Designing an Inclusive and Accessible Sensory Space for School Children at Chaeli Cottage in Cape Town, South Africa

Figure 1: Students at Chaeli Cottage dressed in superhero capes

By
Tyler Bobbin
Olivia Dube
Lindsay Masamery
Katy Stuparu

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by

Tyler Bobbin

Olivia Dube

Lindsay Masamery

Katy Stuparu

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Rosemary Lugar

The Chaeli Campaign

Professors Rosemary Taylor and Steve Taylor

Worcester Polytechnic Institute

Abstract

Exposure to sensory input nurtures appropriate behavioral and emotional regulation, which is crucial for children with disabilities. This project, sponsored by the Chaeli Campaign, created an inclusive and accessible sensory space at the Chaeli Cottage preschool to provide sensory integration for children with disabilities. Through a cyclic iterative design process involving interviews, co-design with professionals, and observation of the preschool routine, we understood the stakeholder needs and designed our sensory space. Our project proposes that inclusivity is a dynamic and ever-changing concept with accessibility and variety at its core.

Acknowledgements

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Executive Summary

Sensory integration is the process of the brain organizing information that comes from the senses: sight, hearing, smell, taste, or touch. It is used by humans every day and is critical for the development of every child, especially because it nurtures the cognitive processing of external stimuli and cultivates appropriate behavioral and emotional regulation. Difficulties with sensory integration can cause physically painful and overwhelming overreactions or underreactions to sensory signals. Children with autism spectrum disorder (ASD) struggle more with sensory integration and are more prone to hyposensitivity or hypersensitivity compared to their able-bodied peers. Children with ASD need to regulate their sensory input to prevent feeling overwhelmed. Children with physical disabilities can also have limited access to sensory integration due to lack of accessibility in educational and play areas.

One way to help children with sensory integration is through a sensory space. A sensory space is an intentionally created area which utilizes multi-sensory elements to support an individual's sensory needs through calming stimulation of the five primary senses. Sensory spaces can help with reducing stress, increasing concentration and learning, developing cognitive and motor skills, and emotional regulation. Students with disabilities and without disabilities alike benefit from sensory spaces because they incorporate sensory integration into their daily routines.

South African mainstream education lacks inclusivity for students with intellectual and physical disabilities because there is an absence of resources to provide for the unique differences these students have. This causes students with disabilities to have missed opportunities that students without disabilities likely receive. Although there is research about how the implementation of assistive technologies, such as sensory spaces in school environments can be beneficial to students with disabilities, little is known about how to construct a sensory space that is inclusive and accessible for all children.

Project Goal and Objectives

The goal of the project was to create an accessible and inclusive sensory space for the Chaeli Cottage preschool, an early childhood development center in Cape Town, South Africa. To meet the goal of the project, we undertook four objectives:

1. Understand the needs of the Chaeli Cottage community including staff and students and identify the design requirements and constraints of a sensory space at the Chaeli Cottage.
2. Create a list of potential sensory space design elements and materials.
3. Identify which elements work best for Chaeli Cottage through a co-design process.
4. Build and test the sensory designs with the students.

Cyclic and Iterative Methodology

We used a cyclical and iterative design process that allowed us to incorporate feedback from the Chaeli Cottage community into our designs. Compared to traditional linear frameworks, an iterative cyclic methodology prioritizes product delivery and functionality through iterative waves of continuous collaboration between project team and stakeholders to understand the scope of the project and what needs to be completed. Our iterative cycle utilized interviews with Chaeli Campaign staff, co-designing with teachers and therapists, building our sensory designs, observing how the children interact with our designs, then analyzing our observation results. The methods used in this cycle were repeated and revisited as needed to create the most functional and beneficial product.

Findings and Sensory Space Deliverable

We first took note of the variety of disabilities present at the Chaeli Cottage to help understand our target audience. We found that the children at the Chaeli Cottage have a wide variety of physical and intellectual disabilities (Figure 2), but the children also graduate and new students enroll so there is not a specific profile of disabilities we are catering to. Based off this, we found that our two main focuses for this sensory space are inclusivity and accessibility.

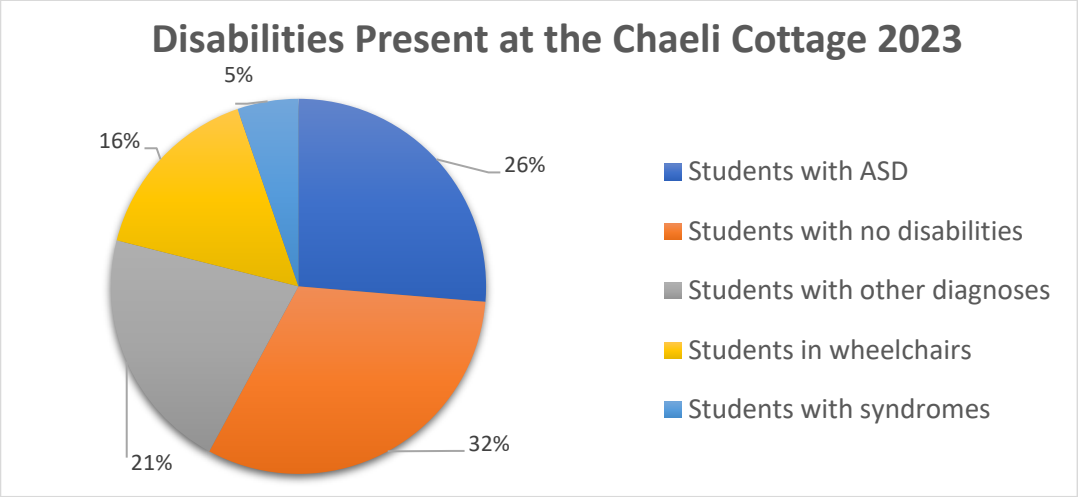

Figure 2: Disabilities present at the Chaeli Cottage as of November 2023

Through interviews with staff, observations, and analyzing the students' individualized education plans (IEPs) we were able to identify the needs of the students at the Chaeli Cottage, and used this information to create a list of potential sensory elements that will be inclusive to all the students. We found that our space should encourage cooperative play, but also parallel play so students can interact with each other. Elements that improve fine motor skills, textures using nature, music, and letters and numbers were some main themes in our list of elements. We learned that the needs of the children at the Chaeli Cottage vary from child to child. Incorporating a variety of toys and activities in our sensory space was crucial to help meet as many needs as possible.

Interview with staff allowed us to identify the needs of the teachers at the preschool. We found that there is limited space to build in their play area so a compact, portable design would work best for the school. The space also needs to be easy to maintain to not give more work to the teachers. Making the sensory space durable and sustainable will ensure that it lasts for many years with little to no maintenance.

We identified that accessibly had to be a primary design requirement through the observation of the students during free play. We found that the students with physical disabilities, especially those who use wheelchairs, were often excluded from activities and social opportunities due to the inaccessibility of the play space and toy design. Creating an accessible sensory space would allow the children using wheelchairs to have more play options and encourage play with the other students.

Through a co-design process with the Chaeli Cottage staff and Happinest™, we designed and built a portable sensory station that the children can interact with, pictured below in Figure 3. Our sensory station has a desk-like design and is on wheels that lock so it can be brought in and out of the play space whenever the teachers wish. Our sensory station was designed with accessibility as its core; this is reflected in the selected dimensions of the desk. The tabletop is 72 centimeters tall, which is high enough to accommodate even the highest wheelchair present at the Chaeli Cottage. Children who use wheelchairs have a place for their legs underneath the desk which allows access to the sensory elements on the tabletop. The tabletop is also 100 centimeters wide, which is wide enough to accommodate two children to engage with the desk side by side. The desk is also accessible on either side, allowing face-to-face interaction. These design choices were made with the encouragement of socialization through corporative and parallel play in mind.

Our sensory station is covered in sensory toys and elements that benefit the children in a variety of ways, such as feeling textures, learning with colors and letters, improving fine motor skills, and more. All sensory toys are attached to the desk using Velcro which increased the versatility of every individual element which in turn increases the inclusivity of the space. The use of Velcro enables our space to cater to different play styles. If children want to play independently, they can detach the desired toy from the sensory station and bring it to a quiet area. The portability of each toy also allows for individual toys to be removed from the desk and placed on the tray table of a child who uses a wheelchair. The Velcro also allows for the teachers to switch around the sensory elements to provide variety and prevent boredom.

Figure 3: Final design of sensory station desk

In addition to the desk, we designed a music wall that is accessible and allows children with varying abilities to play together, pictured below in Figure 4. The wall includes a PVC xylophone that extrudes from the wall, allowing students using wheelchairs a space for their legs to reach the xylophone without their legs getting in the way. The music wall also includes drums made from recycled materials and a few other musical elements. The music wall appeals to the sense of hearing and is also visually pleasing.

Figure 4: Final design of sensory music wall

Conclusions about Inclusive and Accessible Design

Through the completion of this project, we discovered that inclusivity is not a static goal to be achieved, but rather a fluid idea. Based on our findings in studying the user needs and requirements of our sensory space, we learned that disability is unique to every individual who experiences it. We grew to understand that the needs of an individual are not defined, rather needs are shaped by the experiences, abilities, emotions, and behaviors that are intrinsically unique. This individuality creates an immense amount of diversity of needs in any community. The implications of this finding are that the idea of creating a space that is completely inclusive to everyone is implausible. We propose that the principle of inclusivity is dynamic and ever-changing that guides a design to be adaptable to best suit community needs at any given time. We also conclude that inclusion cannot be reached without first addressing accessibility. Through the completion of our project, we understood that the scope of this conclusion reaches beyond our sensory space. We found that the successfulness and usefulness of any design or infrastructure humans interact with is dependent on its ability to be physically accessible to its demographic. In a society where we strive to cultivate inclusivity and provide equal opportunity to all individuals, regardless of ability, accessibility should not only be a design priority, but a responsibility. Accessibility is a steppingstone towards inclusivity, as a space cannot be inclusive if it is not physically accessible.

By designing an environment that prioritizes accessibility, we created a space at the Chaeli Cottage where all the students can engage in equivalent activities.

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1.0 Introduction

In a society where we strive to provide every human being with equal rights and freedoms, regardless of ability, the cultivation of inclusive and accessible design is critical. The lack of inclusive and accessible design in everyday life creates obstacles for individuals with disabilities. These barriers often result in people with disabilities not receiving access to the same opportunities as people without disabilities. The detriment of the exclusion of individuals with disabilities often begins during childhood and in schools. Without inclusive design and the implementation of assistive technologies that provide support for children with disabilities, these children not only miss out on important developmental opportunities, but also are at risk for developing poor self-esteem, passive sensory processing skills, and difficulties with emotional and behavioral regulation (Agostine et al, 2022).

Schools across the globe have been increasing efforts to support children with disabilities, although in many countries, such as South Africa, the implementation of these accommodations has been slow or incomplete. In South Africa, many children with disabilities are enrolled in separate schools than their peers without disabilities called special schools. These special schools have increased accommodation for children with disabilities but are often difficult to access or become enrolled in. The mainstream schools in South Africa often lack proper support systems for these children and could benefit from the implementation of inclusive design and assistive technologies, such as sensory spaces, to better support the development of children with disabilities.

Sensory integration is a critical part of the cognitive development of every child; this is the process of the brain assimilating and organizing information received from sight, hearing, smell, taste, or touch, and allows us to engage in everyday activities (Kilroy et al., 2019). Children with physical and intellectual disabilities often struggle with sensory integration. Specifically, children with autism spectrum disorder (ASD) often struggle with hypersensitivity or hyposensitivity, an overreaction or underreaction to sensory signals which in turn can affect feelings and behaviors. These reactions can be extremely overwhelming to a young child. Increasing sensory integration skills for children with disabilities can be beneficial for improving fine motor skills, social interaction, and coordination. One way to promote sensory integration is through a sensory space. A sensory space is an intentionally created area which utilizes multi-sensory materials and objects

to support an individual's sensory needs through stimulation of the five primary senses. These spaces often provide reduction in agitation and stress, increase focus, and give children a sense of calmness and security to have a comfortable interaction with their senses.

South African mainstream education lacks inclusivity for students with intellectual and physical disabilities because there is an absence of resources to provide for the unique differences these students have. This causes students with disabilities to have missed opportunities that their peers without disabilities likely receive. Although research has been published on how the implementation of assistive technologies, such as sensory spaces, in school environments can be beneficial to students with disabilities, little is known about how to construct a sensory space that is inclusive and accessible for all children. Current studies show that students with disabilities who don't receive or receive improper sensory play attain passive sensory processing patterns (Agostine et al, 2022). The implementation of a sensory space in preschool environments increases sensory integration and cultivates appropriate behavioral and emotional regulation.

The Chaeli Cottage is a preschool located in Cape Town, South Africa that accommodates children of all abilities. This preschool was founded by the Chaeli Campaign, a nonprofit social justice organization that aims to change the societal narrative on disability through increasing inclusion and accessibility. The Chaeli Cottage enrolls a diverse group of students with a variety of disabilities and needs to be accommodated. Each year, this preschool accommodates many students with ASD, causing an increased need for sensory integration in daily routines and an inclusive and accessible play space at the Chaeli Cottage.

The goal of this project was to create an inclusive and accessible sensory space for the children at the Chaeli Cottage. Our goal was achieved through the accomplishment of four objectives: 1) identify and understand the needs of the Chaeli Cottage community; 2) create a list of potential sensory space elements and materials; 3) identify which elements and materials would be most beneficial to the Chaeli Cottage community through a co-design process; and 4) build and test sensory space elements with the students at Chaeli Cottage. We completed our objectives through a cyclical iterative design process which emphasized product delivery and functionality through continuous collaboration between project team and stakeholders. Through the implementation of our sensory space at the Chaeli Cottage, we demonstrated how the incorporation of accessibility and variety into a design increases inclusivity for a given community. Our sensory

space can inspire future inclusive designs in schools and childhood centers. The implications of what we learned through developing our project include perspectives about inclusive and accessible design that reach far beyond the scope of our project and can be realized in the larger domain of understanding the role of inclusion and accessibility in society.

2.0 Inclusivity, Accessibility, and Sensory Spaces

In this chapter, we investigate the issue of inclusivity and accessibility in schools for students with disabilities. We start with a synopsis of the types of intellectual disabilities and the challenges faced with diagnosis and treatment. We then discuss the issue of the lack of accessibility for students with physical disabilities in schools. We introduce the idea of a multi-sensory environment and how it can be beneficial to those with intellectual and physical disabilities. We then discussed how the design of the sensory space is important for making the space accessible and inclusive, and how sensory gardens are a way to incorporate nature into these spaces. Then we discuss the current state of inclusivity and accessibility in South Africa. We then provide background on the Chaeli Campaign and the Chaeli Cottage preschool where our sensory space will be implemented.

2.1 Inclusivity and Accessibility for Children with Disabilities

Children with physical and intellectual disabilities require play spaces with unique, inclusive designs that have been lacking in most schools (Yantzi et al., 2010). A key part of development for these children is sensorimotor skills. The ways in which humans experience sensorimotor capacities enable them to interact with the physical environment successfully, which is key to developing cognitive skills. Garzotto et al. (2020) found that children who have difficulties processing external stimuli also experience issues with fundamental cognitive and functional abilities. This can lead to a lack of interest, insufficient self-regulation, and the inability to avoid distractions. These symptoms are mostly found in children with neurodevelopment disorders (NDDs), especially autism spectrum disorder (ASD).

Early identification of NDDs is important for children to receive early intervention and treatment. NDDs are seen in about ten percent of children worldwide (National Institute for Health and Care Excellence, 2019). In recent years, this number has increased which has resulted in an increase in demand for intervention and support, including support in educational environments (Rivard et al., 2021). However, researchers have questioned the validity of these diagnostic processes for providing essential treatment for the NDD population. A diagnosis is required to acquire any kind of treatment despite how severe the issue is. However, a diagnosis lacks individuality for the treatment, meaning that a disability diagnosis has specific requirements, which disregards that disability can affect individuals differently causing different outcomes (Astle

et al., 2022). Students with NDDs are typically challenged with impairments with attention and impulse control, along with social difficulties and communication issues (Berglund et al., 2020). Assistive technologies such as fidget toys, sensory objects, and adaptations to the presentation of educational materials can be beneficial to these children. Ideally, students with NDDs that have access to these objects and accommodations would be provided specialized care and support and thus be involved within an inclusive environment (Barton et al., 2019).

Children with physical disabilities also face many challenges with accessibility in schools. When researchers surveyed and interviewed children living in an urban part of Canada, they found that elementary-aged children with physical disabilities faced challenges in their supposedly accessible schools. Some of these challenges were due to physically inaccessible facilities, including not being able to use the restrooms, having no means to evacuate the building in case of emergency, and having to stay indoors instead of playing outside. Other challenges, however, were because of social barriers. Some children with disabilities were able to access the outdoor play space but were unable to participate in the same activities as the able-bodied students because of the inaccessibility (Stephens et al., 2017). Another group of researchers looked more closely into the outdoor play area design for schools in Toronto, Canada that claimed to cater to disabled children. While children with disabilities were able to play with some of the equipment, the play areas they could use were not designed for developing the physical and social skills that the non-accessible play areas could (Yantzi et al., 2010). A space designed with accessibility in mind ideally contains no barriers that could prevent people with disabilities from using it. However, many accessible spaces are only designed to accommodate physical impairments, not other types of disabilities, which results in some students not being able to participate in activities due to social and environmental barriers (Stephens et al., 2017, Yantzi et al., 2010).

To provide children with disabilities with the same developmental opportunities as children without disabilities, assistive technologies and accessible architecture should be implemented to make spaces such as schools inclusive. Universal Design is an architectural movement that strives to recognize diversity by making environments inclusive for everyone. The goal of Universal Design is to create environments and objects that all individuals can use and benefit from (Burke, 2012). Inclusive spaces must contain the elements of Universal Design to foster togetherness instead of isolation so children with disabilities can use objects in the same way as abled children.

Universal Design plays a role in achieving inclusivity in spaces like multi-sensory environments. Multi-sensory environments (MSEs) are dedicated, typically indoor, spaces which utilize various sensory-stimulating elements for the purpose of relaxation, focus, and play (Garzotto et al., 2020). Although the use of MSEs in clinical settings dates to more than thirty years ago, there continues to be a lack of empirical evidence of the therapeutic effects. This is because it is difficult to quantify data gathered from the use of MSEs. However, these MSEs have been installed in numerous schools, mainstream and special, as well as therapy centers since their creation. This was observed in studies conducted in the United Kingdom, the United States, and Australia (Garzotto et al., 2020). MSEs are largely utilized as a therapeutic treatment for individuals with severe cognitive disability in hopes of reducing anxiety, increasing relaxation, and improving communication. The addition of a sensory space akin to a MSE in schools could provide children with beneficial assistive technology necessary to make an education system more inclusive and accommodating to all types of learners.

With the combination of early identification of NDDS, Universal Design, and assistive technologies such as MSEs, inclusivity and accessibility can be achieved in mainstream and special schools. This would also provide students with disabilities with the same opportunities as students without disabilities. Although there are ways to make schools more inclusive and accessible, children with NDDS still face cognitive challenges in mainstream schools. To help with brain development and focusing, sensory integration is a solution to this ongoing challenge.

2.2 Sensory Integration

Sensory integration is a process that humans use every day. We receive information through our five senses: sight, hearing, smell, taste, and touch, and our brains organize these stimuli to engage in everyday activities (Kilroy et al., 2019). Exposure to sensory integration is a key part of brain development which nurtures the cognitive processing of external stimuli and allows appropriate behavioral and emotional regulation. Individuals who experience problems with sensory integration, including people with varying neurodevelopmental disabilities, often experience problems with emotions, behaviors, and learning (Lockett, 2022).

All children require sensory play to develop and make sense of the world around them as sensory play helps build neural connections for completing complex tasks (Barton et al., 2015). The use of a sensory space, a designated area which utilizes various sensory stimulating elements

for the purpose of reducing stress, increasing concentration and learning, can be greatly beneficial in the nurturement of cognitive and motor skill development, as well as emotional regulation, for a wide range of children. Sensory play can foster therapeutic effects for all children as every individual has unique sensory sensitivities and ways of responding to stimulation, so the benefit received from sensory integration is tailored to every individual. (Bell, 2019). Although sensory play is important for all children, it is particularly important for children with intellectual disabilities whose sensory processing differs from the neurotypical. Commonly, children with disabilities experience passive sensory processing, having an underreaction to the environment, as well as motor skill issues. This makes it more difficult for children with disabilities to understand and interact with the surrounding environment. Sensory play can be especially helpful for children with disabilities as it aids in stimuli processing in a calm and safe environment.

2.3 An Overview of Sensory Spaces

Sensory spaces can be incredibly beneficial to children with autism spectrum disorder (ASD). ASD, a spectrum of neurological development disabilities, affects the social, communitive, and behavioral aspects of an individual's life (Clouse, 2019). Symptoms of ASD can include repetitive behaviors, limited verbal communication, poor social and speech habits, and having extreme strengths and weaknesses in fine motor skills. Children with ASD can also struggle with sensory processing, how the brain processes information received from the senses (Ghazali et al., 2018). The four different kinds of autism include autistic disorder, childhood disintegrative disorder, pervasive developmental disorder not otherwise specified (PDD-NOS), and Asperger syndrome (Hooker, 2023). Within the four disorders, there is a spectrum from hypersensitivity to hyposensitivity. Hypersensitivity refers to constant overstimulation to the point where the brain cannot endure the stimulation. On the other hand, hyposensitive children's brains have little to no sensory input. Hyposensitivity can result in anxiety, physical pain, and stress. (Ghazali et al., 2018). A sensory space could calm negative emotions, regulate behaviors, and help with communicating one's needs in a calm and safe way. If properly designed, a physical sensory learning environment would boost development and education, while improving the readiness for joining a school environment (Shaari et al., 2016).

On specific type of sensory spaces are sensory integration rooms. Sensory integration rooms are mostly found in schools, hospitals, and therapy centers, which focus on stimulating

multiple senses to calm an individual, enabling a more appropriate function in their environment. Occupational therapists use sensory integration rooms to assist children with ASD. Sensory rooms can contain multiple sensory objects, including swings, sensory lighting, audio fixtures, and toys with many moving parts. The design of sensory rooms can vary depending on the age and disabilities of the target audience (Foy, 2007).

In the 1970s, Jan Hulsegge and Ad Verheul created the concept of a Multi-Sensory Environment (MSEs) called a "Snoezelen." They developed Snoezelen to be a multi-sensory room to stimulate, reduce agitation, and provide a calming environment. Snoezelen rooms differ from other sensory integration rooms because Snoezelen rooms are designed to meet one specific goal based on the user's needs. The design of the room allows for the individual to have complete control over the entire room, specifically being able to choose which senses the room stimulates. The goal of Snoezelen was to help individuals with severe intellectual disabilities and provide comfortable sensory interaction (Pagliano, 2017). Focused on catering to a range of disabilities, sensory spaces can offer a variety of benefits through enhancing self-regulation. Self-regulation is about managing one's own physical state, mental state, and actions. Using sensory spaces can lower fatigue, reduce stress, and anxiety (Kalimullin et al., 2016).

Another type of sensory space that is both accessible for those with physical disabilities and inclusive for those with intellectual disabilities is a sensory garden. A sensory garden is a sensory space in an outdoor environment that incorporates nature for engaging and stimulating the senses. Sensory gardens can be educational, provide therapeutics, and help build developmental strategies. Outdoor play can reinforce collaborative skills and language development and can also improve a child's health, lifestyle, and learning (Barakat et al., 2019). Engaging with nature can reduce stress and strengthen positive feelings. Sensory gardens can include plants, water, soils, musical elements, textured pathways, as seen in Figure 5.

Figure 5: Raised garden beds used in a sensory garden to create an accessible environment

2.4 Key Considerations for Sensory Space Design

Although sensory spaces have many benefits, designing a space that is inclusive for children with physical and intellectual disabilities is challenging. Since ASD is a spectrum, sensory space design for ASD can be difficult due to the variety of preferences and needs to be accommodated. There are multiple disorders on the spectrum and individuals may react to sensory stimulation differently and the overstimulation and under-stimulation caused by sensory input could potentially contradict each other in a sensory space design. Over the course of a decade, researchers created a sensory design model called ASPECTSS ™ design index (Austism-archi). The seven principles of the design index are acoustics, spatial sequencing, escape space, compartmentalization, transitioning zones, sensory zoning, and safety. See Table 1.

Acoustics	Children should be able to control the number of acoustics that they interact with while also blocking out background noise and echoing.
Spatial Sequencing	The space should be organized, and the children should not get overwhelmed by distractions or disruptions.
Escape Space	Allows individuals who are overwhelmed to escape from the sense stimulation and self-regulate in a calm space.
Compartmentalization	The space should be separated into compartments where the children can choose which sense they want to be stimulated at a time and not get overwhelmed by multiple senses at once.
Transitioning Zones	Children can transition from one sense to another.
Sensory Zoning	Space needs separate zones based on their stimulus level.
Safety	The space must be safe to make sure children can't harm themselves.

Table 1: The Seven Principles of ASPECTSS ™ Design Index

While the seven principles of design help with designing a sensory space for ASD, they do not particularly help with designing for physical disabilities. The Center for Universal Design at North Carolina State University created a guide about making architectural spaces usable for as many people as possible (Center for Universal Design). The guide includes making designs with a range of abilities in mind. The guide explains that designs should be simple, flexible, and equitable. When designing spaces for various disabilities, one also must pay attention to the difference between close senses (touch and taste) and distant senses (sight, hearing, and smell) (Hussein, 2016). For example, an individual using a wheelchair may find it difficult to reach

inaccessibly located objects, while individuals with blindness or deafness may find it harder to interact with objects that are far away.

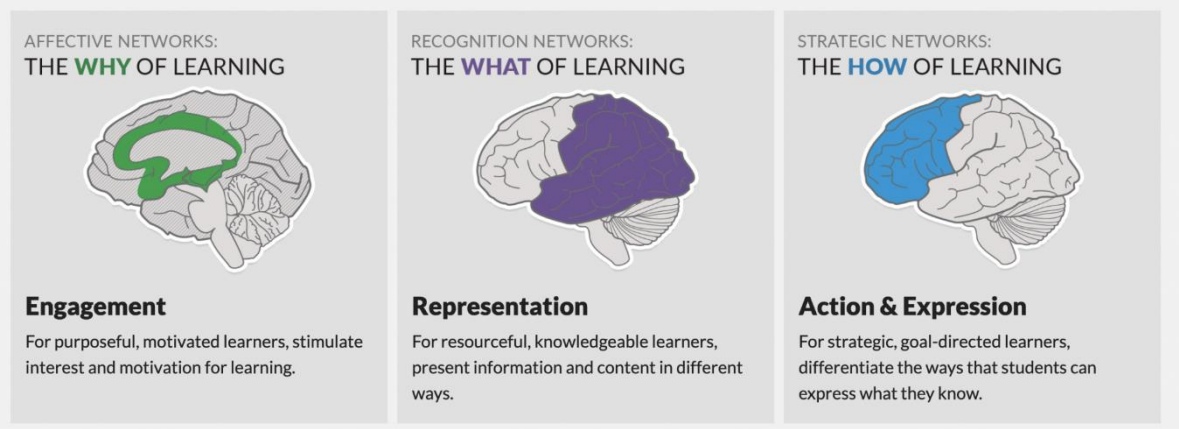

Figure 6: This infographic recognizes the three primary principles of Universal design of learning

Sensory gardens often include many of these principles in their designs. Sensory gardens can benefit physical and mental health, and social and emotional behavior of a child with ASD. Sensory gardens also create a hands-on learning environment for building teamwork and problem-solving skills. This can be through the level of interactions with other students and the incorporation of textures and shapes of plants. A sensory garden should be in a peaceful location with sunlight and wind access. To stimulate children with ASD and physical disabilities, plants with a variety of textures should be in reach. Separating pastel and bright colored plants can also help calm different types of ASD (Barakat et al., 2019). Creating multiple levels of flower and plant beds can help provide a universal design for all to use. Having features such as water fountains with trickling water can help stimulate children through hearing, sight, and touch (Barakat et al., 2019). Sensory gardens are an effective way for children with ASD to fulfill sensory integration needs.

Integrating plants and other garden features can help create a sensory space that is intriguing and effective to children. Although simply engaging with nature can help reduce anxiety and improve mood for any individual regardless of ability, implementing technology such as lights and running water features, within a sensory space also helps to stimulate different senses. Certain

lighting, especially a lack of sunlight, can affect the sensory stimulation of people with disabilities (Barrett, 2010). In a survey of 100 parents or caregivers of children with ASD, acoustics was ranked the most influential feature of a sensory space (Mostafa, 2014). In a sensory garden in the UK, practitioners observed that the musical section was most popular (Hussein, 2016). Implementing different musical instruments including xylophones, wind whistles, and other simple hands-on instruments can give the children opportunities to use hands-on objects while controlling the sounds they hear. Using a combination of sensory elements that cumulatively appeal to all the senses in one space may be the most effective way to design an inclusive space.

2.5 Children in South Africa with Disabilities

The democratic government of South Africa emphasizes the equal treatment and inclusion of all its citizens as a foundational principle. Upon the implementation of democracy in 1994, South Africa aimed to unite and to repeal the harsh segregation, exclusion, and injustice of the past. In the years following the overturning of Apartheid, comprehensive legislation protecting and promoting the rights of all South Africans, persons with disabilities included, was passed. The Integrated National Disability Strategy, developed by the South African government in 1997, acknowledged the significant prevalence of moderate to severe disability in South African society as well as the lack of equal services and opportunities accessible to the disabled public (Office of the Deputy President, 1997). This strategy proposed the creation of an inclusive school system that could accommodate all children. To provide support for all children, the newly democratic South African government opted to retain the system of special schools, schools implemented during Apartheid to separate children with disabilities from mainstream education, as a support system for children with disabilities.

Further legislation followed and built on the nation's goals for inclusivity and equality. The *Education White Paper 6: Special Needs Education: Building an Inclusive Education and Training System (EWP6)* published by the Department of Education of South Africa in 2001 proposed a detailed plan to increase the level of inclusivity in schools, drastically improve special school services and curricula, while making education accessible to all children in South Africa (Department of Education, 2001). The EWP6 publication reported on the current state of education for children with disabilities in South Africa. It was estimated that at the time of publication in 2001 only 20% of learners with disabilities were accommodated in special schools while an

estimated 280,000 students with disabilities were unaccounted for (Department of Education, 2001). This means that the students were either not in a school at all or were in a school without access to proper accommodation for their disability. It was found that special schools are primarily located in provinces with larger urban areas with a large percentage of white citizens like the Western Cape and Gauteng. This creates a large population of children with disabilities who are forced to attend special schools in a different provincial area than their own or are unable to access special schools altogether. Despite the government legislation passed in the last 30 years aiming to improve the lives of people with disabilities in South Africa, implementation has been limited with exclusion and lack of equal opportunity persisting for children with disabilities (Dalton et al., 2012).

Implementation of equal education and disability inclusion policy in the South African education system has been hampered by lack of government departmental collaboration, lack of proper teacher training, and fragmented ideas of the role of people with disabilities in South African society (Dalton et al., 2012; McKenzie, 2021). There have been efforts to increase the inclusivity of mainstream schools; however, most mainstream schools are not yet adapted to be inclusive for a wide variety of needs (Pillay et al, 2021). The Integrated National Disability Strategy is one of many policies proposed which intend to implement an all-inclusive curriculum to mainstream schools, making equal education accessible for all learners. This inclusive curriculum, however, has yet to come to fruition and the South African education system continues to rely on special schools to cater to children with physical and intellectual disabilities (McKenzie, 2021). These special schools do not follow the same curriculum as mainstream schools and often only teach vocational or skill-oriented subjects, rather than adapting teaching methods to better suit the needs of a particular individual in learning the mainstream curriculum. Many children with only mild disabilities often end up in special schools where they would be better suited in a mainstream school environment where they could receive the same opportunities as their peers. A study published in 2021 of over one million children diagnosed with autism spectrum disorder in the Western Cape province found that 89% of students with autism spectrum disorder were in special schools while only 10% were in mainstream schools (Pillay et al, 2021). Without an all-inclusive curriculum, education in South Africa remains largely segregated which propagates a further imbalance of developmental and educational opportunity for children based on disability.

For children with disabilities, early access to support systems is crucial for development and fulfilling the possibilities of behavioral and emotional issues later in life. Decades of research demonstrates that early intervention for children with disabilities, particularly developmental disabilities, can reduce the incidence of future behavioral and emotional problems and has a positive impact on brain development (Goode et al., 2011). The promotion of sensory integration at a young age can serve as a form of early intervention by nurturing proper response to sensory input which aids in emotional and behavioral regulation. The educational system in South Africa, however, only requires students to start school when they are seven years old, which does not provide opportunity for early intervention for children with disabilities. That is why an inclusive preschool that promotes early intervention and provides opportunity for sensory integration is something that is beneficial to children in South Africa.

The current hinderance of equal and inclusive education implementation in South Africa combined with the inaccessibility of services to children and persons with disabilities has spurred the creation of organizations that provide support and early childhood development services that cater specifically to the disabled population of South Africa. For children with disabilities that remain in publicly funded mainstream schools however, a combination of increased special education teacher training and the addition of beneficial assistive technologies such as accessible architecture and sensory environments can progress inclusion (Goode et al., 2011).

2.6 Chaeli Campaign Promotes Inclusivity

The Chaeli Campaign is a nonprofit social justice foundation based out of Cape Town, South Africa which aims to challenge societal views of the roles and capabilities of people with disabilities through raising awareness, advocation, and providing opportunities to people with disabilities that they are otherwise deprived of. Historically, global societies, including South Africa, have viewed disability as an impairment or even a defect, separating a person from the rest of society and imparting stigma (Shah et al., 2015). Although the narrative surrounding disability is shifting away from such oppressive and damaging beliefs, more effort is needed to change society to view and treat people with disabilities as valued, important, and capable members of the community. The Chaeli Campaign believes that for inclusion to become a reality, society must focus on the ability, possibility, and inclusion of all community members. It is the mission of the Chaeli Campaign to teach and inspire individuals living with disabilities to live able and fulfilling

lives. The Chaeli Campaign created the Chaeli Cottage, a preschool for children ages three to five which operates on the values of inclusion, equal opportunity, and providing a safe space for all children. The preschool provides all students a safe space to learn by "playing together in a loving and nurturing environment." The school is inclusive in many ways; children of different race groups, religions, and abilities are all welcome to attend. An occupational therapist, speech therapist, and physiotherapist work with students in group therapy or individual settings on a weekly basis at the school, which allows for early intervention for children with disabilities and a proper assessment of needs. Providing personalized care for each child at the school allows better access to the same educational opportunities as other children, regardless of disability. This can be beneficial to children at a young age as they are just becoming comfortable with school and social environments, especially students who can become uneasy with social and physical interactions. The Chaeli Cottage works with students to integrate activities that will help fulfill individualized needs such as outdoor and sensory play (Chaeli Campaign, 2023). We worked with the Chaeli Cottage to design and build a sensory space that is inclusive and accessible for the students at the preschool.

The purpose of our project was to collect information on sensory spaces and learn how they can be altered to utilize Universal Design and promote inclusivity. Through identifying stakeholder needs and requirements and developing a sensory space design through a co-design process, contributed to the inclusive and beneficial environment at the Chaeli Cottage for all children.

3.0 Methodology

The purpose of our project is to create an inclusive, accessible, and sustainable sensory space for the students at Chaeli Cottage to increase their ability to engage in activities with peers, while furthering their educational goals. We identified four objectives to reach this goal:

1. Understand the needs of the Chaeli Cottage community including staff and students and identify the design requirements and constraints of a sensory space at the Chaeli Cottage.
2. Create a list of potential sensory space design elements and materials.
3. Identify which elements work best for Chaeli Cottage through a co-design process.
4. Build and test the sensory designs with the students.

In this chapter, we discuss the methods used to achieve our objectives. We enacted our methodology in a cyclical and iterative process inspired by Agile Project Management so our methods could adapt with the progression of the project. Agile methodology is a cyclic project management framework which emphasizes quick product delivery accompanied by continuous learning through iteration (Salameh, 2014). Compared to traditional linear project approaches, Agile methodology prioritizes product delivery and functionality through iterative waves of continuous collaboration between project team and stakeholders to understand the scope of the project and what needs to be completed (Figure 7). For our project, the Chaeli Cottage staff prioritized the final deliverable of implemented sensory elements rather than a build plan or an incomplete design. Given the short project time span of seven weeks, an iterative cyclic methodology best ensured that we completed the final deliverable of sensory elements at the Chaeli Cottage. According to Salameh, 2014, cyclic methodology improves responsiveness, speed, flexibility, and quality of projects. By completing all project objectives through cyclic methodology, we created an inclusive, accessible, and sustainable sensory space for preschool students of any ability at the Chaeli Cottage.

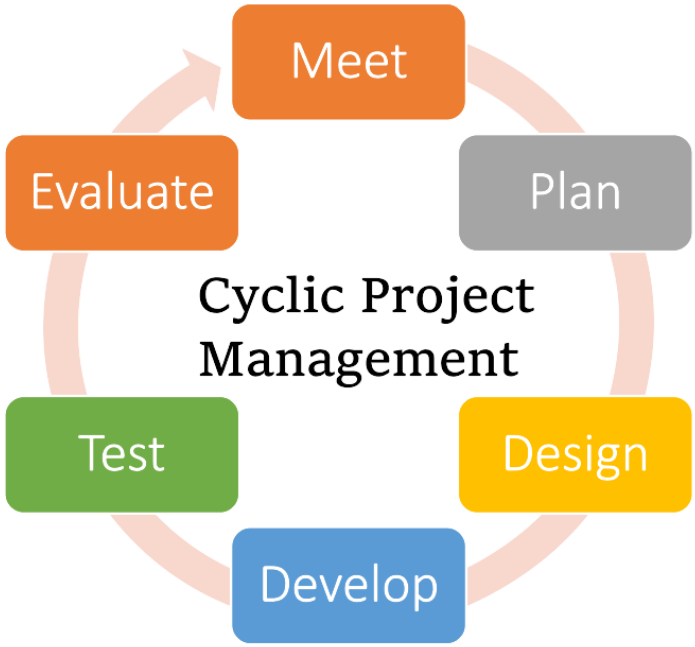

Figure 7: Cyclic methodology inspired by Agile Project Management framework

3.1 Understanding Needs of Community and Identifying Design Requirements

Our first objective was to understand the needs of the Chaeli Cottage community, including the children, staff, and families, as well as understanding the constraints of the play space. The purpose of learning about the needs of the stakeholder community was to answer the research question, what sensory elements will be the most beneficial to the Chaeli Cottage. The objective of understanding the needs of the community was a complex task that required understanding the diverse unmet needs of many people from several perspectives. Thus, we used multiple methods to accomplish the objective, allowing us to gather information from different perspectives. To understand the needs of the community and the requirements of the play space, we reviewed the learning plans for each student, interviewed the Chaeli Cottage teachers, interviewed some of the Chaeli Campaign staff including therapists, and observed the students at play and in their school routine. We reviewed the individualized learning plans for the students because they contained information about what the students required for daily school routine. The teachers and parents worked together to create the learning plans, so the learning plans incorporated the thoughts of both the teachers and parents about what the students need. We interviewed the two preschool teachers who provided valuable input about what the children at the Chaeli Cottage require and

what the teachers themselves require to maintain the sensory space. We interviewed two staff members at the Chaeli Cottage, Zelda Mycroft, the CEO of the Chaeli Campaign, and Chaeli Mycroft, the Co-Founder and Manager of Finance and Relations at the Chaeli Campaign. We interviewed Zelda and Chaeli to gain additional input about what some of the students required, especially the students with physical disabilities. Two therapists, Rosemary Luger and Faziah Toefy, who regularly visit the Chaeli Cottage to assist the students were also interviewed to gain varying perspectives from professionals with clinical knowledge of working with children with disabilities. We observed the children to understand what was lacking from their play and what elements of a sensory space would benefit them the most. With multiple methods to help meet the objective, we were able to tackle the complex task of understanding the needs of the Chaeli Cottage community to build a sensory space.

We began to familiarize ourselves with the Chaeli Cottage children by reviewing their individualized education plans (IEPs). IEPs are legal documents that outline any special education instructions and services that are implemented to help a student with disabilities flourish. As stated in Cooper, 2000, "'An IEP' is one of the most critical elements to ensure effective teaching, learning, and better results for all children with disabilities." The purpose of an IEP is to meet a student's specific needs through a plan that the student's teachers, parents, and therapists develop. The IEPs of the students at the Chaeli Cottage were an important resource to us because they explained the needs of the students. The IEPs specify what the children need regarding daily activities and sensory inputs, movement and positioning, knowing and learning, socialization and promoting good behavior, and communication. To analyze the IEPs, we utilized inductive coding, which involved individually reading through the IEPs and identifying the major, recurring themes. Then, we collaborated with each other to find similarities between the themes we found. We found which recurring IEP themes were most pertinent to our sensory space design, allowing us to identify design requirements and constraints.

We conducted six interviews regarding the design of the sensory space. We interviewed two preschool teachers, Debbie Prudhomme and Ariska Prins, and two therapists employed at the Chaeli Cottage, Rosemary Luger and Faziah Toefy, as well as two Chaeli Campaign staff members, Zelda Mycroft and Chaeli Mycroft. These interviews obtained information about the staff's experiences working with students. They also helped us understand what design elements

we should prioritize to make the sensory space and sensory objects accessible and inclusive for the children as well as sustainable for the staff to upkeep. All six interviews were conducted in a semi-structured fashion in which the topic of the sensory space was discussed freely with some structured questions, found in Appendix A, added to guide the discussion. The semi-structured interview is a widely used method in qualitative research which fits well with our project. We chose a semi-structured format over other interview frameworks as semi-structured interviews permit the discussion to be focused while still allowing the interviewer to explore pertinent ideas that may arise in the conversation and be beneficial to the project (Adeoye-Olatunde & Olenik, 2021). Given the iterative nature of our methods, allowing open input and feedback from our interviewees was crucial to ensuring our design best fit the needs of the Chaeli Cottage community.

We observed the children at play, especially during free play time, to give us a good idea of how the children normally interact with each other, what activities the children gravitate towards, and what activities are inclusive. We wanted to prevent the Hawthorne Effect during our observation, so we tried to be as out of the way as possible, even observing from a window at times, to avoid the children altering their normal behavior. The Hawthorne Effect is the idea that behavior is changed when subjects know they are being observed (Merrett, 2006). Observing the children's natural state was key to our design process as it helped us identify the environment, the current play space, and the best ways to introduce sensory integration. Our observation guide for observing the students during playtime can be found in Appendix B. We documented how many times certain activities were used and how long the activities kept the children focused. After collecting the data, we used the information to identify design requirements for the sensory objects, such as calming the students but also keeping them engaged for a long period of time. A limitation was that we may not have been able to accurately depict how each child interacts with each activity. Each disability has differences so creating a personalized experience for each child is difficult.

Through a co-design process with our sponsors, we decided that a portable sensory space would be the most beneficial to the children and staff at the Chaeli Cottage. A portable space, rather than a permanently installed sensory space, allows the sponsors to make the best use of their play area for purposes of storage and supervision. We also determined that different sensory stimulations would need to be separated to best benefit the students and not overwhelm them. Our

sponsor, Rosemary Luger, specifically described incorporating a design that would allow for certain objects to be removed or added to allow for a variety of sensory play.

3.2 Creating a List of Potential Elements and Materials

Our second objective was to create a list of potential sensory space elements and materials. To fulfill this objective, we learned what specific elements have been implemented in established sensory spaces and which materials and sensory items are recommended by professionals who work in clinical settings with children with disabilities, particularly children with ASD. This knowledge of clinical implementations of sensory elements allowed us to compile a list of sensory elements categorized by targeted sense and anticipated demographic to potentially integrate into our sensory space at the Chaeli Cottage. The materials and sensory elements we chose had to be suitable for our design requirements. The materials used should be weather treated for the outdoor space, durable enough to withstand years of use, safe enough to prevent injury, and inexpensive. The sensory elements themselves should be largely accessible to most physical disabilities and appeal to a wide variety of needs and cognitive ability. To achieve this goal, we reviewed peer-reviewed and grey literature to identify design options and visited other early childhood development (ECD) centers in South Africa.

In conducting literature research, we used peer-reviewed journals and studies conducted on the effects of sensory spaces on children with specific disabilities. We identified the sensory elements that are beneficial for specific disabilities such as autism spectrum disorder, intellectual disorders, hearing disabilities, blindness, and physical disabilities. We reviewed established sensory spaces through online resources and compiled a list of potential elements and materials to be used. We used peer-reviewed research about the therapeutic effects of sensory stimulation for young children and individuals with disabilities to guide our review of sensory elements. Some key search terms we used to focus our search are “sensory space”, “sensory garden”, “stimulation for ASD”, “therapeutic stimulation”, and “sensory play”.

We used grey literature, information not published for academic or commercial use, as a source of unique and diverse sensory space design examples which provided the variety not otherwise addressed by peer-reviewed literature. Online images of sensory spaces and sensory toys that individuals have created in classrooms or at home provided ideas for potential sensory elements with the variety necessary to address the wide range of needs to be considered. By

combining peer-reviewed and grey literature, we were able to integrate the clinical research of sensory integration with specific sustainable sensory toys from online resources to best fulfill our objective. Based on the needs of the Chaeli Cottage sensory space as identified in Objective 1, we refined our literature review to focus on research studies that cater to specific disabilities or circumstances that would be beneficial to the students at the preschool. We categorized sensory space design ideas based on the primary sense stimulated as well as the specific disability or demographic it caters to.

To accompany our literature research, we visited three ECD centers that accommodate young children with disabilities. The occupational therapist at the Chaeli Cottage also works for these centers once a quarter and accompanied us on our visit. We visited an Ocean View ECD center as well as two Masiphumelele ECD centers. We identified elements present at these sites that appeal to the five senses and documented how we could integrate those elements into our sensory space. Upon completion of these methods, we compiled a list of sensory space elements, categorized by targeted sense and anticipated demographic, that are relevant to the needs of the children at the Chaeli Cottage.

3.3 Co-Design Process with Chaeli Campaign

Our third objective was to identify the design elements that worked best for the Chaeli Cottage through a co-design process. The co-design process involved collaboration with the staff to select a design that was accessible and inclusive to as many children as possible. The idea of achieving full inclusivity and accessibility in a sensory space at the Chaeli Cottage is a difficult undertaking as the experience and needs of every person with a disability are unique and wide ranging. We addressed this by co-designing with as many staff members as possible to gather different perspectives. We recognized the difficulty in accommodating the sensory space to the varied expectations of the staff at the Chaeli Cottage. We addressed the issue of conflicting stakeholder expectations through our co-design process. During our co-design process, we developed a compromise between stakeholder ideology while prioritizing the concerns and suggestions of the teachers and therapists. The teachers and therapists spend the most time with the children daily and are responsible for addressing any overstimulation or injury that could potentially result from inconsiderate design.

For sensory garden research in the United Kingdom, interviewing practitioners, teachers, and therapists was effective in creating a practical design for a new garden (Hussein, 2016). We chose to interview the teachers and therapists because they have an extensive background of working with the children at the Chaeli Cottage school and therefore have a good understanding of the children's needs, we presented our ideas from Objective 2 to them and narrowed down a design based on their feedback regarding any safety or overstimulation concerns. We also interviewed the other staff members at the Chaeli Campaign to incorporate different perspectives into our design. The staff at the Chaeli Cottage come from a variety of backgrounds and have varied experience working with children with disabilities, so every new perspective gathered through the co-design process contributed to the inclusiveness of the sensory space design.

We presented the design options identified in Objective 2 to the teachers at the Chaeli Cottage and interviewed them to determine if the design is a good fit for their community. The teachers at the Chaeli Cottage work directly with the children on a day-to-day basis, so their feedback is important. The conversations with the two teachers focused on how the design affects sensory stimulation for children and any potential overstimulation, injury, or concern that could be avoided by altering the design. Interviewing the teachers helped ensure the design is safe and beneficial for the community and will give us insights as to how the sensory designs can help young children with disabilities. We also presented the designs identified in Objective 2 to the three therapists at the Chaeli Cottage. These therapists work with the students in biweekly intervals to strengthen a variety of skills, such as communication, socialization, and emotional regulation. During these interviews we discussed our designs and got their feedback as to which designs are most beneficial and inclusive to the students at the Chaeli Cottage.

After interviewing the professionals, we reviewed the design options and selected the ones that would work best for the Chaeli Cottage. To analyze the interview data, we used deductive coding, which is sorting qualitative data using a predefined set of themes (Stacey, 2019). The interview data helped us determine which designs best fit the requirements and constraints identified in Objective 1. An engineering or decision matrix uses weighted design requirements and constraints to identify which items best meet the design goals (Jack, 2022). Our engineering matrix with design requirements can be found in Table 6 in Appendix C. We used an engineering matrix to help choose the design options that work best for the sensory space. After identifying the

top designs from the engineering matrix, we used them in conjunction with qualitative information about the designs to determine the final designs. Once we created the final designs, we created lists of costs and materials, ensuring the cost of the designs are minimal.

3.4 Building Sensory Objects and Testing through Observation

Our fourth objective was to build our proposed ideas after completing the co-design process. We built sensory objects with recycled materials to keep costs low. The sensory objects were put into place and the children at the Chaeli Cottage were allowed to use them. The goal of this objective was to ensure that the sensory objects stimulate different senses of the children while helping them self-regulate if needed. As the children interacted with the designs, we observed how they play with the materials. This process was followed with our observation protocol for children interacting with out sensory elements, found in Appendix D, which we developed using the Teaching Dimensions Observation Protocol (TDOP). TDOP is a customizable observation protocol that produces "robust and nuanced depictions of dynamics that unfold among teachers, students, and technologies in the classroom" (Osthoff, 2009). This allowed us to obtain formative feedback and document types of learning methods through technical feedback of active learning.

We observed the children interacting with our designs over the course of a few days so we could estimate the level of interest in the sensory objects. The purpose of observing children over a long duration such as multiple days is to ensure that we can maximize natural play. When a new sensory element is introduced into the play space, it is anticipated that the novelty of a new object will cause many children to interact with the object in an unnatural manner. When given multiple days, the novelty of new objects should lessen, providing more natural play for the children. The goal of the observation was also to confirm that the sensory objects are inclusive for all the students. The sensory objects are typically catered towards students with ASD as this is one of the needs of the Chaeli Cottage. However, the sensory space and objects must be fully accessible to students who are using wheelchairs.

Observations of the children interacting with the design elements guided us in reviewing and editing the designs to cater to the needs of the students. The information we gathered helped us to create a sensory space that will benefit the Chaeli Cottage to the greatest extent possible.

4.0 Findings and Deliverables

In this chapter, we discuss the findings that helped us create a sensory space that would best fit the needs of the Chaeli Cottage community. This chapter details the needs and user requirements of the stakeholder community that we identified through the completion of our cyclic and iterative methodology. We also present the design and build process of our sensory space, including information on the materials acquired. In addition, we highlight how the design choices support the Chaeli Cottage community needs and deliverable requirements.

4.1 The Needs of the Chaeli Cottage Community and Design Requirements

Through the completion of our staff interviews, observation, and literature reviews, we identified the most prevalent needs of the Chaeli Cottage community and learned how we could incorporate the user needs into our design requirements. We identified the current profile of disabilities present at the Chaeli Cottage. We found that there is a wide variety of disabilities ranging from children diagnosed with ASD, to children with physical disabilities who use wheelchairs, to children with no diagnosed disability. Figure 8, pictured below, shows the percentages of disabilities at the Chaeli Cottage in 2023. Although this data is fixed during the school year, it changes each year because some students graduate, and others begin enrollment at the preschool. Due to the dynamic nature of the disability profile at the school, the percentages of disabilities will change each year.

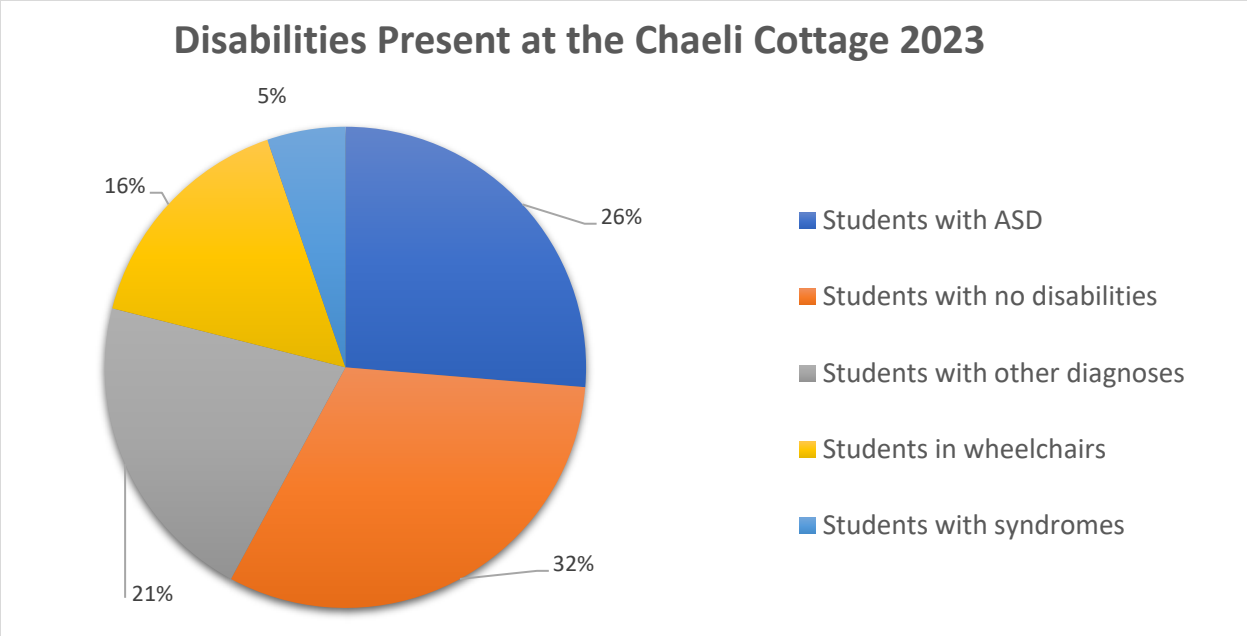

Figure 8: Disabilities currently present at the Chaeli Cottage as of November 2023

Based on the wide variety of disabilities present at the Chaeli Cottage in any given class year, we identified inclusivity as a primary need of the Chaeli Cottage community that our sensory space needed to address. Every student is affected differently by their disability and has unique sensory needs. We want every student at the Chaeli Cottage to be able to use and benefit from our sensory space without encountering the barriers of exclusion. Based on the immense diversity of needs present in any community of unique individuals, we learned that creating a design that is inclusive to all disabilities is a complex task with limitations. While the goal of this project was to create a space that is inclusive to all disabilities, we found that the achievement of a completely inclusive design is implausible. We found that the needs of one individual often overlap and contradict the needs of another individual. Regarding sensory needs, we found that the incorporation of musical elements would be engaging and beneficial to some students, but overstimulating and consequential for others. We identified the need to separate energizing and noise-making sensory elements from calming and quiet elements to accommodate as many needs as possible while avoiding conflict. Although inclusivity is complex and difficult to achieve, further understanding of the Chaeli Cottage community needed helped us increase the inclusivity of our deliverable.

We found that a major boundary to inclusivity was inaccessibility. During our observations of the students during free play, we found that students with physical disabilities, especially those

who use wheelchairs, were excluded from activities and social opportunities due to the inaccessibility of play space and toy design. More details on our observations can be found in Table 5 in Appendix B. Based off these observations, we found that accessibility had to be a primary design requirement. We learned that inclusion cannot exist without first addressing accessibility and that accessibility should be one of the core considerations in any design.

Based off interviews with the teachers, staff, and therapists, and analysis of the student IEPs, we learned that variety would be a major design component in making our sensory space inclusive. There is a wide variety of individual needs to be addressed in the Chaeli Cottage community, and we identified that our sensory elements should reflect this variety to be as inclusive as possible. Through a co-design process with the staff, we were able to identify a variety of sensory elements that can stimulate the five senses. We were able to separate the toys into four main categories: calming, educational, fine motor skills, and cognitive challenge. Based off the interviews, we found that this space should be a calming place for children, especially with ASD, to come to when they feel overwhelmed. When analyzing the IEPs, we found that educational toys using shapes, colors, numbers, and letters were a big necessity for the students. Toys that help develop fine motor skills were also important to incorporate because they help with coordination, strengthen hand muscles, and encourage independence. Lastly, toys that present a range of cognitive challenges will build critical thinking and problem-solving skills.

Another design requirement that we identified was adaptability. We learned that inclusivity is not a static goal, but a changing idea about accommodating a design to suit community needs. We realized that to make our space inclusive, we had to reflect this adaptability. Through our interviews with the staff, we found that a stationary sensory space would not suit the community's needs. The size of the Chaeli Cottage play space was limited and consensus on where to put a stationary space was not reached between the staff. Teachers at the school also voiced that events are held in the space and all the toys were often removed or cycled through to avoid boredom amongst the students. We concluded that to make our space adaptable to the dynamic needs of the community, we had to make our sensory space portable. We furthered this idea of adaptability and portability by concluding that all the sensory elements on our sensory space should be able to be readily removed, altered, and able to detach from the space to make our sensory space adaptable.

Lastly, we found two major design requirements that cater to the Chaeli Cottage teachers. We identified that the space should be low maintenance for the staff to prevent more work for the teachers during their busy schedules. We also found that the sensory space should be sustainable for many years. We want our sensory space to provide benefit at the Chaeli Cottage for as long as possible which means all our materials used need to be durable enough to last through years of use at the preschool.

By understanding the needs of the Chaeli Cottage community, we were able to compile the design requirements identified above which guided our design choices. All the design requirements we identified were utilized in our engineering matrix in Table 6 in Appendix C.

4.2 Analysis of Sensory Elements and Designs

With the information we gathered through a literature review, interviews, observation, and a co-design process with Chaeli Cottage staff, we created a table of potential design elements. The table includes the element, the targeted sense, and what population of the children this would affect. This table can be found below in Table 2. Overall, much of the anticipated demographic is overstimulated children who need help self-regulating. Through observation and interviews, we were able to decide that the Chaeli Cottage community seeks more self-regulation, rather than energizing activities.

Potential Design Elements		
Element	**Targeted Sense**	**Anticipated Demographic**
Texture Boards	Touch, Sight	Calm overstimulated children
Sensory Bottles	Sight	Calm overstimulated children
Plants and herbs	Sight, Smell, Touch	Calm overstimulated children
Xylophone	Sound, Sight	Energizing or calming of students
Drums	Sound	Energizing of under stimulated children
Mobility Toys	Sight, fine motor skills, range of cognitive challenge	Help learning and regulating senses
Cause and Effect Toys	Sight, range of cognitive challenge	Help learning and regulating senses
Magnetic Mazes	Touch, range of cognitive challenge	Help learning and calm overstimulated children

Pin-art toy	Touch, Sight, fine motor skills	Calm overstimulated children

Table 2: Potential design element, targeted sense, and anticipated demographic

The above table was used to create an engineering design matrix that was able to rank the ideas from the most effective to least effective in accordance with the design requirements identified above in section 4.1. This matrix can be found in Table 6 in Appendix C. Through this process, we decided that a sensory station with toys and a separate music wall would be the most effective design to cater to students' needs.

Due to students with hypersensitivity and hyposensitivity, we concluded that separating designs that are energizing and calming would be most beneficial to the students at the Chaeli Cottage. Musical sensory elements have potential to cause overstimulation due to loud noises, so we decided that separating the music wall from the sensory station would be best accommodate a variety of sensory needs while avoiding consequential sensory reactions.

4.3 Sensory Station Design

Our final sensory station design was created through a co-design process with the staff at Chaeli Cottage and Happinest™. This desk-like design was designed to be dynamic and accessible to allow students of all abilities to interact. The desk itself was constructed using MDF wood and was primed, painted, and weather sealed to ensure durability. Table 8 in Appendix E details all materials used and the corresponding acquisition.

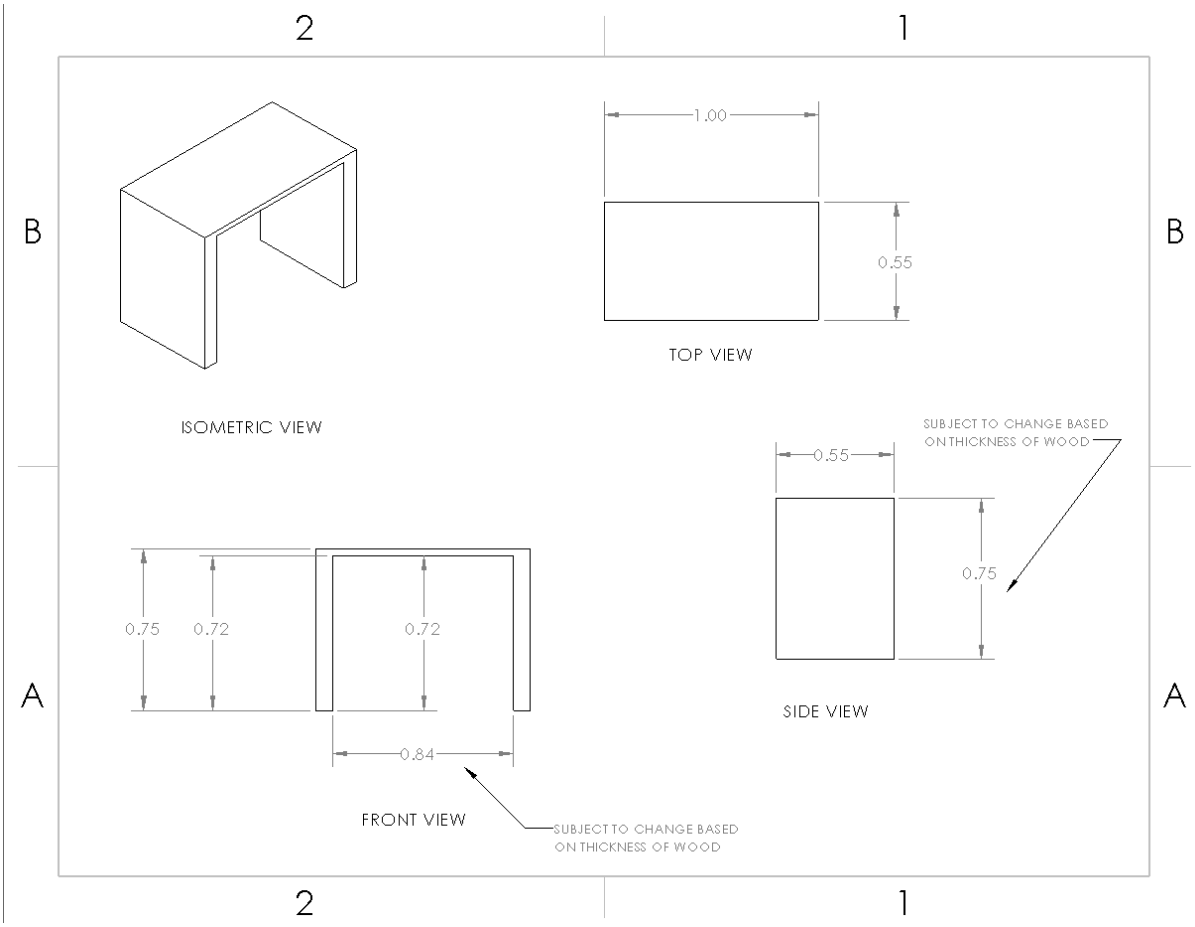

Figure 9: CAD drawing of sensory desk

Our sensory station was designed with accessibility as a primary design requirement. This is reflected in our selection of our dimensions, as shown in Figure 9; the tabletop of our station is 72 centimeters tall, which can accommodate even the tallest wheelchair used by children currently enrolled at the Chaeli Cottage to be rolled underneath with a space for the children's legs. The tabletop is accessible from both sides, allowing multiple children who use wheelchairs to play collaboratively across from one another. The desk is also 100 centimeters wide, allowing two children to play on one side of the station side by side. The tabletop dimensions were designed with the encouragement of socialization through collaborative and parallel play in mind. There is enough room for a student in a wheelchair and another student to stand on one side or two students

using wheelchairs to sit across from each other and play collaboratively at the top of the desk. An example of this collaborative and parallel play can be seen in Figure 10.

Figure 10: Children who use wheelchairs playing face-to-face as other students play parallel at the sensory station

The desk was put on lockable wheels to meet the needs of the students and the teachers. The teachers at the Chaeli Cottage explained that their play space is often used for events, wheels allow the desk not only to be moved around the play space itself, but also to be removed from the space or brought inside when desired. Lockable wheels prioritize safety to prevent the desk rolling away or causing injury to the children. We also ensured that the desk was narrow enough to easily fit through indoor doorways at the Chaeli Cottage. The portability and removability of the sensory station also prevents boredom as the teachers voiced that they continuously cycle through which toys are available to play with.

Figure 11: Final sensory station with sensory elements Velcroed to the desk

In addition to the sensory station being portable, each individual sensory element on the station is portable and removeable as well. Each sensory element is attached to the desk using Velcro. The use of Velcro increases the versatility of each individual sensory element, which in turn increases the inclusivity of the space. With toys that are easily removeable, our space can accommodate a wider range of play styles. During our observations of the preschool playtime, we observed that some of the students, especially those diagnosed with ASD, prefer to play by themselves in a private space. We wanted to allow these students with varying play styles to feel safe using our sensory space without forcing socialization where it may be consequential. Our removeable sensory elements allow any student to detach the desired object and play or self-regulate in the desired environment. The use of Velcro also allows each sensory element to be removed from the desk and placed on the tray table of wheelchair to make each toy accessible. It is also important to us that our sensory space remains adaptable, durable, and low maintenance for the teachers and staff at the Chaeli Cottage. The simple application of Velcro allows broken or problematic toys to be removed, replaced, or altered to best suit the needs of the preschool community at any given time.

We also understood that variety was one of the primary needs of the Chaeli Cottage and we wanted our sensory elements to reflect this. The sensory toys we selected were separated into

different categories to best help with sensory integration. The different elements and their target senses are seen in Table 2. Most of the elements on our sensory station were selected to provide a sense of calm and increase focus. This is exemplified in the oil and water sensory bottles we created as well as the varying texture panels, many of which are inspired by natural elements. We also wanted to foster learning through the incorporation of shapes, colors, numbers, and letters into our sensory toys. The magnetic alphabet and number board we incorporated onto our station meets these educational criteria. Another community need we identified from analyzing the student IEPs was the practice of fine motor skills. To accommodate this need, we created a mobility board that contains various latches, locks, keys, wheels, hinges, carabiners, and fidget spinners. These mobile sensory elements strengthen hands, nourish fine motor skills, and improve coordination. Lastly, we wanted to address the diverse abilities of each child through incorporating a variety of toys that present a range of cognitive challenges. The sensory elements that we implemented teach skills such as solving mazes, tying shoes, telling time, and turning on and off light switches. We also included a blue box, Velcroed to the top of the sensory station, that contains a variety of smaller, loose toys that can easily be taken away from the sensory station to provide sensory integration in any environment. This variety of sensory elements attached to the desk can be seen in Figure 11 and a more detailed view of the sensory toys which highlight specific design requirements are pictured in Figure 12.

Figure 12: The variety of sensory toys that we attached to the sensory station; this includes fine motor skill toys, sensory bottles, cognitively challenging toys, and other educational toys

4.4 Music Wall Design

The music wall features a PVC pipe xylophone, mounted to a wheelchair-accessible box which is also mounted to the wall. The primary purpose of this music wall was to separate the energizing and loud musical sensory elements from the otherwise calming and quiet sensory elements contained on the sensory station. This separation of the auditory sense from the others allows both the energizing and calming elements to be present at the Chaeli Cottage while minimizing the potential for overstimulation. This wall caters to auditory sensory input, but also has visual components with a brightly painted PVC xylophone (Figure 13).

Figure 13: Final sensory wall design with PVC pipe xylophone attached to mountable box

The xylophone was made of PVC piping that was attached to an MDF box. This makes this feature accessible as the box extends from the wall, allowing students who use wheelchairs to reach it has their legs can fit underneath (Figure 14).

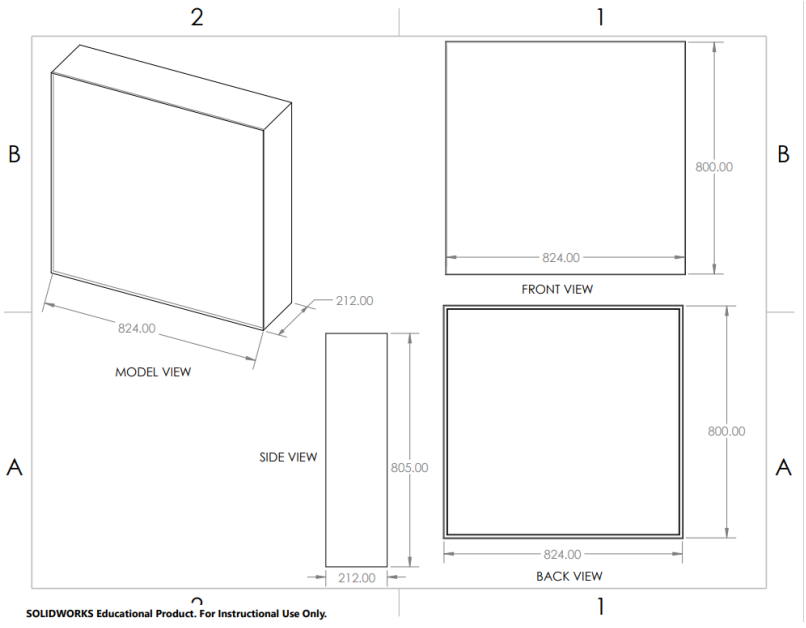

Figure 14: CAD drawing of the MDF wood box used to create the accessible extended box design

The xylophone was also designed to be portable and is connected to the wall by hooks, allowing the teachers to remove the musical elements whenever needed. The music wall also consists of drums made of recycled material along with other instruments that would make music. We designed this space to be separate from the sensory station because the sensory toys used were noisier and more energizing than the material and toys localized on the desk. We did this to increase inclusivity by separating loud and energizing elements that have a greater potential to cause overstimulation from the quieter and more calming sensory elements.

5.0 Conclusions and Recommendations

The goal of this project was to create an inclusive and accessible sensory space for the students at the Chaeli Cottage preschool that best suits the diverse needs of the community. Our sensory space aims to provide a space for students to self-regulate, prompt cognitive challenges, improve fine motor and coordination skills, and encourage parallel and cooperative play. We completed this goal through a cyclic and iterative design process which helped us identify and understand the needs of the Chaeli Cottage community. We incorporated the stakeholder needs into our design requirements, allowing us to create a sensory station and music wall that are accessible, adaptable, and inclusive. This chapter begins with the recommendations we propose for the Chaeli Cottage and future inclusive designs. After discussing our recommendations, we detail the conclusions and implications of our project in respect to inclusive and accessible design.

5.1 Recommendations for the Chaeli Cottage Sensory Space and Future Inclusive Play Space Designs

Upon the completion of our sensory space at the Chaeli Cottage and understanding the implications of our findings, we have compiled a series of recommendations which are intended to guide the design of sensory spaces and inclusive play spaces. We advocate that the following recommendations be implemented at the Chaeli Cottage and guide the work of future projects aiming to create inclusive play spaces.

We recommend the addition of plants and nature elements in a sensory garden to further sensory integration for the children at the Chaeli Cottage.

Many of the teachers and therapists at the Chaeli Cottage expressed interest in a sensory garden, which is a sensory space that focuses on providing sensory regulation through nature. Our literature review supported the implementation of a sensory garden at the Chaeli Cottage as evidence showed that routine exposure to plants and nature reduces anxiety through sensory input. Despite our findings supporting the addition of a sensory garden, we did not prioritize building a sensory garden as the teachers and staff at the Chaeli Cottage voiced that plants would be difficult to maintain long term and it would not have been a sustainable design option. The teachers and therapists also voiced concern surrounding the durability of plants in an environment where they may be easily broken or uprooted by the children. For the purposes of this project, a sensory garden did not meet the stakeholder needs of being durable, sustainable, and low maintenance and

therefore was not prioritized and unable to be implemented due to time constraints. However, the children at the Chaeli Cottage might benefit from a green sensory space which provides pleasant and calming stimulation of the visual, tactile, and olfactory sense in the future.

We recommend that future sensory space designs prioritize accessibility as the primary criteria for inclusive design.

Our observations of the preschool routine at the Chaeli Cottage demonstrated that children with physical disabilities who use wheelchairs are often excluded from playground activities and socialization with peers due to inaccessibility of the toys and environments being used by their peers without physical disabilities. We found that inaccessibility was the primary reason for the exclusion of children with physical disabilities. To solve this problem, we recommend that future play space designs address accessibility as the primary criteria to be met in an inclusive space. We conclude that a space cannot be made inclusive without first being accessible. Accessibility was the primary design consideration for our sensory space, with the desktop allowing wheelchairs to be wheeled under the desk on both sides, not only allowing children who use wheelchairs access to the space, but also encouraging socialization and cooperative play between students of all abilities. Our music wall also prioritizes accessible design as the entirety of the sensory elements are fixed to a large box that overhangs the wall, which gives children who use wheelchairs a space to comfortably fit their legs and access the instruments. Accessibility must be treated as a steppingstone to inclusivity in any community-oriented design meant to address the diverse needs of individuals.

We recommend that future sensory space designs utilize removable and portable elements to keep the play space adaptable to change and increase inclusivity.

Our results showed that a completely inclusive design is fundamentally implausible due to the immense diversity of needs in any given community of unique individuals, which often contradict each other. To address this problem, we recommend that future play space designs rely on variety of elements, and modifiable designs to promote inclusion to the greatest extent possible. We used Velcro to attach each sensory toy to the sensory station to allow the teachers to switch the placement of toys on the desk, remove the toys from the desk for private play, and to adapt the play space to better suit the community needs as they see fit. The portability of individual sensory elements allows each toy to become more inclusive of versatile play styles. Each toy can be

removed and played with in isolation to encourage sensory integration in a private space. All toys can also be removed and played with on wheelchair tray tables, making sensory integration more accessible. Incorporating removable and portable elements keeps the play space dynamic, prevents boredom from the children, and cultivates the idea of inclusion through variety, accessibility, and increased versatility of each sensory element.

5.2 Concluding Thoughts on Accessibility and Inclusive Design

After understanding the needs of the Chaeli Cottage community, identifying the design requirements, and creating and implementing our sensory space, the implications of our findings proposed three concluding ideas surrounding accessible and inclusive design.

The first implication of understanding the diverse community needs at the Chaeli Cottage is that accessibility is a steppingstone to inclusivity. We found that accessibility had to be a primary design criterion in our sensory space design at the Chaeli Cottage, but we learned that the implications of this finding reach far beyond the scope of this project. We propose that inclusivity cannot exist without first addressing accessibility. In our daily lives, the successfulness and usefulness of any design or infrastructure we encounter is dependent on its ability to be physically accessible to its desired demographic. And in a society where we strive to treat every human being as equal, to cultivate inclusivity, and to provide opportunities to all, regardless of ability or background, accessibility may not only be treated as a design criterion, but as a responsibility.

Second, we find that inclusivity is not a static goal to be achieved, but rather a fluid and dynamic idea. In our time at the Chaeli Cottage, we learned that disability is different and unique for every individual who experiences it. The needs of every individual, regardless of ability, are not defined, but rather shaped by experiences, abilities, emotions, and behaviors that are ever-changing and intrinsically unique. The individuality of every human creates an immense diversity of needs to be accommodated in any given community. The implication of this diversity is that a completely inclusive design is implausible. We propose that inclusivity is not defined or constant as an achievable objective, rather, inclusivity is the dynamic and ever-changing concept of adapting a design to best support the needs of a community at any given time.

Lastly, although we conclude that a completely inclusive design is implausible, we identify the means we undertook to create a sensory space at the Chaeli Cottage that is as inclusive as possible. We conclude that the implementation of accessibility and variety contributes to

increasing the inclusivity of any design. In our design, we relied on the incorporation of accessibility and variety to increase the inclusivity of the space. These were two design requirements we recognized through identifying the profile of disabilities present at the preschool and observing the children during free play. The incorporation of these two design requirements shaped the ability of our sensory space to be as inclusive to the Chaeli Cottage community as possible. Accessible design prevents the exclusion of individuals with physical disabilities from our sensory space. Incorporating variety allows our space to cater to the diverse range of needs present the community at any given time. We concluded that the use of accessibility and variety are primary design criteria in any design that aims to increase inclusivity.

In conclusion, our sensory space provides the students at the Chaeli Cottage with an inclusive play space to incorporate sensory integration into daily routine. The space presents the same sensory play opportunities for students with intellectual and physical disabilities as it does for the students without disabilities. The sensory space encourages all the children at the Chaeli Cottage to use sensory regulation as a soothing exercise and develop skills that are important to cognitive development. After designing and implementing an inclusive and accessible sensory space for the Chaeli Cottage community, we identified that the implications of our results and findings propose several concluding ideas regarding inclusive design. The first being that accessibility is a steppingstone towards inclusivity as inclusivity cannot exist without meeting the criteria of accessibility. We can also conclude that inclusivity is not a static goal to be reached but is a fluid and ever-changing idea. We learned that disability is different for every individual who experiences it and that the needs of every individual are unique. Therefore, inclusivity should be understood as a dynamic concept of adapting a design to best suit the community's needs at any given time. We also learned that the incorporation of accessibility and variety as design requirements increases the inclusivity of a sensory space. The sensory space that we developed with the Chaeli Cottage advanced the Chaeli Campaign’s mission of helping individuals with disabilities live fulfilling and capable lives. We hope that the lessons learned about inclusivity through the completion of this sensory space guide future inclusive designs to promote equal opportunity for all, regardless of ability.

Figure 15: Final sensory space with students at Chaeli Cottage interacting with the station

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Appendices

Appendix A: Semi-Structured Interviews with Chaeli Cottage Staff

Interviewee	Professional Title	Date of Interview
Rosemary Luger	Occupational Therapist, Director of Therapies	10.31.2023
Chaeli Mycroft	Manager of Relations and Funds	11.6.2023
Zelda Mycroft	CEO	11.6.2023
Ariska Prins	Teacher	11.13.2023
Debbie Prudhomme	Principal	11.13.2023
Faziah Toefy	Speech Therapist	11.14.2023

Table 3: List of interviewees, titles, and dates of interviews

Interview Questions:

1. What sensory play do you think would be beneficial to the students?
2. What purpose should this sensory space serve for the children at the Chaeli Cottage?
3. Do you have any safety concerns or considerations with our presented sensory space design?
4. Do you have anything else you would like us to know about your hopes for sensory space?

What sensory play do you think would be beneficial to the students?	What purpose should this sensory space serve for the children at the Chaeli Cottage?	Do you have any safety concerns or considerations with our presented sensory space design?	Do you have anything else you would like us to know about your hopes for sensory space?
Music, textures, nature-inspired elements, interactive elements, fine motor skills and coordination, toys with a range of cognitive challenge	Calming the students, self-regulation, some energizing elements, but mostly calming, also encouragement of socialization, cooperative play, and parallel play between all students	No sharp objects or textures, no small and loose objectives to avoid choking hazards, durable materials that do not have to be frequently replaced, low maintenance, able to be removed from the space when needed	Plants could be a beneficial addition at some point

Table 4: Generalized consensus of the interviews

Appendix B: Observation Protocol of Students at Natural Play

This guide directed the observer to collect information about how the children at the Chaeli Cottage play. The information helped us understand which play objects are currently inaccessible and not inclusive. It also provided us with information about what toys or activities the students are most attracted to and how they socialize with each other. This method contributed to our findings regarding the needs of the Chaeli Cottage community.

Guide for observers:

- Sit or stand in an area where the observer's presence is least likely to interfere with the natural play of the children.
- Document areas that the children play in, or the objects children play with.
- Record socialization with other children.
    - Solitary play – interacting and playing with toys independently or in a separate space from other children.
    - Parallel play – playing with peers side-by-side but without interacting.
    - Cooperative play – interacting and playing together with peers.
- Record interactions with peers.
    - Positive or negative – an interaction is positive if the children are smiling, laughing, or having fun interacting with each other; an interaction is negative if the children look upset, are crying, or are not benefitting from the interaction.
- Note the duration of the play.

Date/Time	Location at Chaeli Cottage	Socialization	Interactions	Duration
November 11, 2023	Outdoor Play Area	No engagement at beginning of play, running around with each other, able-bodied students only playing with each other	Independent, cooperative	1 hour
Reflections	Some students diagnosed with ASD seemed to prefer independent play, trampoline, sand, water, and bikes held attention, Accessibility seems to be an issue as many toys or activities are inaccessible to with students who use wheelchairs and are unable to move themselves			

Findings	Little accessibility for students using wheelchairs, self-regulation needed, disabilities created different groups. There appears to be a need to encourage cooperation and socialization between all groups of students
Next Steps	Look into more accessible designs and designs that encourage socialization

Table 5: Observation guide from Nov 11, 2023, after observing students during free play

Appendix C: Sensory Element Engineering Design Matrix

Design Requirements & Weights		Texture Boards	Music Wall	Latches & hooks	Sensory Bottles	Cause & Effect	Sensory Desk with Toys
Accessibility	10	10	9	6	9	9	10
Inclusivity	9	8	6	8	5	6	10
Portability	9	9	7	3	10	4	8
Calming	8	9	9	5	8	5	8
Educational	7	4	7	10	3	6	9
Practice of fine motor skills	6	3	5	10	2	5	8
Range of cognitive challenge	6	1	6	8	2	4	7
Encouragement of cooperative play	5	1	9	2	2	3	8
Safety	10	10	9	8	10	10	9
Maintenance	7	9	10	9	9	6	8
Sustainability	7	7	8	9	9	7	8
Low cost	6	6	8	6	5	5	5
	900	630	703	629	600	552	751

Table 6: Engineering design matrix of sensory elements

The table above ranks the design requirements on a scale of one to ten on how important our team decided they were through a discussion. We then went through each of the ideas and ranked how well the ideas fit the design requirement. This occurred through a discussion of all team members before landing on a final ranking.

Appendix D: Observing Children at Play with Designed Sensory Elements

This guide directed the observer to gain information on how a child interacts with the designed sensory objects. The information helped us understand how effective the sensory objects were regarding meeting the design requirements. Using the knowledge gathered, we were able to revise designs to specifically meet students' needs.

Guide for observers:

- Sit or stand in an area where the observer's presence is least likely to interfere with the natural play of the children.
- Observe each child’s interactions with each sensory object. Note relevant actions and reactions.
- Record the sensory objects that are played with most frequently to understand which objects are preferred.
- Record the recognized senses for each sensory object:
    - Touch – providing sensory stimulation through contact with the surface of the skin.
    - Smell – providing sensory stimulation through perceiving a scent or odor.
    - Visual – providing sensory stimulation through seeing light, color, and movement.
    - Auditory – providing sensory stimulation through hearing sounds or vibrations.
    - Taste – providing sensory stimulation through distinguishing sweet, sour, salty, and bitter objects with taste buds (if safe and applicable).
- Record socialization between the children.
    - Sharing – the children take turns with their peers when playing with toys.
    - Independent play – the children play individually, without interacting with peers.
    - Engaging with peers – the children play jointly with their peers.
- Record the duration that the students play with each sensory object.

Date/Time	Location	Objects	Behavior Description	Sense	Social	Duration
Nov. 29 11:30 am	Chaeli Cottage Play area	Sensory Bottles	Children were very focused playing with the sensory bottles. Some children forgot about them quickly while other children didn't want to give them up. Children interacted with the bottles by shaking them or tipping them slowly upside down to watch the oil and water separation form bubbles	Sight and touch	The children were independently playing with the bottles, but they were generous when encouraged to share	30 min
Reflection	Some of the children lost interest in the sensory bottles quickly while others didn't want to put them down. Some of the children diagnosed with ASD seemed particularly enveloped with the sensory bottles. We hoped that these would be able to keep children occupied for a while and we observed signs of that in only half the children.					
Findings	The sensory bottles calmed the children down during their rambunctious play time. All the children focused on the bottles when they were using them and weren't distracted by the other children playing.					
Next Steps	Our next steps will be building a couple more sensory bottles and adding them to the sensory desk so that the teachers can use them to help calm children down.					

Table 7: Observation guide from Nov. 29, 2023, after observing the students with sensory bottles

Appendix E: Resources Used to Create Sensory Space

List of Resources for Sensory Station

Item	Cost ZAR	Cost USD	Supplier
MDF (wood)	Donated	N/A	Happinest™
Screws and nails	Donated	N/A	Happinest™
Primer	Donated	N/A	Happinest™
Paint	Donated	N/A	Happinest™
Wood Glue	Donated	N/A	Happinest™
Wheels	296 ZAR	$16.28	Gelmar
Sensory Toys	6084.2 ZAR	$334.63	Crazy Store, PnA, miscellaneous craft stores

Table 8: List of resources for the sensory station including price and amount needed along with the supplier

List of Resources for Music Wall

Item	Cost ZAR	Cost USD	Supplier
50mm (2 inch) PVC pipes	Donated	N/A	Happinest™
MDF Wood	Donated	N/A	Happinest™
Acrylic Paint	1005,71 ZAR	$53.05	PnA, Builders Warehouse

Table 9: List of resources for the music wall including price and amount needed with the supplier