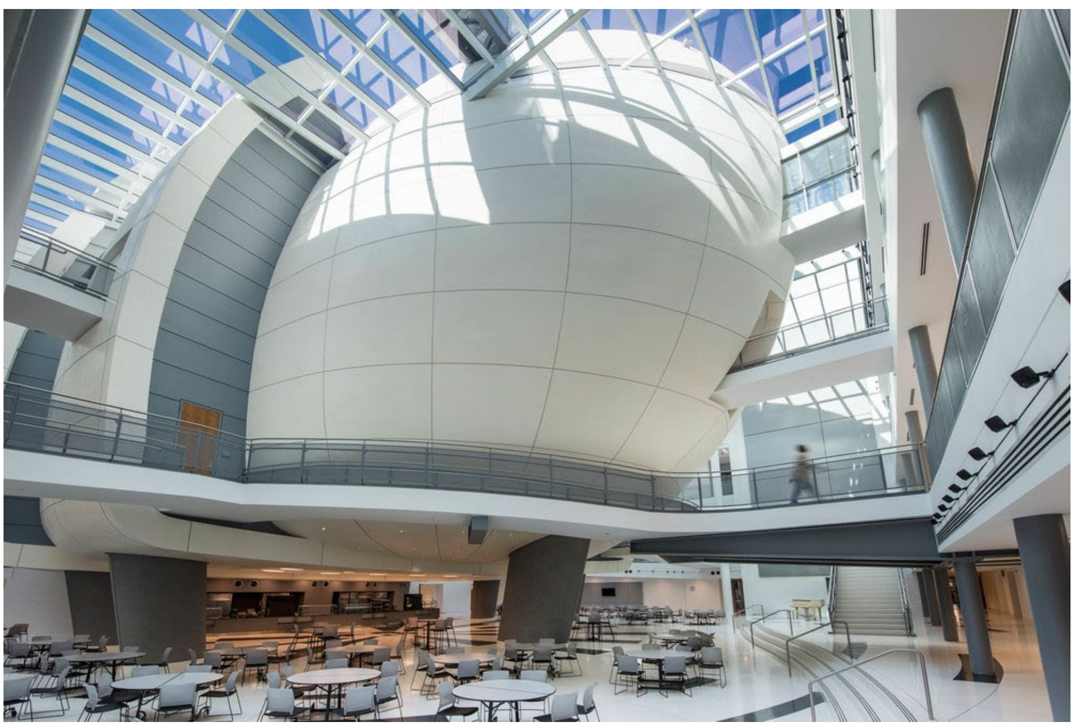


Figure 15: Duke Ellington School interior.

Berklee College of Music, Boston, MA

The Berklee College of Music by William Rawn Associates, built in 2014, is an interesting case study of a flexible music performance space and common area for students with multiple floors of residences halls built above. This project takes a similar program to the Duke Ellington School in Washington, D.C. and presses it down into a smaller package, allowing it to fit within the more regular urban fabric of its site in Boston with which the prior precedent did not have to wrestle.

Figure 16: Berklee College of Music exterior. (Source Bruce T. Martin Photography)

The cost of this shrinking of the building footprint – and the constraint of residential units being built above, where typically the project would have expanded upwards when it could not outwards – is the requirement that many common spaces be flexible into multiple uses. For example, the cafeteria space on the second level serves food and seats residents during daytime hours, providing a social space and lounge for students. However, at night the space is able to be transformed into a performance venue for music and theater acts, while the upper level serves as a balcony for extra viewing. Along with the key arts program, Berklee College of Music also has a gym, study rooms, music technology studios, lounges, and public-facing retail along the first four floors – the floors not included in the residential units – all packed into a footprint of only 14,000 ft². This development pushes the magnitude of program that can fit into a limited site within an urban environment while also projecting outwardly to the public to interact with the street as well.

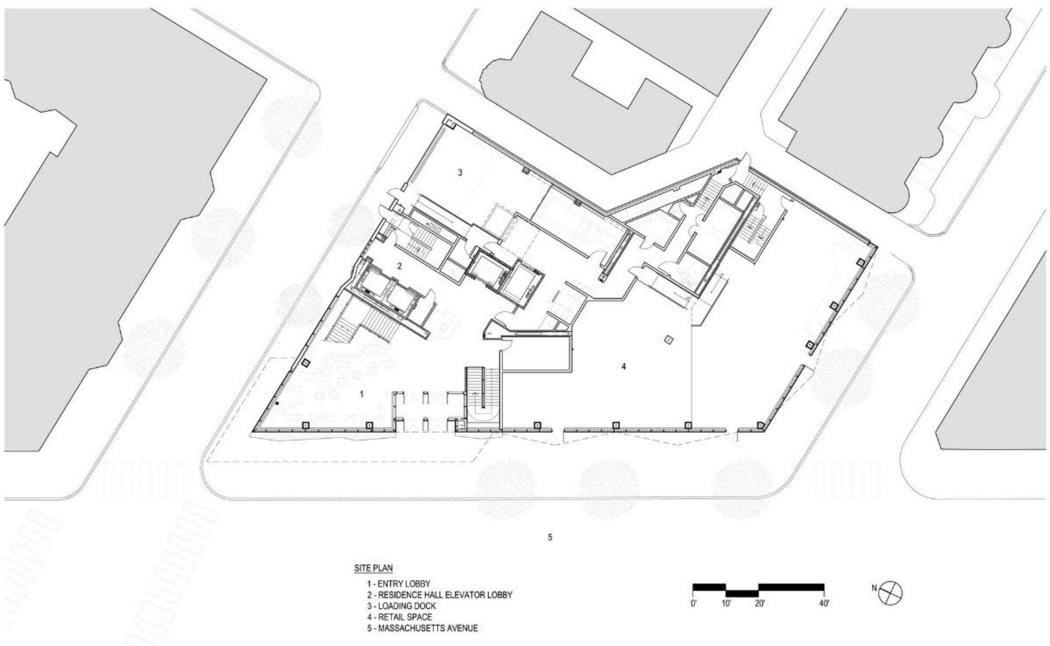


Figure 17: Site Plan of Berklee College of Music.

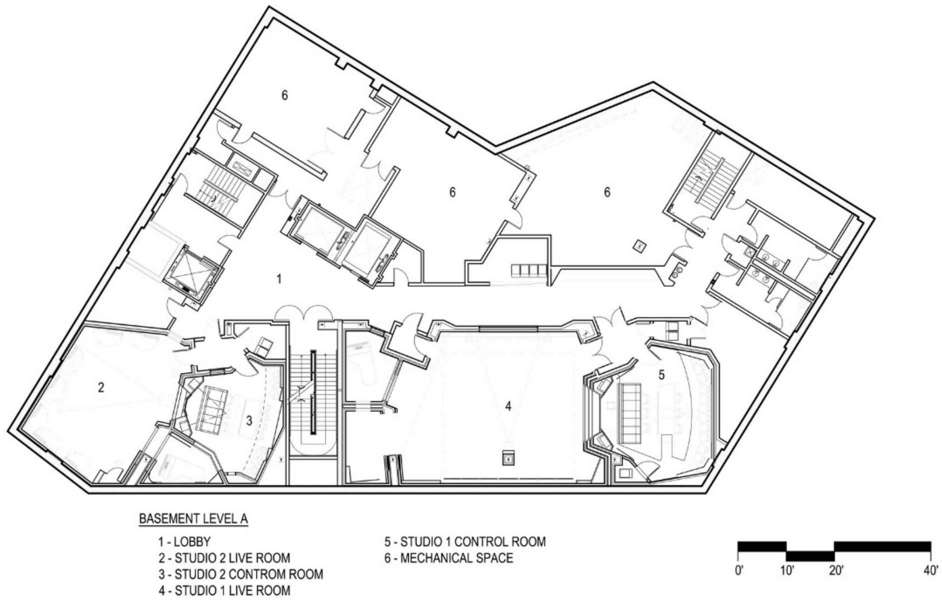


Figure 18: Berklee College of Music flex space Plan A.

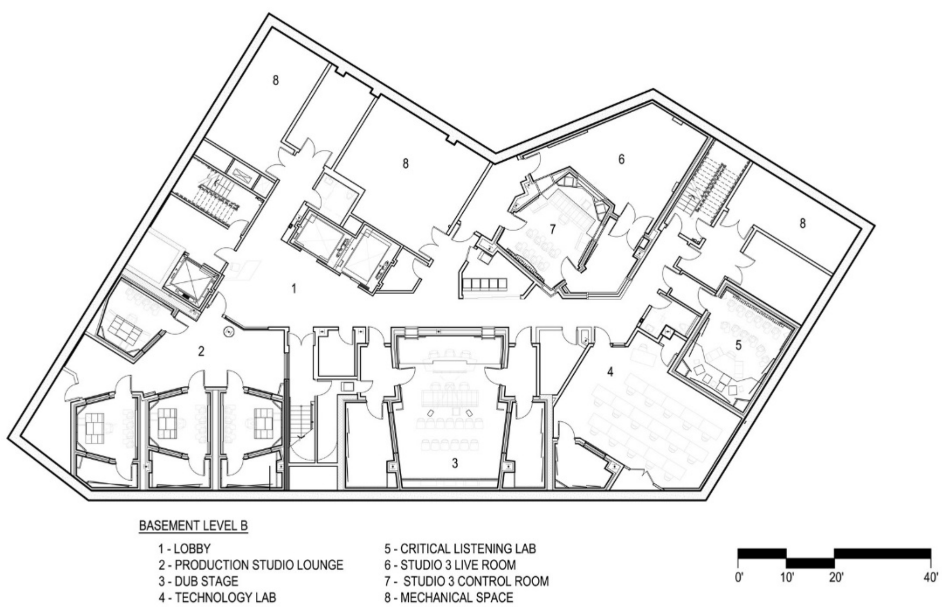
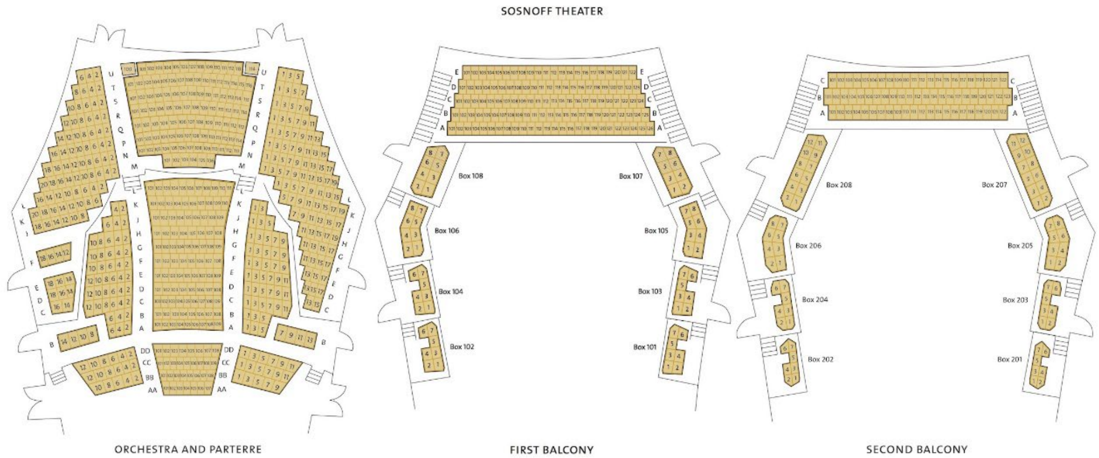


Figure 19: Berklee College of Music flex space Plan B.

Fisher Center at Bard College, New York



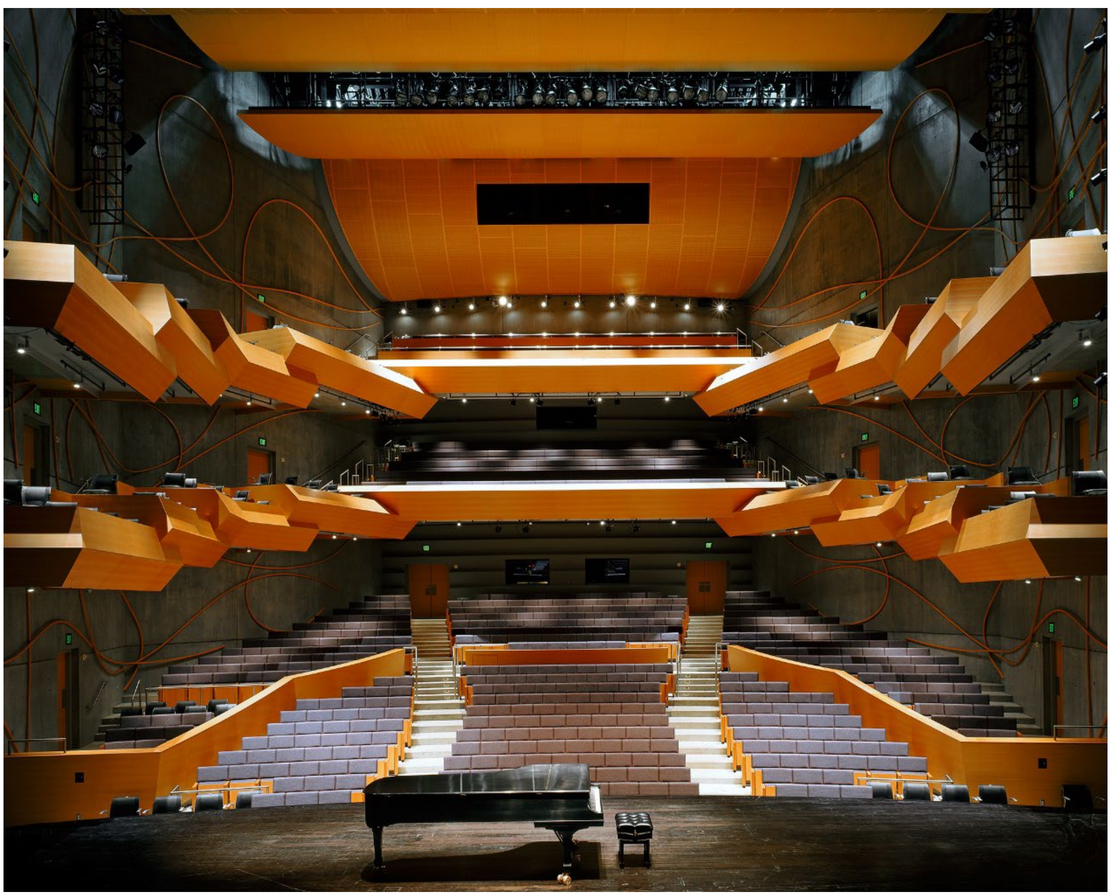
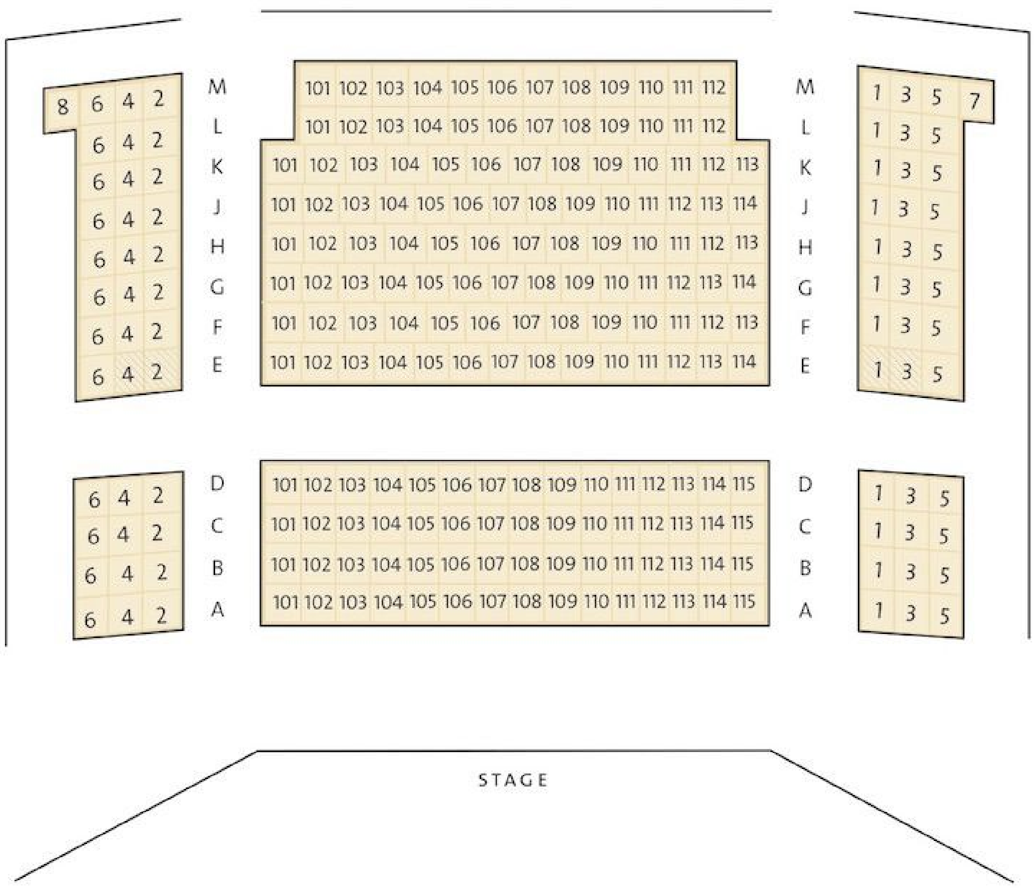


Figure 20: Sosnoff Theater at Bard College. (Source: fishercenter.bard.edu)

Designed by Frank Gehry and completed in 2003, the Fisher Center at Bard College in Annandale-on-Hudson, New York is a great example of an elegant design wrapped around a variety of high-end facilities. Clad almost entirely in angel hair stainless steel panels, the 107,000 ft² project's undulating exterior provides a stark metallic contrast to the backing wood on site. Inside, the main two larger theaters provide the primary organization for the spatial sequence, with dance and theater studios – namely the smaller Resnick flex space, and "The Old Gym" black box theater – are dotted around them.



LUMA THEATER

Figure 21: LUMA Theater at Bard College. (Source: fishercenter.bard.edu)

The crucial impact of this project on this thesis' research is the size of these theaters and their capacities, not so much the organization and holistic program that was found in prior case studies. The larger of the two theaters, Sosnoff Theater, seats nearly 800 in the audience, and provides a more complex and intimate experience for a wide variety of performance types, from music, to improv, to rehearsed theater, and opera. The smaller of the two main spaces, the LUMA Theater, seats closer to 200 within a black box typology, allowing for flexibility in stage configuration and usage, even providing a space for student-led projects and independently led outside group work. The variety in scope and style of provided spaces allow for a lot of flexibility in what the project can offer its users, creating a venue that can adapt to current needs and perform well in a multitude of circumstances.

Chapter 4: Site Selection

Site Characteristics

The nature of this project leans itself to a heavily urban environment with high walkability and the ability to be discovered by passersby. The program, a music-focused educational typology with public facing facilities, is best suited when the highest number of individuals have access to the site, and as the thesis posits that an additive musical experience in the urban environment will boost the happiness of city residents, as well as have a positive effect on all who are impacted by the proposed typology, the greater the number of individuals that this project can reach the more successful the proposal would become. As such, Population Density, Walkability, and Urbanity highlight the list of site criteria for selection. The higher the number of people who can take part in the outdoor performances and walk past the site and experience the sound of the project the more successfully this thesis will perform.

Site Matrix
Architectural Harmony

Nick Majka

	K Street NW, Washington D.C. 56,600 ft²	Cobb Park, Washington D.C. 47,000 ft²	14th Street NW + S Street NW, Washington D.C. 26,000 ft²
Population Density	1	2	3
Walkability	1	2	3
Urban	3	2	1
Music Culture	2	1	3
Ambient Noise (Quiet = Better)	1	2	3
Economic Growth	2	3	1
Access to Amenities	3	1	2
Resident Happiness	0	0	0
Climate	2	2	2
Green Space	1	2	3
Pollution	1	2	3
Access to Light	1	3	2
Total	18	22	26

Figure 22: Example of initial Site Selection matrix iteration, with selection criteria and scoring. (Source: Nick Majka)

Ambient Noise, Economic Growth, and Access to Amenities sit in the second tier of importance in the selection of a site. Ambient Noise levels must be low enough, or manageable, in order to allow the exterior environment to be enjoyable and for the music to maintain as the central focus. Heavy traffic, industrial typologies, and loud trains are all elements that would negatively impact a potential site. Economic Growth and Access to Amenities are tied tightly into Walkability, in that a site with a large amount of retail and commercial spaces in a well-developed neighborhood would provide a safer and more pleasurable walking experience that would positively impact the discovery and placemaking aspects of the proposed project.

The remaining criterion for selecting a successful site are Climate, Resident Happiness, Access to Light, and Pollution. Climate and Pollution lean directly into outdoor comfort, where the less comfortable the site may be for walking and outdoor experiences, the less favorable it would be as a candidate. Resident Happiness is an important metric but can be interpreted along two avenues. Lower Resident Happiness could imply that the site would benefit greatly from a music-centric typology that improves the street experience. Higher Resident Happiness could imply that the proposed thesis project finding its site there would be used to its greatest extent and would be appreciated instead of ignored. Both lenses through which these criteria could be seen are plausible and would require greater study into specific site during the selection process.

<u>L St. NW at 10th St. NW, Washington D.C.</u>

Figure 23: Site 1 Diagram. (Source: Nick Majka)

This potential site lands on the smaller side of possibilities, totaling a lot area of 8,100 ft². However, what it lacks in size its makes up for in context and location. This site is situated directly north-west of the Mount Vernon Convention Center in Washington, D.C., in a fairly walkable neighborhood and with access to facilities in all directions. As a corner site, public exposure and the ability for the project to reach out and interact with the street are both high. The largest drawback, aside from the size of the lot, lies on the opposing two corners of the lot, with the imposing multi-family projects providing the backdrop from L St. and 10th St. The project would have the opportunity to fit nicely into a comfortable and intimate context, while battling the challenges of vertical schooling and fitting a performance space into a smaller footprint.

Swann St. NW, Washington D.C.

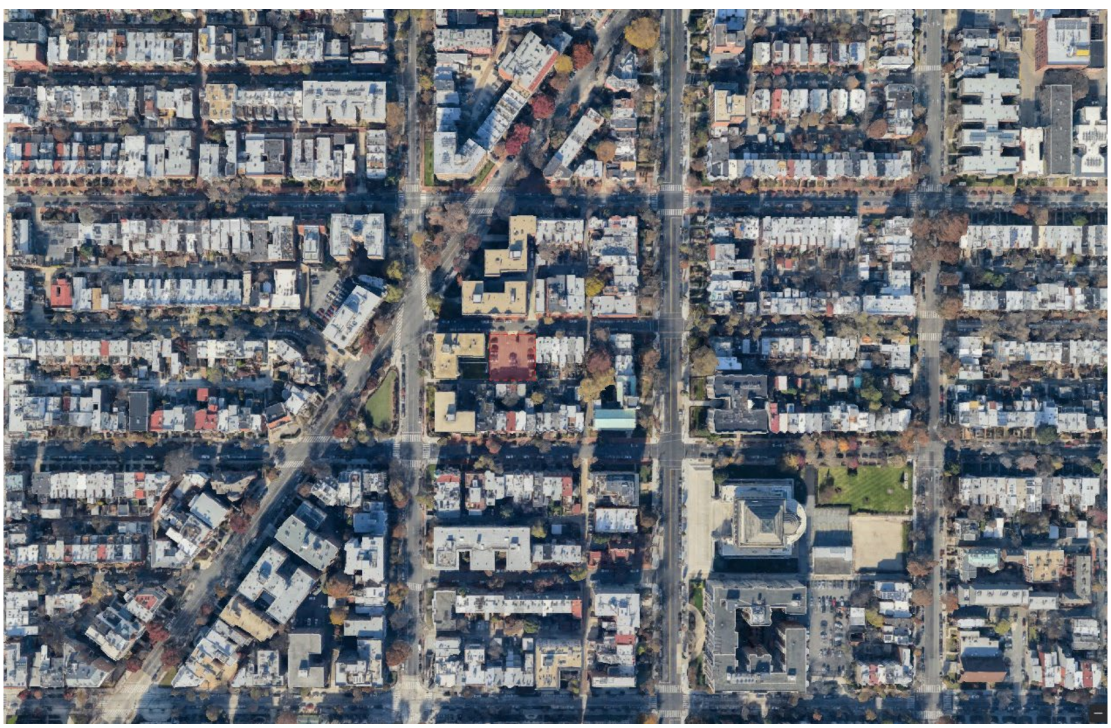


Figure 24: Site 2 Diagram (Source: Nick Majka)

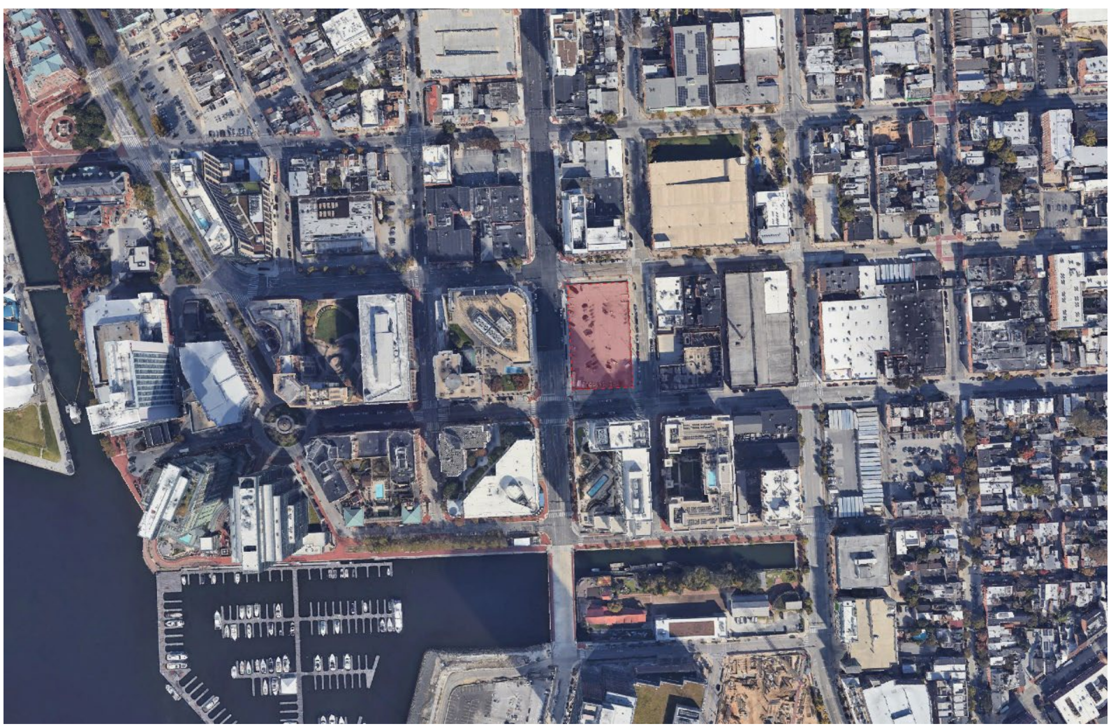
Proposed site 2, having a lot size of 9,115 ft², benefits from a multitude of typologies in its immediate context, but sits more hidden from view as opposed to site 1. Nestled between multi-family, single family, and retail along three sides, the site has only one exposure that can make an impact on the street experience. This unique position, however, does provide the opportunity to fill more of a "hidden gem" role in the urban fabric, allowing passersby to discover the project instead of having it serve as a prominent feature within the urban fabric. Walkability and intimacy are high in this proposed site, but the drawbacks of its hidden position along a side street may impact the project too negatively to serve as an ideal location.

Rhode Island Ave. NW at R St. NW, Washington D.C.

Figure 25: Site 3 Diagram (Source: Nick Majka)

Jumping in scale, site 3 is about 14,710 ft² and sits along a main artery in Washington D.C.: Rhode Island Ave. The intersection along which it is located, and where the site is exposed on three sides, manages a heavy load of daily traffic through the city, and contains important structures within the city itself, including Shaw Library and a multi-family residential retrofitted structure to its south. This site enjoys a healthy mix of typologies in its immediate context, ranging from retail, institutional, and multi-family, while the roadways are so heavily used that walkability and availability of transport nearby are very high. This location is heavily noticeable and highly public, both very positive impacts on the proposed thesis project, and would immediately allow the new structure to influence the surrounding context and city as a whole.

Fleet St., Fells Point, Baltimore, MD



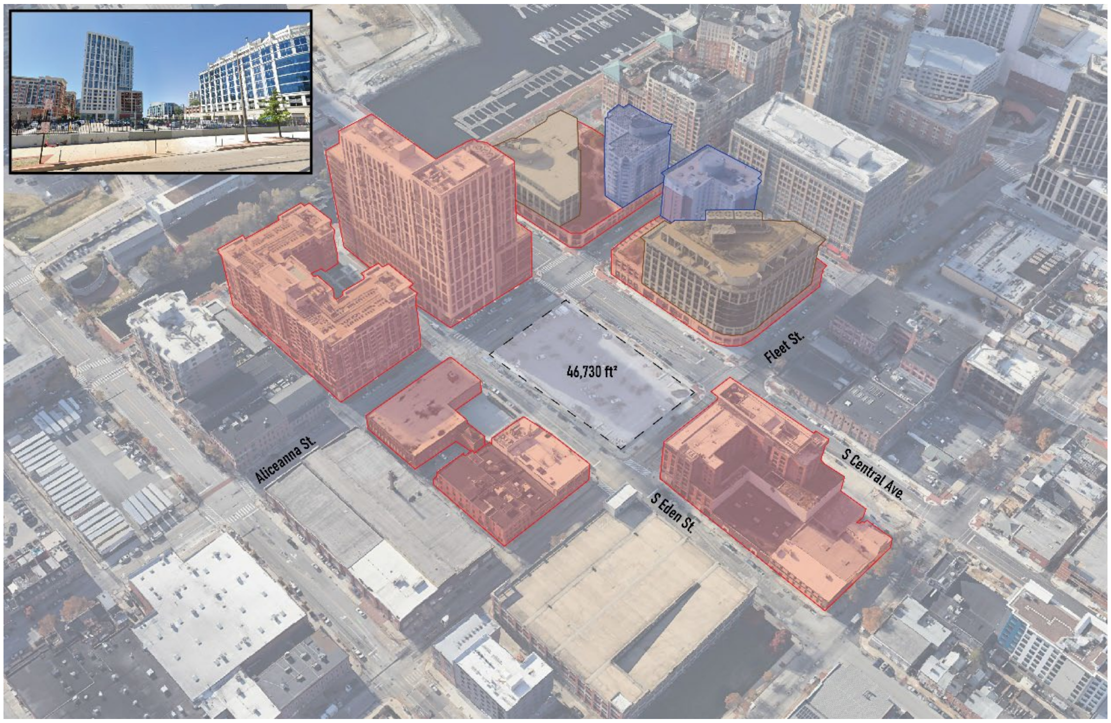


Figure 26: Site 4 Diagram (Source: Nick Majka)

Looking at a site outside of Washington, D.C., this standalone proposed site is also much larger in scale than the previous proposals, sitting near 46,730 ft². The project benefits from 360° exposure and a variety of economically valuable contextual usage types. In only the immediate context, the site is near multi-family residential, commercial, retail, and institutional typologies and is positioned in the extremely walkable and well-developed Baltimore neighborhood of Fells Point. The scale of this site allows for the thesis proposal's program to expand in scope if necessary and would permit a spacious on-site garden or other outdoor space for impromptu performances.

Chapter 5: The Broad-View of Process

Section 1

At its most general, this thesis will be performed across three main phases: Interpretive Process, Direct Connections Between Music and Architecture, and Successful Sound Design. The goal of this thesis is not only to create and design *from* music and sound, but to effectively create highly functional and diverse soundscapes within the proposed typology *for* music and sound. Musical form, programmatic spaces, and material choices will all be selected and optimized to both create a physical structure that can be seen as the physical form of music, but also a series of spaces that are designed with sound at the forefront.

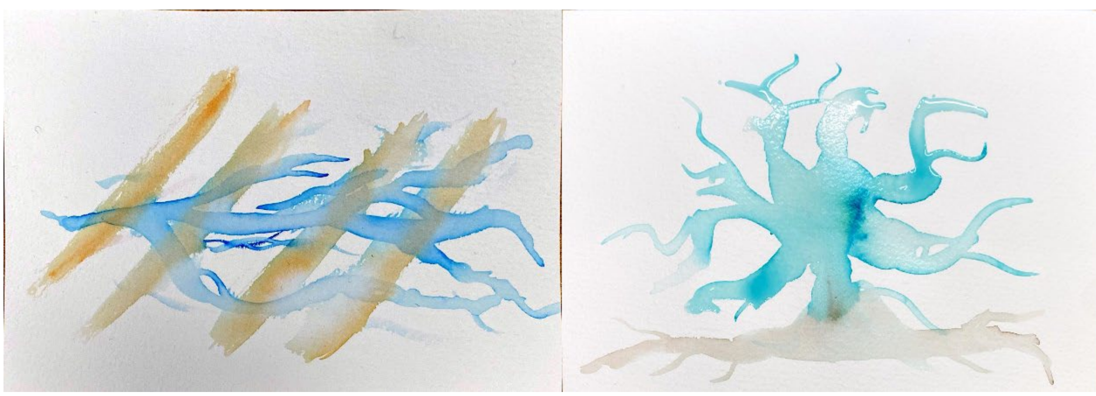


Figure 27: Initial explorations of watercolor as a medium for process.

The first of these phases will be the author's own translation of sound, music, and musical form into a physical output. The jump from music and sound directly to an architecture that must operate and provide for its users is a chasm that can be divided into smaller leaps. For this reason, an intermediate step will be used to bridge the gap. The interpretation of music in its most pure physical form will most easily be found in art. The possible artistic mediums are wide in scope, but the first step in this process is finding a method that effectively transforms sound and music into a visual representation – something that can aid the interpretation of material form from that which is unseen. Watercolor painting and pencils are a medium that would allow for effective layering of emotional responses, instrument choices, and harmonies within music, producing outputs that provide depth and complexity of visual representation and offering plenty of material to make the next step from artistic form to architectural form. Graphite or charcoal sketching is an option that begins to swing in the opposite direction, requiring less reliance on color to portray layers and composition, while instead allowing for crisper and more definite linework that can illustrate repetition and rhythm easily. Where the abstractness of watercolor is lost, the simplicity and sharpness of pencil or charcoal can allow for a visual representation more akin to architectural schematic design, creating an easier transition into the later phases of design where much of the abstraction of audio to visual may already be removed and solved. Finally, aside from any direct blending of the mentioned mediums, there is the final option: markers and acrylic paints. These mediums have a bit more pigment control than watercolor and bring much more of the ability to fine line from pencils, but allow for color to represent layers, emotions, and instrumentation. Markers and acrylics find a sort of middle ground between the two aforementioned mediums, not quite excelling at what is so great about the others, but not failing in other areas quite as much either. Overall, the medium selection is a step in the process, and whichever ends up chosen as the method to translate music into physical art does not affect the next step in the sequence.

Section 2

Once the medium is selected, the second half of bridging the gap between music and architecture can be made. In this phase the pure physical artistic form of music can be translated into a functional and usable series of architectural forms, molded and bent into shape depending on what is necessary for each design element and space to function appropriately. This is also the step where decisions relating to connected terminology can be made. Rhythm, texture, layering, pattern, structure, harmony, and articulation are all terms that find homes in both worlds of music and architecture. The relationship between their meanings and usages can provide resources that aid the decision-making process and add another facet of strong connections between the source material and the product. These terms can help when thinking about spatial sequencing and promenade experience, as well as façade treatment, structure design, and programmatic layout.

Section 3

The final phase of the design process will be the creation of an effective series of soundscapes. Material choices and careful room proportions will be key to a successful design *for* sound. Amplification and attenuation of desired frequencies is the core of this phase, with the material selections playing a large part in the characteristics of certain spaces. Performing spaces will want to accentuate the activities, reducing reverberation time to avoid echoes, while more relaxed spaces such as study, education, and practice rooms, as well as tightly sound controlled program such as production rooms, will want to seal off outdoor noises and reduce ambient sounds to appropriate levels. Keeping program elements closer or further to performance spaces depending on their tolerance to sound carrying through will be a key piece of the puzzle as well. Café and lobby spaces would appreciate ambient music performances to carry under conversation or personal work, while education and practice rooms would much prefer to be controlled and resistant to outside noise. Production will be a special case, as this program element needs the extreme cases in both interior and exterior control, with no outside noise creeping in, and interior conditions not allowing for unwanted reverberations and phasing issues.

SOUND LEVELS	DECIBEL EFFECTS	dB	SPEECH EFFECTS	COMPARE TO 70 dB	COMPARATIVE EXAMPLES OF NOISE LEVELS
Loudest Sounds Possible	Permanent Hearing Loss	194	Speech Impossible		Shock Waves
Deafening Sounds	Eardrum Rupture	150	Speech Impossible		Jet Take-Off / Cap Gun / Pistol
	Possible Immediate Hearing Loss	140	Nausea After Minutes		Aircraft Carrier Deck / Rifle / Fire Cracker
	Pain Threshold / Eardrum Vibration	130	Loudest Recommended Exposure w/o Protection		Propeller Aircraft / Balloon Pop / Jackhammer
	Discomfort Threshold / Painfulness	120	Maximum Vocal Effort	32 x Louder than 70 dB	Oxygen Torch / Pneumatic Hammer / Thunderclap
Extremely Loud Sounds	Average Human Pain Threshold	110	Unintelligible	16 x Louder than 70 dB	***Live Rock Music*** / Riveting Machine
Very Loud Sounds	Serious Hearing Impairment (8 hr)	100	Unintelligible	8 x Louder than 70 dB	Lawn-Mower / Disco
	Likely Hearing Impairment (8 hr)	90	Conversation Nearly Impossible	4 x Louder than 70 dB	***Motorcycle*** / ***Diesel Truck*** / Blender / Construction Site
	Possible Hearing Impairment (8 hr)	80	Conversation Difficult	2 x Louder than 70 dB	Freight Train at 15m / ***Whistle*** / Hair-Dryer
Loud Sounds	***Arbitrary Base of Comparison***	70	Raised Voice Conversation	70 dB	Vacuum / Shower / ***Heavy Street Noise***
Low Sounds	No Detrimental Effects	60	Restaurant Conversation	1/2 x As Loud As 70 dB	***Office*** / ***Laser Printer*** / ***Light Street Noise***
	No Detrimental Effects	50	Home Conversation	1/4 x As Loud As 70 dB	***Refrigerator*** / ***Moderate Rainfall*** / ***Quiet Suburbs***
Faint Sounds	No Detrimental Effects	40	Quiet Conversation	1/8 x As Loud As 70 dB	***Library*** / Private Office / ***Lowest Limit of Ambient Urban Noise***
Very Faint Sounds	No Detrimental Effects	30	Whisper	1/16 x As Loud As 70 dB	Bedroom / Rural Area
	No Detrimental Effects	20	Barely Audible Sounds		Empty Theatre / Watch Ticking / Mosquito
Quiet Sounds	No Detrimental Effects	10	Barely Audible Sounds		Breathing / Pin Drop from 1cm at 1m / Rustling Leaves
Weakest Sounds Possible	No Detrimental Effects	0	Silence		Absence of Sound

Figure 28: Chart depicting various decibel levels, their effects on hearing and speech, and examples of what produces comparable Sound Pressure Levels.

Floor materials	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Carpet	0.01	0.02	0.06	0.15	0.25	0.45
Concrete (unpainted, rough finish)	0.01	0.02	0.04	0.06	0.08	0.1
Concrete (sealed or painted)	0.01	0.01	0.02	0.02	0.02	0.02
Marble or glazed tile	0.01	0.01	0.01	0.01	0.02	0.02
Vinyl tile or linoleum on concrete	0.02	0.03	0.03	0.03	0.03	0.02
Wood parquet on concrete	0.04	0.04	0.07	0.06	0.06	0.07
Wood flooring on joists	0.15	0.11	0.1	0.07	0.06	0.07

Seating Materials	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Benches (wooden, empty)	0.1	0.09	0.08	0.08	0.08	0.08
Benches (wooden, 2/3 occupied)	0.37	0.4	0.47	0.53	0.56	0.53
Benches (wooden, fully occupied)	0.5	0.56	0.66	0.76	0.8	0.76
Benches (cushioned seats and backs, empty)	0.32	0.4	0.42	0.44	0.43	0.48
Benches (cushioned seats and backs, 2/3 occupied)	0.44	0.56	0.65	0.72	0.72	0.67
Benches (cushioned seats and backs, fully occupied)	0.5	0.64	0.76	0.86	0.86	0.76
Theater seats (wood, empty)	0.03	0.04	0.05	0.07	0.08	0.08
Theater seats (wood, 2/3 occupied)	0.34	0.21	0.28	0.53	0.56	0.53
Theater seats (wood, fully occupied)	0.5	0.3	0.4	0.76	0.8	0.76
Seats (fabric-upholsterd, empty)	0.49	0.66	0.8	0.88	0.82	0.7
Seats (fabric-upholsterd, fully occupied)	0.6	0.74	0.88	0.96	0.93	0.85

Reflective wall materials	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Brick (natural)	0.03	0.03	0.03	0.04	0.05	0.07
Brick (painted)	0.01	0.01	0.02	0.02	0.02	0.03
Concrete block (coarse)	0.36	0.44	0.31	0.29	0.39	0.25
Concrete block (painted)	0.1	0.05	0.06	0.07	0.09	0.08
Concrete (poured, rough finish, unpainted)	0.01	0.02	0.04	0.06	0.08	0.1
Doors (solid wood panels)	0.1	0.07	0.05	0.04	0.04	0.04
Glass (1/4" plate, large pane)	0.18	0.06	0.04	0.03	0.02	0.02
Glass (small pane)	0.04	0.04	0.03	0.03	0.02	0.02
Plasterboard (12mm (1/2") paneling on studs)	0.29	0.1	0.06	0.05	0.04	0.04
Plaster (gypsum or lime, on masonry)	0.01	0.02	0.02	0.03	0.04	0.05
Plaster (gypsum or lime, on wood lath)	0.14	0.1	0.06	0.05	0.04	0.04
Plywood (3mm(1/8") paneling over 31.7mm(1-1/4") airspace)	0.15	0.25	0.12	0.08	0.08	0.08
Plywood (3mm(1/8") paneling over 57.1mm(2-1/4") airspace)	0.28	0.2	0.1	0.1	0.08	0.08
Plywood (5mm(3/16") paneling over 50mm(2") airspace)	0.38	0.24	0.17	0.1	0.08	0.05
Plywood (5mm(3/16") panel, 25mm(1") fiberglass in 50mm(2") airspace)	0.42	0.36	0.19	0.1	0.08	0.05
Plywood (6mm(1/4") paneling, airspace, light bracing)	0.3	0.25	0.15	0.1	0.1	0.1
Plywood (10mm(3/8") paneling, airspace, light bracing)	0.28	0.22	0.17	0.09	0.1	0.11
Plywood (19mm(3/4") paneling, airspace, light bracing)	0.2	0.18	0.15	0.12	0.1	0.1

Absorptive wall materials	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Drapery (10 oz/yd2, 340 g/m2, flat against wall)	0.04	0.05	0.11	0.18	0.3	0.35
Drapery (14 oz/yd2, 476 g/m2, flat against wall)	0.05	0.07	0.13	0.22	0.32	0.35
Drapery (18 oz/yd2, 612 g/m2, flat against wall)	0.05	0.12	0.35	0.48	0.38	0.36
Drapery (14 oz/yd2, 476 g/m2, pleated 50%)	0.07	0.31	0.49	0.75	0.7	0.6
Drapery (18 oz/yd2, 612 g/m2, pleated 50%)	0.14	0.35	0.53	0.75	0.7	0.6
Fiberglass board (25mm(1") thick)	0.06	0.2	0.65	0.9	0.95	0.98
Fiberglass board (50mm(2") thick)	0.18	0.76	0.99	0.99	0.99	0.99
Fiberglass board (75mm(3") thick)	0.53	0.99	0.99	0.99	0.99	0.99
Fiberglass board (100mm(4") thick)	0.99	0.99	0.99	0.99	0.99	0.97
Open brick pattern over 75mm(3") fiberglass	0.4	0.65	0.85	0.75	0.65	0.6
Pageboard over 25mm(1") fiberglass board	0.08	0.32	0.99	0.76	0.34	0.12
Pageboard over 50mm(2") fiberglass board	0.26	0.97	0.99	0.66	0.34	0.14
Pageboard over 75mm(3") fiberglass board	0.49	0.99	0.99	0.69	0.37	0.15
Performated metal (13% open, over 50mm(2") fiberglass)	0.25	0.64	0.99	0.97	0.88	0.92

Ceiling Material	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Plasterboard (12mm(1/2") in suspended ceiling grid)	0.15	0.11	0.04	0.04	0.07	0.08
Underlay in perforated metal panels (25mm(1") batts)	0.51	0.78	0.57	0.77	0.9	0.79
Metal deck (perforated channels,25mm(1") batts)	0.19	0.69	0.99	0.88	0.52	0.27
Metal deck (perforated channels, 75mm(3") batts)	0.73	0.99	0.99	0.89	0.52	0.31
Plaster (gypsum or lime, on masonry)	0.01	0.02	0.02	0.03	0.04	0.05
Plaster (gypsum or lime, rough finish or timber lath)	0.14	0.1	0.06	0.05	0.04	0.04
Sprayed cellulose fiber (16mm(5/8") on solid backing)	0.05	0.16	0.44	0.79	0.9	0.91
Sprayed cellulose fiber (25mm(1") on solid backing)	0.08	0.29	0.75	0.98	0.93	0.76
Sprayed cellulose fiber (25mm(1") on timber lath)	0.47	0.9	1.1	1.03	1.05	1.03
Sprayed cellulose fiber (32mm(1-1/4") on solid backing)	0.1	0.3	0.73	0.92	0.98	0.98
Sprayed cellulose fiber (75mm(3") on solid backing)	0.7	0.95	1	0.85	0.85	0.9
Wood tongue-and-groove roof decking	0.24	0.19	0.14	0.08	0.13	0.1

Miscellaneous surface material	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
People-adults (per 1/10 person)	0.25	0.35	0.42	0.46	0.5	0.5
People-high school students (per 1/10 person	0.22	0.3	0.38	0.42	0.45	0.45
People-elementary students (per 1/10 person)	0.18	0.23	0.28	0.32	0.35	0.35
Ventilating grilles	0.3	0.4	0.5	0.5	0.5	0.4
Water or ice surface	0.008	0.008	0.013	0.015	0.02	0.025

Figure 29: List of material absorption coefficients. Decimal to be interpreted as a percentage, where the closer the number is to 1, the closer the material is to absorbing 100% of sound waves.

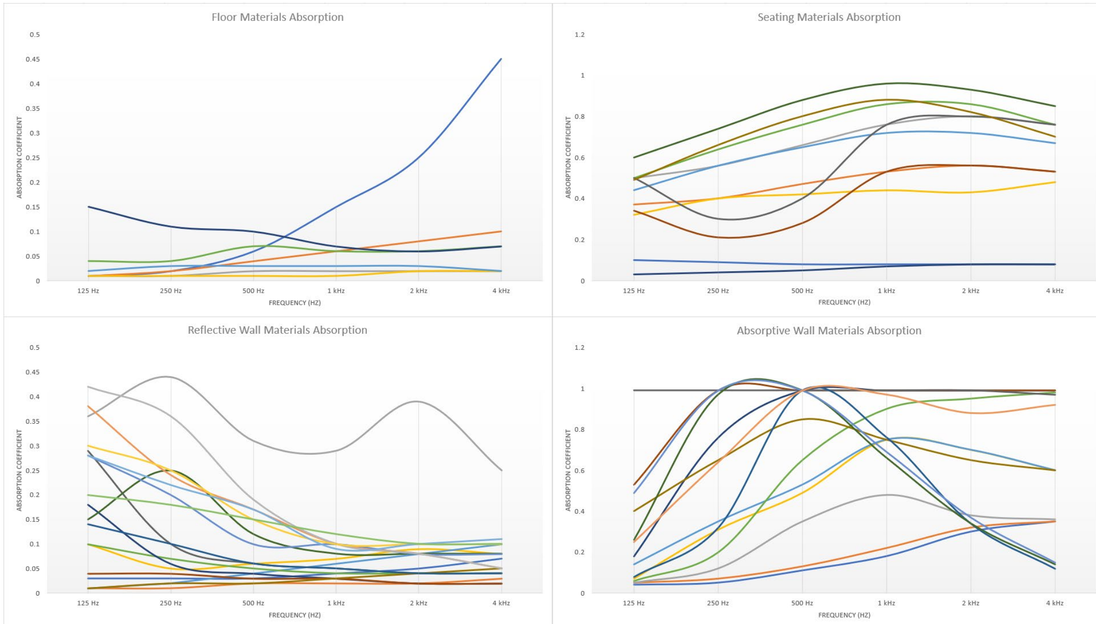


Figure 30: Graphic representation of Figure 26, data sheet of material absorption coefficients.

These considerations must be made for every element of the program, as each space has its own acoustic needs and is tolerant to a different degree of adjacent spaces. The organization and form decisions that are made previously will need to be appropriately reinforced by materiality. For this proposal to sing at its fullest potential, not only will it be necessary for it to adequately sculpt a structure from the influence and detailing of music, but the micro-decisions made near the end of the design process will need to effectively craft successful soundscapes that perform in all situations.

Chapter 6: Design Solution

Change in Methodology

It seems appropriate to begin the chapter covering the final design by explaining how the process caused changes to the core intentions of the thesis. Initially, the core essence of the thesis process revolved around the desire to design *with* music as a driver for architectural form, a very regular and well-traveled idea that could have handled one more attempt thrown into the arena. However, after various discussions with multiple committee members and reflections centered around my own experiences in the music industry, there was great emphasis placed on verbalizing what the true intentions of a project with this nature could explore, and how it could differentiate itself from a field of other designs in an oversaturated field. With those reflections, it was decided that this building could provide more and carve out a much more powerful role in the urban fabric if it would not be a structure that was built *with* music, but rather *for* music. More candidly, in my experience working with musicians and recording music, it has been a fairly regular idea that artists would select songs to suit particular venues in which they would be performing, allowing the spatial characteristics of each venue to dictate – in some way – what they would play. Instead, I wanted to see how architectural solutions could shape a concert venue specifically for each performer who would enter. One night it could be configured to optimize rock music, the next day it could be a piano recital, and that night perhaps a comedy club. I posed the question of "how could architectonic features and design decisions create adaptable spaces that bend and conform to each unique artist, and how can this space study, explore, and refine information to best be utilized by the concert venue?" This is what the thesis became, and this is the explanation for such a starkly adjacent answer to the prior question posed in previous chapters.

Design Solution

With that brief introduction complete, the exploration into the final design can begin. The project that I propose has been titled The Lab for short, and contains three main components within: The Sound Lab for research, classes, and tech demos, the Concert Hall for performances and private events, and the Public Room for street interaction, display and exhibition, and more outward-facing events. Together, these three pieces of the building's program would operate symbiotically, with the Sound Lab acting as the heart of it all. The research performed in the Sound Lab would inform how the Concert Hall and Exhibition Space could conform to each activity, and material manufacturers would be contacted to supply The Lab with wall coverings to be tested and used. Adjustable hanging panels in all spaces, and changeable wall panels in the Sound Lab and Concert Hall would allow for alterations to the spatial dimensions (and therefore, reverb time) as well as materiality on all surfaces (changing the frequency response). By altering those items, a room could effectively become more lively, more full, have richer sound, be deadened, or have any other acoustic quality per each use. If a rock concert takes place, the ceiling panels could be raised and wall materiality swapped into a bit more reflective paneling to adjust to the optimal spatial qualities. Wall materials could be made even more reflective to get more of a lively and reverberant atmosphere for perhaps a choir or classical performance.

The final component of The Lab would be the Public Exhibition Space where the prominent street corner that the site is located on could be interfaced with when desired. The corner, which houses plenty of retail from along 14th Street and two exits from the Columbia Heights metro station, received high volumes of foot traffic each day, and is the perfect location to allow ambient music from the lobby to leak into the public realm, while also allowing for selectively operating the facades to block heavy city noise when necessary or to allow the public and private zones to blend together and create what would essentially act as a "public room" along the corner. The glass volume that is the Public Exhibition space is pushed as far onto the corner as possible to emphasize the connection between the city and The Lab. What results is the Sound Lab operating as the heart of the structure, the Concert Hall as the soul, and Public Exhibition zone as the face, forming a highly-experimental typology in a very suitable region of Washington D.C., that perfectly blends both private and public usage types that have been charged with the power to adapt and flex to the needs at the time. A living and breathing Sound Lab that will enhance the urban fabric and positively put its stamp on the lives of anyone who experiences it.

Final Boards

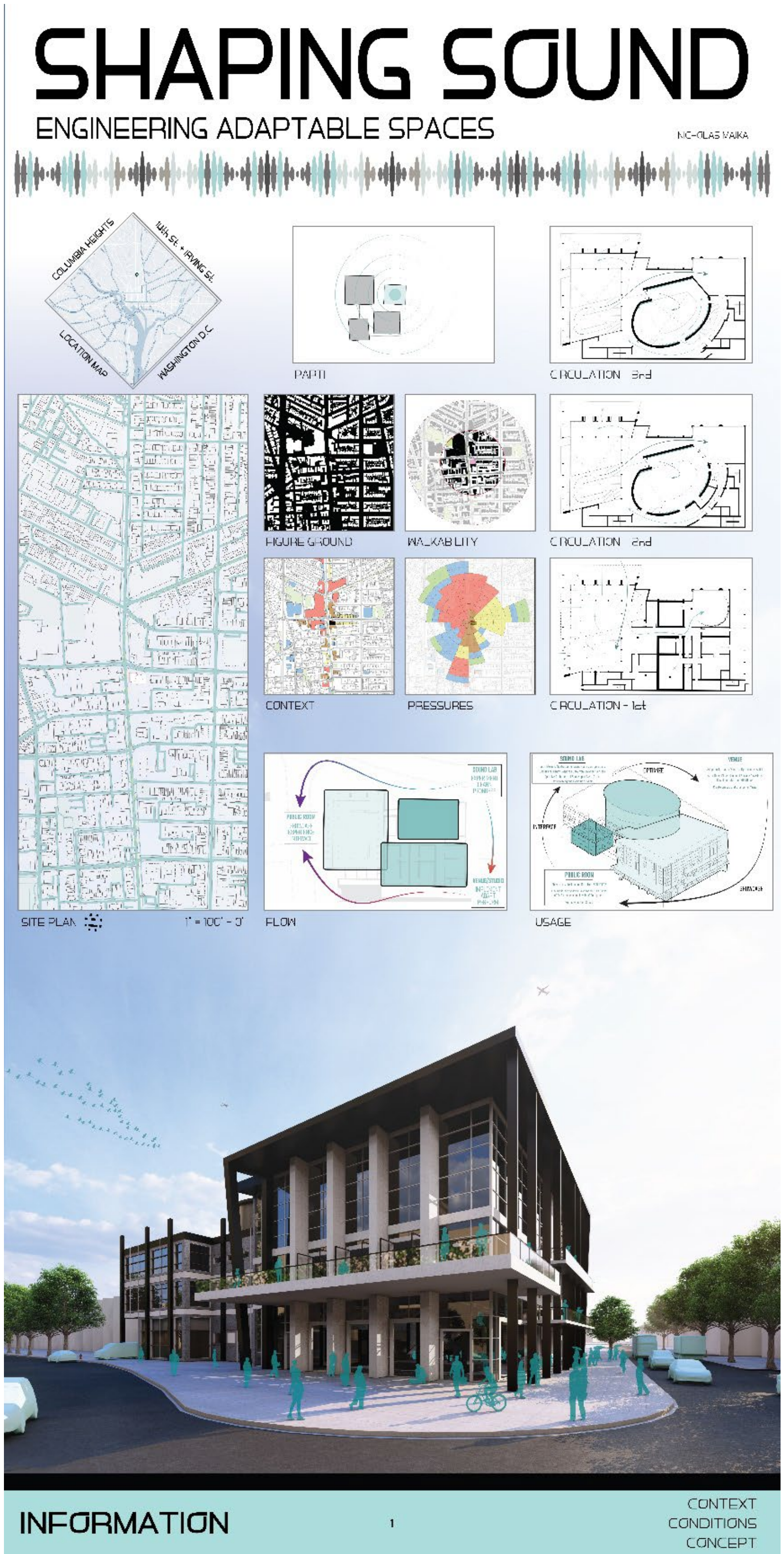


Figure 31: Final Board 1 (Source: Nick Majka)

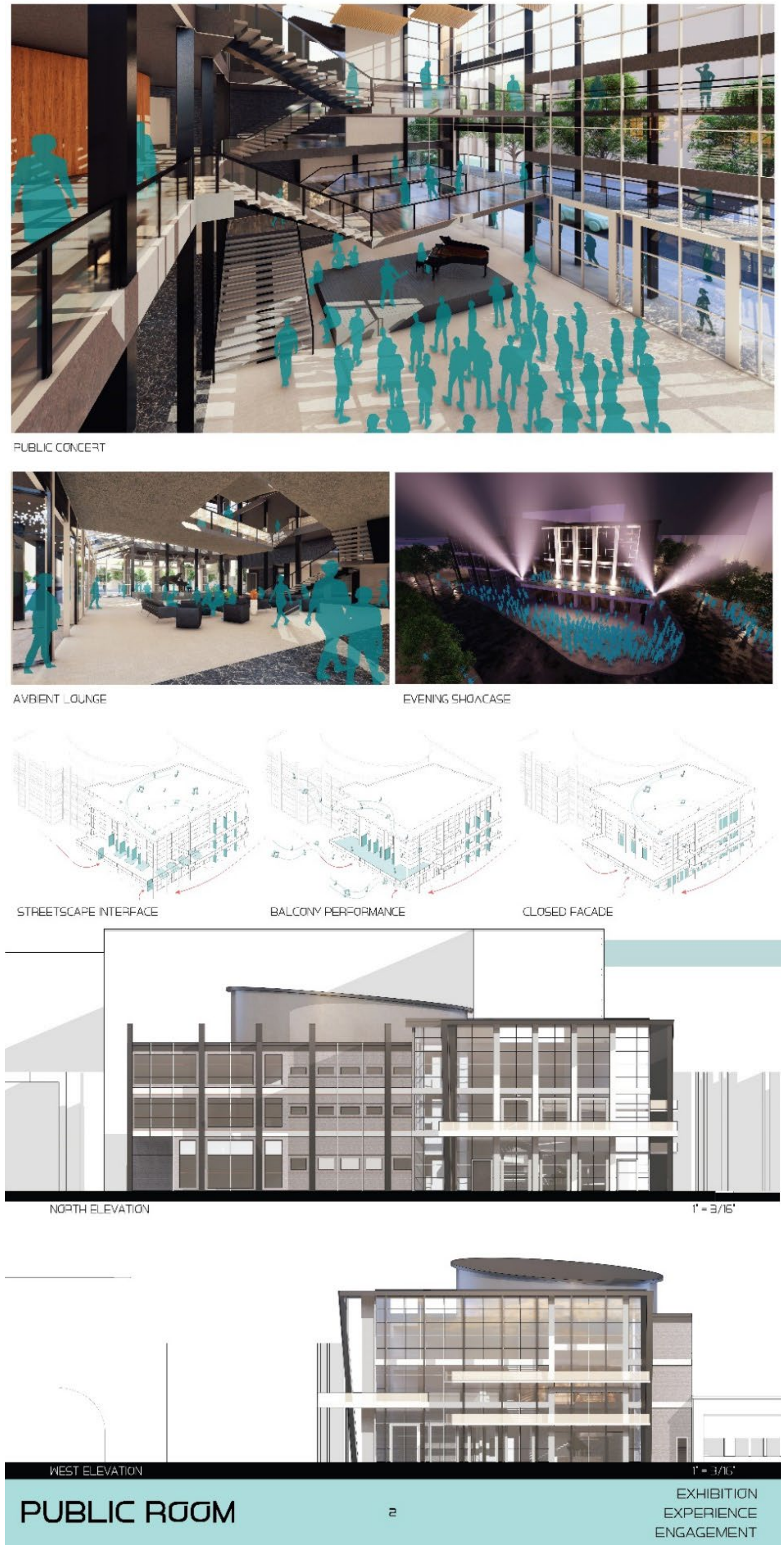


Figure 32: Final Board 2 (Source: Nick Majka)

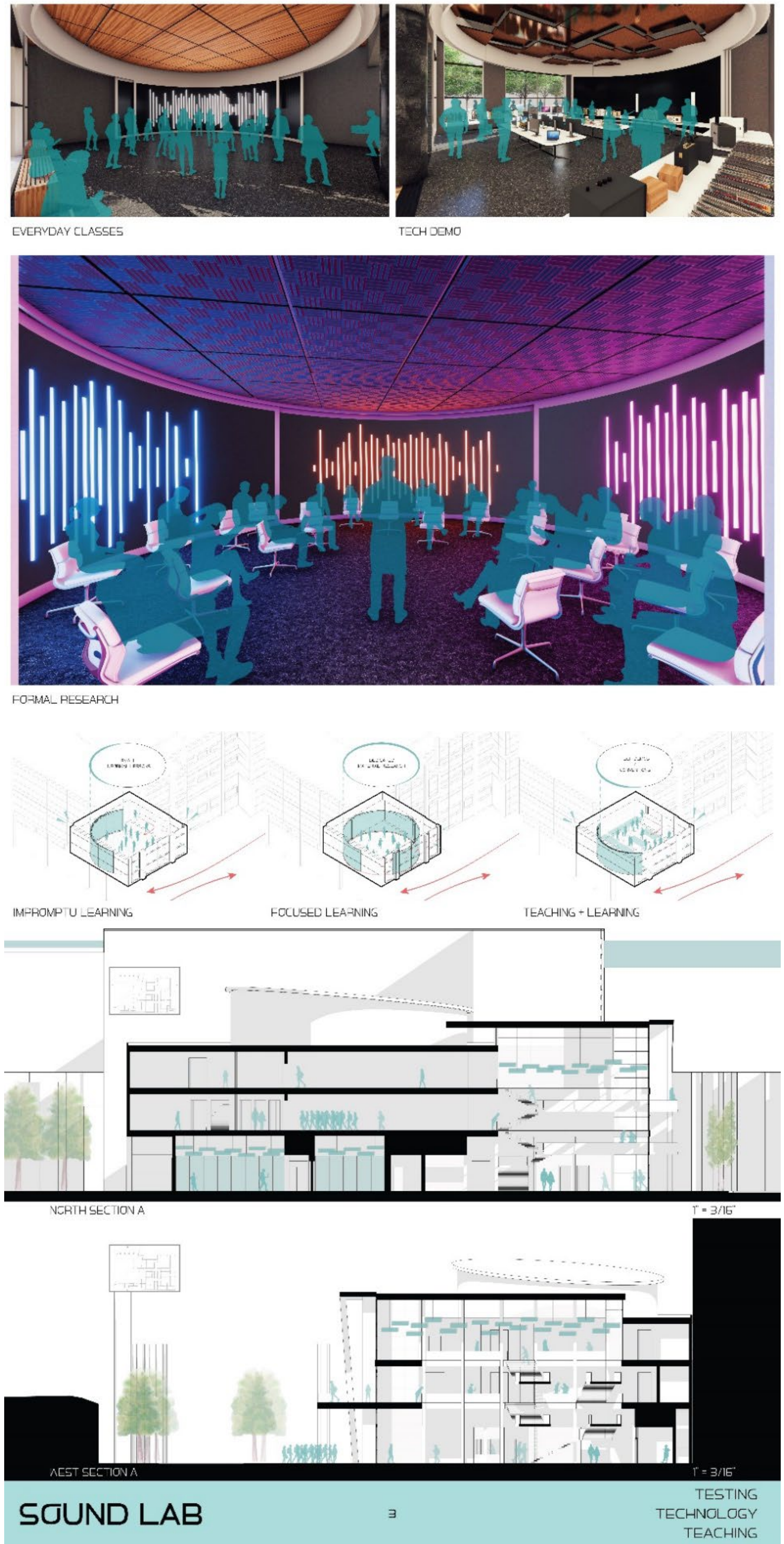


Figure 33: Final Board 3 (Source: Nick Majka)

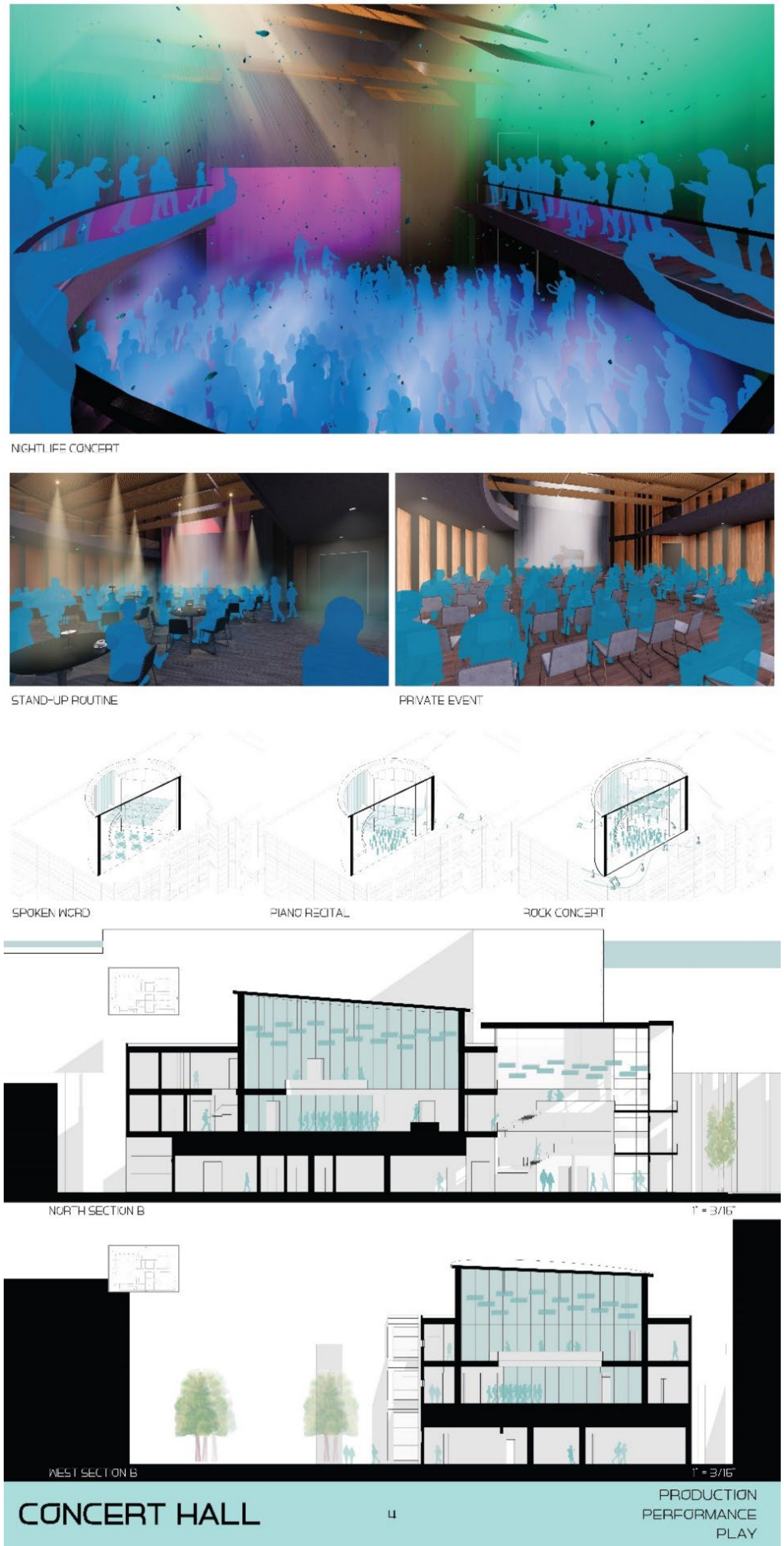


Figure 34: Final Board 4 (Source: Nick Majka)

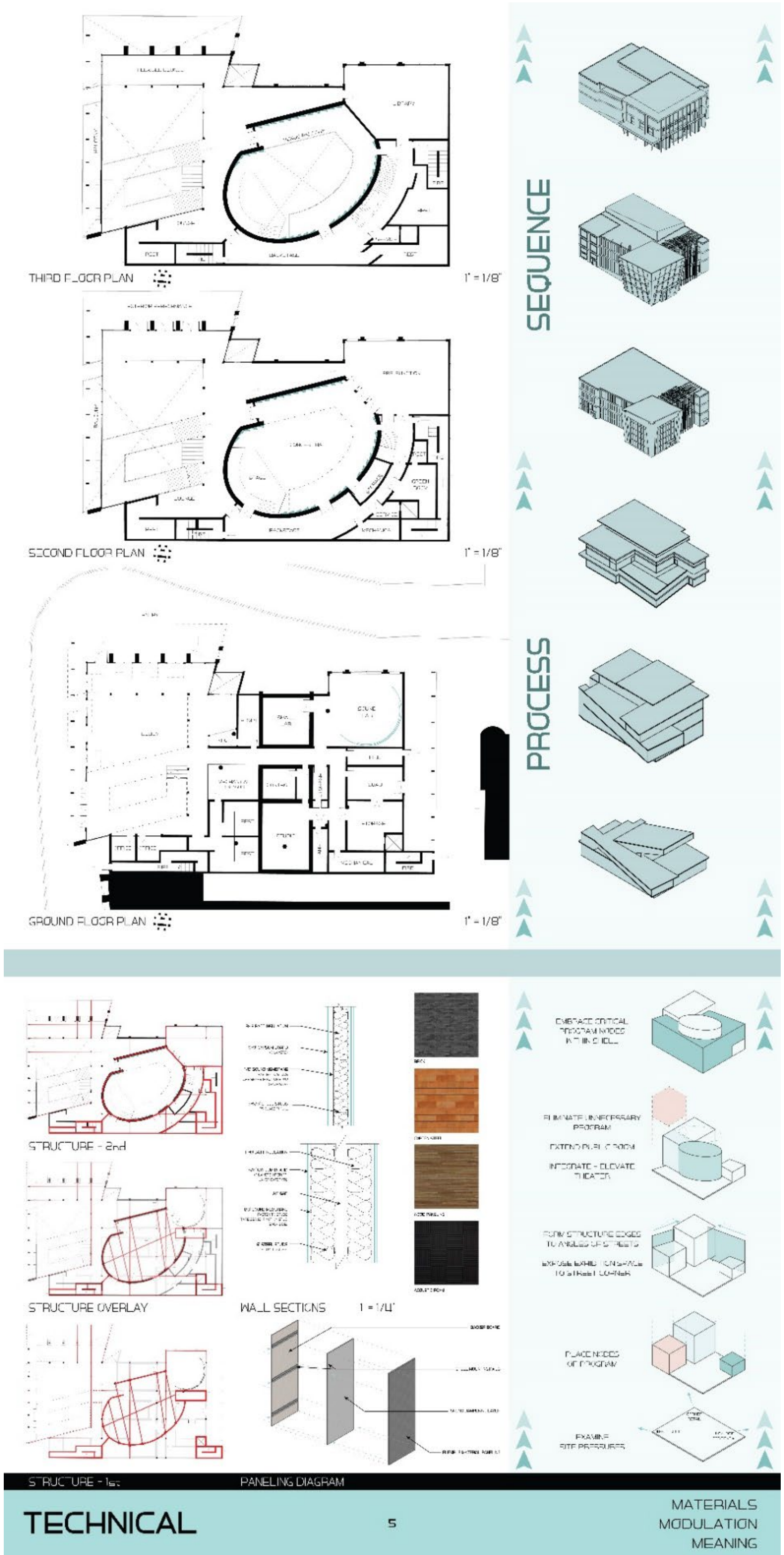


Figure 35: Final Board 5 (Source: Nick Majka)

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