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# VestibulOTherapy: vestibular interventions to support learning and memory

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BOSTON UNIVERSITY  
SARGENT COLLEGE OF HEALTH AND REHABILITATION SCIENCES

Doctoral Project

**VESTIBULOTHERAPY:  
VESTIBULAR INTERVENTIONS  
TO SUPPORT LEARNING AND MEMORY**

by

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requirements for the degree of  
Doctor of Occupational Therapy

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## **DEDICATION**

I would like to dedicate this doctoral project to my encouraging husband Mark, my supportive children Eli, Isaiah, Zach, Katie, and Liz, and my comforting dogs Griffin, Remi, and Ava, who patiently stuck with me through many hours of research and writing.

I would be remiss if I did not also mention the many children I have worked with in school based OT, who have taught me lessons that cannot be learned in the classroom. They have shared my love for the art and science of occupational therapy.

It is my hope that this project will promote joy and confidence in both the adults and children who engage with its constructs. I am hopeful the contents of this educational programming for vestibular interventions will be transformative to classroom and school-based OT programs, helping more children achieve in their social and academic occupations through improved vestibular maturation.

## **ACKNOWLEDGMENTS**

I would like to thank the many people who have shaped my perspectives and helped me to aspire to reaching this endeavor. I would especially like to thank my Boston University cohort for their discussions and posts that helped me to reflect on my thinking and critically appraise research and applications. I would like to thank my heavenly creator for guiding me through this journey, which I feel was ordained to help more children succeed in our challenging times.

I sincerely thank my professors at Boston University for their inspiring educational programming that promoted global views, political interest, and meaningful insight to diverse topics relevant to our esteemed profession. I would especially like to thank Drs. Liat Gafni-Lachter and Nancy Doyle for their exceptional dedication and inspiration by procuring the highest standards for my educational performance. I appreciate a bar that is set to the highest standard.

**VESTIBULOTHERAPY:  
VESTIBULAR INTERVENTIONS  
TO SUPPORT LEARNING AND MEMORY  
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**ABSTRACT**

VestibuloTherapy is an emerging frame of reference, grounded in contemporary neuroscience evidence with supporting theories from OT-Ayres Sensory Integration and vestibular rehabilitation. Through its application, children with vestibular under-registration will experience adequate vestibular activation to generate myelination and develop neuropathways supporting communication and learning.

Through a combination of etiologies, the suspected prevalence of pediatric vestibular dysfunction impacts approximately 3.3 million US children annually, while few receive appropriate diagnosis or treatment (Li et al., 2016). For comparison, the most recent statistics indicate a prevalence rate of 2.3% frequency of autism in US children (Maenner et al., 2021). Delayed maturation of this vital system may be related to increasingly sedentary and low-risk lifestyles or compromise from inner ear functioning. With increasingly sedentary landscapes, evidence-based practice and supporting literature is needed to inform and guide OT practitioners in the identification and application of vestibulotherapies to support children struggling with communication and academic

performance. Vestibulotherapy principles will guide therapists in the identification and intervention of delayed vestibular maturation through a combination of clinical and home or classroom-based activities that are embedded into the child's occupations of play and learning.



## **Preface**

Did you ever wonder why kids, who seemingly want to pay attention, fall out of their chair while working in the classroom? Or why some children are always moving and cannot stay still? Their underperforming vestibular system is either not providing adequate feedback to maintain posture or sending them signals to activate the system through movement. How does this idea fit with the common notion that “movement anchors learning”?

Through decades of working with children, it has become increasingly evident that the vestibular system is the foundation on which learning becomes possible. Through its connections to the visual and auditory systems, as well as the thrust for myelination leading to the frontal cortex, the vestibular system drives learning and memory, while supporting our attention and engagement.

The basis for this research emerged from my observations of children’s learning in response to vestibular interventions. As children become increasingly more sedentary in a low-risk landscape, it is now more important than ever for occupational therapists in school based or pediatric OT to provide quality, evidence-based treatment focused on improving vestibular maturation to support learning and communication. A high prevalence of children’s vestibular dysfunction remains undetected and untreated (Li et al, 2016), manifesting challenges relating to learning and communication.

The dearth of knowledge and evidence around applications for vestibular maturation in OT has been the inspiration for writing this manuscript. Fortunately, contemporary neuroscience has provided extensive knowledge supporting my

observations. It is my intention to connect contemporary neuroscience evidence to lived experiences in OT, supporting further development of “vestibulotherapy” to help neurotypical children succeed in learning and communicating.

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## **LIST OF ABBREVIATIONS**

ASI	Ayres Sensory Integration
BU	Boston University
DCD	Developmental Coordination Disorders
DLD	Developmental Language Disorders
ICF	International Classification of Functioning
ISO	International Standards Organization
LD	Learning Disorders
NIH	National Institute of Hearing
OT	Occupational Therapy
OTPF	Occupational Therapy Practice Framework: Domain and Process, 4th Edition
SBI	Sensory Based Interventions
UDL	Universal Design for Learning
VeDA	Vestibular Disorder Association
VI	Vestibular Impairment
VR	Vestibular Rehabilitation
WHO	World Health Organization
WFOT	World Federation of Occupational Therapy

## **GLOSSARY**

**Ayres Sensory Integration (ASI)** – ASI is a theoretical framework guiding OT practice for children who demonstrate poor sensory integration, as evidenced by comprehensive testing with the Sensory Integration and Praxis Test (SIPT) or similar evaluation measures. The key ingredients for ASI include active and individually tailored, sensory-motor activities contextualized in play at the just right challenge, targeting an adaptive response for participation and engagement. Activities must include a combination of proprioception, vestibular and tactile sensations and invoke an adaptive response, promoting increased neural connectivity and efficiency. To meet fidelity, all ten essential elements must be met (Parham et al., 2011).

**Sensory Based Interventions (SBI)** – A theoretical framework guiding OT practice with children who demonstrate sensory processing deficits. SBI employs a variety of sensory modalities for a variety of purposes, often aimed toward increasing engagement and participation through improved regulation or arousal. Strategies may be extended beyond youth.

**Vestibular Rehabilitation** – is based upon three theories of neural plasticity invoked through a.) *adaptation* which invokes changes at the neuron level of the vestibular nuclei, impacting functional portions of the peripheral vestibular system; b.) *substitution*, which relies on compensation from other areas of the central nervous system; and c.) *habituation*, which improves the individual's tolerance to motion through desensitization through repeated motion over time (Hall et al, 2016; Christy, 2019).

**Vestibulotherapy** – an emerging frame of reference aiming to help neurotypical children with under-performing vestibular systems develop neuropathways supporting communication and learning. Given adequate vestibular activation through targeted activities (in an otherwise under-performing vestibular system), myelination and neuroplasticity propagate along learning pathways leading to greater neural connectivity and efficiency for sequencing, ordinance, attention, memory, body schema, spatial cognition, executive function, and interoception (Besnard, et al., 2016; de Wall, 2019; Hitier et al., 2014; Kashfi et al., 2019; Lopez et al., 2020; Mast et al., 2014; Melo et al., 2019; Moossavi & Jafari, 2019; Schoen, et al., 2019; Watling & Hauer, 2015; Andelin, 2019; Lotfi et al., 2017; Matuszkiewicz & Gałkowski, 2021; Mulligan, 2011).

## **Chapter One**

### **A Call to the Profession**

#### **Defining the Problem**

A dearth of awareness and knowledge exists within the pediatric medical profession about the role of the vestibular system in child development. Consequently, there is an inability to effectively support this vital system during the formative years (de Veer, 2017). Despite scientific research documenting direct benefits from vestibular interventions on cognitive performance (Hitier et al., 2014; Lopez et al., 2020; Lotfi, et al, 2017; Kashfi et al., 2019; Mast et al., 2021; Moossavi & Jafari 2019) as well as historical evidence from occupational therapy within the Ayres Sensory Integration (ASI) framework (Lane et al., 2019; Ayres, 2005, 1972), many OTs lack appreciation of the impact vestibular interventions have on the development of sensorimotor foundations for learning, motor development, communication, and overall occupational performance (Wall, 2021).

Within the literature, Vestibular Rehabilitation (VR) is employed by OTs and PTs with specialized training to address vestibular impairment (VI) symptoms that fall into four categories including vertigo, dizziness, vestibulo-visual, and postural limitations (Rine, 2018). Similarly, but slightly different for children with VI, symptoms include gaze instability, disequilibrium and deficits in postural control, motor development delay, and vertigo (Rine, 2018). However, many sources feel that children younger than 10 years are unable to identify or articulate the presence of such symptoms, adding to the limited diagnosis of VI in children (Rine, 2018). Based upon parent reports of children

demonstrating symptoms of dizziness or balance problems such as vertigo, unsteadiness during transitional postures, clumsiness / poor coordination, frequent falls, fainting or light-headedness, or other dizziness and balance symptoms, an estimated 3.3 million US children are suspected of having vestibular dysfunction, yet most go undiagnosed or untreated (Li et al., 2016).

Over the past decade, research aimed at better understanding the role of the vestibular system in relation to cognition and memory has been documented and embedded within neuroscience publications. However, very little of this recent knowledge has made its way to occupational therapy literature. Except for the position paper from AOTA on vestibular rehabilitation, which addresses adult-based or adult-like challenges associated with VI, there is little mention of pediatric vestibular considerations from within our professional association.

When surveyed, fellow OTs indicated they lack confidence for measuring and recognizing vestibular deficits and needed objective measures that are easy to administer (Wall, 2021). Within pediatric OT settings, which are often schools, an absence of funding may prohibit the purchase of sophisticated equipment for measuring vestibular functioning, furthering the need to identify practical, hands-on methods to identify vestibular dysfunction as well as monitor vestibular progress during therapies.

It is unclear, but seemingly unlikely, if treatment for young children with developmental vestibular delays should follow adult-based vestibular rehabilitation recommendations found in AOTA position paper on VR. Challenges relating to delayed vestibular maturation differ from adult-like VI symptoms, where children's delayed

vestibular maturation results in subsequent delays in communication, motor sequencing, bilateral integration, memory, and learning (Besnard, et al., 2016; Hitier et al., 2014; Kashfi et al., 2019; Lopez et al., 2020; Mast et al., 2014; Lotfi et al, 2017; Melo et al., 2019; Christy, 2019; Moossavi & Jafari, 2019).

### **Importance of the Problem and Consequences to Clients**

There are increasing reports of vestibular dysfunction in children (Christy & Rine, 2016; Li et al., 2016). Problems with balance, attention, motor development, gaze stability, and reading acuity have been reported consequences of vestibular deficits in children (Li et al., 2016; Lotfi et al., 2014; Kashfi et al., 2019). Posture, movement experiences, and perception, collectively referred to as “embodiment” (Lopez et al., 2020), are supported by the vestibular system and provide a foundation through a sense of self (Besnard et al., 2018; Lopez, et al., 2020). Perceiving and thinking involve all sensory systems and are reliant on a well-developed vestibular foundation (Lopez et al., 2020). Limited vestibular functioning will result in poor engagement - motorically, socially, visually, and academically (Besnard et al., 2018; Lopez et al., 2020). Our emotional development through our limbic system is directly impacted by vestibular functioning, impacting our psychological and cognitive development (Moossavi & Jafari 2019; Lopez et al., 2020), as well as engagement in childhood occupations within family, school, and social situations.

Within the classroom setting, vestibular dysfunction is rapidly apparent in the student who repeatedly falls out of his or her chair when trying to pay attention. Due to relying on focused attention to remain in his or her seat, this child has limited capacity for

engaging in learning, much less reading or writing, which requires skilled visual motor coordination supported by the postural system (Kashfi et al., 2019). A child who must use vision as a compensatory system for poor balance (vestibular under-registration) encounters competition for their attention at the expense of poor engagement and limitations with functional vision for learning (Kashfi et al., 2019). The capacity for sustained, self-directed engagement increases in conjunction with maturation of perceptual motor function with balance and postural control at the core, providing a foundation for attention, regulation, inhibition, and motor skill development (Kashfi et al., 2019; Mast et al., 2021; Lotfi et al., 2014). To effectively engage in reading and writing, a child's postural control must be established, and vestibular, proprioceptive, and visual systems must be in sync (Kashfi et al., 2019).

Vestibular sensations project through the nervous system establishing cortical pathways for spatial cognition, memory, numeracy, sequencing, and emotional stability (Moossavi & Jafari 2019; Hitier, et al, 2017; Lopez, 2020) supporting successful communication and learning. The vestibular system provides a sense of reference for all incoming information leading to activation or inhibition based on perception of the input. In turn, the vestibular system sets up our navigation system for engagement with the environment and people and objects within it (Moossavi & Jafari 2019; Lopez et al., 2020).

Decreased vestibular responses are associated with deficits in bilateral integration, righting and equilibrium reactions, and coordination of eye and head movements (Lane et al., 2019). Such foundations support the child for readiness for learning and social



engagement. “Ayres hypothesized that vestibular processing inefficiencies would negatively affect the higher-level cognitive functions needed for academic learning, as well as the arousal regulation capacities needed for self-regulation of emotions and behavior. She further speculated that the vestibular system could be engaged in the context of individualized intervention to help children function more fully and successfully in school, at home, and in play” (Lane et al., 2019, p3).

Correlations are highly prevalent between vestibular dysfunction and reading challenges (Toshiyuki & Capov, 2014), with reading scores significantly lower than those of children with typically developed vestibular functioning. Similarly, balance measures correlated well with nystagmus, supporting research findings on the importance of vestibular efficiency to reading competency (Toshiyuki & Capov, 2014). When a child lacks vestibular foundations, he or she must compensate visually to guide posture and movement, diminishing full attention to learning and the development of visual motor skills such as writing (Kashfi et al., 2019). Binocular vision skills used in reading are negatively impacted by vestibular inefficiencies, further limiting the child from academic success (Kashfi et al., 2019). Vestibular applications positively impact reading and writing skills which are highly correlated with language development (Matuszkiewicz, & Gałkowski, 2021). Therefore, we can surmise that vestibular therapies will positively impact communication, reading, and writing skill development.

The following case scenario illustrates how a student receiving OT might benefit from this professional development series through its impact on his OT’s hermeneutic interpretation of sensorimotor challenges and interventions.

**Figure 1.1***Case Scenario*

Case Scenario: Joey is a first-grade boy who hopes to benefit from this educational program series. Joey feels his biggest problem is that he frequently falls out of his chair when he tries to engage in his schoolwork. It is frustrating and embarrassing. His teacher reports that he is always moving, has poor awareness of where he is in space, and difficulty engaging during circle time. She also shared that he has poor visual motor skills, spatial organization, numeracy, ordinance, and sequencing challenges which negatively impact his limited success with communication, reading, and math. His OT has background knowledge in vision therapy to support reading and related functional vision. However, she is unaware of how to measure vestibular performance or apply vestibular interventions. As she becomes aware that Joey has dysfunctional vestibular foundations, she will be more likely to integrate vestibular practices into his daily routine and biweekly therapy sessions to develop vestibular learning foundations including postural control, spatial awareness, numerical and sequential processing, functional vision, and sustained attention for learning. By improving these foundations through improved myelination and neuroplasticity, Joey will experience greater success with communication and academic performance.

This project is a call for knowledge, both locally and globally. We are called by the World Federation of Occupational Therapists (WFOT) to generate, synthesize, exchange, disseminate, appraise, and mobilize cutting edge theoretical frameworks and bodies of evidence, which can be translated into impactful educational practices and policies, while respecting diversity across geographical and cultural regions (WFOT, 2021). Through this continued pursuit of generating, synthesizing, exchanging, and disseminating knowledge, we can help children globally to increase their occupational performance through identification of vestibular dysfunction and applied vestibulotherapies in pediatric OT.

## **Causes and Contributors to The Problem**

Children with vestibular symptoms (e.g., dizziness, balance problems, visual instability, and motor coordination problems) and related diagnoses including neurological problems; ear infections; head or neck injuries or concussions; developmental motor coordination disorder; genetic causes; metabolic problems such as hypoglycemia; prescription medication or drugs; severe headaches or migraines; malformation of the ear; and vision problems have potential for vestibular dysfunction (Li et al., 2016). Children with any reported difficulty hearing were two times more likely to have vestibular dysfunction compared with children who had normal hearing (Li et al., 2016). Other risk factors included environmental conditions or physical impairments that limit a child's ability to crawl, walk, run, or play, (Li et al., 2016), which may simply include a sedentary lifestyle. Certain developmental delays and stuttering/stammering in speech are also potential conditions that may suggest vestibular impairment (Li et al., 2016).

A historic lack of distinguishing features between sensory based interventions and Ayres Sensory Integration (ASI) created professional confusion in interpreting research findings and understanding vestibular applications (Parham, 2011). To address this problem, fidelity measures have been established for clarifying essential elements of ASI in comparison to general sensory based interventions (Parham, 2011) and ASI training has become widely accessible (clasi.org). Despite clarifying measures of fidelity and growing evidence from ASI, terminology remains blended outside of ASI perpetuating confusion and limited metacognition, resulting in overconfidence and limited

employment of interventions. Surveyed OTs reported feeling confident using vestibular interventions for the intentions of supporting motor and postural development, regulation, and possibly functional vision, however, they were unaware of outcomes of vestibular therapies for positively impacting learning or communication (Wall, 2021). Until you can appreciate the differences, you don't know what you don't know.

In the preface to their neuroscience textbook, Bear and colleagues (2016) dismiss the value of the vestibular system and later conclude with “we are well aware that the complexities of the motor systems are daunting to students and instructors alike” (Bear, et al., 2016, p. x) while the vestibular system may very well be the answer to such complexities. Similarly, survey responses from fellow pediatric OTs, professors, and clinicians confirmed their lack of understanding or appreciation of the benefits of vestibular interventions to support the complexities of learning and communication (Wall, 2021). Fortunately, current research from neuroscientists strongly disputes this dismissal and lack of understanding, and rather, advocates for vestibular interventions to address all said issues (Hitier, et al., 2014; Besnard, et al., 2016; Moossavi & Jafari, 2019; Lopez et al., 2020).

OTs in my community lack confidence for measuring vestibular functioning and recognizing its impact on academic performance and motor development (Wall, 2021). While most OTs recognize measures of post rotary nystagmus as a means for measuring vestibular function, they do not feel comfortable or confident that they are observing this with accuracy, so they don't measure or acknowledge its presence or absence as a potential barrier for learning (Wall, 2021). With so many children reporting problems

relating to vestibular functioning, yet most going undetected (Li et al., 2016), the problem lies first with identifying the presence of vestibular dysfunction. With limited insight of atypical sensory experiences, the presence of vestibular dysfunction should be considered through observation of children's behaviors including clumsiness, poor balance, insecurity, excessive risk taking, fear of movement, falling from their chair when trying to pay attention, poor sequencing of language, delayed visual tracking or scanning, challenges with learning, and difficulties with motor development (Wall, 2022).

On the national resource of Vestibular Disorder Association (Christy & Rine, 2016), 1187 professional contacts were listed, 841 were physical therapists, while 15 were occupational therapists. OT and PT literature surrounding vestibular topics are predominantly concerned with posture, balance, gait and motor control. Within the AOTA scope of practice for school OT, there is no mention of vestibular therapies to improve memory, attention, or learning (Asher, 2017). Rather, recommendations are left vague, delineating support services within the universal design learning model.

Vestibular rehabilitation is well articulated in AOTA scope of practice as a specialized role for OTs and PTs working with adults or children (with adult-like symptoms) needing remediation of an impaired vestibular system with no mention of delayed vestibular maturation, only remediation. Based on our strong foundation of Ayres Sensory Integration, vestibular therapy applications with children should be inherent to OT, yet we are scarcely represented by the national vestibular disorder association and lack distinguished developmental vestibular applications for young children who do not present like adults with VI. Our profession may be facing a crisis

when it realizes, too late, the need for us to not only specialize but also to market our services.

Lastly, while the suspected prevalence of vestibular dysfunction is high, few receive appropriate diagnosis or treatment (Li et al., 2016). Evidence based practice and supporting literature is needed to inform and guide OT practitioners in the identification and application of vestibular therapies for children struggling with communication and academic performance.

### **Proposed Intervention to the Problem**

An educational series will prepare fellow OTs to confidently identify and remediate vestibular dysfunction to facilitate growth and development of children's skills relating to communication and academic performance. Research evidence will be summarized, followed by practical applications of evaluation and intervention throughout the learning series. This knowledge will be transformative to fellow therapists to effectively meet the needs of children who present with average intelligence, an absence of medical conditions that attribute to their learning challenges, and demonstrate an under registration of vestibular sensation, with delays in: communication, motor, vision, learning, and / or occupational performance. Recommended interventions will be embedded within the occupations of play and learning and occur through multi-disciplinary collaboration.

The educational series will provide evidence for understanding and applying vestibular interventions aligned with postulates from Ayres Sensory Integration, pediatric vestibular rehabilitation, and contemporary neuroscience, including methods for

identifying dysfunction, measuring progress, applying interventions, and anticipating outcomes in children's learning, communication, and occupational performance. To distinguish the proposed interventions, from traditional vestibular rehabilitation, consideration will be given to coining the paradigm *vestibulotherapy*.

Long term objectives include sharing a testimony of evidence with AOTA, WFOT, and the VeDA for consideration of adding clinical practice guidelines for developmental vestibular dysfunction. Professional practice guidelines that align with OT standards will facilitate appropriate, occupation-based interventions for children with delayed vestibular maturation. Stakeholders will recognize the distinct role of developmental vestibulotherapies for helping children improve communication, motor skills, and academic success.

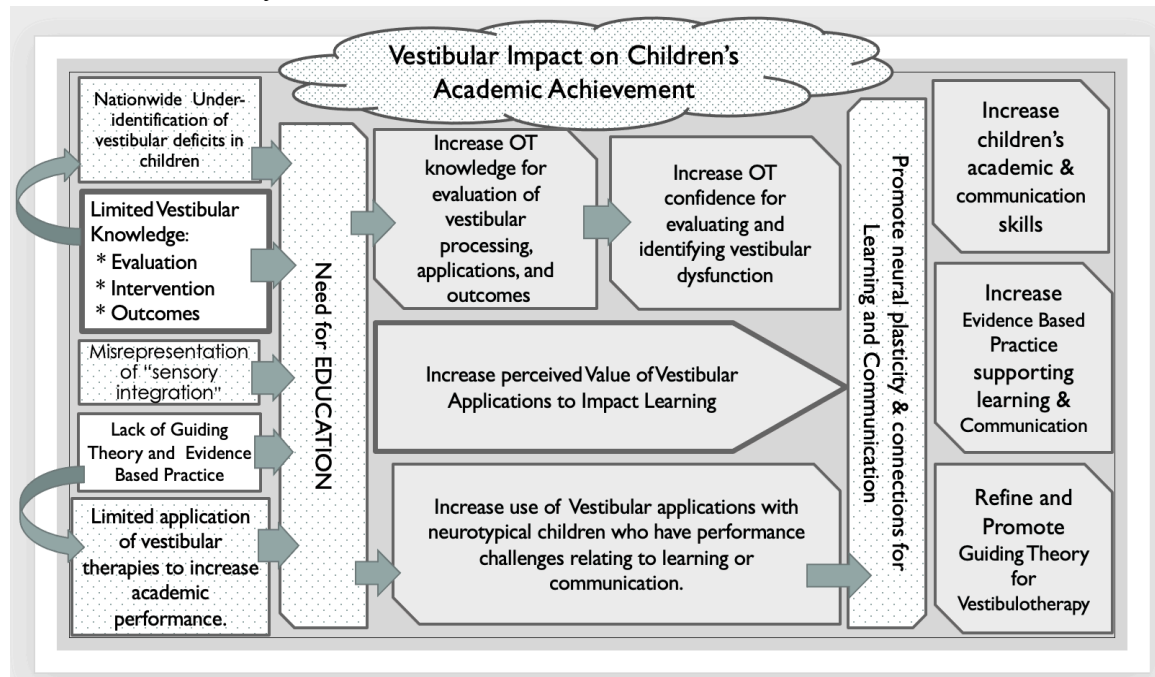
## Chapter Two

### An Explanatory Model

#### General Overview of Problem and Solution

**Figure 2.1**

*General Overview of Problem and Solution*



As illustrated in Figure 2.1, a combination of limited knowledge, professional miscommunication, and a global lack of awareness for pediatric vestibular dysfunction, establish a need for professional education to recognize problems and provide interventions which support vestibular processing so more children succeed in their social and academic roles. Having not experienced typical vestibular development, many children do not recognize their dysfunction expressed through imbalance, clumsiness, or poor functional vision as out of the ordinary. OTs in my community misunderstand concepts relating to sensory integration, with limited understanding of potential



vestibular applications and outcomes (Wall, 2021). Their guiding theory is limited to sensory-based interventions, which target regulation, while missing opportunities for building neural connections through a more adaptive response or targeted vestibular interventions.

The proposed educational series will benefit OTs and their pediatric clients demonstrating delayed vestibular maturation with an average cognitive ability and learning or communication challenges. Evaluation methods and functional observations of this delay will be developed to promote increased awareness among therapists, teachers, and families.

In this model we examine vestibular constructs through the lens of neuroscience propositions with vestibular rehabilitation and Ayres Sensory Integration (ASI) as our supporting OT theories. When ASI is reflected in the evidence from contemporary neuroscience, we see validation of Ayres' early hypothesis underlying vestibular applications for supporting learning and academic performance (Lane et al., 2019). Vestibular activation mediates the internetworking of cortical structures to promote development of children's attention, numeracy, spatial representation, sequencing, visual tracking, memory, motor control, and navigation with myelination and neuroplasticity as the mechanisms of change (Hitier et al., 2017; Besnard, et al., 2018; Lotfi et al., 2017; Lane et al., 2019; Moossavi & Jafari, 2019; Koziol et al., 2014; Kashfi et al., 2019; Christy, 2019).

As OTs gain knowledge for recognizing dysfunction, applying interventions, and appreciating learning outcomes, they will gain value and integrate vestibulotherapy

concepts into their professional practice. As the benefits of this intervention are observed by school and family stakeholders, this emerging paradigm will develop into an area of evidence-based practice and support neurotypical children, with delayed vestibular maturation, in their learning and social roles. The explanatory model (Figure 2.1) serves as a dynamic guide for professional education, therapy intervention, and ongoing critical reflection on the impact of vestibular applications on children's academic achievement.

### **Conceptual Framework - Ayres Sensory Integration**

Sensory integration is the process by which people register, modulate, and discriminate sensations received through the sensory systems to produce purposeful, adaptive behaviors in response to the environment (Ayres, 1972, as cited by Smith-Roley et al., 2007). Sensory integration dysfunction may be considered along two pathways, which may intersect or stand-alone including: a.) impaired registration or discrimination of sensory input resulting in challenges with perceptual and motor development or b.) impaired abilities to regulate or modulate sensory input resulting in behavioral challenges typically associated with engagement or social participation (Roley & Mailloux, 2020). Regardless of the pathway, in ASI there exists an intentional collaboration between child and therapist to create a play scheme, where the child actively engages in affordances of tactile, proprioceptive, and / or vestibular sensations, producing an adaptive response during occupations of play that employ the child's strengths and challenges (Lane et al., 2019; Roley & Mailloux, 2020). It is through this adaptive response where sensory integration and neural connections develop in response to the child's ability to receive and process sensation from movement and the environment and use it to plan and

organize behavior (Lane et al., 2019; Roley & Mailloux, 2020; Smith-Roley et al., 2007). Without advanced training, ASI is often confused with other sensory based interventions, which provide tactile, vestibular, and /or proprioception to engage the child through means of regulation or modulation of sensory reactions (Camarata, Miller, & Wallace, 2020). Unless its application meets the ten elements of fidelity (Parham, 2008, 2011), simply employing these sensory affordances is not Ayres Sensory Integration.

Ayres Sensory Integration (ASI) theory is based on the understanding that impaired sensory and neurological processing impedes development of skills needed for occupational performance. According to Dr. Ayres, children who demonstrate participation challenges often have vestibular-based deficits that could be readily improved through OT, resulting in greater performance in childhood occupations (Ayres 1978, as cited by Roley et al., 2007). Outcomes of Ayres Sensory Integration illustrate how sensory processing integrates with cortical systems to evoke change in our emotional, social, and learning pathways. Sensory Integration speaks to our abilities to receive and process sensory information from our environment, our stored perceptions, and from within our bodies so that we may learn and participate in daily social and academic occupations (Lane et al., 2019).

Through measures of fidelity, Ayres Sensory Integration has distinguished itself from other sensory-based interventions and become an area of evidence-based practice for children with autism (Shoen, et al., 2019; Schaff et al., 2015). While some of the most impressive gains included participation in self cares, increased independence with ADLs, and improved confidence, sense of self-worth, risk taking, and perceived social

competence (Schaff et al., 2015), these were not the original aim of Ayres' Sensory Integration theory (Aryes, 2005, 1976). Rather, Ayres' focus was to improve academic performance for those children identified as having a learning disability (Aryes, 2005, 1976). "Learning is dependent on the ability to receive and process sensation from movement (vestibular) and the environment and use it to plan and organize behavior" (Roley, et al., 2007, p. 5). Through a combination of the ASI theory and contemporary neuroscience evidence of vestibular interventions for improving memory and cognitive processes, one could postulate a renewed connection for ASI to support learning outcomes (Lane et al., 2019; Hitier et al., 2014; Koziol et al., 2014; Besnard et al., 2018).

Praxis is necessary for successful performance of school roles and relies on efficient sensory integration for the initiation of activity, execution, use of space, tool use, interactions (people or environment), and accessing affordances of objects (Kaye, 2018; Mailloux & Roley, 2020). Through sensory integration, we support praxis development with foundational building blocks including ideation, body scheme, and internal maps that interact to connect knowledge about our body (sensory and motor maps) with thoughts and ideas to formulate new plans and envision increasingly more complex actions and interactions (Kaye, 2018; Lane et al., 2019). When we effectively take in sensory information and create sensory memories, we store these perceptual memories for later use to expand ideation. Similarly, we build perceptual maps, motor memory, and action schemas (motor planning to refined automated motor plans) to draw upon for increasingly more complex interactions with our environment (Mailloux & Roley, 2020). While building increasingly efficient sensory integration, one develops action chains,

which are complex motor sequences that are linked together to provide efficiency with performing skills and navigating through more complex processes (Kaye, 2018).

Developing pathways are reinforced by vestibular innervation, which increases memory, sequencing, and ordinance for language and motor skills (Kaye, 2018).

In consideration of this complex tiered learning through ASI, we begin to recognize how ASI, when done with fidelity, is so much more than sensory based interventions that are done to a child to help them regulate or modulate sensory input. ASI interventions will build foundations through vestibular applications to improve body schema, perceptual awareness, repertoire of action skills, future actions, organizing time and materials, building increasingly complex motor schemes, and anticipating the need for action (Kaye, 2018; Mailloux & Roley, 2020).

### **Conceptual Framework – Vestibular Rehabilitation**

Vestibular rehabilitation (VR) for children is designed to improve gaze stability, visual-spatial perception, balance, and motor development through exercises embedded throughout the child's day. Pediatric VR activities employ repetitive and simultaneous head movements with visual focus, static and dynamic balance exercises, and challenging gross motor activities (Christy, 2019; Hall et al., 2016). Pediatric VR is intended for children with any degree of unilateral or bilateral vestibular hypofunction who also have difficulty with gaze stability, balance, and/or motor skill development (Christy, 2019).

VR evidence supporting the proposed mechanism of change is based upon three theories of neural plasticity: adaptation, substitution, and habituation (Hall et al., 2016). Adaptation invokes changes at the neuron level of the vestibular nuclei, impacting the

remaining functional portions of the peripheral vestibular system (Christy, 2019). Substitution relies on compensation from other areas of the central nervous system (Christy, 2019). Habituation improves the individual's tolerance to motion through desensitization through repeated motion over time (Christy, 2019). Within the educational series, participants will consider how vestibulotherapy might utilize adaptation and substitution attributes to promote vestibular maturation, myelination, and neural plasticity to support learning and communication within play-based activities for children demonstrating delayed vestibular maturation.

### **Evaluation of the Evidence for Vestibular Interventions**

The Boston University's CINHAL and PubMed databases were used in conjunction with the AOTA database to navigate available evidence relating to vestibular applications for supporting children's learning and academic performance. Global research literature was drawn from disciplines including occupational therapy, physical therapy, audiology, otorhinolaryngology, ophthalmology, and neurology from publications within the past decade (2011-2021). The search query utilized a combination of terms including "pediatric", "vestibular", "vestibular dysfunction", "developmental", "cognition", "occupational therapy", "Vestibular Rehabilitation", and "communication". The search query for the AJOT database included "vestibular", "pediatric", "evidence-based practice", "vestibular rehabilitation" and "sensory integration" to gather relevant evidence. Additional research articles were adopted through referenced articles within database sourced documents. In all, 343 search results were narrowed down through a title review, with 76 articles progressing to an abstract review, and 46 underwent a full

review and reflection of key findings included within this document. Selected articles were chosen for their relevance to understanding vestibular rehabilitation (VR), vestibular impairment (VI), professional practice guidelines, Ayres Sensory Integration, and related vestibular therapy applications to promote academic achievement in children. Eleven of forty-six articles were systematic reviews (Besnard, et al., 2018, Hitier et al., 2014, Kashfi et al., 2019, Lopez et al., 2020, Mast et al., 2014, May-Benson, et al., 2016, Melo et al., 2019, Moossavi & Jafari, 2019, Schoen, et al., 2019, Watling & Hauer, 2015; and Smits-Engelsman et al., 2012), while six were experimental studies (Andelin 2019, Lotfi et al., 2017; Matuszkiewicz & Gałkowski, 2021, Sadeghi, N.G., Sabetazad, et al., 2019, Vetrayan 2012,) and one was a meta-analysis (Mulligan, 2010).

Boston University databases provided an abundance of high-quality literature relevant to the mechanisms, understanding, processes, and mediation of the relationship between vestibular interventions and outcomes which support underlying foundations of the children's learning and communication. Despite an absence of direct involvement of OTs or teachers in the research, the evidence is highly generalizable to the work of occupational therapy in addressing issues relating to children's delayed vestibular maturation, particularly through the lens of Ayres Sensory Integration (ASI).

Research studies employed quantitative analysis, randomization, use of a control group, and statistical reporting with large populations of children using a wide variation of interventions and outcome measures, producing salient themes including consistent support for vestibular interventions positively impacting foundations of learning. Within traditional vestibular rehabilitation the literature reflects guidelines for interventions with

adults or children who present with adult-like symptoms, lacking a distinction of vestibular impairment from delayed maturation of this system, with recent citations for pediatric VR addressing hypo-responsiveness.

Within OT literature, when vestibular applications were targeted toward specific motor outcomes, the CO-OP method or other task-orientated approaches are preferred over sensory integration or process-based interventions (Smits-Engelsman et al., 2012). However, the focus of this paper is concerned with supporting learning and communication, rather than specific motor skills, through vestibular applications which promote neuroplasticity and neural connectivity as the mechanism of change.

Whether in response to challenges associated with dementia or vestibular impairment (from acquired insult), the need for vestibular rehabilitation to resolve related balance and vision issues has propelled neuroscience researchers to investigate the causal pathway of vestibular sensations throughout the central nervous system. Research generated has undergone scrutiny through repeated studies, producing quality results, applicable to a variety of audiences experiencing vestibular challenges. Consistent evidence validated the role of vestibular sensations' connecting neural pathways, promoting myelination, for improved foundations of learning and memory (Besnard, et al., 2018, Hitier et al., 2014; Kashfi et al., 2019; Lopez et al., 2020; Mast et al., 2014; Melo et al., 2019; Moossavi & Jafari, 2019; Schoen, et al., 2019; Watling & Hauer, 2015; Andelin et al., 2019; Lotfi et al., 2017; Matuszkiewicz & Gałkowski, 2021; Sadeghi et al., 2019; Vetrayan, 2012; Mulligan, 2010).

Advanced training in Ayres Sensory Integration (ASI) or pediatric vestibular



rehabilitation (VR) provides insight and guidance for addressing the needs of this underserved pediatric population. Outside of ASI or pediatric VR, pediatric therapists need to advocate for clinical practice guidelines on developmental vestibular applications to meet the needs of children, which may be vastly different than adults with VI. Bridging vestibular evidence from contemporary neural science into pediatric occupational therapy will provide distinct value and have a profound impact on children's communication and learning within their social and academic contexts of occupational performance.

### **Summary of the Vestibular Evidence**

Vestibular inefficiencies moderate a child's success with learning, behavior, and communication (Ayres, 2005; Lane et al., 2019). In turn, vestibular applications mediate neural connections to enhance foundations and cortical processes necessary for successful learning and engagement within children's social and academic contexts (Ayres, 2005; Lane et al., 2019). This mechanism of change is most apparent in children who present with predominantly neuro-typical conditions with an under-responsive vestibular system manifesting in delays associated with motor development and learning (Hitier et al., 2014; Besnard, et al., 2018; Lotfi et al., 2017). Some individuals included in studies with vestibular applications expressed mild deviations from neurotypical, possessing characteristics of attention deficit, coordination disorder, language disorder, or hearing impairment, all of which are influenced by vestibular maturation.

Over the past decade, neuroscience research has increased our understanding of the vestibular system's role in perceptual and cognitive functions, impacting learning,

perceptual reasoning, and mental health (Hitier et al., 2014; Besnard, et al., 2018; Lotfi et al., 2017; Lopez, et al., 2020). Dr. Ayres' early hypothesis claimed that vestibular interventions positively impact higher learning centers, despite rebuttal from neuroscientists of the age (Lane et al., 2019). Without the knowledge for applying developmental vestibulotherapies or ASI, local pediatric OTs lack the knowledge to help children reach their highest potential in learning and social occupations. AOTA updated their position paper on vestibular rehabilitation in 2017, with further updates in 2018. However, there is no discernment for delayed vestibular maturation as compared to vestibular impairment (VI) associated with sensorineural hearing loss (SNHL), vestibular lesions, or head injury in children or adults, which may, in part, account for the vast number of children's vestibular dysfunction remaining undetected and untreated.

Recently, delineation has been initiated for addressing the needs of our target pediatric population possessing poor registration of vestibular input. Outcomes ascribed with these interventions promote improvements in balance, vision, and motor development with no consideration of learning outcomes. Fortunately, contemporary neuroscience has generated robust knowledge indicating improved learning and memory across all ages in relation to vestibular interventions (Andelin et al., 2019; Besnard, et al., 2018; Hitier et al., 2014; Kashfi et al., 2019; Lopez et al., 2020; Lotfi et al., 2017; Mast, et al., 2014; Matuszkiewicz & Gałkowski, 2021; May-Benson, et al., 2016; Melo et al., 2019; Moossavi & Jafari, 2019; Mulligan, 2010; Sadeghi et al., 2019; Schoen, et al., 2019; Watling & Hauer, 2015).

The following sections answer the posed research questions, based on the evidence procured through this investigation.

### **Methods for evaluation of vestibular functioning**

A variety of means exist for detecting vestibular dysfunction including caloric testing, rotary chair, post rotary nystagmus (PRN), video head impulse testing, balance / postural measures (Oyewumi et al., 2016), and most recently wearable sensors programmed through cell phone applications (Ghislieri et al., 2019). Neurological research substantiates the connections between each of the semicircular canals to motor neurons resulting in muscle activation for postural control, thus making balance an obvious predictor of vestibular functioning, particularly with stable postures and vision occluded. Balance measures, such as those on the Bruininks Oseretsky Test of Motor Proficiency 2, provide a valid representation of vestibular functioning (Andelin, et al., 2019; Oyewumi et al., 2016; Christy, 2019). Such measures are highly objective and engaging for children, building confidence and reliability in the assessment of this critical sensory performance area (Oyewumi et al., 2016; Mulligan, 2011; Folsom-Meek, 1992; Andelin et al., 2019; Christy, 2019). To establish a vestibular screening tool that did not require specialized equipment, Oyewumi and colleagues (2016) found the two best tasks are 1) one foot standing, eyes closed and 2) tandem stance, eyes closed. Descriptive processes and references for normative information for these measures are included in Appendix E.

Many OTs would consider the test of post rotary nystagmus, which measures the ocular reflex, to be OT's gold standard for evaluating vestibular functioning (Mulligan,

2011; Peterson et al., 2020). However, many local colleagues report limited confidence in this measurement, feeling it is not sensitive to change or reflective of vestibular maturation as compared to balance measures (Wall, 2021). Low post rotary nystagmus (PRN) scores may indicate a vestibular processing deficit associated with difficulties in balance, motor coordination, kinesthesia, praxis, and motor accuracy (Mulligan 2011; Rine, 2018). However, through lived experience, it has been frequently observed that PRN does not consistently change over time to reflect maturation of vestibular functioning, particularly with asymmetrical results. Instances of asymmetry with PRN suggest vestibular damage. Improved vestibular functioning is likely a result of neuroplasticity through adaptation, where intact vestibular organs compensate for non-functioning counterparts.

The integration of the vestibular-ocular reflex with good postural control and balance, leads to efficient visual and motor accuracy, each dependent upon adequate vestibular functioning (Parham & Mailloux, 2010; Kashfi et al., 2019; Christy, 2019). Therefore, clinical observations may provide keen insight into vestibular dysfunction which may be apparent in many everyday performances of occupation relating to posture, balance, vision, sequencing, and motor coordination. Teachers or parents should be encouraged to complete the vestibular screening tool (Appendix D), which utilizes everyday occupational performance observations to quantify the impact of vestibular dysfunction.

### **Vestibular intervention's mechanisms of change**

Vestibular sensations were found to mediate cognitive performance by forming

overlapping pathways between main memory centers (hippocampus - spatial representations & navigation; amygdala - emotional learning, thalamus - declarative memory and internal representations; frontal cortex - working memory; and cerebellum - procedural memory) and vestibulo-cortical tracts to develop processes for object recognition, inner speech, numerical cognition, spatial navigation, sequencing, attention, impulse control, future planning, ordinance, and a variety of mental activities including attributes of a theory of mind and executive function (Moossavi & Jafari, 2019; Hitier et al., 2017; Lane et al., 2019; Koziol et al., 2014; Besnard, et al., 2018; Lotfi et al., 2017). The vestibular system further supports learning by way of establishing spatial cognition through its modulation of information being processed to represent information in a specific spatial order, providing mental imagery, numeracy, and sequencing (Mast et al., 2014; Besnard, et al., 2018; Hitier et al., 2014).

Vestibular information, carried in the medial longitudinal fasciculus to the cranial nerves controlling the extraocular muscles, supports coordinated eye and head movements. These connections enable the eye muscles to adjust eye positions while the head is moving, so that a moving person perceives their environment as visually stable—even when shifting gaze rapidly and precisely during movement (Lotfi et al., 2016; Christy, 2019; Solan et al., 2007; Kavar, 2002; Lane et al, 2019). Visuospatial processing, which is essential for learning and many cognitive operations (Moossavi and Jafari, 2019), should be a consideration for OT practitioners who routinely address related issues including reading and writing (Kashfi et al., 2019).

Through strong connections with vision and proprioception, the vestibular system

contributes to anticipatory motor actions and plans (Lane et al., 2019; Lotfi et al., 2016; Kawar, 2002; Lane et al., 2019). Because the vestibular system is a bilateral system that affects muscle activation throughout the body, it contributes to bilateral motor coordination and inter-hemispheric processing for learning and communication (de Wall, 2019; Kashfi et al., 2019; Mailloux et al., 2020). Ayres hypothesized that vestibular processing inefficiencies would negatively affect the higher-level cognitive functions needed for academic learning, as well as the arousal regulation capacities needed for self-regulation of emotions and behavior (Lane et al., 2019). She further speculated that the vestibular system could be engaged in the context of individualized intervention to help children function more fully and successfully in school, at home, and in play (Lane et al., 2019).

The capacity for sustained, self-directed engagement increases through the maturation of postural foundations and perceptual motor function, giving rise to focused attention, regulation, inhibition, and motor skill development (Kashfi et al., 2019; Mast et al., 2021; Lotfi et al., 2014). This mechanism of change is most apparent in children who present with generally neuro-typical characteristics, with an under-responsive vestibular system manifesting in delays associated with motor development and learning (Hitier et al., 2014; Besnard, et al., 2018; Lotfi et al., 2017; Ayres, 2005, 1972).

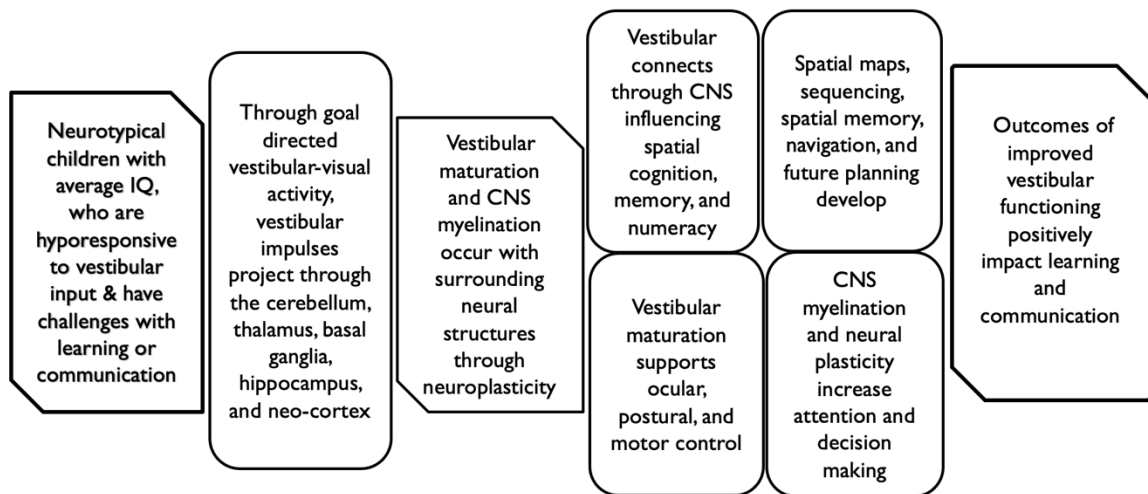
### **Recommended vestibular interventions**

Delayed vestibular maturation or dysfunction causes challenges with balance, body image, directionality, sequencing, navigation, spatial awareness, and social cognition (Mast et al., 2014; Moossavi & Jafari, 2019; Lopez et al., 2020). Therefore,

scaffolding must be provided during activities to ensure the child’s safety. While the evidence reviewed showed consistent findings, a wide range of vestibular applications were employed within the studies, lacking a prescriptive guide for intervention. As with ASI, clinicians should employ individual interests, strengths, and challenges to fully engage the child in “just right activities” within the context of play, to promote an adaptive and integrative response (Kaye, 2018; Mailloux & Roley, 2020; Ayres, 2005, 1972). Vestibulotherapy recommendations will be drawn from pediatric vestibular rehabilitation and contemporary neuroscience evidence, supported by lived experiences in pediatric OT.

**Figure 2.2**

*Vestibulotherapy: Mechanism of Change*



As illustrated in Figure 2.1, the key ingredients of vestibular therapy interventions and neural plasticity are mediated by the vestibular system and its connections with the cerebellum, basal ganglia, hippocampus, amygdala, thalamus, parietal cortex, and frontal cortex for improved processes in spatial cognition, memory, sequencing, ordinance, and

attention (Lotfi et al., 2016; Hitier, et al., 2014; Besnard, et al., 2018; Moossavi & Jafari, 2019; Lopez et al., 2020). Contemporary researchers employed a combination of stability/ mobility activities using a therapy ball, balance board, balance beam, T-stool, or trampoline; vision exercises (near far / accommodation, gaze, saccades, pursuits, and optokinetic exercises); and vestibular exercises involving eye hand coordination, visual motor, eye-head coordination, fundamental motor skills, and perceptual-motor skills, (Lotfi et al., 2016, Christy, 2019; Hall et al., 2016; Melo et al., 2019). When planning interventions, one might consider additional actions that offer vestibular affordances such as swinging, sliding, jumping, launching, rocking, rolling, riding, twirling, and tumbling (Schaaf & Smith Roley, 2006). Self-seeking of vestibular input which never satisfies the need, demands more novel and intensive vestibular experiences, such as vestibular-ocular protocol (Kawar, 2002) described in Appendix F, to positively impact the developing system.

As vestibular processing improves, graded vestibular affordances are aimed at developing body schema, perceptual awareness, repertoire of action skills, future actions, time and materials organization, increasingly complex motor schemes, and anticipatory awareness to address related issues of praxis and ideation (Mailloux & Roley, 2020; Lane et al., 2019). Early objectives of the interventions included improving gaze stability, balance, and motor development (Lotfi et al, 2016, Christy, 2019; Hall et al., 2016).

The frequency of the activities varied by author but went as high as 4-5 times per day for 20 minutes per session, with a range of 4–10 weeks (Lotfi et al, 2016, Christy, 2019; Hall et al., 2016). In consideration of these recommended frequencies, it will be



most beneficial to embed supporting activities into the child's classroom or home routine. With varying degrees of vestibular dysfunction, the duration of the program will need to be tailored to the needs of the child, based upon results of ongoing assessment throughout the course of the intervention.

Activities are tailored to the feasibility of the setting as well as the needs, interests, and abilities of each child. The use of games and swings were encouraged to provide movement during visual stabilization (Lotfi et al., 2016). Through activities that commingle visual, vestibular, and auditory demands, their shared cranial nerve VIII receives joint activation. In the presence of vertigo, habituation and substitution exercises should be incorporated to support gaze stability (Lotfi et al., 2016, Christy, 2019).

### **Outcomes of vestibular interventions**

Vestibular interventions mediate neural connections to enhance foundations and cortical processes necessary for successful learning and engagement within children's social and academic contexts (Ayres, 2005; Lane et al., 2019; Lopez et al., 2020). Contemporary neuroscience elucidates that vestibular applications are not experimental, but rather, neural networking originates in the vestibular apparatus and continues throughout the neural pathways (hippocampus, reticular formation, basal ganglia, insula, neocortex, cerebellum, thalamus) to mediate and myelinate for neuroplasticity to increase attention and impulse control, memory, spatial cognition, vision, navigation, future planning, sequencing, numeracy, and social cognition for overall improvement in cognitive performance (Hitier, et al., 2014; Besnard, et al., 2018; Moossavi & Jafari, 2019; Lopez et al., 2020). Additionally, visual and auditory processing is founded on the

integration of body-centered senses (vestibular and proprioception), which together impact learning, communication, and behavior (Ayres, 1972; Roley, et al., 2007; Mailloux & Roley, 2020).

As the child's vestibular system matures through interventions, the therapist will begin to observe initial improvements in gaze stability, balance, and motor development (Lotfi et al., 2016; Christy, 2019; Hall et al., 2016; Andelin et al., 2019). Based upon lived experiences, as vestibular processing matures, it is likely the child's teacher will begin to observe related improvements which positively impact speech, attention, participation, and, over time, academic performance. Therapists should be encouraged to observe pre and post-performance on related vestibular measures regularly to notice subtle changes in response to the intervention. Progress monitoring might include one foot balance with vision occluded, ocular scanning, or dynamic stability activities, such as catching a ball or bean bag from a balance board or t-stool.

### **Reflection on vestibular applications**

Despite evidence from contemporary neuroscience supporting the role of vestibular interventions to enhance learning and engagement, OTs are not employing this information to adapt their professional practice or intervention plans. Problems lie in the dissemination or receipt of new knowledge. At first glance, recipients would seem to be OTs but the circle has broadened to teachers, parents, and nurses, among others who recognize vestibular benefits for more immediate regulation and engagement applications within the classroom (de Veer, 2017). Contemporary neuroscience needs to connect targeted audiences who can orchestrate vestibular interventions to help children succeed

in learning. OTs need to engage in ongoing education, reflect critically on therapy applications and outcomes, and disseminate knowledge from research to promote successful occupational performance in children with developmental vestibular dysfunction. Unless challenged, professionals may fail to appreciate what they don't know and become complacent with stale interventions.

In summary, contemporary neuroscience and ASI attenuate the importance of attention, balance, and coordination as foundations for learning, each supported by the vestibular system (Blythe, 2007; Kashfi et al., 2019; Lane et al., 2019; Hitier et al., 2014; de Veer, 2017). Targeted vestibular applications were found to improve motor skills and academic performance in children with average IQ, who experienced learning challenges and hypo-responsiveness to vestibular activation (Kashfi, et al., 2019). For successful engagement in learning and school related occupations, sensorimotor foundations, including vestibular, proprioceptive, ocular, and motor systems must be in sync (Kashfi, et al., 2019). Distinction and social marketing are needed for clear delineation of vestibular applications and outcomes associated with the vestibular dysfunction of a mature system (acquired head trauma, hearing impairment, lesions/ structural differences), as compared to delayed vestibular maturation.

Raising awareness and providing early identification of vestibular dysfunction is needed to help children before they experience significant delays. Those infants and children not reaching their gross motor or expressive language milestones should routinely be screened for delayed vestibular maturation. Many considerations about the role of the vestibular system for specifically impacting academic performance and

communication are inferential and based upon the evidence from neuroscience supporting myelination and neuroplasticity, as a product of vestibular activation, in children who demonstrate vestibular hypo-functioning (Hitier et al., 2017; Besnard, et al., 2018; Lotfi et al., 2017; Moossavi & Jafari, 2019; Koziol et al., 2014; Kashfi et al., 2019; Mast et al., 2014; Mailloux & Roley, 2020; de Waal, 2019).

As pediatric occupational therapists, we are called to become experts in developing sensory and sensorimotor systems to improve motor and related occupational and academic performance outcomes. Through neuroscience research, our sensorimotor expertise further transcends our interventions to directly impact students' learning potential by improving capacities for memory, attention, numeracy, sequencing, and processing through improved vestibular functioning.

Transdisciplinary research is needed to track data with learning and communication outcomes paired with vestibular interventions. Extended to its full launch, this educational program may become transformative to national or global pediatric OT and elementary education practices through increased knowledge for vestibular evaluation and intervention with pediatric populations demonstrating delayed vestibular maturation and challenges with learning or communication.

## **Chapter Three**

### **Theoretical and Conceptual Frameworks for Professional Development**

#### **Program Background**

With vestibular dysfunction affecting 5.3% or approximately 3.3 million U.S. children between ages 3–17 years (Li et al., 2016), a call to action is needed to increase awareness, knowledge, and accessible interventions. Problems are not recognized or reported by children who lack neurotypical awareness but evidenced through unexplained delays in their development of motor skills, communication, attention, functional vision, and academic performance (Lopez et al., 2020; Rine, 2018). Historically, fellow OTs have considered vestibular applications as a sensory based intervention for supporting emotional regulation, posture, visual skills, and motor control, lacking appreciation of the potential that vestibular processing has for developing skills associated with communication and academic achievement (Wall, 2021).

Traditional and contemporary methods for delivering professional education will be employed to shift the guiding OT paradigm in my local community to one that envisions vestibular interventions to build children’s memory and learning capacities. In this proposed educational series, evidence from lived experience, Ayres Sensory Integration, vestibular rehabilitation, and contemporary neuroscience will be employed to provide knowledge and methods for evaluating and applying interventions to address vestibular dysfunction.

**Quality and limitations of research for methods of professional development (PD)**

A literature search was conducted using CINAHL, PubMed, EBSCO, AOTA, and BU Education databases, which procured a critical appraisal of the research necessary to guide the formation of a professional education program. Search terms including “occupational therapy,” “professional development,” and “adult learning” were used to identify articles published between 2010 and 2021. Of the 230 relevant articles, selection for inclusion was determined through review of the title and abstract to identify those articles that evaluated processes of professional development leading to illumination of best methods of educating professionals for improving practice. The twenty-two chosen articles were peer reviewed and included large audiences who provided evaluation of their perceived effectiveness of PD methods over short term or long-term measures. Articles were intentionally selected to include fields within the medical or educational professions to relate to the intended audience most specifically. The research literature collectively illustrated a variety of salient themes for orchestrating effective professional development (PD) which will set the foundation for the proposed program.

While a significant number of quality articles were reviewed, it seems the avenues for learning and providing professional development are unfolding at an accelerated pace, particularly in relation to the recent world health challenge. This has resulted in new landscapes for accessible education opportunities. This literature review included many high quality empirical and scoping studies reflecting high volumes of referenced articles, which had been published in peer reviewed journals over the past ten years. This

combination of high volume and peer review portrays information that is respected while being highly generalizable for professional development practices. However, the research literature lacked the methodological rigor found in experimental or randomized control trial comparisons.

Within the literature review, many perspectives were represented across a large array of organizations and leadership styles. Salient themes emerged for likely outcomes of PD including evidence of building confidence, facilitating applications of new knowledge, increasing effectiveness of interventions, improving perceived value, and maximizing job retention. There were noticeable shifts in PD research, which were possibly influenced by the global health pandemic: Earlier research studies focused on quantitative results, where more recent studies considered qualitative measures, such as perceived value and professional relationships, as being more indicative of impacting change (Burman et al., 2021).

### **Theoretical and conceptual frameworks for professional development**

Through a comprehensive literature review of effective methods of professional development, it was evident that educational experiences must be cleverly orchestrated to meet OT practitioners' needs, which are identified through a common goal or purpose (Ritchison et al., 2021; Hayes, et al., 2007; Smith, et al., 2020) and embedded within professional relationships that foster engagement with learning and therapeutic interventions over time (Smith, et al., 2020; Hayes et al., 2007; Pearce et al, 2012; Burman et al., 2021; Schimasaki et al., 2021). An educational series should include qualitative and quantitative measures prior to, during, and after, and, at times, following a

latent period, for establishing levels of confidence that the intervention positively impacts professional practice (Ritchison & Embree, 2021). The format of the professional training program should employ an interactive and multi-faceted approach including didactic presentations employing videos and content slides along with interactive components such as role playing, demonstrations and case studies (Pearce, et al., 2012). Problem-based discussions are recommended to promote shared teaching and learning among participants, employ a variety of theoretical concepts and applications, and establish a common goal that directs joint learning (Pearce et al., 2012; Lewis & Thompson, 2017; Smith et al., 2020; Burman et al., 2021; Henry et al., 2019; Allen et al., 2019). The use of supplemental resources was inconclusive for its' effectiveness to support professional learning (Pearce et al, 2012).

Learning is best supported through an extended cycle of inquiry, where participants engage in reflective feedback around guiding theory and client goals, interventions, and outcomes, followed by data collection and interpretation (Smith, et al., 2020; Hayes et al., 2007; Pearce et al., 2012; Lysberg & Ronning, 2021; Henry et al., 2019). While I believe the OTs in my community are internally motivated toward learning, this method of inquiry and reflection over time provides coherence for engagement and effective framing of professional development (Allen et al., 2019; Hayes, et al., 2007; Lysberg & Ronning, 2021). When extended over a duration of time, collaborative and cumulative learning occurs through discussions of real-life clinical problems, while developing gradual proficiency with higher-level skills emerging (Van Lew et al., 2010; Shimasaki, et al., 2021; Ritchison et al., 2021; Smith et al., 2020). This model of engagement drives



educational participants to gain knowledge toward a results-driven outcome, reinforces new methods, and promotes transformative practices over time (Hayes et al., 2007; Lysberg & Ronning, 2021).

Empirical research involving the Team Teaching and Learning (TTL) professional development model (Smith et al., 2020) considers these same salient themes, including ongoing professional engagement, resulting in high rates of applied knowledge which was sustained over a two-year duration of PD (Smith et al., 2020). The key features of TTL included content knowledge, active learning, coherence, collective participation, reflection, and duration. Given these parameters, participants ranked related professional development an average of 9 out of 10 (in comparison to all other PD they have engaged in) and perceived change to their professional practice as a result of the TTL experience an average of 7 out of 10, contradicting typical low scores of PD (Smith et al., 2020).

With many parallels between the TTL and Extension for Community Healthcare Outcomes (ECHO) models of professional development, research on the effectiveness and satisfaction with the ECHO model also resulted in high rankings for PD. With an average of 700 respondents, 90% reported satisfaction with the usefulness and relevance of the didactic presentations and more than 80% satisfaction with usefulness and relevance of case presentations, and 82% reported implementing the practices they learned (Burman et al., 2021). Additionally, 95% reported confidence that the skills and knowledge gained will improve competencies, with 69% intending to use learned practices with moderate to significant frequencies. 92% of the ECHO participants of a

smaller sample (n=196) reported inclusion in a professional network to be a key success measure for their learning and application of new practices (Burman et al., 2021).

Themes of social networking, opportunities for collaboration with shared problem solving, and joint reflection ran through the TTL, ECHO model, and much of contemporary PD literature. Within these PD models, successful professional learning communities (PLC) create safe space to identify problems and seek solutions where social interaction and collaboration are essential (Henry et al., 2019).

### **Critical Components of Professional Development**

Literature evidence provided robust consideration and guidance for developing an educational series. While each theory has unique attributes, many themes run concurrently. Setting the stage for learning should begin with establishing a positive learning environment where participants establish rapport to feel safe asking questions, collaborating on developing interventions, and sharing honest feedback while collectively learning and working toward shared problem solving (Lysberg, & Rønning, 2021; Henry, et al., 2019; Allen et al., 2019; Higgs & Rowland, 2011; Atkinson, 2014; Gesme & Wiseman, 2010). An educational series should be multifaceted including didactic presentations, shared videos, and case studies with a focal point of inquiry around evidence produced from targeted interventions to meet client goals (Ritchison & Embree, 2021; Van Lew & Singh, 2010; Hayes et al., 2007; Shimasaki et al., 2021; Burman et al., 2021; Wingard & Blosser, 2010).

Continuous efforts should be made to advance the culture of the professional learning community to promote perceived value of both professional relationships and

content knowledge of the educational series. Therefore, professional teaching methods will be drawn from theories including Adult Learning (Knowles 2015), Problem Based Learning (Burman et al., 2021), and Double Loop Learning (Argyris in Lysberg & Ronning, 2021), where the OT participants (the learners) are motivated both internally and through engagement with their professional learning community (Burman et al., 2021; Lewis & Thompson, 2017). Centered around the common goal of improving children's vestibular functioning, educational elements should include ongoing and shared problem solving, collaboration, reflection, and direct applications of learned content. Authentic learning opportunities will be essential for OT participants to observe, rehearse, and apply methods of evaluation and intervention learned through the educational series that will become transformative to their professional practice (Hayes et al., 2007; Ritchison & Embree, 2021). Program participants should engage in methods of inquiry, both collectively and independently, followed by joint reflection of their lived experiences during learning sessions (Burman et al., 2021; Schimasaki et al., 2021; Smith et al., 2020; Van Lew & Singh, 2010).

Contemporary theorists recognize the value of building collaborative relationships between educators and learners with an emphasis on guided facilitation or shared problem solving (Knowles et al., 2015, Burman et al., 2021; Lewis & Thompson, 2017). Collaboration is grounded on mutual trust and respect, where everyone teaches and everyone learns. When health professionals partner with teachers and parents, many experts are at the table. During times of collaboration, their valued contributions fuel their motivation and ownership over learning plans that are the product of their

partnership (Knowles et al., 2015, Burman et al., 2021).

The learning climate should be cultured so that it becomes conducive to accepting or embracing tensions that challenge existing beliefs and practices that evoke changes to professional practice (Lysberg & Ronning, 2021). When possible, a *change champion* who demonstrates positive leadership within the participant cohort (Atkinson, 2014; Smith et al., 2020) should be recruited to help build enthusiasm and momentum for working toward a culture of collaboration where new methods of intervention are learned and adopted with sustained implementation.

### **Barriers to employing methods of evidence informed practice**

There is an ever-changing and mountainous landscape of research, making it difficult to manage and assimilate incoming evidence into professional practice. Timely translations of research into clinical applications often experience a 17-year maturation before full bloom (Burman et al., 2021). Once clinical practice guidelines are established, additional lapses of time occur before clinicians become aware or implement them into their clinical practice, or more often, fail to implement them into practice (Burman et al., 2021). Research implementation is further belabored by the complexity of related materials, which may be perceived as too statistical or lack credibility, as well as medical professional's lack of motivation or attitude toward the source of change - management (Rycroft-Malone et al., 2004; Humphris et al., 2000). Clinicians perceive a lack of time, desire for autonomy, perception that experience exceeds research knowledge, and limited mentorship perpetuating complacent interventions (Burman et al., 2021). Further, a perceived locus of control may positively or negatively impact a learner's sense of

responsibility and motivation for adopting and implementing research into practice (Braungart et al., 2020).

Upon reflection of a recent survey, the perceived barriers for applying vestibular applications included confusion of terminology and applications, limited knowledge, and absence of established clinical practice guidelines for developmental vestibular therapies (Wall, 2021). While strengths include a willingness to learn, theoretical background of sensory processing, an established professional support network, and emerging confidence and value for vestibular applications stemming from contemporary neuroscience evidence (Wall, 2021).

### **Evidence-based methods for building confidence and implementing change**

Setting the stage for growth is best met within a positive environment where change is seen as an opportunity rather than a threat in a culture of professional learning and collaboration, with unity as the goal (Gesme & Wiseman, 2010; Atkinson, 2014). A systems approach is recommended for integrating research into practice that is initiated through management with supporting and engaging leadership trends, rather than demands on individual clinicians or “leader-centric” behaviors, which halt growth and collaboration (Higgs and Rowland, 2011). When the locus of control over professional learning is seen in a positive light, a learner is more motivated to engage in the process (Braungart et al., 2020). Enthusiasm within the work setting fosters rapport and positive working relationships leading to feelings of trust and safety to collaborate and share honest feedback (Higgs & Rowland, 2011; Smith et al., 2020).

The educator orchestrates learning by setting up the environment and

understanding the needs of the learner to establish perceived value of the new knowledge and impact change. The educator begins this process by identifying the learners' strengths and challenges. A learner profile, such as the intended example in Appendix A, should be employed to understand the learners' needs, preferences, motivation, and readiness for learning to determine the “what”, “how”, and “when” of instruction (Braungart et al., 2020). Understanding their preferred learning styles, background knowledge, needs, motivation, and objectives will further engage the learner toward goal directed outcomes (Braungart et al., 2020). Once the educator understands their audience, they impart essential knowledge that reflects best methods in a manner that is easily understood (Kitchie & Arnaud, 2020). Throughout the process the educator monitors learning progress, exchanges feedback, reinforces learning, and evaluates the effectiveness of education provided (Kitchie & Arnaud, 2020). A clear extension of the presented research to clinical practice must be evident to promote acceptance and implementation of learned concepts (Rycroft-Malone, et al., 2004). When professional development occurs within a safe setting, collaborative efforts to master content, apply strategies, and evaluate outcomes foster lasting change in new methods learned through the educational process (Higgs & Rowland, 2011; Atkinson, 2014; Allen et al., 2019; Henry et al., 2019).

Evaluations of professional development typically measure changes in knowledge and confidence, but often fail to address more meaningful and relevant qualitative questions such as perceived value to determine an actual impact on professional practice (Allen et al., 2019; Burman et al., 2021). PD must strive to produce professional

behavioral changes based on perceived value which are facilitated through professional relationships within the learning environment (Allen, et al., 2019; Henry et al., 2019). In social learning situations, professionals collaborate, share interests, apply knowledge, and reflect on learning, resulting in higher job satisfaction and retention (Allen, et al., 2019). The relevance of these elements of PD suggests a need to qualitatively measure professional relationships and content appreciation when evaluating program effectiveness. Such qualitative measures will allow for unanticipated outcomes which are difficult to measure quantitatively.

The Extension for Community Healthcare Outcomes (ECHO) model of professional education esteems the value of professional relationships and recommends combining social and situated learning with community practice theories (Burman et al., 2021; Allen et al., 2019; Shimasaki et al., 2021). Professionals appreciate the benefit of educational opportunities and accept their initial lack of confidence and proficiencies with new methods that outweigh the potential for growth and development of new practices (Burman et al., 2021; Allen et al., 2019; Shimasaki et al., 2021). When confronted with new knowledge, we experience tension caused by confrontation with our existing knowledge. Whether experienced personally or professionally, how we respond can result in growth or stagnation. As part of an educational series, professionals should be encouraged to engage in joint reflection to share and discuss experienced tensions, while confronting existing beliefs and practices to evoke change (Lysberg & Ronning, 2021; Burman et al., 2021; Allen et al., 2019; Shimasaki et al., 2021). This combination of social and situational learning fosters reflective practice, growth, and confidence.

Our professional association encourages OTs to be self-directed and reflective when engaging in professional learning aimed at improving client outcomes, expanding professional practice roles, and achieving career goals (AOTA, 2017). Professional development (PD) meets an ethical obligation and contribution of OTs toward AOTA's *Vision 2025* (AOTA, 2017). PD should occur within learning settings that foster authentic or active learning, with participants sharing a common goal and opportunities for reflection within a professional learning community over a duration of time (Burman et al., 2021; Lewis & Thompson, 2017; Smith et al., 2020; Henry et al., 2019; Lysberg & Ronning, 2021; Shimasaki et al., 2021).



## **Chapter Four**

### **Vestibular impact on learning - An educational series**

#### **A Call to the Profession**

“During Ayres’ lifetime, the idea that vestibular processing contributed to high-level cortical functioning was considered inappropriate by many scientists because they believed that vestibular projections did not reach the cerebral cortex” (Lane et al., 2019, p. 3). However, Ayres esteemed the value of vestibular activation for its impact on behavior and attention and hypothesized that “vestibular processing inefficiencies would negatively affect the higher-level cognitive functions needed for academic learning, as well as the arousal regulation capacities needed for self-regulation of emotions and behavior” (Lane et al., 2019, p. 3). Ayres postulates are now supported by contemporary neuroscience (Hitier et al., 2014; Besnard et al., 2015; Mast et al., 2014), which together, will guide the education series.

An estimated 5.3% or 3.3 million US children are suspected of having vestibular dysfunction, yet most go undetected because children do not recognize their reality to be unusual (Li et al., 2016; Wein & Bryant, 2016). This problem surely exists globally and is not limited by demographics, diagnosis, culture, or age. Performance challenges observed in motor development, postural control, communication, and learning, such as those associated with Developmental Coordination Disorders (DCD), Developmental Language Disorders (DLD), and Learning Disorders (LD) should raise a red flag for vestibular dysfunction.

Through contemporary neuroscience and historical foundations of Ayres Sensory Integration, we are grounded in theory to implement vestibular interventions which will positively impact memory and functions relating to learning and communication to benefit many children. As occupational therapists, we are called by our profession to act in accordance with the highest ideals and provide best methods of service delivery founded in evidence-based practice (AOTA, 2020).

### **Conceptual framework for the educational series**

This course has been inspired by a dim understanding of sensory practices, particularly vestibular interventions (Wall, 2021). Professional teaching methods will be drawn from theories including Adult Learning (Knowles 2015), Problem Based Learning (Burman et al., 2021), and Team Teaching and Learning (Smith et al., 2020), where the OT participants (the learners) are motivated internally and through engagement with their professional learning community (Burman et al., 2021; Lewis & Thompson, 2017). Centered around the common goal of improving children's learning and communication through improved vestibular functioning, educational elements will include ongoing and shared problem solving, collaboration, reflection, and direct applications of learned content (Smith et al., 2020). OTs will engage in a joint and reflective learning process where participants gather, share, and integrate learned concepts until all parties feel confident with understanding and applying new methods of intervention (Burman et al., 2021; Lewis & Thompson, 2017). Measured student successes will emerge following the educational program as therapists are able to fully implement their knowledge translation into practice with the children they serve.

**Program participants & resources**

Participants in the pilot of this educational series will be approximately twelve in number and include school OTs, local OT professors, and clinic based pediatric OTs. The educational series will take place either in person or virtually during real time instruction, proposed to occur 2 hours, once monthly, over three sessions. An emerging therapeutic alliance already exists within this familiar cohort, fostering an atmosphere of trust and collaboration as they deepen their shared responsibilities for fostering children's learning success. In preparation of the educational series, a learner profile (Appendix A) will be dispatched to the cohort members of this pilot program. Insight reflecting their background knowledge, motivation, interests, needs, preferred learning styles, and personal objectives will determine the "what", "how", and "when" of the instruction.

A flipped classroom model will provide OTs with the background knowledge necessary to equip them with expanded knowledge and methods of delivery around vestibular concepts. The modules for each month's lessons will be provided on a web-based learning platform with links to research articles, video modeling, and reference manual information. Professional CEUs and OT products may also become available through this website. Participants will have opportunities to apply learned concepts within individual therapy sessions or the pediatric play lab on campus. They will share their experiences through joint reflection and shared problem solving at monthly learning sessions, as new concepts transcend into their professional practice.

**Methods of delivery and the learning process**

The intended learning process is based upon Problem Based Learning (PBL)

model and Team Teaching and Learning (Smith et al., 2020), where participants engage in joint learning to problem solve, reflect, collaborate, and integrate learned concepts until all parties feel confident with understanding and applying new methods of intervention. Postulates of contemporary science, vestibular rehabilitation, and historical underpinnings of Ayres' theory will illuminate the causal factors and mechanisms of change guiding vestibular intervention to mediate children's learning. To provide further clarity, ASI fidelity points will be compared to sensory based interventions, and methods of vestibular evaluation, intervention and potential outcomes will be reviewed. Through ongoing discussion with reflection and sharing of lived experiences with employing former and contemporary vestibular concepts, a determination will emerge if a shift in practice is appropriate.

Initially, this pilot program will be led by this author as the educator and curator of articles of education shared through a flipped classroom instructional model with didactic presentations, video examples, case studies, facilitated discussion, lived experiences, referenced articles, demonstration, applied applications for skill development, and potential recruitment or consultation from field experts. Perceived value of professional relationships will ensure the essential elements of trust, safety, and vulnerability to accept tensions caused by confronting beliefs to embrace change (Lysberg & Ronning, 2021). Formal education will be planned for a minimum of three months with ongoing qualitative evaluation of therapists' perceived confidence and value around educational concepts as an indicator of necessity to continue additional educational programming.

To engage in reflective learning, OTs will be encouraged to first reflect on their current methods of evaluation and intervention with children who experience challenges with motor skills, functional vision, communication, and learning, along with associated outcomes and perceived effectiveness. Throughout educational sessions they will be invited to share video examples of evaluation or intervention methods, followed by group reflection on the strengths observed in current practices to develop a trusting and positive learning environment. Defensive responses will be minimized while encouraging genuine conversation and reflection, vulnerability, and integrative (rather than win-lose) practices (Bokeno, 2003).

Between educational sessions, OTs will be invited to observe and measure vestibular functioning of their current students using a comparative balance measure (Appendix D) and test of post rotary nystagmus (PRN) (Appendix D) to gather baseline data for future comparisons. It will be necessary to have access to computers with internet access for learning materials and / or virtual instruction. Participants will be encouraged to employ a vestibular screening tool (Appendix D), which will bridge vestibular observations with teachers and parents. Professional, web-based resources and cohort generated intervention activities will also be available to expand interventions. Over the duration of the educational series, participants will have opportunities to engage with new methods and then reflect within the learning cohort, employing methods of double loop learning to encourage coupling of contemporary science and Ayres' traditional approach within their guiding paradigms of intervention (Lysberg & Rønning, 2021). This knowledge will be transformative to fellow therapists to identify and

remediate vestibular dysfunction, particularly in children who present with challenges relating to motor performance, communication, and learning without other medical conditions or mental retardation that could be attributed to such challenges.

OTs participating in the learning series will be encouraged to educate parents and families about vestibular interventions thereby expanding their personal understanding and fostering greater opportunities for building memory capacity and neural networking of the children they work with. An infographic containing a QR code linked to an easy-to-use padlet of supporting activities will be shared with parents and teachers to encourage daily vestibular opportunities. In this pilot educational program, the embedded padlet of activities will be a dynamic element, where OT participants may add preferred activities or create their own personalized activity menu, emphasizing learner centeredness, guided facilitation, and intrinsic motivation by personalizing their experience and interactions with others using this tool (Knowles et al., 1998). The OTs learning experience will be enhanced by their collaboration and control over making a shared product and reflecting on the recommended activities for parents and teachers to employ with children. By teaching others, they will experience greater comprehension and esteemed value of vestibular applications, which will benefit parents and teachers in making informed choices supporting children's academic success (Van Heck, 2019).

Pending IRB approval, participants of the educational series will initiate learned evaluation and interventions with children on their OT caseloads. Observations and data will be shared monthly within the education series with strict use of confidentiality regarding children's identity. Confidential shared data will be recorded on a password

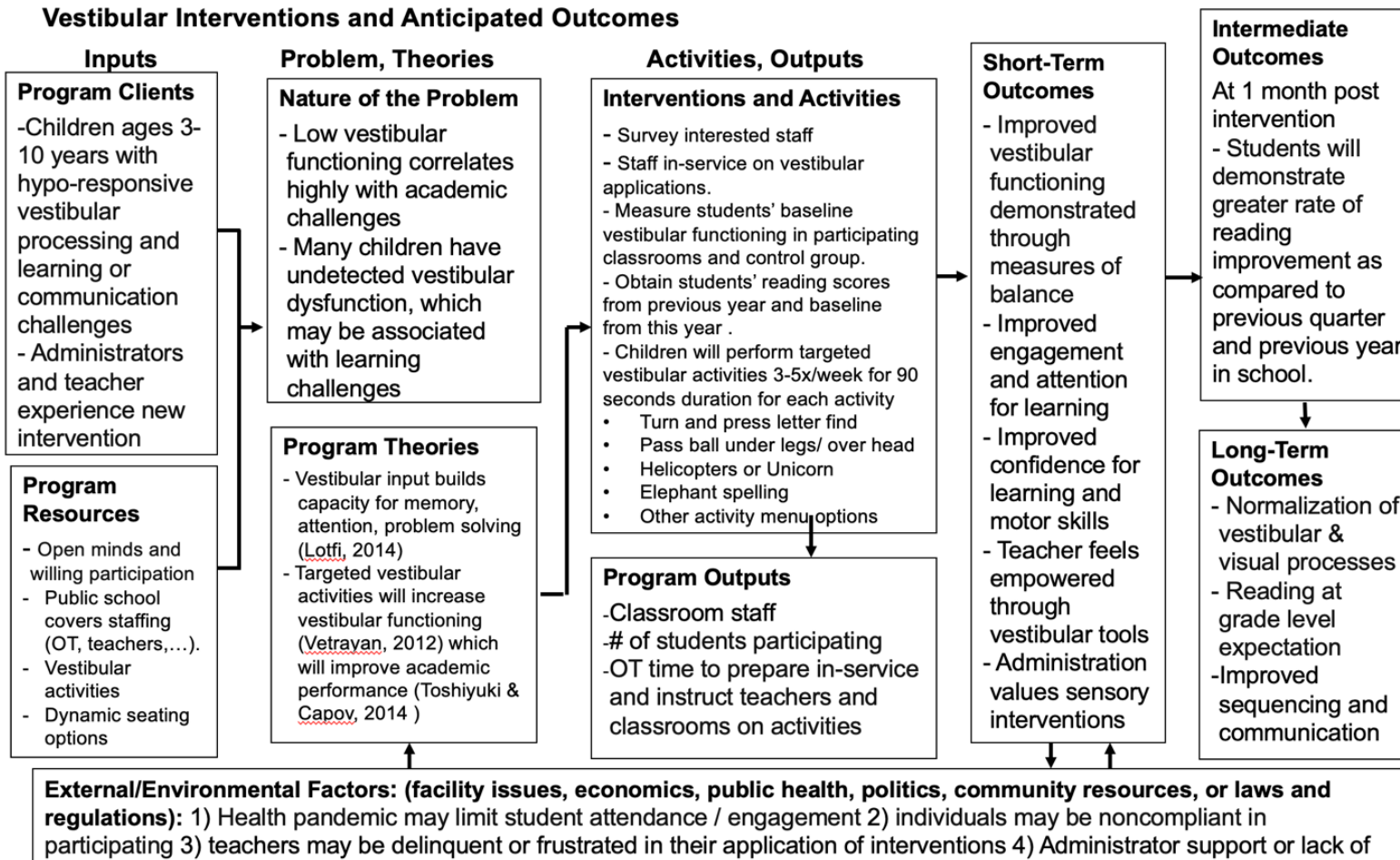
protected and fire walled web-based spreadsheet, documenting baseline data, interventions, and progress measurements of students identified as demonstrating vestibular dysfunction. Collective results will be discussed during monthly meetings with opportunities to extend cumulative results with stakeholders.

### **Content of the Educational Series**

Figure 4.1 represents the foundation of the educational series and serves as a dynamic guide to support the learner in applying educational concepts through sound program implementation, evaluation processes, and ongoing critical reflection as part of their learning experience.

**Figure 4.1**

*Vestibular Interventions and Anticipated Outcomes*





As illustrated in Figure 4.1, vestibulotherapy supports children ages 3-10 years of age, who present with developmental vestibular dysfunction that may be described as under responsive or hypo-responsive and expressed through delayed speech and language, academics, and motor skills without comorbidity of diagnosis that account for their deficits, except perhaps ADHD, Developmental Coordination Disorders (DCD), Developmental Language Disorders (DLD), and Learning Disorders (LD). Each of these related diagnoses are given to children whose attention, coordination, language, or academic skills (respectively) develop atypically without comorbidity of cognitive, auditory, environmental, or neurological deficits, and affect approximately 7% of the population (Matuszkiewicz & Gałkowski, 2021). Each of these disorders correlate highly with coexisting delays in vestibular-based gross motor skills, fine motor skills, general motor clumsiness, balance, bilateral coordination, imitation of positions and movements, pace of task completion, precision, error complexity, and attention (Matuszkiewicz, & Gałkowski, 2021; Lotfi et al, 2017; Hitier et al., 2014).

Neuroscience research supports vestibular applications to remediate conditions, such as those associated with DCD, DLD, and LD, to improve skills relating to motor, attention, sequencing, spatial cognition, and problem solving, (Lotfi, et al, 2017; Hitier, et al, 2014; Melo et al., 2019), which would likely positively impact communication and academic performance. To better recognize delayed vestibular maturation, performance challenges observed in motor development, postural control, communication, and learning, such as those associated with DCD, DLD, LD, and ADHD should raise a red flag for vestibular dysfunction.

To end departmental confusion within sensory intervention practices, a review of ASI fidelity measures, sensory based applications, and related terminology will help OT practitioners have a greater understanding of sensory integration and related vestibular applications and their potential to positively impact occupational outcomes. While vestibular therapies may be provided outside of an ASI model, together ASI and contemporary neuroscience will illuminate a comprehensive outlook on the influence of vestibular interventions on learning and communication.

Research evidence and lived experiences of applying vestibular methods in therapy will be foundations of the educational process, elucidating that techniques are not experimental, but rather, validate that interventions improve children's communication and academic performance. A recap of the theoretical underpinnings for vestibular applications from Chapter Two reminds us the data showed consistent findings but lacked a prescriptive guide for intervention. However, contemporary neuroscience revealed a variety of salient themes for procuring evaluation and interventions of vestibular dysfunction, which will set the foundation for the educational content (Lotfi et al., 2016, Rine, 2018, Christy, 2018; Van Hecke et al., 2021; Solan et al., 2007).

Within the educational series, participants will have opportunities to apply learned methods of both evaluation and vestibular interventions with children on their immediate caseload. This professional practice learning platform will allow for robust and meaningful conversations, collaboration, and reflections within the cohort over time. As part of their real time interventions, they will collaborate with teachers to observe related change within the classroom setting.

Research approval will be requested from all relevant stakeholders, including the local school district and school board, the partnering university, and families. Program concepts will best be experienced through learned applications of measuring and observing vestibular attributes in the children on educational participants' caseloads. Initially, consideration will be given to all children on their caseloads and then determine inclusion eligibility. Children will be eligible for this intervention cohort if they present with vestibular dysfunction that can be described as hypo-functioning with related performance challenges in communication or academic achievement without other diagnosis or conditions that can account for such challenges. Each OT will be able to make this determination based upon their current knowledge of the children on their caseloads. The learned applications will be applied within the children's regular therapy sessions to promote higher performance on their existing IEP objectives.

To engage and connect OTs with stakeholders, the educational program will establish a long-range vision for applying learned concepts to school wide improvement plans for reading outcomes. The opportunity for them to implement classroom based vestibular programming and educate teachers about vestibular benefits will advance their perceived value of the knowledge gained through the educational series. A Padlet infographic tool will provide a vehicle for OTs to educate parents and teachers about supporting children's learning through vestibular practices inside and out of the classroom setting. They can share this infographic either electronically or through hard copy with parents and teachers for further implementation of building the child's learning and memory capacity in the home and school settings. Children and teachers in our

schools are familiar with using the QR codes, making this an easily accessible tool.

While employing this teaching tool with parents and teachers, OT participants will gain metacognitive awareness that will help them move from their limited understanding and application of vestibular interventions to one that enhances the learning and memory capacity of their students. School or pediatric based OT practices depend on collaboration of the family and school community to help a child fully achieve their potential. This teaching tool will connect them through a child-centered focus, fostering growth through play and movement.

Through direct instruction and collaborative learning processes, the educational participants will examine the underlying science behind vestibular interventions. They will consider how vestibular inefficiencies moderate children's success with learning, behavior, and communication, as well as how vestibular interventions mediate neural connections to enhance foundations and cortical processes necessary for successful learning and engagement within children's social and academic contexts (Ayres, 2005; Lane et al., 2019). OTs will compare learned applications, their personal observations, and related outcomes of the interventions while collectively reflecting on how this impacts children's occupational performance.

Research approval and educational components will be led by the author of this program with encouragement and recruitment of all members to engage in clinical trials of learned applications, reflection, and ongoing participation in shared problem solving. Formal education will be planned for a minimum of three months with ongoing qualitative evaluation of therapists' perceived confidence and vested interest for

evaluating and treating vestibular dysfunction as an indicator of necessity to continue additional educational programming during the pilot program.

Once OTs become experts with measuring and treating vestibular dysfunction, mainstream interventions may become possible through tiered school interventions to help more children succeed in their academic performance. After recognizing how many children's vestibular dysfunction remains undetected and negatively impacts learning outcomes, teachers, parents, therapists, and other school stakeholders will value vestibulotherapy concepts and adopt prescribed activities into their classroom, clinical setting, and home routine to help children succeed in learning.

### **Teaching Plan**

The proposed education series is based upon a Problem Based Learning (PBL) model, which is a joint and reflective learning model where participants gather, share, and integrate learned concepts until all parties feel confident with understanding and applying new methods of intervention. OTs who will engage in the pilot educational series will be interested in gaining knowledge for evaluation, intervention, and outcome measures with children who present with vestibular dysfunction. As illustrated in the teaching plan in Figure 4.3, participants will gain knowledge through didactic presentations, video examples, case studies, facilitated discussion, lived experiences, assigned readings, demonstration, applications for skill development, and potential recruitment or consultation from field experts.

Centered around the common goal of improving vestibular functioning with the children served, educational elements will include shared problem solving, collaboration,

double loop learning, and perceived value of professional relationships facilitated by mutual trust, safety, and vulnerability to accept tensions caused by confronting beliefs to embrace change (Burman et al., 2021; Smith et al., 2020). Formal education will be planned for a minimum of three months with ongoing qualitative evaluation of therapists' perceived confidence and value around educational concepts as an indicator of necessity to continue educational programming.

This teaching plan will fully engage professional learners first through valued relationships and an established network where early elements of trust and vulnerability have emerged through familiarity of living and working in a shared community. Establishing a common purpose will unify collaborative efforts to help children overcome challenges and succeed at learning and role performance through applied concepts from contemporary neuroscience incurred from the educational series. Teaching elements will ensure that concepts are valued through shared problem solving and reflective learning over time as participants discuss their lived experiences of learned applications over time.

Although my educational program is focused on OTs gaining knowledge, I chose to measure growth primarily through affective domains of value and confidence (Burman et al, 2021). If learners associate program content with these attributes, it will make a lasting difference in their professional practice and in the lives of the children they work with. Each of the learning objectives will have nearly equal time dedicated to instruction, with concepts introduced progressively over the three, monthly sessions.

**Figure 4.2***Teaching Plan*

<p><b>Domain:</b> Overall, the objectives are based upon Affective outcomes with Instruction &amp; Learning through interdependent and simultaneous engagement with Affective, Psychomotor, and Cognitive domains.</p>
<p><b>Overall learning goal:</b> By the end of the three-month educational series and based upon baseline ratings using a Likert type scale, OTs will report increased confidence and value in relation to identifying vestibular dysfunction, applying vestibular interventions, and appreciating outcomes of the intervention.</p>
<p><b>Specific learning objectives:</b></p> <ol style="list-style-type: none"> <li>1. After demonstrating learned evaluation methods with a peer, OT will report confidence increasing 50% over baseline for evaluating vestibular dysfunction in 2/2 opportunities during the educational series</li> <li>2. After sharing lived experiences using learned applications, the OT will indicate increased perceived value of vestibular knowledge and applications through shared reflections in 2/2 opportunities</li> <li>3. After identifying vestibular dysfunction in members of their current OT caseload and gaining related insight into their students' performance challenges, OTs will indicate increased perceived value of knowledge &amp; concepts, in 2/2 opportunities.</li> <li>4. By the conclusion of the learning series, OT will identify 5+ preferred vestibular activities for classroom or home applications and share those with 2+ teachers or parents to support children's development.</li> <li>5. By the end of the educational series, OTs will report observations of children's improved outcomes they attribute to learned vestibular interventions in 2/2 opportunities.</li> </ol>

**Learning activities**

Direct instruction	Practice of Methods	Video examples
Instructional Feedback	Shared problem solving	Case Studies
Collaboration	Applications for skill development	Double Loop Learning
Lived experiences	Assigned readings	Research initiation
Structured learning tasks	Instructional feedback	Affective domains

**Method of Teaching / Supporting learning theory:**

Cooperative Learning	Brain Based Learning	Double Loop Learning
Adult Learning Theory	Problem Based Learning	Learned applications
Ayres Sensory Integration	Vestibular Rehabilitation	

**Resources & instructional materials:**

Vestibular screening tool - Appendix D	Contemporary neuroscience research (Wall, 2022)	Teaching Plan – Figure 4.2
Vestibular Measures (Oyewumi, et al., 2016) - Appendix E	Learner Profile – Appendix A	Prescribed methods of vestibular intervention
Test of Post Rotary Nystagmus - Appendix E	<a href="#">padlet</a> activity menu for parents and teachers with	Descriptive narration for Kavar rotations – Appendix F
Vestibulotherapy Model of change – Figure 2.2	Norm referenced evaluation tools – Appendix E	Children’s occupational profile – Appendix G

**Evaluation Plan:**

Qualitative evaluation - open and close ended questions	Formal and informal observation with applied learning from educational series
Quantitative evaluation using scaled scores or group interview	Video analysis (optional for collaborative purposes) of learned / applied techniques
Monthly focus group interviews	Logic Model outcome measures - Appendix C
Program evaluation research questions – Appendix G	3-month post educational series follow up interview to determine impact.



### **Evaluation of the Effectiveness of the Educational Series**

Quantitative data will be collected from program participants to establish baseline knowledge and confidence with understanding, evaluating, and applying vestibular interventions. During progressive learning sessions and at the summation of the series, assessment of OT's confidence with learned applications will be measured through focus group interviews with open ended questions to determine readiness for expert involvement and / or conclusion of the educational series. Evaluation stories will be encouraged to benefit all participants through the sharing of lived experiences in relation to their application of learned concepts and outcomes of interventions.

Ongoing formative evaluations will occur at monthly educational meetings with scaled responses and focus group interviews to determine both satisfaction and effectiveness of the educational process, with program adjustments made accordingly. Qualitative and quantitative data will be collected in both the formative and summative program evaluation portions of this research design. At the conclusion of the educational series, formative and summative evaluations will reflect knowledge and confidence gained, perceived value of the learned concepts and satisfaction with the educational process. Comparisons will be made with baseline measurements.

To establish relevance to occupational performance, summative information will be gathered from the child participants, their teachers and possibly parents, to quantify the impact of the intervention on communication, motor skills, or academic performance. Because this data may not be fully distinguished at the conclusion of the educational series, a three month follow up survey will be administered for full appreciation of the

effects of the vestibular interventions.

Participating OTs will benefit from having children to work with - both to experience the learning applications firsthand and to observe the effects of the interventions. Through the emerging transformation of their guiding paradigm, OTs will likely develop an increasing awareness of related outcomes impacting development of their students' learning and communication.

### **Outcomes**

#### **One month into the education series:**

1. OTs will demonstrate increased interest and perceived value reflected through observations and inquiries regarding learned concepts.
2. IRB approval will be received for integrating learned concepts into existing treatment plans for children receiving OT by educational program participants.
3. OTs will identify and measure vestibular functioning of students on their current caseload, establishing baseline data prior to starting the intervention cycle
4. OTs will complete interviews with their students, who will participate in the vestibular interventions, to determine their strengths, challenges, interests, cultural values, and personal goals, to best align therapy interventions.
5. Educator / Author will meet with stakeholders regarding the proposed intervention and intentions for positively impacting students' academic achievement.

#### **Two months into the education series:**

1. OTs will demonstrate increased confidence with evaluating vestibular performance, applying vestibular interventions, and identifying a variety of performance outcomes associated with vestibular processes.
2. Together the author and OT participants will determine if there is a need for a field expert involvement in the learning series and secure their involvement for future sessions.
3. OTs will have initiated collaborative interventions with teachers and / or parents to further enhance children's learning potential.
4. OTs will demonstrate an understanding of vestibular connections to support motor, communication, and academic performance as evidenced through group interview and collaborative problem solving around therapy interventions and

projected outcomes.

**Conclusion of the Education Series:**

1. OTs will confidently evaluate vestibular functioning, recognize the distinct value of vestibular applications within our professional scope of practice relating to performance skills, implement learned vestibular applications into therapy interventions, observe and attribute related outcomes to interventions, and extend learning beyond the educational series through continued opportunities to reflect and collaborate within the professional network over time.
2. Classroom and home networking will continue to provide meaningful and engaging vestibular opportunities to enhance student learning and performance outcomes.
3. Stakeholders will report observations of initial benefits of vestibular interventions as positively impacting academic performance and / or communication.

**Three months following completion of the education series:**

1. Qualitative and quantitative information will be gathered formally and informally from school stakeholders to reflect perceived benefits toward student growth related to interventions.
2. Qualitative and quantitative information will be gathered formally and informally from OTs to reflect perceived benefits of the educational series and quantify the impact it had on their professional practice.
3. OTs will report continued learning and application of learned concepts through ongoing engagement with the professional cohort to reflect and collaborate on related problem solving on a post-educational series continuum.

**One or more years following completion of the pilot educational program:**

1. A testimony of evidence will be presented to AOTA, WFOT, and the Vestibular Disorder Association (VeDA) regarding the necessity of distinguished clinical practice guidelines for populations with developmental vestibular dysfunction as compared to recommendations employing adult vestibular rehabilitation methods with children.
2. National statistics will report a decrease in frequency of children going undiagnosed and untreated for vestibular dysfunction (Li, et al., 2016)
3. The educational program will become transformative to national or global pediatric OT practice, increasing OT knowledge for vestibular evaluation and treatment as well as establishment of accepted clinical practice guidelines for

developmental vestibular therapies in pediatric populations for intended outcomes.

4. Children involved in the pilot program of this educational series will have achieved marked improvement in their academic and / or communication skills as compared to baseline measures.

### **Anticipated Barriers and Challenges**

Within my local OT community, members of the educational pilot cohort are in the earliest stages of change – the precontemplation stage (Wang et al., 2019), where they have no awareness or intention of changing their professional practice. Within our local university, there exists a negative bias imprinted by a former faculty member regarding all things sensory related in OT theory and practice. She has since retired but left a strong impression on students and faculty from the program, limiting their acceptance of sensory based interventions. Because we have a strong and positive relationship and I feel they value my professional opinion, I am hopeful they are entering the contemplation and preparation stages as I complete my doctorate, readying themselves for action (Wang et al., 2019).

In addition to the predisposed negative bias, there has been a growing trend in education for all special education supports to be included within the classroom setting. I find value in inclusion when it provides a match for the child's needs. I also feel strongly that many children benefit from being in the classroom for the instruction and modeling from their peers. However, I do not feel that all therapies and interventions are appropriate within the regular classroom setting. Fortunately, our school administration allows our professional judgement to guide our practice with encouragement to work

within the classroom setting when possible. For some OTs, I feel this trend of inclusion has left them lackadaisical in their efforts and limited in their perception of potential impact, believing if the child needs clinical based OT services, their family will arrange for this to happen. It has been my experience that very few children ever receive OT outside of the school setting. Between the time, costs, and health related knowledge, this supplemental service is either unrecognized or lacks priority for allocated resources within most families.

In their research, contemporary science used vestibular interventions with predominantly neurotypical children, who may also demonstrate Attention Deficit or motor challenges. Similarly, vestibulotherapy applications may be applied confidently with this population for positively impacting motor development, as well as attributes supporting learning and communication skills. Although studies identified attributes that support improved learning and communication, few authors specifically collected data on academic or social outcomes in relation to the intervention. It is through the relationship of the learning and communication to the attributes of ordinance, sequencing, attention, balance, vision, spatial cognition, and memory that we predict increased academic and social performance outcomes from vestibulotherapy. Research is needed to verify these proposed outcomes.

Throughout the many research studies, a variety of vestibular activities were applied with salient outcomes, lacking a prescriptive quality of intervention. Rather, recommendations were general including a variety of static and dynamic balance activities, which often included visual targeting to pair the vestibular-visual systems

together. Through lived experience, the Kavar rotation protocol, as described in Appendix F, provides a significant impact on the hypo-responsive vestibular system. While no research was found in publications to support this intervention, years of lived experience employing this OT intervention suggests strong positive results at providing adequate vestibular stimulation to activate an under-performing or delayed vestibular system. This intervention frequently resulted in marked improvement to communication and learning as compared to interventions without significant vestibular activation in children with hypo-functioning vestibular systems.

## **Chapter Five**

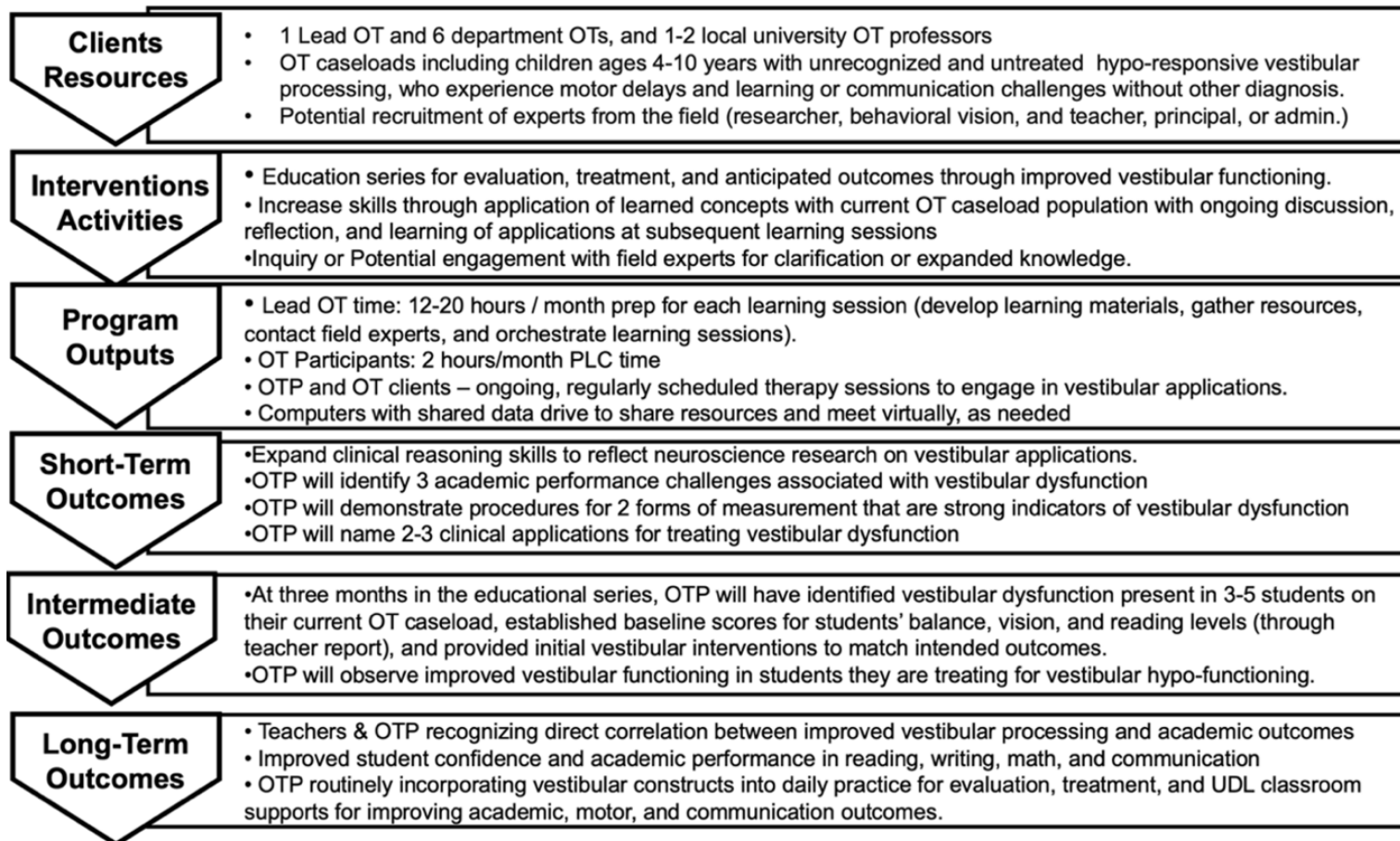
### **Vestibular impact on learning: A program evaluation research plan**

#### **Vision for the program evaluation research**

Evidence of a successful launch of the educational program will be evaluated through stakeholder research questions (Appendix G) and logic model outcome measures (Appendix C). Affective domains will provide further evidence through increased OT confidence and perceived value with recognizing vestibular performance, applying vestibular interventions, and identifying a variety of performance outcomes associated with vestibular processes. Figure 5.1, a simplified logic model, illustrates the author's intentions for the educational series including necessary resources, outputs, and related outcomes. Outcomes reflecting increased knowledge for identifying vestibular dysfunction, designing intervention programs, and connecting vestibular processing with learning objectives will be measured over time, recorded, and shared with stakeholders as a product of the educational series.

**Figure 5.1**

*Simplified Logic Model*





### **Confirmatory Process**

Baseline measurements and peaked interest in potential outcomes will be used to establish a common goal for engaging in educational processes to gain knowledge for measuring and implementing vestibular interventions with current OT caseloads. Participants will complete a baseline rating scale for assessing both knowledge of occupational performance areas influenced by vestibular functioning and perceived confidence with identifying and treating vestibular dysfunction. To fully engage participants in the learning process, the proposed logic model and a full spectrum of potential outcomes and applications will be discussed after the self-appraisal and prior to establishing outcome goals specific to the needs of the group. By establishing a common goal for vestibular applications, participants will be highly vested in mastering educational principles monthly at prescheduled OT PLC meetings within a select school location or university setting.

Prior to each monthly learning session, program participants will be provided with a clear outline of learning objectives along with educational resources within an online, flipped classroom format to preview and then discuss within each learning session. Initially, the educational series will focus on research data regarding the extensive role of the vestibular system in learning. Following this foundation, IRB approval will allow participants to focus on measuring vestibular performance, applying interventions, and observing functional outcomes.

Growing confidence for interventions and observations will be measured through focus group interviews with open ended questions to determine readiness for expert

involvement within the educational series. Evaluation stories will be encouraged to benefit all participants through the sharing of lived experiences with applying learned concepts and observing outcomes of interventions.

Within the educational series, teachers, parents, and administrative stakeholders will be represented through a predominantly indirect role and kept informed through bi-monthly updates. The proposed logic model (Appendix C) reflecting anticipated program outcomes and illustrating how the intervention supports the school improvement plan will be shared with principals, teachers, and school administrators during the initial confirmation meeting. Involving stakeholders will be helpful in establishing accountability and making connections between the school improvement plan, educational outcomes, and learned applications of the educational series.

Having a common goal creates relevance to engage program participants in learning objectives. School stakeholders will be asked to prioritize their needs, so interventions and outcomes align. School staff and administrative stakeholders will assist in the program planning by articulating the school wide learning needs and improvement plans, while making connections to intended student educational outcomes. Having a vision of where OTs are in their knowledge and confidence with projected outcomes will confirm the need for the educational program and dedication of resources.

During stakeholder meetings, progress toward educational objectives and related student performance outcomes will be reviewed. Ongoing communication with teachers and school administrators will mediate accountability to remain focused on long range goals of improving students' academic performance. Summative data collected at the

conclusion of the series will be shared with representative teachers and administrators during the planning phase for progression to the next level of intervention. At that time, qualitative and quantitative information will be gathered formally and informally from this audience to reflect perceived benefits toward student growth related to interventions.

Prior to receiving vestibulotherapy interventions, child stakeholders will be interviewed using an occupational profile to determine their strengths, challenges, interests, and cultural values, as well as identify personal goals. Active participation in goal setting provides motivation and full engagement in the therapy process. Input will also be gathered from parents and teachers using the Family Life Impact Questionnaire (Mailloux & Smith, 2018) and Vestibular Screening Tool (de Veer, 2017) respectively. Information gathered before, during, and after the interventions from children, families, and teachers will orchestrate intervention plans as well as contribute to ongoing monitoring of performance outcomes.

As the educational series evolves, the need for field expert involvement in the discussion of specific processes relating to vestibular interventions will be determined and contacts made prior to subsequent dates to schedule collaboration or seek consultation with shared results. The proposed logic model will be shared with field experts, along with OT strengths and challenges with addressing vestibular dysfunction. Field experts and researchers may be considered distant stakeholders for their vested interest in raising awareness and providing treatment for this underserved population. Field experts may be asked to answer targeted questions from the group regarding

specifics of vestibular interventions through their direct or indirect involvement in the learning series.

By engaging a variety of field experts, the educational series will take on a more robust content to formulate processes and capacities to better meet the needs of this under identified and under addressed problem. Assuredly, the strong background that OTs possess for sensory processing would address some of the disparity of treatment if more awareness of the problem was brought to light. The capacity to develop vestibular processing and paired visual functioning should be strongholds within the OT domain and fill the void of this service need.

### **Program Evaluation Research Questions**

At the conclusion of the learning series, children, parents, and teachers will be asked to provide qualitative and quantitative data regarding developmental and academic outcomes related to vestibular functioning to further measure progress and benefits of the intervention. Research questions in Appendix G will be posed to determine effectiveness of the intervention during and / or after the initial program launch.

### **Research Design**

This program involves a non-experimental, single group design which will be evaluated using pre and post summative measurements as well as ongoing formative assessments. Initially, quantitative data will be collected from program participants to establish baseline knowledge and confidence with understanding, evaluating, and applying vestibular interventions. Ongoing formative evaluations will occur at monthly educational meetings with scaled responses and focus group interviews to determine both

satisfaction and effectiveness of the educational process, with program adjustments made accordingly. Qualitative and quantitative data will be collected in both the formative and summative program evaluations, reflecting knowledge and confidence gained, perceived value of the learned concepts, and satisfaction with the educational process. Comparisons will be made with baseline and concluding evaluations with data numerically reported.

To establish relevance to occupational performance, summative information will also be gathered from the children receiving interventions during this educational series, as well as their teachers and parents, to determine the extent that improvements were observed in communication, motor skills, or academic performance. Because this data may not be fully distinguished at the conclusion of the educational series, a three month follow up survey will be administered for full appreciation of the effects of the vestibular integration on communication and academic performance.

## **Methods**

To meet program objectives, the educational series will utilize contemporary research and lived experiences to establish program content and opportunities for OT participants to employ learned applications with their clients over time. Participants in this educational series will include occupational therapists (OT) working in the school district and faculty teaching in our graduate OT program. Participants will be formally invited to the educational series with detailed information regarding the objectives of the program. The emphasis of this intervention is to educate OTs on vestibular evaluation and intervention, which will be fully experienced through learned applications of measuring and observing vestibular attributes in the children on their OT caseloads.

Initially, all children on OT caseloads will participate in the initial screening to determine inclusion eligibility. Children selected for this cohort will present with vestibular dysfunction that can be described as hypo-functioning with related performance challenges in communication or academic achievement without other diagnosis or conditions that can account for such challenges. There will not be a control group for this initial launch focusing on educational outcomes.

Parents will be given a general description of the educational series and expected outcomes of the learned interventions through review of the simplified logic model (Figure 5.1). They will be informed that the time involved requires no additional time beyond children's current therapy sessions, where interventions will continue to address children's needs as identified within their IEP. To follow professional ethical guidelines, clinicians will be asked to receive signed permission from students' parents to participate with options to photograph and / or videorecord treatment sessions for educational purposes. If parents have questions or objections, they will be given contact information for this researcher and may withdraw at any time.

### **Confidentiality and IRB approval**

IRB members will be assured of the ethical considerations for maintaining confidentiality through the application of coded identification numbers paired to their OT to conceal children's personal identification. Data associated with each student will be stored within a shared spreadsheet using password protected Google Drive, whose contents are only accessible to those participants invited to access the shared drive. Individual OTs will maintain children's identity within their clinical records, not to be

shared in the related database and all data will be reported through their identity code. Any follow up information will be conducted through the OT directly involved with the child. Upon request, access to data may be made available to research review board members with strict confidentiality of children's protected identity.

IRB approval will be sought through both the local school district and the partnering university. These governing agencies seek to protect the rights and welfare of human subjects to assure clinical research is conducted in accordance with the laws, regulations, and IRB policies. As articulated in the IRB application draft (Appendix H), an ethical conduct of proposed research will be illustrated through several concept models explaining the need for the educational series and the proposed logic model for intended outcomes, giving purpose for the research. Details of the various phases of implementation and expected duration will be shared, as well as how interventions fit into the children's existing OT intervention plan and school day.

Program justification will be illustrated through examples of the impact vestibular dysfunction has on academic achievement. Supporting documentation for the effectiveness of vestibular interventions will be shared through ongoing data collection and lived experiences. The educational program will build the knowledge and confidence of OTs to implement vestibular practices and begin recognizing related outcomes. Measured student successes will emerge following the educational program as therapists are able to fully implement their knowledge translation into practice.

### **Formative Data Collection Methods**

Formative data collected monthly during educational sessions will illuminate the

effectiveness and satisfaction with the educational process and content. Surveys created through Qualtrics will include both scaled score and open-ended questions to gain individualized and insightful feedback that is both qualitative and quantitative in nature, fostering program adjustments as needed. Quantitative data will be obtained through survey questions that reflect OT levels of perceived confidence or satisfaction with learned concepts, as well as through evaluation stories from learned applications. At the conclusion of the learning series, a final survey will collect formative data to reflect OT satisfaction and ease of engagement with the educational process, clarity of materials, perceived value and confidence in concepts learned. This closing survey will be administered online with participation remaining confidential to encourage honest feedback.

### **Formative data management and analysis**

Parametric statistical operations will be applied when analyzing formative program evaluation data that is descriptive in nature but represented through numerical value. Qualitative and quantitative data will be recorded during monthly educational meetings and analyzed through a combination of descriptive coding that summarizes data through a common word or phrase, in-vivo coding which identifies phrases from open ended questions to establish recurring themes that could then be coded numerically, enumerative methods, and / or inductive coding through salient themes found in open ended questions. Coded qualitative data that can be represented numerically, will be entered into a network display pattern revealing how the learning series progressively transcends therapists' perceived value and confidence with vestibular applications. If



formative evaluation data does not convert readily to numerical values, classical content analysis methods will be applied to analyze the presence, value, and relationships of recurring themes in participant responses.

Results will be reviewed by an external observer to limit potential bias and compare hypothesized outcomes. Inductive coding, established through gathered data from this initial launch, will be applied to program analysis in future educational series.

### **Summative data collection methods**

Summative evaluations will be a mixed-method design comparing pre and post measures of OT knowledge and application. Summative data will be gathered through survey responses using interval scaled data and open-ended questions. Variables of interest potentially impacted by the educational series include knowledge attainment for performance outcomes associated with vestibular functioning, identification of vestibular dysfunction, and application of vestibular interventions. Additionally, OTs and related service providers will be surveyed about the impact therapy interventions may have had on their students' academic, motor, or communication performance. Additional measurements of interest include the children's academic profiles, strengths and challenges, and the percentage of children on each OT caseload who present with vestibular dysfunction.

Qualtrics will be used to generate surveys and record data retrieved from Likert type scales or short answer responses. Data will be stored on password protected computer with backup storage on a web-based storage drive such as RedCap or similar data storage. Summative evaluation will be taken at the conclusion of the learning series

to determine the effectiveness of the educational program and again at 3 months following the educational series to determine the long-standing impact of learned concepts on professional practice.

Prior to initiating learned vestibular applications as a product of the educational series, OT program participants will gather pre and post measurements using a scaled score survey with related service providers, parents, and teachers to investigate and record observations from specific variables of interest including attention, problem solving, sequencing, numeracy, and spatial or visual representation relating to academics or communication within the school or home setting. This will provide each OT an opportunity to articulate educational concepts and expected outcomes of the interventions. As part of applying learned concepts, OTs will conduct pre and post vestibular evaluations so they may observe direct changes relating to the interventions, adding to their perceived value and effectiveness of the educational series.

Program outcomes measuring OTs' perceived value of the learned concepts will be obtained through focus interviews, producing qualitative data reflecting clinician's likelihood to implement learned applications and continue them over time. Qualitative measurements will be collected, recorded, and transcribed monthly through peer-mentor opportunities, including discussion of video recorded therapy interventions or evaluation procedures, and reflection of applied learning. Sharing lived experiences through evaluation stories will illuminate program outcomes, generate rich discussion among participants, and provide insight for gaps and improvement opportunities in the learning process

### **Summative data management and analysis**

Summative evaluation will be a mixed-method design using descriptive statistical data with applied inferential statistics when comparing pre and post measures of OT knowledge and application at three time points: pre-program, immediately post-program, and 3-months post program. Data will be gathered through survey responses using Likert-scale and open-ended questions, which will be analyzed for salient themes and then coded and reported through enumerative methods. Scaled score responses will be collated by the Qualtrics survey system and represented through graph or percentage outcomes. Open ended questions, evaluation stories, and lived experiences will be recorded, transcribed by this author and the assistance of dictation, and stored on a shared Google document. Transcribed data will be stored on the password encrypted and firewall protected data warehouse.

Program outcomes are dependent upon the causality of the educational series upon dependent variables including OTs' perceived value and understanding of the knowledge and applications of learned concepts. Quantitative data will be analyzed with inferential statistical methods for single-group pre and post designs to analyze the effectiveness of the educational series. Statistical analysis will numerically represent the degree of change within the variables. The data will be analyzed using repeated measures of analysis of variance (ANOVA) through comparisons of pre and post data (at 2 time points) of educational objectives. This information will be used to determine if desired changes in dependent variables took place as a result of the educational program.

Program evaluation summative data will be shared with school stakeholders and

advocacy organizations at the conclusion of the educational series to review and evaluate the effectiveness of the educational program. This summative information will fuel the launch of the next phase of program implementation to a broader population of children struggling with learning, who demonstrate vestibular limitations but are not eligible for special education or occupational therapy services.

**Anticipated strengths and limitations (of evaluation methods)**

During the evaluation process, course participants, particularly from the pilot series, may feel the need to report a certain level of satisfaction or value regarding the course due to familiarity with the instructor. To ensure honest feedback necessary for course modifications, evaluation results will be reviewed by an external observer to limit potential bias while maintaining confidentiality. Knowledge of confidential reporting will be ensured to participants prior to evaluations.

Through propagation of rapport and trust as foundations of each professional learning community, I am hopeful that participants will freely express concerns with clarity of instruction, the need for further extrapolation of concepts, or other opportunities for improvement to facilitate their course satisfaction and confidence with learned applications.

As the educational series expands to more diverse audiences, there will be a growing need to consider and address cultural issues within learning cohorts. The learner profile will provide culturally sensitive insight into their needs, preferences, motivation, and readiness for learning from which to tailor instructional methods and practical applications.

## Chapter Six

### Dissemination Plan

#### Proposed program

With millions of US children currently experiencing vestibular dysfunction that remains undetected and untreated (Li et al., 2016), OT and teacher awareness is needed for recognizing vestibular dysfunction that limits children's success with academic achievement and implementing clinical and classroom interventions to support development of this vital system. Knowledge gained through the educational series and supporting resources will guide OTs in recognizing and providing interventions, as well as observing vestibulotherapy's effectiveness with impacting occupational performance. Identifying and understanding challenges which influence a child's potential for successful performance, participation, and health are critical for implementation of services and generation of research evidence.

Depending on the audience, the VestibulOTherapy Fact Sheet (Appendix I), Executive Summary (Appendix J), or media-linked information will be shared, providing contemporary neuroscience concepts reflected through the lens of occupational therapy. To distinguish this developmental and sensory based intervention aimed at improving children's occupations of learning and communication from vestibular rehabilitation (VR), consideration shall be given to coining this term vestibulOTherapy, with "OT" in the middle. Embedding interventions within the child's occupational of play and aiming for outcomes supporting learning and communication will distinguish vestibulotherapy from pediatric vestibular rehabilitation. Successful outcomes of the learning series and

related information will be evident when therapists routinely identify developmental vestibular dysfunction and procure a culture where vestibular therapies, embedded within the occupation of play, help children succeed in areas of occupational performance.

### **Dissemination goals**

***Long-term objective:*** Web-based educational programming and resources will be available supporting vestibulotherapy concepts across a variety of platforms including, but not limited to, an established website, udemy.com, and a webinar educational series.

***Short-term objective:*** Supporting this long-term objective, introductory vestibulotherapy concepts will be published in journals distributed to audiences within OT, vestibular, pediatrics, elementary education, otorhinolaryngology, and neuroscience for the facilitation of vestibular maturation in neurotypical children with under-responsive vestibular processing, impacting learning and communication outcomes.

### **Target audiences**

***Primary audience:*** Pediatric and School-based OTs

With a push for inclusion, school OT seems to be facing a steady decline in science-based interventions. Children in school need far more than handwriting and sensory supports to overcome challenges that limit them from succeeding in school and social occupations. Their neurodevelopmental foundations for learning and communication skills will otherwise not likely be fully supported by families, who most often also experienced learning or executive function challenges of their own.

To reach more pediatric and school-based OTs, a testimony to extend developmental vestibular therapy knowledge and practices will be shared with American

Occupational Therapy Association (AOTA), the Vestibular Disorder Association (VeDA), and World Federation of Occupational Therapy (WFOT) to expand professional practice guidelines for the identification and intervention with varying vestibular impairments.

**Figure 6.1**

*Key messages of dissemination plan*

Audience	Key Message	Delivery Spokesperson
<p>Pediatric OT (School and clinic based), and OT professors to developing OTS</p>	<ol style="list-style-type: none"> <li>1. School staff (teacher and speech therapist) will give testimony regarding their observations for how vestibulotherapy has helped their students overcome learning and communication challenges and made significant changes in classroom skills in response to a combination of clinical and classroom-based vestibular interventions.</li> <li>2. School staff will give testimony correlating delayed vestibular maturation to academic challenges, promoting increased awareness for educators and therapists to recognize vestibular dysfunction and provide necessary interventions.</li> <li>3. School staff will provide testimony regarding the ease or challenges of classroom-based vestibular interventions to support learning and communication to promote universal and clinic-based interventions.</li> </ol>	<p>Special Education Team (Speech &amp; regular education teacher) – via recorded video message to be shared on website or during educational series, AOTA convention, or other vestibulotherapy promotion.</p>

OTs	<p>1. Provide a summation and promotion of research applying vestibular evidence from contemporary neuroscience to OT.</p> <p>2. Recognition and differentiation of clinical practice guidelines for vestibular injury (vestibular rehabilitation) as compared to delayed vestibular maturation (vestibulotherapy).</p>	American OT Association and (long term objective) World Federation of Occupational Therapy
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### Dissemination Activities

1. Publication in American Journal of Occupational Therapy, WFOT Bulletin, vestibular journal, and/ or other OT journals promoting *vestibulotherapy* concepts.
2. Establish a web-based platform for providing information and resources related to vestibulotherapy at vestibulotherapy.com
3. Promote concepts of vestibulotherapy at AOTA Inspire 2023 through short course or poster session.
4. Provide testimony and establish professional contact with World Federation of Occupational Therapy for the global promotion of vestibulotherapy.
5. Provide web-based introductory short course on Udemy for global promotion of vestibular interventions to help more children succeed in learning.
6. Implement web-based educational series for OT professionals.
7. Initiate research through educational series through OT participants and working caseloads.
8. Partner with university OT students to conduct research with evaluation and interventions around vestibulotherapy and children's occupational performance in learning and communication.
9. Present short course on vestibulotherapy at WFOT in 2026



## Budget

### *Dissemination Funding Needs – Annual projected costs Electronic Media*

- Laptop with data storage (cloud) and web capabilities - internet \$1200/year
- Recording of educational sessions \$0
- Communication – email, phone (\$50/month x 12), mailings (\$200/year) = \$800 / year
- Video conferencing (WebEx, Google Meet, or Zoom) \$0
- PowerPoint presentation & related software (Microsoft office) \$0
- Learning Platform such as Trainual \$199/ month for 20 people = \$2400 / year
- Marketing and resource domain - Square Space \$23/month = \$ 276 / year
- Web design or marketing consultant \$100/hour x 3 hours = \$300 / year
- Desk top camera for zoom demonstrations \$40
- Home office \$0
- Allow for purchase of new laptop every 6-8 years @ \$600/ year (total cost \$3600)
- Total = \$5715 / year

### *Dissemination Funding Needs – Annual Scholarly Publication, Research, and Marketing*

- AOTA professional membership (including attendance at national AOTA convention) \$675/year.
- Article submission to academic journals for publication (building credibility and marketing) \$0 (time)
- CINHAL Database with full text subscription \$163,375 (on hold until cost can be justified)
- PubMed Database subscription \$0 (time)
- IRB application \$0 (time)
- Field expert consultation \$250/ hour x 1-2 hours = \$250- \$500
- E-poster at convention \$0 (time)
- Udemy marketing and interest building short course / infomercial (\$0)
- Wisconsin Occupational Therapy Association annual convention – travel & lodging \$400
- Total = \$1325 - \$1575

*Dissemination Funding Needs – Personnel – First year Pilot Launch*

- This author's time for research, content development, materials preparation, related publications, travel, marketing, professional development, web design, and course instruction throughout educational series. Estimate 300 hours x \$30 / hour = \$9000
- Employment of Udemy for marketing and interest building short course / infomercial (\$0) <https://www.udemy.com/teaching/>
- Field Expert Consultant (if needed) \$250/ hour x 1-2 hours = \$250 - \$500
- Web design consultant \$100 / hour x 2-3 hours = \$200 - \$300
- Total = \$9450 - \$9800

*Dissemination Funding Needs – Personnel – Second year Commercialized Educational Series*

- This author's time for research, content and materials update, related publication, marketing, travel, professional development, web design, professional blog, and course instruction throughout educational series repeated throughout the year. Estimated 600 hours x \$30/ hour = \$18,000
- Employment of Udemy for marketing and interest building short course / infomercial (\$0) <https://www.udemy.com/teaching/>
- Field Expert Consultant (if needed) \$250/ hour x 1-2 hours = \$250 - \$500
- Lawyer for any patents relating to label, products, or content \$300 / hour
- Total = \$18,550 - \$18,800

*Dissemination Funding Needs – Annual Miscellaneous Expenses*

- Conference Registration (included in AOTA annual membership) \$0
- AOTA Conference lodging and meals \$1000
- Handout and Poster printing \$40
- State regional educational conferences 4 x \$35 each = \$140 / year
- Travel and lodging at state regional educational conferences = \$800 / year
- Attend WFOT once every four years – registration \$850.00 (prorated = \$212/year)
- Travel and lodging for attending WFOT 1x/4 years \$4000 (prorated = \$1000/year)
- Total \$3192

*Dissemination Funding Needs – Total Expenses*

Year One \$20,282  
Year Two \$29,282

**Evaluation**

Evidence of a successful initial launch of the educational program will be evaluated through stakeholder research questions (Appendix G) and logic model outcome measures (Appendix C). Affective domains will provide further evidence through increased OT confidence and perceived value with recognizing vestibular performance, applying vestibular interventions, and identifying a variety of performance outcomes associated with vestibular processes. The impact of the educational series is dependent upon the perceived value of learned concepts by participating occupational therapists. Quantitative data reflecting this value will be shared with stakeholders as well as future educational program participants as a testament to the quality of the knowledge and potential impact concepts may have on professional practice.

The program evaluation report shared with school stakeholders will mirror the logic model in Appendix C, addressing outcomes of the educational series including knowledge, methods of evaluation and intervention, perceived confidence, and increased student achievement. Visual presentation of the summary will be organized with graphic elements, integrating the logic model with reflective and summative information, while creating style and sophistication with a professional appearance. Concluding textual information will be housed within a framed text box used to capture the attention and guide the reader with supporting documents linked to the vestibulotherapy website (once established).

Effectiveness of the educational series and resources will be measured through the following logic model objectives:

Short Term Objectives	<ul style="list-style-type: none"> <li>• Expand OT clinical reasoning skills to reflect neuroscience research on vestibular applications</li> <li>• Participating OTs will identify 3 academic performance challenges associated with delayed vestibular maturation</li> <li>• Participating OTs will demonstrate 2 evaluation methods for identifying delayed vestibular maturation</li> <li>• OTs will name 2-3 key clinical interventions of vestibulotherapy</li> </ul>
Intermediate Outcomes	<ul style="list-style-type: none"> <li>• 3-months following educational series, participating OTs will have identified 3-5 children with vestibular dysfunction, established baseline measurements, and initiated interventions and identified intended / related outcomes.</li> <li>• Participating OTs will have observed improved vestibular functioning in response to vestibulotherapy interventions</li> </ul>
Long-Term Objectives	<ul style="list-style-type: none"> <li>• Teachers and OTs will recognize a direct correlation between vestibular processing and academic outcomes</li> <li>• Child recipients of the vestibulotherapy interventions will demonstrate improved confidence and academic performance in reading, math, and communication</li> <li>• OTs will routinely incorporate vestibular constructs into daily practice for evaluation, intervention, and UDL classroom programming to support students’ learning and communication outcomes.</li> </ul>

Supporting evidence beyond the logic model will speak to stakeholders’ specific interests including summative or formative information, fact sheet (Appendix I), or executive summary (Appendix J) depending upon the needs of the audience. Information presented will range from a verbal exchange which passes “the mom test” to a “killer paragraph” (Grob, 2015) for school administrators and teachers. Follow up conversations will include recommendations for the next phase of implementation within the school community employing tiered classroom interventions to support learning universally as

well as research initiation. Stakeholders will continue to receive outcome data over time, reflecting the effectiveness of the educational series and the applied interventions.

After a successful launch of the pilot program, future audiences would be reached through professional conferences, social media, commercialized continuing education, udemy.com, or professional connections. This author would promote interest through publication of related articles prior to extending the learning series beyond the local community. To meet the needs of all learners, consideration has also been given to creating an interactive vestibulotherapy blog, offering a question / answer format for clarification of concepts supported through contemporary neuroscience research, OT, and Ayres Sensory Integration as well as disseminating knowledge, applications, and the promotion of research around this topic.

As the principles of vestibulotherapy become integrated into professional practice, research will be necessary to validate its contemporary neuroscience evidence within the framework of occupational therapy. Within the research, it will be imperative to correlate progress in vestibular maturation with children's occupational performance within academic and social roles. The inclusion of confirmatory factor analysis will provide credibility to this emerging paradigm.

### **Conclusion**

Vestibulotherapy is an emerging frame of reference aiming to help neurotypical children with under-performing vestibular systems develop neuropathways supporting communication and learning while gaining confidence across all roles of occupational performance. Occupational therapists with specialized knowledge of vestibulotherapy

will recognize it's mechanism of change to be a combination of myelination and neuroplasticity leading to greater connectivity and efficiency for learning, sequencing, establishing ordinance, and building memory capacity (Besnard, et al., 2016; de Wall, 2019; Hitier et al., 2014; Kashfi et al., 2019; Lopez et al., 2020; Mast et al., 2014; Melo et al., 2019; Moossavi & Jafari, 2019; Schoen, et al., 2019; Watling & Hauer, 2015; Andelin, 2019; Lotfi et al., 2017; Matuszkiewicz & Gałkowski, 2021; Mulligan, 2011). Methods of intervention supporting this change may occur through clinical applications, classroom interventions, and home programming.

For the learning series and related resources to be effective, the needs and readiness of the learner must be met to fully engage their acquisition and application of knowledge. Maintaining themes of collaborative and problem-based learning to build a professional network will build value into applying vestibulotherapy concepts. Affective domains will be elicited through research initiation with positive outcomes and professional relationships to impact changes in professional practices. When the participating OTs find value or confidence associated with new knowledge, this will transform their practice, where knowledge alone will not necessarily lead to change (Burman et al., 2021).

This author will provide testimony discerning delayed vestibular maturation from typical VR profiling and promote vestibulotherapy with interventions integrated into occupations of play and learning with the American Occupational Therapy Association (AOTA), the Vestibular Disorder Association (VeDA), and World Federation of Occupational Therapy (WFOT). Within the testimony, commission for a multidiscipline

advisory panel of experts will be proposed to collaborate on meeting the needs of the millions of children with vestibular dysfunction (Li et al, 2016). The Advisory Board may be connected to the VeDA and would oversee research, publish supporting articles, and author clinical practice guidelines differentiating vestibulotherapy from traditional vestibular rehabilitation.

Professional practice guidelines would ensure fidelity for the identification and intervention of this young and under-identified population with delayed vestibular maturation, which negatively impacts their occupational performance. Extended to its full launch, vestibulotherapy may become transformative to national or global pediatric and school-based OT through increased competencies supporting vestibular evaluation, performance implications, and therapy interventions.

This multi-faceted educational opportunity will provide knowledge and applications that will be strongholds of pediatric OT. Should they choose to work in an area other than pediatric or school-based OT, the awareness and insight for the influence of vestibular processing on balance, memory, and cognitive performance may be beneficial to persons of any age with delayed vestibular maturation or declining memory (Agrawal et al., 2020). Further research is needed across all populations for the application of this contemporary neuroscience evidence and its applications in occupational therapy.

## Chapter Seven

### Funding Plan

#### **Budget proposal**

The implementation of the educational series requires resources of time, technology, access to contemporary research, and funding for personnel and related materials. The proposed budget in Table 7.1 includes projections for both the first and second years of implementation, including anticipated expenditures for scholarly dissemination and marketing activities that will be conducted by the primary author. Further projections anticipate that this course will become part of a greater web-based resource, offering educational resources, referenced materials, intervention manuals, and related products. Potential funding sources are outlined in Tables 7.2 and 7.3.

#### ***Electronic Media***

To run an educational series through a virtual platform, there are a vast number of things to consider relating to technology and dissemination of information. The educational series content will be organized on a web-based platform with content chosen for each module and presented in a flipped classroom format. Costs relevant to this method of instruction include time for the author to develop the content, research related materials, and orchestration of the lessons, as well as computer hardware and software, data storage, learning platforms, and domain space. A website will need to be developed on a public platform, such as square space, with the intended domain *vestibulotherapy.com*. Additionally, marketing and general educational principles of *vestibulotherapy* will be available online to promote concepts and interest in the



educational series and resources.

***Scholarly publication, research, and marketing***

The author and developer of this educational series will need to build credentials for professional interest of OTs to attend the webinar / web-based educational series. Initially, validation of content will be procured through publication and presentation at local and national OT, vestibular, and educational conferences as well as Udemy.com. Annual costs are not anticipated to change significantly from year one and two. An estimation of the costs associated with the production of the educational series including annual conference admission, travel and lodging, as well as professional time allotment for course development, publications, and marketing may be found in Table 7.1.

***Personnel***

Time will be compensated financially for the author's development and expertise relating to the course content and orchestration. As the program becomes more established and the rate of participants rises, additional compensation will be given for increased frequency of educational sessions, initiation of research phases, and related propaganda to expand the growing area of intervention. Professional consultation will be necessary for web design and field expert insight to support the learning of program participants. Anticipated costs are listed in Table 7.1.

**Table 7.1***Funding Needs*

<i>Funding Needs – Annual projected costs associated with Electronic Media</i>
<ul style="list-style-type: none"> <li>• Laptop with data storage (cloud) and web capabilities - internet <u>\$1200/year</u></li> <li>• Recording of educational sessions \$0</li> <li>• Communication – email, phone (\$50/month x12 months), mailings (\$200/year) = <u>\$800 / year</u></li> <li>• Video conferencing (WebEx, Google Meet, or Zoom) <u>\$0</u></li> <li>• PowerPoint presentation &amp; related software (Microsoft office) <u>\$0</u></li> <li>• Learning Platform such as Trainual \$199/ month for 20 people = <u>\$2400 / year</u></li> <li>• Marketing and resource domain - Square Space \$23/month = <u>\$ 276 / year</u></li> <li>• Web design or marketing consultant \$100/hour x 3 hours = <u>\$300 / year</u></li> <li>• Desk top camera for zoom demonstrations <u>\$40</u></li> <li>• Home office \$0</li> <li>• <u>Total = \$ 5115 / year</u></li> </ul>
<i>Funding Needs – Annual Scholarly Publication, Research, and Marketing</i>
<ul style="list-style-type: none"> <li>• AOTA professional membership (including attendance at national AOTA convention) <u>\$675/year</u>.</li> <li>• Article submission to academic journals for publication (building credibility and marketing) <u>\$0 (time)</u></li> <li>• CINHAL Database with full text subscription <u>\$163,375 (on hold until cost can be justified)</u></li> <li>• PubMed Database subscription <u>\$0 (time)</u></li> <li>• IRB application <u>\$0 (time)</u></li> <li>• Field expert consultation \$250/ hour x 1-2 hours = <u>\$250- \$500</u></li> <li>• E-poster at convention <u>\$0 (time)</u></li> <li>• Udemy marketing and interest building short course / infomercial (\$0)</li> <li>• Wisconsin Occupational Therapy Association annual convention – travel &amp; lodging <u>\$400</u></li> <li>• <u>Total = \$1325 - \$1575</u></li> </ul>

*Funding Needs – Personnel – First year Pilot Launch*

- This author's time for research, content development, materials preparation, related publications, travel, marketing, professional development, web design, and course instruction throughout educational series. Estimate 300 hours x \$30 / hour = \$9000
- Employment of Udemy for marketing and interest building short course / infomercial (\$0) <https://www.udemy.com/teaching/>
- Field Expert Consultant (if needed) \$250/ hour x 1-2 hours = \$250 - \$500
- Web design consultant \$100 / hour x 2-3 hours = \$200 - \$300
- Total = \$9450 - \$9800

*Funding Needs – Personnel – Second year Commercialized Educational Series*

- This author's time for research, content and materials update, related publication, marketing, travel, professional development, web design, professional blog, and course instruction throughout educational series repeated throughout the year. Estimated 600 hours x \$30/ hour = \$18,000
- Employment of Udemy for marketing and interest building short course / infomercial (\$0) <https://www.udemy.com/teaching/>
- Field Expert Consultant (if needed) \$250/ hour x 1-2 hours = \$250 - \$500
- Lawyer for any patents relating to label, products, or content \$300 / hour
- Total = \$18,550 - \$18,800

*Funding Needs – Annual Miscellaneous Expenses*

- Conference Registration (included in AOTA annual membership) \$0
- AOTA Conference lodging and meals \$1000
- Handout and Poster printing \$40
- State regional educational conferences 4 x \$35 each = \$140
- Travel and lodging at state regional educational conferences = \$800
- Total \$1980

*Funding Needs – Total Expenses*

Year One \$18,470  
Year Two \$27,470

**Potential funding sources**

Based upon expected growth of the program and anticipated expenses outlined in Table 7.1, funding for years 1 and 2 of the course implementations may come from a variety of sources and very greatly from the pilot phase to the full launch. Funding sources for the pilot phase outlined in Table 7.2 may include grants from federal, state, foundational, and local sources which will launch the educational series into existence. As outlined in Table 7.3, Year Two’s educational programming and research efforts will be supported through continued federal, national, foundational, and local funding, as well as participant’s paid course tuition and related revenue. Grants.gov provides extensive guidance and will be used to facilitate the grant writing process.

**Table 7.2**

*Funding source and description Year One Pilot Program*

<b><i>Pilot Launch Educational Series – Year One</i></b>
<b><i>Federal grants</i></b>
<p>Institute of Education Sciences <a href="http://ies.ed.gov">ies.ed.gov</a>                  The Institute of Education Sciences supports research that addresses important issues in education and develops solutions that improve school readiness and academic achievement for all students</p>
<b><i>Federal grants</i></b>
<p><b><i>National Institute of Health (NIH) Small Grant Program (R03)</i></b>                  Provides limited funding for a short period of time to support a variety of types of projects, including: pilot or feasibility studies, collection of preliminary data, secondary analysis of existing data, small, self-contained research projects, development of new research technology, etc.</p> <p>Example of NIH Small Grant Funding Application: Research designed to elucidate the etiology, epidemiology, diagnosis, and optimal means of service delivery in</p>

relation to Autism Spectrum Disorders (ASD)

<https://grants.nih.gov/grants/guide/pa-files/PA-21-199.html>.

An R03 grant supports small, discrete, well-defined projects that can be completed in two years and that require limited resources. R03 applications may include development of new research methodologies or technology, secondary analysis of existing data, and pilot or feasibility studies. Preliminary data are not required, particularly in applications proposing pilot or feasibility studies. Applicants pursuing exploratory/developmental research to support early and conceptual stages of project development should consider the companion R21 FOA, [PA-21-200](#). Applicants pursuing larger studies in established scientific areas where preliminary data are expected should consider the companion R01 FOA, [PA-21-201](#).

#### ***State grants***

Wisconsin Department of Health Services

DHS is committed to protecting and promoting the health and safety of the people of Wisconsin, making sure everyone can live their best life.

DHS ensures that the care provided to Wisconsin residents is high quality and provided in accordance with state and federal law. DHS works with local counties, health care providers, community partners, and others to continue Wisconsin's long tradition of strong health outcomes and innovation.

#### ***National Foundation***

The American Occupational Therapy Foundation (AOTF) awards Intervention Research Grants as part of its mission to “advance the science of occupational therapy to support people's full participation in meaningful life activities”. Through vestibulotherapy, children experience a client-centered and occupation based (play) intervention to increase occupational performances aligned with the core values and guiding principles of occupational therapy. AOTF IRG provides seed funding for the development of new and/or novel ideas to generate preliminary data as proof of concept. Through knowledge gained and applied within the educational series, OT participants will contribute to establishing groundwork for larger intervention and implementation studies while supporting the profession’s Vision 2025 of occupational therapy as an evidence-based profession. Further development and expanded research through application of neuroscience evidence into OT practice will promote our role as leaders in supporting children’s occupational performance.

<https://www.aotf.org/Grants/Intervention-Research-Grant>

***Local Foundations***

La Crosse Public Education Foundation – provides funding for innovative projects that support student success within the La Crosse School District.

***Local community grants*** - Gundersen Foundation, La Crosse WI

The Gundersen Foundation resources local funds to improve the lives of patients and our larger community through medical education, research, outreach and philanthropic support of Gundersen Health System.

Gundersen has received more than \$5 million annually from private foundations and government agencies to fund critical research, boost medical education and improve patient care. This money has been applied to research programs, development of Telemedicine, innovative programming for patients, and medical education for staff and clients.

Currently, this author has been invited to collaborate with Gundersen research faculty to discuss potential research utilizing principles aligning with vestibulotherapy for outcomes relating to learning and communication (Contact person: Pam Johnson-Stuhr, DPT on May 27, 2022).

<https://www.gundersenhealth.org/foundation/news/2019/gundersen-medical-foundation-2018-year-in-review/>

Some examples of how local funds were applied include:

- \$1.6 million awarded to Gundersen Health System departments for equipment, education, programs, and services
- \$1,165,500 million from donor-restricted funds used for medical education, research, Global Partners and Resolve Through Sharing programs
- \$45,000 helped equip Gundersen Tri-State Ambulance with three state-of-the-art CPR devices
- \$3,000 funded Dig DEEP (Diet and Exercise to Ease Pain) pilot program that focuses on lifestyle changes to help people manage pain

**Table 7.3***Year Two: Educational Series and Initiation of research*

<b>Commercialized Educational Series with Initial Research Stages – Year Two</b>
<b><i>Federal grants</i></b>
<p>Institute of Education Sciences <a href="http://ies.ed.gov">ies.ed.gov</a></p> <p>The Institute of Education Sciences supports research that addresses important issues in education and develops solutions that improve school readiness and academic achievement for all students</p>
<b><i>Federal grants</i></b>
<p><b><i>National Institute of Health (NIH) Small Grant Program (R03)</i></b></p> <p>Provides limited funding for a short period of time to support a variety of types of projects, including: pilot or feasibility studies, collection of preliminary data, secondary analysis of existing data, small, self-contained research projects, development of new research technology, etc.</p> <p>Example of NIH Small Grant Funding Application: Research designed to elucidate the etiology, epidemiology, diagnosis, and optimal means of service delivery in relation to Autism Spectrum Disorders (ASD)</p> <p><a href="https://grants.nih.gov/grants/guide/pa-files/PA-21-199.html">https://grants.nih.gov/grants/guide/pa-files/PA-21-199.html</a>.</p> <p>An R03 grant supports small, discrete, well-defined projects that can be completed in two years and that require limited resources. R03 applications may include development of new research methodologies or technology, secondary analysis of existing data, and pilot or feasibility studies. Preliminary data are not required, particularly in applications proposing pilot or feasibility studies. Applicants pursuing exploratory/developmental research to support early and conceptual stages of project development should consider the companion R21 FOA, <a href="#">PA-21-200</a>.</p>
<b><i>National Foundation</i></b>
<p>The American Occupational Therapy Foundation (AOTF) awards Intervention Research Grants as part of its mission to “advance the science of occupational therapy to support people's full participation in meaningful life activities”. Through vestibulotherapy, children experience a client-centered and occupation based (play) intervention to increase occupational performances aligned with the core values and guiding principles of occupational therapy. AOTF IRG provides seed funding for the development of new and/or novel ideas to generate preliminary data as proof of</p>

<p>concept. Through knowledge gained and applied within the educational series, OT participants will contribute to establishing groundwork for larger intervention and implementation studies while supporting the profession’s Vision 2025 of occupational therapy as an evidence-based profession. Further development and expanded research through application of neuroscience evidence into OT practice will promote our role as leaders in supporting children’s occupational performance.  <a href="https://www.aotf.org/Grants/Intervention-Research-Grant">https://www.aotf.org/Grants/Intervention-Research-Grant</a></p>
<p><b><i>Local Foundations</i></b></p>
<p>La Crosse Public Education Foundation – provides funding for innovative projects that support student success within the La Crosse School District.</p>
<p><b><i>Local community grants</i></b> - Gundersen Foundation, La Crosse WI</p>
<p>The Gundersen Foundation resources local funds to improve the lives of patients and our larger community through medical education, research, outreach and philanthropic support of Gundersen Health System.          Gundersen has received more than \$5 million annually from private foundations and government agencies to fund critical research, boost medical education and improve patient care. This money has been applied to research programs, development of Telemedicine, innovative programming for patients, and medical education for staff and clients.          Currently, this author has been invited to collaborate with Gundersen research faculty to discuss potential research utilizing principles aligning with vestibulotherapy for outcomes relating to learning and communication (May 27, 2022).  <a href="https://www.gundersenhealth.org/foundation/news/2019/gundersen-medical-foundation-2018-year-in-review/">https://www.gundersenhealth.org/foundation/news/2019/gundersen-medical-foundation-2018-year-in-review/</a></p>
<p><b><i>OT program participant tuition</i></b></p>
<p>OTs may utilize individual or departmental funding from their employer for continuing education to participate in the educational series and earn CEUs toward licensure or area of specialization.</p>



## Chapter Eight

### Conclusion

#### Summary

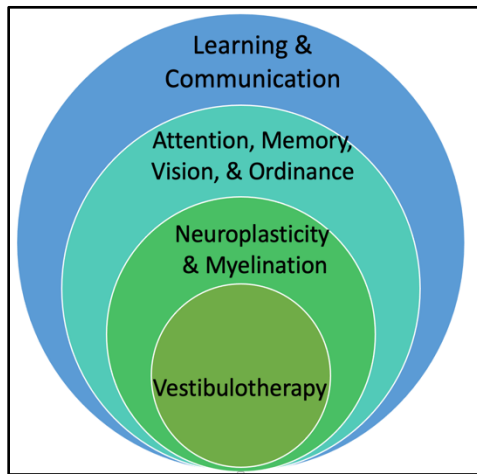
Traditional Vestibular Rehabilitation (VR) offers a conceptualized approach to addressing the needs of people with a mature vestibular system which encounters dysfunction from insult or injury. Adult and pediatric VR outcomes aim to recover posture and gait while normalizing sensations of vertigo and disrupted balance (Rine, 2018; vestibular.org). However, with a high frequency of vestibular dysfunction remaining undetected in children (Li et al., 2016), the need for heightened awareness, detection, and intervention have become increasingly clear. To address this problem, *vestibulotherapy*, which is founded on evidence from contemporary neuroscience and viewed through the OT lens of ASI and pediatric vestibular rehabilitation (Christy, 2019), prescribes methods for identifying and providing vestibular interventions to build neural pathways for learning and related outcomes. The vestibulotherapy model addresses the needs of neurotypical children who have an under-registration and immature vestibular processing system, experiencing delays with learning, motor skills, communication, and related areas of occupational performance.

As illustrated in Figure 8.1, the mechanism of change through vestibulotherapy is a combination of myelination and neuroplasticity leading to greater connectivity and efficiency for learning through improved sequencing, memory capacity, spatial cognition, attention, and ordinance (Besnard, et al., 2016; de Wall, 2019; Hitier et al., 2014; Kashfi

et al., 2019; Lopez et al., 2020; Mast et al., 2014; Melo et al., 2019; Moossavi & Jafari, 2019; Schoen, et al., 2019; Watling & Hauer, 2015; Andelin, 2019; Lotfi et al., 2017;

### Figure 8.1

#### *Mechanism of Change*



Matuszkiewicz & Gałkowski, 2021;

Mulligan, 2011). Presently, while local pediatric

OTs desire to address the learning needs of

children, barriers founded in limited OT

knowledge and negative bias toward sensory

integration impede their success (Wall, 2021).

They lack the skills for recognizing vestibular

dysfunction, employing appropriate interventions, and misunderstanding related concepts and potential applications of vestibular interventions.

### Program significance

As pediatric occupational therapists, we are called to become experts in developing sensory and sensorimotor systems to improve motor and related occupational and academic performance outcomes (AOTA, 2016). Through merging concepts from contemporary neuroscience and traditional occupational therapy, our sensorimotor expertise further transcends our impact on students' learning potential by improving capacities for memory, attention, numeracy, sequencing, spatial cognition, and processing through improved vestibular functioning (Moossavi & Jafari 2019; Kashfi et al., 2019; Lotfi et al., 2017; Besnard et al., 2016).

While millions of children's vestibular dysfunction remains undetected and untreated (Li et al., 2016), untapped potential persists for positively impacting their academic performance through vestibular interventions. This educational series will begin to address this problem by creating awareness and a professional skill set to identify and impact children's vestibular maturation while building efficient foundations for learning.

Throughout the literature and my community, a confusion of terms around sensory integration and sensory applications has limited a comprehensive understanding of vestibular applications. The educational series will provide clarity and insight to the potential of vestibular applications and differentiate vestibulotherapy from traditional vestibular rehabilitation.

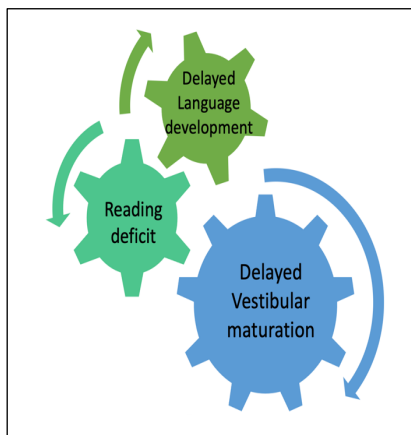
### **Program innovation**

This educational series considers contemporary science and reflects it with OT theory and established vestibular rehabilitation processes, resulting in a program tailored to specifically address the needs of children with delayed vestibular maturation. Considering the scientific findings, we can directly attribute vestibular functioning to the development of learning foundations supported by memory, sequencing, spatial cognition, attention, and attributes of executive functioning. With millions of US children currently experiencing vestibular dysfunction that remains undetected and untreated (Li et al., 2016), OT and teacher awareness is needed for recognizing vestibular dysfunction that limits children's success with academic achievement and implementing clinical and classroom interventions to support development of this vital system. Salient

features of vestibular interventions improve foundations essential for successful learning and communication including ordinance, sequencing, spatial cognition, memory, and attention. Vestibulotherapy provides increased awareness to the under-recognized problem of vestibular dysfunction, guided interventions, and, when implemented, improved occupational performance of children in their social and academic roles.

**Figure 8.2**

*Codependent variables*



While evidence did not frequently attempt to correlate language or academic outcomes, one can surmise the correlation between delayed vestibular maturation with delays in reading and language. As illustrated in Figure 8.2, codependent variables often coexist between delayed vestibular maturation and

delays in communication and reading. It is recommended that practitioners who implement this intervention gather information regularly from the teacher and family regarding progress in this area. The inclusion of confirmatory factor analysis will provide credibility to this emerging paradigm.

While there has been recent consideration of delayed vestibular maturation within vestibular rehabilitation (Chisty, 2019), VR programs predominantly considered a vestibular system that was fully developed but had acquired insult and impairment, with interventions attempting to restore function through adaptation, substitution, and habituation (Hall et al, 2016). Vestibulotherapy employs VR and ASI theories to

implement child-friendly and play-based interventions tailored to the interests and needs of the child, to promote neuroplasticity and myelination from the vestibular apparatus throughout learning and memory centers to the frontal cortex. By increasing awareness and available interventions for vestibular dysfunction, students will experience greater success in social and academic performance areas. Success in these areas will likely lead to greater confidence and social emotional competencies supporting lifelong occupational roles.

### **Professional impact**

Extended to its full launch, this educational program may become transformative to national or global pediatric OT practice, increasing OT knowledge for vestibular evaluation and treatment as well as establishment of accepted clinical practice guidelines for developmental vestibular therapies in pediatric populations for intended outcomes. Through a variety of educational platforms, this knowledge will increase parent, teacher, and medical providers' awareness of vestibular dysfunction and its impact on children's occupational performance and learning. Through increased awareness and knowledge, more children will receive vestibular interventions to help them succeed in roles that demand vestibular efficiencies.

Consideration of this knowledge will generate research to determine the impact of specific vestibular interventions on varying attributes related to learning and occupational performance. For example, the complex anatomy of the vestibular system leads one to question the exact function of each component. Beyond knowing the semicircular canals respond to movement and directionality while the otolithic organs respond to gravity,

there may be specific roles that each structure contributes toward building connections for learning and memory processes. It has been suggested that linear movement supports language and communication, rotary contributes to balance and vision, and vertical impacts postural control (O’Koye, 2006).

It would be warranted to establish a multi-discipline (audiology, neurology, otolaryngology, patient representative, occupational therapy, and physical therapy) vestibular advisory board, potentially in association with the VeDA, to oversee research, consolidate findings, and establish clinical practice guidelines for children with developmental vestibular dysfunction. Evidence based practice and supporting literature is needed to inform and guide OT practitioners in the identification and application of vestibulotherapies for children struggling with communication and academic performance. Successful programming will be evident when therapists routinely identify developmental vestibular dysfunction and procure a culture where vestibular therapies, embedded within the occupation of play, help children succeed in areas of occupational performance.

**Appendix A**

*Learner Profile*

<p>PROFILE</p>	<p>Please complete the following profile so this educational series may consider and address your learning and outcome preferences. Please mark as many responses as apply for each question.</p>
<p>Characteristics</p>	<p>How did you become interested in learning more about vestibular interventions?</p> <hr/> <p>Settings that I have prior experience with vestibular dysfunction include:</p> <ul style="list-style-type: none"> <li><input type="radio"/> Family</li> <li><input type="radio"/> Work</li> <li><input type="radio"/> Volunteer</li> <li><input type="radio"/> Other _____</li> </ul> <p>When working with a child with a learning disability or dyspraxia, I am most likely to use applications from this therapy model:</p> <ul style="list-style-type: none"> <li><input type="radio"/> Developmental</li> <li><input type="radio"/> Ayres Sensory Integration</li> <li><input type="radio"/> Vestibular</li> <li><input type="radio"/> Vision</li> <li><input type="radio"/> Assistive Technology</li> <li><input type="radio"/> Other _____</li> </ul> <p>Please describe your use of vestibular interventions in your current practice _____</p> <p>Please describe the areas of occupational performance you might address through vestibular interventions</p> <hr/> <p>Please describe the factors that contribute to or impede your likelihood to integrate vestibular applications into your professional practice</p> <hr/> <p>To what extent would you attribute developmental challenges in communication, academics, and motor skills to under-developed or under-responsive vestibular functioning</p> <ul style="list-style-type: none"> <li><input type="radio"/> High</li> <li><input type="radio"/> Moderate</li> <li><input type="radio"/> Low</li> <li><input type="radio"/> Unsure</li> </ul>

	<p>My current job description most predominantly includes:</p> <ul style="list-style-type: none"> <li>○ School OT</li> <li>○ Clinic Based pediatric OT</li> <li>○ University Professor in OT</li> <li>○ Other _____</li> </ul>
Needs	<p>What knowledge or methods relating to vestibular processing will assist you in meeting the needs of the children you serve?</p> <ul style="list-style-type: none"> <li>○ Evaluation methods</li> <li>○ Intervention methods</li> <li>○ The theory, concepts, and understanding of why it works</li> <li>○ Other _____</li> </ul> <p>If you currently employ methods of vestibular rehabilitation, which of the following best describes the interventions you most often use</p> <ul style="list-style-type: none"> <li>○ Rotations</li> <li>○ Astronaut Program</li> <li>○ Gaze stabilization / visual therapy methods</li> <li>○ Large motor vestibular exercises</li> <li>○ Other _____</li> </ul> <p>Please list general or specific objectives or outcomes you would like this educational series to address regarding vestibular functioning, evaluation, and treatment</p> <p>_____</p> <p>_____</p>
Preferences	<p>When engaging in a learning series, I prefer to meet</p> <ul style="list-style-type: none"> <li>○ Face to face</li> <li>○ Virtual</li> <li>○ In a group</li> </ul> <p>When applying learning concepts outside of the classroom, I prefer to</p> <ul style="list-style-type: none"> <li>○ Work independently and discuss with a group later</li> <li>○ Work virtually in a group</li> <li>○ Work face to face in a group</li> <li>○ Other _____</li> </ul> <p>Methods of instruction that I most prefer include:</p> <ul style="list-style-type: none"> <li>○ Direct instruction</li> <li>○ Self-guided learning</li> <li>○ Hands on / Kinesthetic learning</li> <li>○ Podcast or video learning</li> <li>○ Written information or research articles</li> </ul>



	<ul style="list-style-type: none"> <li>○ Other _____</li> </ul> <p>When learning a new clinical skill, I prefer</p> <ul style="list-style-type: none"> <li>○ Having it demonstrated and then practice it within the learning session</li> <li>○ Reading about it</li> <li>○ Watching a video demonstration</li> <li>○ Practicing it on my own</li> </ul> <p>If a collaborative learning method, such as Problem Based Learning (PBL) is applied to this series in part, would you feel value in collaborative learning where everyone teaches and everyone learns?</p> <ul style="list-style-type: none"> <li>○ Yes</li> <li>○ No</li> </ul>
<p>Readiness</p>	<p>How often do you participate in professional development?</p> <ul style="list-style-type: none"> <li>○ Often, any chance I get</li> <li>○ 1-2 per year</li> <li>○ Rarely, but I engage in self-study</li> <li>○ Other _____</li> </ul> <p>What is your preferred length of time for professional development?</p> <ul style="list-style-type: none"> <li>○ 1-2 hours (once)</li> <li>○ 1-2 hours and meet several times</li> <li>○ 1-2 days (once)</li> <li>○ Other _____</li> </ul> <p>Estimate your knowledge level regarding vestibular therapies in pediatric OT:</p> <ul style="list-style-type: none"> <li>○ Entry level knowledge</li> <li>○ Moderate experience / knowledge</li> <li>○ Advanced knowledge, just looking for new ideas</li> </ul> <p>Rate your confidence for applying vestibular therapies with children to impact communication or academic goals:</p> <ul style="list-style-type: none"> <li>○ High</li> <li>○ Moderate</li> <li>○ Low</li> <li>○ None</li> </ul>
<p>Motivation</p>	<p>How would you like this educational series to change your professional practice? _____</p> <p>_____</p> <p>How did you hear about this educational opportunity?</p> <ul style="list-style-type: none"> <li>○ Co-worker</li> <li>○ Website</li> <li>○ Internet</li> </ul> <p>Was this educational opportunity initiated by</p>

	<ul style="list-style-type: none"> <li><input type="radio"/> Yourself</li> <li><input type="radio"/> Supervisor</li> <li><input type="radio"/> Co-Worker</li> <li><input type="radio"/> Other _____</li> </ul> <p>Do you have a specific child in mind for participating in this educational series?</p> <ul style="list-style-type: none"> <li><input type="radio"/> Yes</li> <li><input type="radio"/> No</li> </ul> <p>What do you value most in your profession?</p> <p>_____</p>
Goals	<p>What do you hope to take away from the educational series?</p> <p>_____</p> <p>_____</p> <p>What are your goals for using this information?</p> <ul style="list-style-type: none"> <li><input type="radio"/> Teach others</li> <li><input type="radio"/> New methods of intervention</li> <li><input type="radio"/> New methods of evaluation</li> <li><input type="radio"/> Understanding relative outcomes to expect from vestibular therapies</li> <li><input type="radio"/> Other _____</li> </ul>

## **Appendix B**

### **Guiding Questions of the Educational Series**

*Question 1:* What will be the most effective way to educate fellow OTs on vestibular applications?

*Question 2:* What methods should be used for collecting feedback and measuring OTs' increased knowledge and application of vestibular interventions?

*Question 3:* What are the best methods for building confidence and actively implementing new methods of intervention in a therapy setting?

*Question 4:* What kinds of learning resource materials or teaching methods are most helpful for engaging in learning and promoting a change in practice?

*Question 5:* Educational course content: Given a child of average intellectual abilities who presents with delayed vestibular maturation, will occupational therapy with vestibular centered interventions create the desired change in academic engagement and achievement?

### **Guiding Questions the Content of the Educational Series**

*Course Content Question 1.* Has scientific research documented evidence that vestibular rehabilitation has a direct correlation with gains associated with a.) cognition, b.) motor development, and / or c.) communication?

*Course Content Question 2.* Within pediatric OT, what evidence-based practice or evidence informed practice exists for applying vestibular rehabilitation to enhance occupational performance relating to a.) academic growth, b.) motor development, or c.) communication?

**Course Content Question 3.** Is there scientific evidence supporting the use of balance measures to reflect vestibular functioning? If so, what are the recommendations / protocols for measurement? Does this data apply to children? What measures of vestibular function have normative data reflected in balance measures for children? For adults?

**Courses Content Question 4:** What other methods are used for measuring vestibular functioning? Are they reliable? Sensitive to change? What are the best methods of evaluating vestibular functioning within school based OT? (evaluation tool kit)

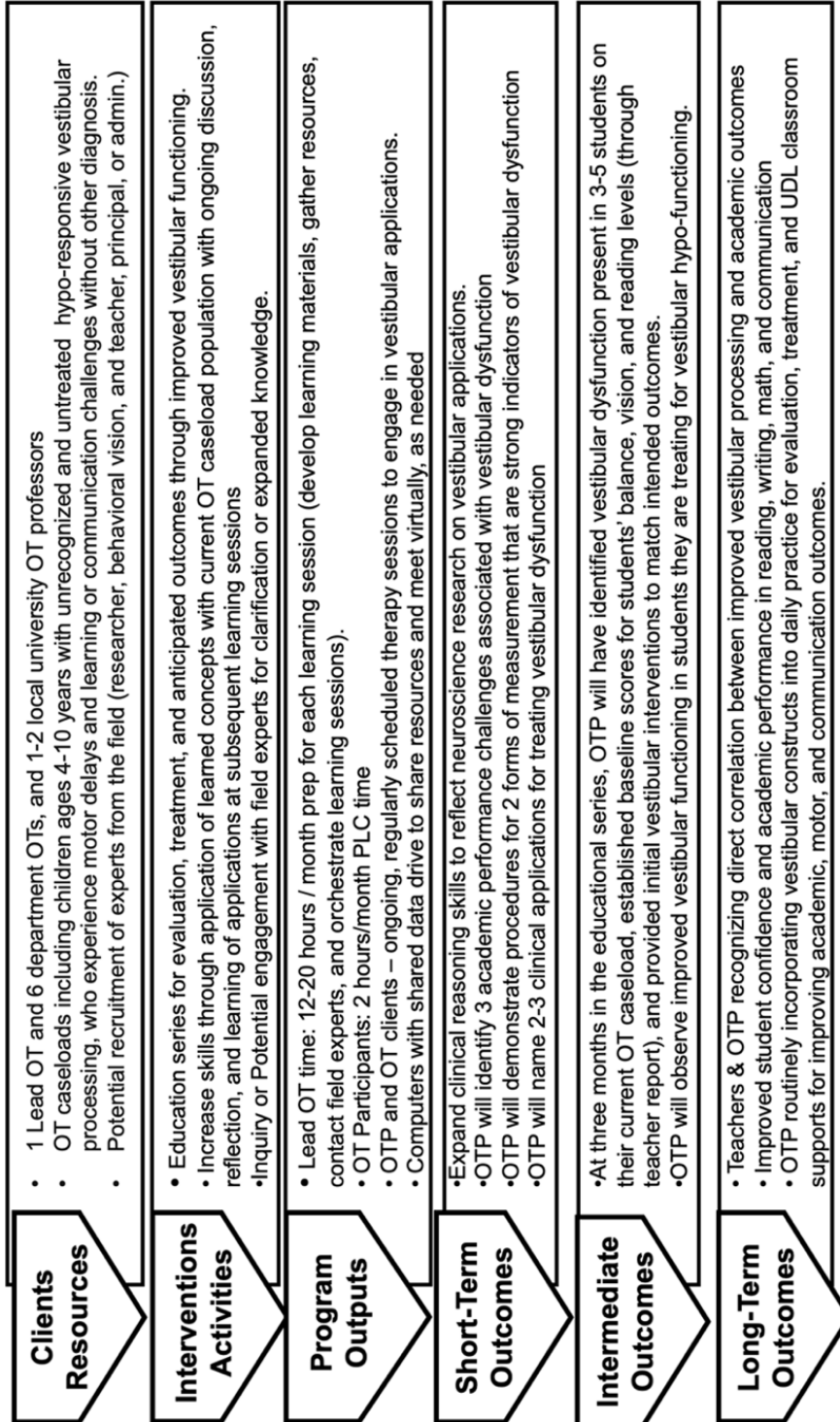
**Course Content Question 5:** What are the prescribed interventions from pediatric vestibular experts to support communication and / or academic achievement in children ages 4-10 years with hyporesponsive vestibular systems.

**Further Considerations: 1.)** Define intended population with theoretical clinical applications for each performance outcome to be addressed (ie motor skills, vision, communication, academic, etc).

**Further Considerations: 2.)** If developmental vestibular dysfunction varies from that cited in the literature relating to VR, is there or should there be separate terminology for identification and treatment? Is there literature that discerns delayed maturation of vestibular performance as compared to an impaired vestibular organ?

**Appendix C**

*Simplified Logic Model*



## Appendix D

*Vestibular screening tool for teachers*

### Vestibular System Screener

<b>Child's Name:</b>	<b>Child's Age:</b>
<b>Questionnaire Completed By:</b>	<b>Date:</b>

Please rate each item by circling the number that best fits the behavior of the child you are rating. The numbers correspond to the frequency with which the behavior is observed. Please consider these items carefully when rating each possible behavior. A child may or may not display one or more of these behaviors. A high rating in one or more of the areas does not indicate any particular pattern. If you are undecided about a particular item, use your best judgment. If you have not had an opportunity to observe the behavior, enter N/A.

#### SCALE

<b>4 = Frequently</b> <i>(75% of the time)</i>	<b>3 = Often</b> <i>(50% of the time)</i>	<b>2 = Sometimes</b> <i>(25% of the time)</i>	<b>1 = Never</b>	<b>N/A = No Opportunity to Observe</b>
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#### At school or in the classroom how frequently does the student:

Touch furniture or walls when walking	4	3	2	1	N/A
Lose his/her place on the page when reading	4	3	2	1	N/A
Have difficulty reading out loud	4	3	2	1	N/A
Seem restless	4	3	2	1	N/A
Invert his/her head	4	3	2	1	N/A
Show excessive caution on the stairs	4	3	2	1	N/A
Crash or fall	4	3	2	1	N/A
Seek movement which interferes with daily routines	4	3	2	1	N/A
Rest his/her head in hand(s) or on desk	4	3	2	1	N/A
Have an emotional outburst	4	3	2	1	N/A

#### When sitting on the floor how frequently does the student:

Avoid sitting crossed legged by sitting on his/her knees or in a W position	4	3	2	1	N/A
Fall onto another student	4	3	2	1	N/A
Lay down	4	3	2	1	N/A

Rock back and forth or side to side	4	3	2	1	N/A
<b>While sitting in a chair how frequently does the student:</b>					
Rock back and forth or side to side	4	3	2	1	N/A
Wrap his/her legs around chair legs	4	3	2	1	N/A
Fall out of chair	4	3	2	1	N/A
Slump in chair	4	3	2	1	N/A
Sits on the edge of his/her chair	4	3	2	1	N/A
<b>When playing at recess, P.E., or during free time, how frequently does the student:</b>					
Avoid moving playground equipment	4	3	2	1	N/A
Have difficulty on playground equipment (slide, ladder, or climbing equipment)	4	3	2	1	N/A
Spin, rock back-and-forth, or jump	4	3	2	1	N/A
Avoid physical activities or team games	4	3	2	1	N/A
Bump into other students	4	3	2	1	N/A
Has a difficult time calming his/her body after high movement times	4	3	2	1	N/A

COPYRIGHT 2017

de Veer, K. (2017). Vestibular balancing act and screener. *The Educational Therapist*, 38(2),14-20.  
[https://static1.squarespace.com/static/5592f615e4b095762505dd60/t/5af1e9a6352f5317c23b0070/1525803431802/05\\_Balancing+Act%E2%80%94The+Vestibular+System+in+the+Classroom%E2%80%93Kay+de+Veer.pdf](https://static1.squarespace.com/static/5592f615e4b095762505dd60/t/5af1e9a6352f5317c23b0070/1525803431802/05_Balancing+Act%E2%80%94The+Vestibular+System+in+the+Classroom%E2%80%93Kay+de+Veer.pdf)

## Appendix E

### *Child friendly and easily accessible vestibular evaluation measures*

- A. *Bruininks- Oseretsky Test of Motor Proficiency 2 (BOT2) - Balance subtest*  
(as recommended by Oyewumi et al., 2016)

Bruininks, R. H., & Bruininks, B. D. (2005). *BOT2: Bruininks- Oseretsky Test of Motor Proficiency: Manual*. Minneapolis, MN: Pearson Assessments.

- B. *Mann's Tandem Stance Balance test* with normative information  
Heel-toe posture for 10 seconds eyes open, with eyes closed comparison  
(as recommended by Oyewumi et al., 2016)

- C. PRN description and normative info

- D. Supplemental data and score sheet

### *Functional vision screening*

- E. Wearable sensors programmed through cell phone applications are revolutionizing the assessment of standing balance.

Ghislieri, M., Gastaldi, L., Pastorelli, S., Tadano, S., & Agostini, V. (2019). Wearable Inertial Sensors to Assess Standing Balance: A Systematic Review. *Sensors (Basel, Switzerland)*, *19*(19), 4075.  
<https://doi.org/10.3390/s19194075>



## Appendix F

### *Modified Kawar Vestibular-Ocular protocol*

Clinical therapy applications promoting vestibular activation will be initiated through a modified Kawar vestibular protocol (2005), otherwise recognized as *side lying rotations* in the *Astronaut Program* (Kawar et al., 2005) paired with stability and mobility activities with visual targeting. The Kawar protocol includes visual saccades following each set of rotations. However, in practice, this visual element distracted from the child's occupation of play, which the rotations alone paired well and provided the desired vestibular intensity. Additional visual saccades are integrated into corresponding play schemes.



*Side lying rotations* may be completed by an occupational therapist who has been trained in this protocol with an understanding of vestibular precautions and related applications in the event of over stimulation. The child is positioned so that the head comfortably rests at a 45 degree angle to the floor, thus promoting movement of the fluid within each semicircular canal with rotations in left and right side lying, as well as sitting upright. Following clinical practice guidelines will ensure fidelity for this intervention. Once the child is correctly positioned in side-lying with their head at 45 degrees, ten rotations are made in a clockwise direction (CW), followed by ten rotations in the counterclockwise (CCW) direction, with each rotation at a rate of two seconds. Between sets of ten a recovery period of about ten seconds or longer is given for the vestibular system to return to resting. In accordance with research and best practice methods, the child's eyes are closed or vision is occluded during this protocol.

Observations of PRN are monitored after succession of rotations to determine when the vestibular system has returned to a resting state. Supportive proprioception may be

needed if the child experiences an excessive reaction to the vestibular activation. Ten revolutions in each position is the recommendation based upon the belief that ten rotations would adequately move the fluid through the semicircular canals (Kawar et al., 2005). In the event the child cannot tolerate a full ten rotations, it would be advised to reduce the number but attempt to activate each the left and right in both the CW and CCW directions. Based upon professional experience, rotations in upright provide the least impact, as the child receives most of their ongoing vestibular experiences in upright, where the lateral positions provide novelty and greater velocity impact.

Within the educational series, adherence to the intervention will be verified through periodic peer review either live or through video recording of treatment sessions to be critiqued by a trained therapist who can review for fidelity of procedures.

**Hypothesis of the rotation intervention impacting vestibular functioning:**

Through the intervention, vestibular-cortical connections will be increased to facilitate more active participation. Neuro networking originates in the vestibular apparatus and continues throughout the neural pathways (hippocampus, reticular formation, basal ganglia, insula, neocortex) to influence attention, vision, motor development, problem solving, sequencing, ordinance, and learning (Hitier, et al, 2014; Lopez, 2020). The capacity for sustained, self-directed engagement increases in conjunction with maturation of perceptual motor function with balance and postural control at the core, providing a foundation for attention, regulation, and motor skill development (Kashfi et al., 2019).

When a child lacks vestibular foundations, he or she must compensate visually to guide posture and movement, diminishing full attention to learning and the development of visual motor skills such as writing. Binocular vision skills used in reading, are typically delayed when vestibular foundations are also delayed, further limiting the child from academic success (Kashfi et al., 2019).

## Appendix G

### *Program evaluation research questions*

<b>Stakeholders</b>	<b>Program Evaluation Research Questions</b>
Author and researcher	<p><b><i>Formative:</i></b></p> <ul style="list-style-type: none"> <li>· Upon completion of the learning series, in what ways were program participants sufficiently prepared to apply the learning content in their clinical practice?</li> </ul> <p>Upon completion of the learning series, to what extent do OTP understand the variety of outcomes associated with improving vestibular functioning and the impact the vestibular applications will have beyond motor development on communication and academic skills?</p> <ul style="list-style-type: none"> <li>· Upon completion, to what extent do OTP participants express valuing the content, to the extent that suggests they will implement learned interventions beyond course completion?</li> <li>· Were OTs actively engaged in the learning process?</li> <li>· Within the course: To what extent are OTs comfortable sharing information, discussing challenges, and celebrating successes?</li> <li>· Within the course: To what extent did OTs engage a positive attitude, high level of interest and willingness to apply new interventions?</li> <li>· Within the course: To what extent do OTs demonstrate a new sense of confidence in measuring and applying vestibular interventions for children on their OT caseload?</li> <li>· Within the course and upon completion: What processes or methods should be changed to improve program content or delivery?</li> <li>· Within the course and upon completion In what ways were problems or issues reported with applications of methods learned?</li> <li>· Upon completion: What other key issues or problems faced by participants were not addressed in the program?</li> <li>· Within the course: Is the program on course to meet educational objectives?</li> </ul>

<p>OTP program participants</p>	<p><b>Summative:</b></p> <ul style="list-style-type: none"> <li>· Within the course and upon completion: Will the program participants report increased confidence in using the skills they have gained?</li> <li>· Upon program completion: Was content and delivery successful in preparing OTs to begin using the new skill sets for evaluation and treatment of vestibular hypo-functioning in school aged children with performance challenges not relating to other medical conditions?</li> </ul> <p><b>Formative:</b></p> <ul style="list-style-type: none"> <li>· Were the initial courses of instruction sufficient for the participants to begin applying knowledge with children on their caseload</li> <li>· Were initial courses of instruction sufficient for OTP to participate in group discussion in subsequent learning sessions regarding these vestibular applications?</li> <li>· Prior to engaging in the educational series, to what extent did OTP attribute occupational performance challenges in the areas of communication, academics, and motor skills to under-developed, under-responsive vestibular functioning?</li> <li>· Upon completion: To what extent do OTP value the gained knowledge and skills that will transform practices beyond course completion?</li> <li>· Upon completion: What resources or professional contacts can OTP continue engaging with to extend learning and application of learned concepts?</li> </ul> <p><b>Summative:</b></p> <ul style="list-style-type: none"> <li>· Upon completion: To what extent did participants acquire knowledge consistent with program goals?</li> <li>· Within the course and upon completion: To what extent did program participants have confidence that evaluation measures were reflective of vestibular functioning?</li> <li>· Upon completion of the educational series, to what extent are OT able to observe and identify vestibular dysfunction that was previously not apparent in children on their caseload?</li> <li>· Upon completion: To what extent will OT implement vestibular screening with future children on their caseload?</li> <li>· Prior to and Upon completion: To what extent do OT implement vestibular therapy applications into treatment plans for children currently on their caseload?</li> </ul>
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	<ul style="list-style-type: none"> <li>· Prior to and upon completion: To what extent do OTs feel the vestibular dysfunction may be linked to the child’s communication or learning challenges?</li> <li>· During and upon completion: To what extent did OTs begin to observe change in vestibular functioning as a result of interventions with the intended audience?</li> <li>· Upon completion: To what extent do OTs connect manifestations of vestibular interventions to observed academic and communication outcomes, consistent with program objectives?</li> <li>· Upon completion: To what extent do program participants feel vestibular interventions will impact school wide goals for increased reading outcomes?</li> </ul>
<p>School staff including principal, teachers, parents, students, special educators, related service providers, special education administrators, and school superintendent</p>	<p><b><i>Formative</i></b></p> <ul style="list-style-type: none"> <li>· In what ways does the program align and support school improvement goals?</li> <li>· In what ways does the course content align with existing curriculum of occupational therapy college and university programs?</li> <li>· In what ways has this intervention benefitted children’s occupational performance or learning outcomes?</li> <li>· To what extent did OT value the content and applied interventions?</li> <li>· To what extent did OT express intentions to implement learned concepts into professional practice?</li> <li>· In what ways did external factors impede execution of the educational process or research methodology?</li> </ul> <p><b><i>Summative:</i></b></p> <ul style="list-style-type: none"> <li>· Upon completion: To what extent will the research data show that the intervention led to desired change in dependent variables of interest?</li> <li>· To what extent can the research data be used to demonstrate achievement of professional learning outcomes as part of ongoing professional practices?</li> <li>· To what extent do school stakeholders observe improvements to students’ occupational performance or learning outcomes?</li> <li>· To what extent has the program positively impacted job-satisfaction, particularly for our newest OTs in the school district?</li> </ul>

	<ul style="list-style-type: none"> <li>· To what extent is delivery of the program a cost-effective means for building skill capacity for school district staff?</li> </ul>
<p>Advocacy and policy organizations, including AOTA, WFOT, Wisconsin OTA (WOTA), Vestibular Disorders Association, and future funding organizations</p>	<p><b>Summative:</b></p> <ul style="list-style-type: none"> <li>· In what ways do participants report increased understanding of the distinctive role of occupational therapy in provision of services relevant to the project?</li> <li>· In what ways are participants confident that they will be able to advocate for the role of occupational therapy as a change agent in areas relevant to the project?</li> <li>· In what ways are the long-term goals, beyond the initial launch of the project, realistic and achievable?</li> <li>· In what ways will the project increase awareness of the distinct value of OT in facilitating children’s academic success?</li> <li>· In what ways will the project increase awareness of the distinct value of OT in facilitating children’s communication skills?</li> <li>· To what extent will knowledge translation heighten OT awareness of vestibular dysfunction to impact this clinical void (as identified by Li et al., 2016)?</li> </ul>
<p>Children ages 4–10 years</p>	<p><b>Summative:</b></p> <ul style="list-style-type: none"> <li>· To what extent do children exhibit change in response to the interventions?</li> </ul>

## **Appendix H**

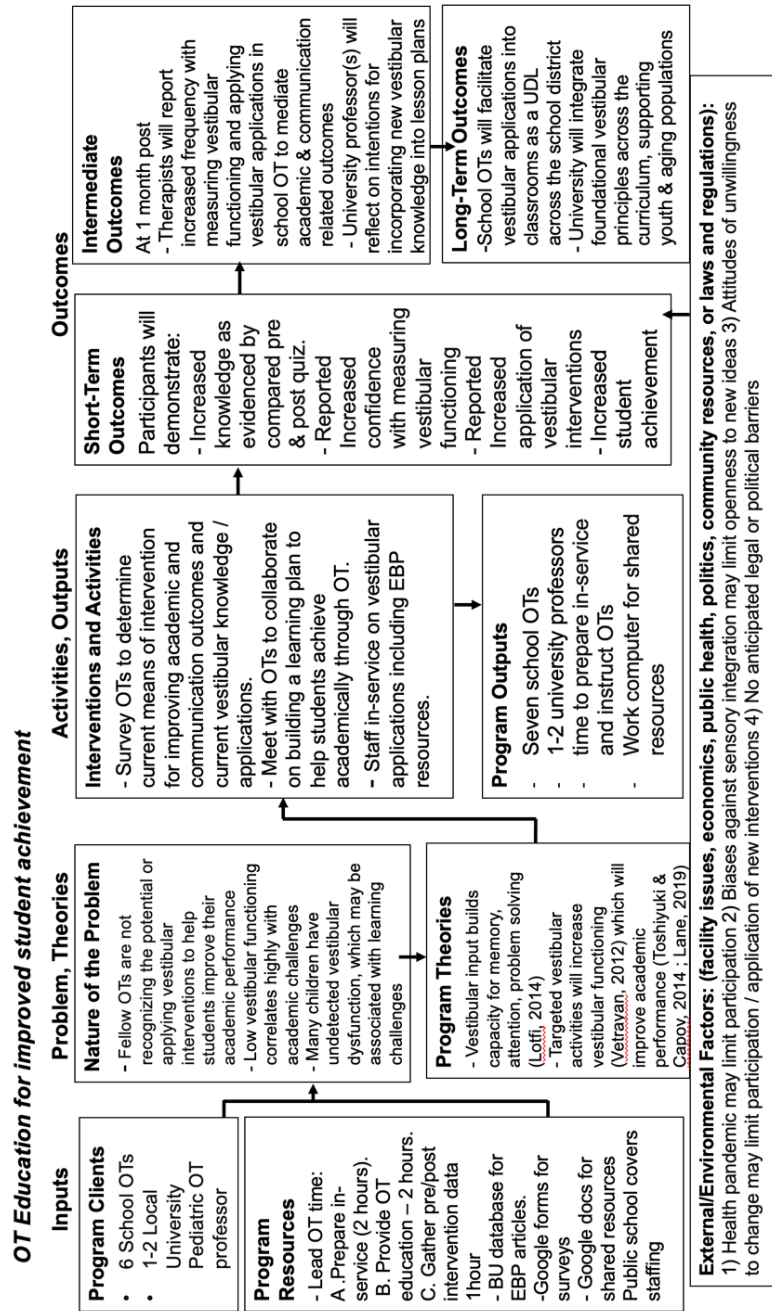
### *IRB Application*

#### **Research Program**

To meet program objectives, an educational series has been developed utilizing recent research and lived experiences to develop program content with opportunities for participants to apply learned applications with their clients over time. Participants in this educational series will include occupational therapists (OT) working in the school district and faculty teaching in our graduate OT program.

The emphasis of this intervention is to educate OTs on vestibular evaluation and intervention, which will be fully experienced through learned applications of measuring and observing vestibular attributes in the children on their OT caseloads. Initially, consideration will be given to all children on OT caseloads for participation and to determine inclusion eligibility. Children will be eligible for this cohort if they present with vestibular dysfunction that can be described as hypo-functioning with related performance challenges in communication or academic achievement without other diagnosis or conditions that can account for such challenges. Each OT will be able to make this determination based upon their current knowledge of the children on their caseloads. There will not be a control group for this initial launch focusing on educational outcomes.

The following model illustrates the logic application for the educational series:

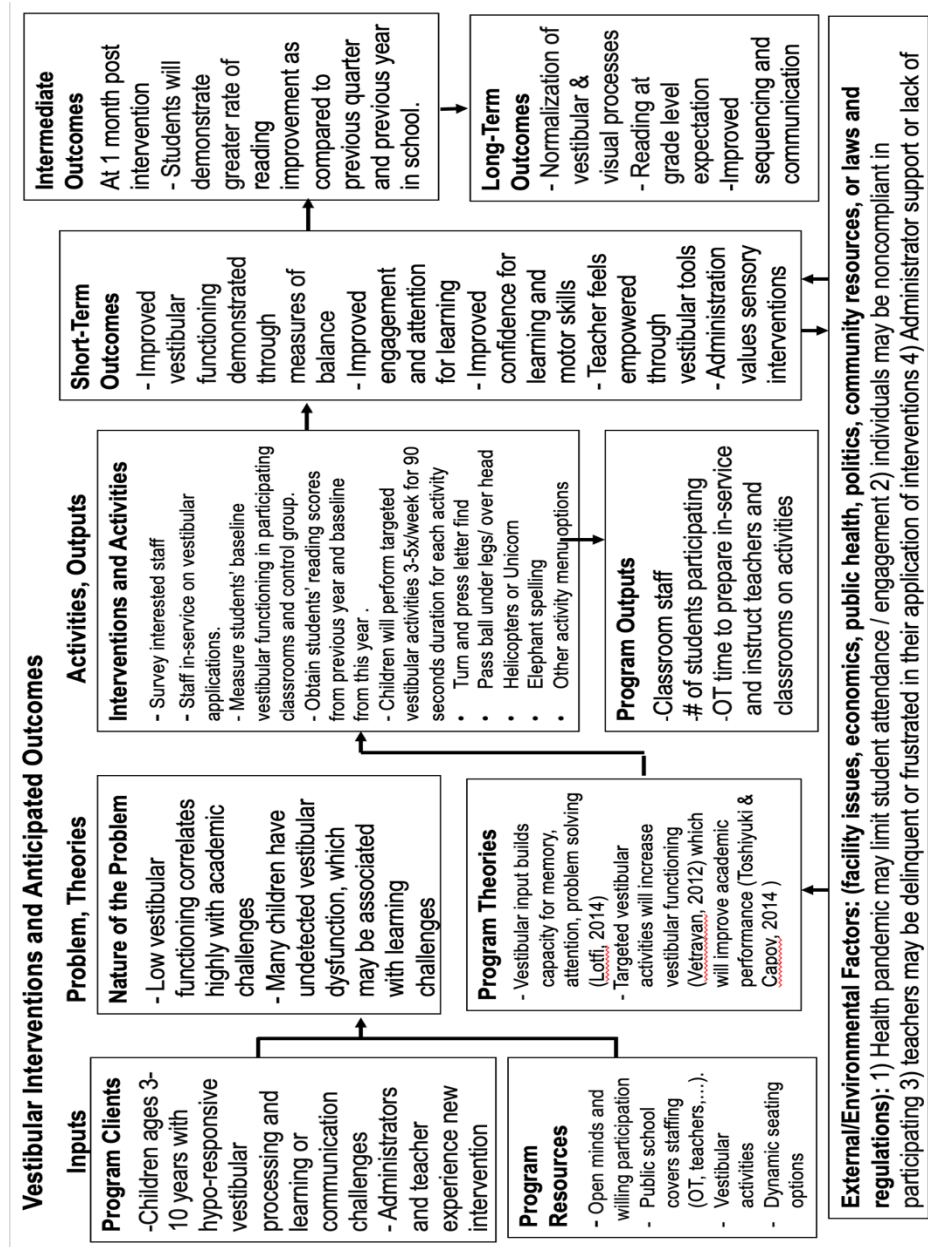


**Purpose**

Research for this educational series will focus on the effectiveness of the research knowledge and learning experience as well as the perceived value and satisfaction with the educational program and content. The program is aimed at building the knowledge and confidence of OTs to implement vestibular practices and begin recognizing related outcomes. Measured student successes will emerge following the educational program as therapists are able to fully implement their knowledge translation into practice.



This additional logic model illustrates the proposed therapy outcomes to be learned in the educational series and applied as a result of the educational series to increase children’s academic performance.



Research evidence and lived experiences of applying vestibular methods in therapy will be foundations of the educational process, elucidating that techniques are not experimental, but rather, there is a connection between research knowledge and practiced OT interventions that improve children’s communication and academic performance.

**Expected duration of the subject's participation**

OT program participants will be engaged in the learning series for approximately three months, extended longer if needed, at a frequency of once monthly for two hours per month. The primary investigator of this research will be available for consultation during this time. This learning series will be embedded within an ongoing professional learning community which will continue meeting after conclusion of the series. This professional learning community will continue to discuss therapy applications and processes related to the content of the course, as it will become part of the OTs regular professional practice.

The involvement of the children on the OT caseloads will occur during their regularly scheduled therapy times, without the addition of more time within their regular school day. The learned applications will be applied to the children's therapy sessions to promote higher performance in related skills such as communication, coordination, motor skills, and learning.

For some, the OT may already be utilizing principles that will be taught in the educational series and will result in minimal modification to therapy plans.

**Research Procedures**

This program involves a non-experimental, single group design which will be evaluated using pre and post summative measurements as well as ongoing formative assessments. Initially, quantitative data will be collected from program participants to establish baseline knowledge and confidence with understanding, evaluating, and applying vestibular interventions. Ongoing formative evaluations will occur at monthly educational meetings with scaled responses and focus group interviews to determine both satisfaction and effectiveness of the educational process, with program adjustments made accordingly. Qualitative and quantitative data will be collected in both the formative and summative program evaluation portions of this research design. At the conclusion of the educational series, formative and summative evaluations will reflect knowledge and confidence gained, perceived value of the learned concepts and satisfaction with the educational process. Comparisons will be made with baseline and concluding evaluations with data numerically reported.

To establish relevance to occupational performance, summative information will also be gathered from the children receiving interventions during this educational series, as well as their teachers and possibly parents, to determine the extent that improvements were observed in communication, motor skills, or academic performance. Because this data may not be fully distinguished at the conclusion of the educational series, a three month

follow up survey will be administered for full appreciation of the effects of the vestibular integration.

**Non-experimental**

Educational content is research based and grounded in OT theory. Content based therapy applications are established within the OT profession with new research supporting the potential impact such therapy applications may have on learning and children's academic performance.

**Risk**

There is no foreseeable risk anticipated for the OTs participating in the learning series nor for the children on their OT caseloads. The children have already been identified as needing occupational therapy and are currently on the OTs caseload. The children's identity will be represented by a numerical code that ties them to the treating therapist for tracking purposes. All data will be stored on password and firewall protected storage belonging to the school district.

**Benefits**

Participating OTs may benefit from gaining knowledge and applications to help the children on their caseload improve in their occupational performance.

Children receiving OT and the benefits of the interventions learned through the educational series may, over time, experience greater success with occupational performances related to vestibular functioning. Children's perceived benefits will be experienced beyond the educational series, as therapists are able to fully apply learned knowledge and concepts into the treatment sessions.

**Confidentiality**

Ethical considerations for maintaining confidentiality will be made through the application of coded identification numbers paired to their OT to conceal children's personal identification. Data associated with each student will be stored within a shared spreadsheet using password protected school district Google Drive, whose contents are only accessible to those school district employees invited to access the shared drive. This storage system is firewall protected with password encrypted access to ensure data confidentiality. Data is routinely backed up on the shared server.

Individual OTs will maintain children's identity within their clinical records, not to be shared in the related database and all data will be reported through their identity code.

Any follow up information will be conducted through the OT directly involved with the child.

**IRB access to data**

Upon request, access to data may be made available to research review board members with strict confidentiality of children’s protected identity.

**Research Contact Information**

Questions regarding the research may be directed to this primary investigator at [cwall22@bu.edu](mailto:cwall22@bu.edu) or 608-799-0172. Follow up may be made to the faculty advisor (Lauren Stone) at [stola@bu.edu](mailto:stola@bu.edu).

**Participation**

OT participation is voluntary, as is the children’s participation within the therapy setting. Children will be invited to participate by their OT through the process of going through a written letter of accent, indicating all involved parameters. For children who opt to participate, written consent will be received from their parents prior to their involvement in the learning applications. There will be no loss of benefit if they should choose to not participate. The subjects may end their participation at any time.

Surveys will be used to gather qualitative and quantitative data from OT participants as well as teachers and / or parents of children who received learned applications from the educational series. This will both gather data and provide observational opportunities to adult observers for possible changes from the interventions. The option to skip any questions or not respond to the surveys will be permissible without penalty or judgment.

**Population Size**

1. OT – There will be approximately seven OTs, with a max of twelve OTs participating in the pilot educational series.
2. Children – An estimate of 20 - 30 children will be potentially identified as meeting eligibility for the vestibular applications, which will be the focus of the educational series.

**Contact Information**

Any questions regarding this proposed learning series may be directed to Connie Wall, M.Ed., OTR/L at [cwall22@bu.edu](mailto:cwall22@bu.edu) or [cwall@lacrossesd.org](mailto:cwall@lacrossesd.org), 608.799.0172

Appendix I

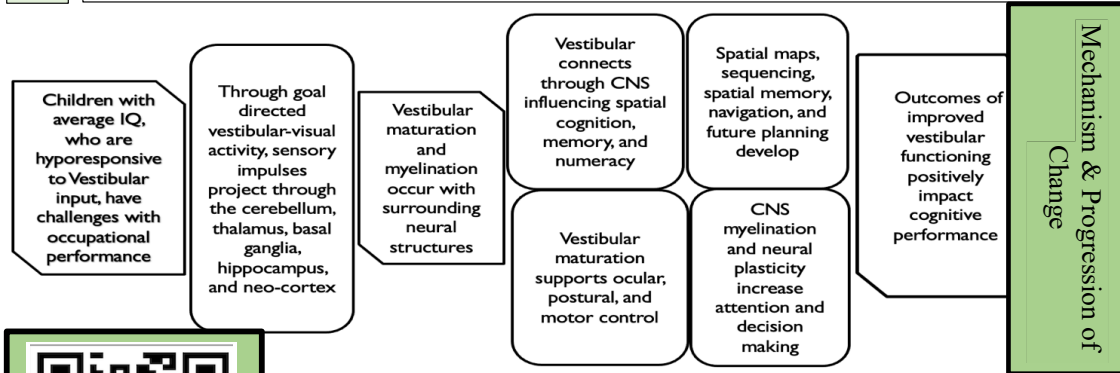
VestibuloTherapy Fact Sheet

**VestibuloTherapy  
Fact Sheet  
Connie Wall, MEd. ,OTR/L**



**Background**

<b>PROBLEM</b>	Vestibular dysfunction often remains undiagnosed and untreated in children (Li et al., 2016). This is problematic because delayed vestibular maturation is associated with learning challenges (Blythe, 2017; Kashfi et al, 2019). Professional confusion of terms between Ayres Sensory Integration and other sensory applications may contribute to the limited awareness. OTs report challenges with measuring and recognizing vestibular dysfunction and do not associate vestibular with learning outcomes. Together, these limit the OT scope and application of vestibular interventions (Wall, 2021).
<b>SOLUTION</b>	The proposed vestibulotherapy learning series will equip OTs with knowledge and confidence to provide evaluation and intervention for children with vestibular dysfunction. Educational concepts are founded on evidence from contemporary neuroscience indicating that vestibular sensation promotes myelination and neuroplasticity, which are essential to children’s learning and communication (Hitier et al., 2014, Kashfi et al, 2019). Interventions will be embedded within the child’s occupations of play and learning within the clinic and classroom settings.



- Educational series and related resources for pediatric occupational therapists
- Application of contemporary neuroscience evidence into OT practice
- Introduction of vestibulotherapy presented on a variety of media platforms to promote and market the educational series, concepts, projected outcomes, and necessary research.
- Publication of supporting literature, online resources, and vestibular manual.
- Pending IRB approval, Initiation of research through the educational series, local hospital, and university
- A multidiscipline, global enterprise supporting and promoting vestibulotherapy.

### Implications and Outcomes

- Increased OT confidence and perceived value for integrating vestibulotherapy concepts into professional practice
- Increased identification and intervention of developmental vestibular dysfunction
- Increased aptitude and confidence for children's learning and communicating.
- Multi-discipline awareness for vestibular screening and intervention
- Universal, classroom-based vestibulotherapy facilitating academic success for all.
- Generation of research and clinical practice guidelines for vestibulotherapy.
- Emerging evidence-based practice through sound reasoning and data.



"Postural control provides the basis for balance and gravitational security, which provides a reference point for physical and mental operations in space." (Blythe, 2017)

Vestibulotherapy is an emerging frame of reference, grounded in contemporary neuroscience evidence with supporting theories from Ayres Sensory Integration and vestibular rehabilitation. Through its application, children with vestibular under-registration will experience adequate vestibular activation, promoting myelination and neuroplasticity to enhance communication and learning.

Occupational therapists gaining specialized knowledge of vestibulotherapy's concepts and applications will become proficient at recognizing and addressing delayed vestibular maturation, both through clinical applications and classroom interventions, to help more children succeed in academics and occupational performance.

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## Appendix J

### *Executive Summary*

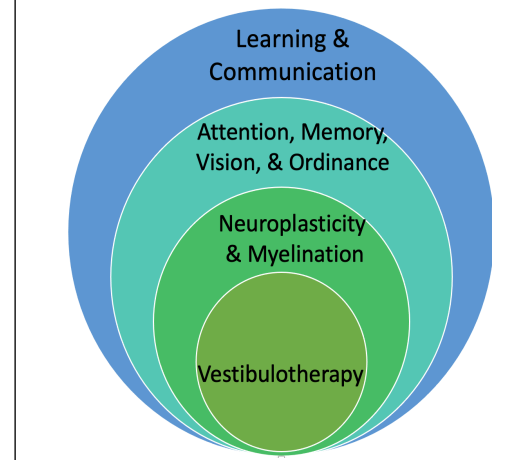
#### **Introduction to Vestibulotherapy**

Many children experience vestibular dysfunction, which often remains undetected and untreated (Li et al, 2016) yet manifests motor and learning challenges (Besnard, et al., 2016; Hitier et al.,2014; Kashfi et al., 2019; Lopez et al., 2020; Mast et al., 2014; Lotfi et al, 2017; Melo et al., 2019; Christy, 2019; Moossavi & Jafari, 2019). Traditional Vestibular Rehabilitation (VR) offers a conceptualized approach to addressing the needs of people with a mature vestibular system which encounters dysfunction from insult or injury. However, with a high frequency of dysfunction remaining undetected (Li et al., 2016), the need for heightened awareness for varying levels of dysfunction and intervention has become increasingly clear. The aim of this doctoral project is to create educational programming and resources so that OTs will recognize delayed vestibular maturation in children, associate learning outcomes with vestibular functioning, and implement related evidence-based practice interventions. This information will benefit children and be disseminated through educational resources for occupational therapists, teachers, parents, and related professionals.

As illustrated in Figure 1, *Vestibulotherapy* will promote myelination and neuroplasticity through vestibular sensations

**Figure 1**

*Mechanism of Change*



embedded within movement-based activities to build neural pathways supporting children's learning and related outcomes (Besnard, et al., 2016; Hitier et al., 2014; Kashfi et al., 2019; Lopez et al., 2020; Mast et al., 2014; Lotfi et al., 2017; Melo et al., 2019; Christy, 2019; Moossavi & Jafari, 2019). The vestibulotherapy model addresses the needs of predominantly neurotypical children, ages 3–10 years of age, who have an under-registration and immature vestibular processing system, experiencing delays with learning, motor skills, communication, and related areas of occupational performance.

Presently, while local pediatric OTs desire to address the learning needs of students, barriers founded in limited knowledge and negative bias impede their success (Wall, 2021). They lack the skills for recognizing vestibular dysfunction, employing appropriate interventions, and understanding related concepts and potential outcomes.

### **Program Overview and Implementation Plan**

The vestibulotherapy education series has been developed to address numerous barriers and empower pediatric OTs to navigate new methods for evaluation and intervention of vestibular-based deficits which have propagated children's learning challenges. Concepts employed for both orchestrating professional development, as well as building course content, were derived from extensive literature review, profiling numerous studies to capture best practices.

Professional teaching methods will be drawn from theories including Adult Learning (Knowles 2015), Problem Based Learning (Burman et al., 2021), and Double Loop Learning (Argyris in Lysberg & Ronning, 2021), where the OTs' motivation and perceived value for adopting new methods of intervention excels through engagement

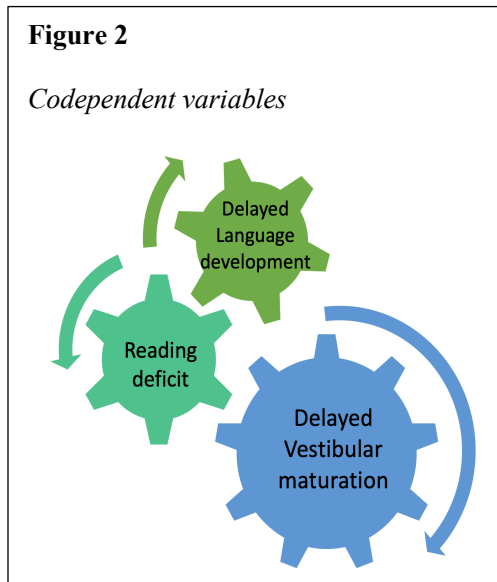


with their professional learning community (Burman et al., 2021; Lewis & Thompson, 2017). Centered around the common goal of improving children's learning and communication through increased vestibular functioning, professional education elements should include ongoing and shared problem solving, collaboration, reflection, and direct applications of learned content (Knowles et al., 2015, Burman et al., 2021; Lewis & Thompson, 2017). Within their professional learning community, OTs will engage in joint and reflective learning processes where participants gather, share, and integrate learned concepts until all parties feel confident with understanding and applying new methods of intervention (Burman et al., 2021; Lewis & Thompson, 2017). Benefits of applied vestibular interventions will emerge following the educational program as therapists experience value through their fully implement knowledge translation into practice with the children they serve.

Within the learning series, OTs will have the opportunity to collaborate with families, teachers, and therapists. It will be through this partnership that each members' valued contributions will fuel motivation and ownership over classroom, home, and therapy interventions (Knowles et al., 2015, Burman et al., 2021). After completion of the first learning module, where they will obtain consent and IRB approval, they will screen for vestibular dysfunction through clinical, home, and classroom measures. Once identified, those children with vestibular dysfunction will engage in child-centered and play-based motor and visual targeting activities to build learning foundations, which will be the focus of learning modules two and three. Having the opportunity for OTs to teach and collaborate with others will advance their understanding and perceived value of the

knowledge gained through the educational series. Through collaborative programming, parents and teachers will support vestibular applications across multiple domains, helping more children fully succeed to their potential.

Vestibulotherapy provides increased awareness to the under-recognized problem of vestibular dysfunction, guided interventions, and, when implemented, improved occupational performance of children in their social and academic roles. Salient



outcomes of vestibular interventions included essential foundations of learning and communication such as ordinance, sequencing, spatial cognition, memory, and attention. While evidence did not frequently attempt to correlate language or academic outcomes with interventions, one can recognize the codependency between delayed vestibular

maturity with delayed reading and communication as illustrated in Figure 2, it is recommended that practitioners who implement this intervention gather information regularly from the teacher and family regarding related outcomes.

The educational series may run virtually or face to face over three, monthly sessions, with progressive course content and objectives outlined in Appendix A. By meeting monthly, participants will have ample opportunity to employ learned concepts from which to reflect and engage in collaborative problem solving within their professional learning community.

Learners will prepare for each monthly educational session by reviewing didactic information presented in the learning module. Concepts gained from the educational series will be translated into practice through specific tasks to complete each month with their clients, providing common lived experiences for collaborative problem solving and reflection each month. Learners will be encouraged to connect with one another outside the classroom to discuss learned applications while building a professional learning community that may remain intact long after conclusion of the series.

Evaluation measures from the pilot launch and subsequent educational series will be shared with stakeholders and used to improve overall quality of the educational program where needed. The inclusion of confirmatory factor analysis and data gathered through IRB approved research, vestibulotherapy concepts will gain credibility for this emerging paradigm. Through various means of educating OTs, the presence of developmental vestibular dysfunction will no longer get overlooked, but rather, children will receive appropriate intervention to enhance their learning potential.

### **Key Findings**

***Professional Development*** A learner profile should be employed to understand the learners' needs, preferences, motivation, and readiness for learning to determine the “what”, “how”, and “when” of instruction (Braungart et al., 2020). Themes of social networking, opportunities for collaboration with shared problem solving, and joint reflection were consistently recommended within professional learning communities (PLC). It is within this safe space where learners may share and discuss experienced tensions from new concepts and real-life clinical problems, while confronting existing

beliefs and practices, to evoke change over a duration of time (Lysberg & Ronning, 2021; Burman et al., 2021; Allen et al., 2019; Henry et al., 2019).

***Vestibular Interventions to support learning*** Over the past decade, neuroscience research has increased our understanding of the vestibular system's role in perceptual and cognitive functions, impacting learning, perceptual reasoning, and mental health (Hitier et al., 2014, Besnard, et al., 2018; Lotfi et al., 2017; Lopez, et al., 2020). Posture, movement experiences, and perception, collectively referred to as “embodiment” (Lopez et al., 2020), are supported by the vestibular system and provide a foundation through a sense of self (Besnard, et al., 2016; Lopez, et al., 2020). Vestibular sensations mediate cognitive performance by forming overlapping pathways between main memory centers (hippocampus, amygdala, thalamus, frontal cortex, and cerebellum) and vestibulo-cortical tracts to develop processes for object recognition, inner speech, numerical cognition, spatial navigation, sequencing, attention, impulse control, future planning, ordinance, and a variety of mental activities including attributes of a theory of mind and executive function (Moossavi & Jafari, 2019; Hitier et al., 2014; Lane et al., 2019; Koziol, 2014; Besnard, et al., 2016; Lotfi et al., 2017). The vestibular system further supports learning by way of establishing spatial cognition through its modulation of information being processed to represent information in a specific spatial order, providing mental imagery, numeracy, and sequencing (Mast et al., 2014; Besnard, et al., 2016; Hitier et al., 2014). Contemporary neuroscience elucidates that vestibular applications are not experimental, but rather, validate that origins of neural networking emit from the vestibular apparatus continuing throughout the neural pathways (hippocampus, reticular formation, basal

ganglia, insula, neocortex, cerebellum, thalamus) to mediate attention and impulse control, memory, spatial cognition, vision, navigation, future planning, sequencing, numeracy, and social cognition for overall improvement in cognitive performance (Hitier, et al., 2014; Besnard, et al., 2016; Moossavi & Jafari, 2019; Lopez et al., 2020).

## **Conclusion**

VestibuloTherapy is an emerging frame of reference, grounded in OT-ASI theory, VR, and contemporary neuroscience evidence, aiming to help children with vestibular under-registration develop neuropathways supporting communication and learning, while gaining confidence across all roles of occupational performance.

Occupational therapists gaining specialized knowledge of vestibulotherapy concepts and applications will become proficient at recognizing and addressing delayed vestibular maturation, both through clinical applications and classroom interventions, to help more children succeed in academics and occupational performance.

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## Appendix AA (of the Executive Summary)

### *Vestibular educational series content outline and objectives*

Module	Learning objectives	Learning activities
<p>Learning Session One</p> <ul style="list-style-type: none"> <li>Evidence from contemporary neuroscience on vestibular processes.</li> <li>Ayres Sensory Integration.</li> <li>Clarification of Terminology</li> <li>Vestibular evaluation.</li> <li>Vestibular screener for classroom and home.</li> <li>IRB approval and parent consent.</li> </ul>	<ul style="list-style-type: none"> <li>OT will demonstrate confidence with measuring vestibular functioning using 2-3 prescribed methods with a peer by the end of the first learning session in 1 of 2 opportunities.</li> </ul>	<ul style="list-style-type: none"> <li>Flipped classroom learning module 1.</li> <li>Didactic instruction.</li> <li>Video examples of vestibular evaluation, interventions, and outcomes</li> <li>Collaborative case study.</li> <li>Vestibular screening tool - demonstration &amp; practice</li> <li>Vestibular assessment tool – demonstration &amp; practice</li> <li>Research articles</li> <li>Breakout sessions within the learning session to practice and demonstrate evaluation measures</li> </ul>
<p>Learning Session Two</p> <ul style="list-style-type: none"> <li>Reflections of vestibular screening and evaluation with current caseload.</li> <li>Discuss expected outcomes of vestibular interventions.</li> <li>Vestibular intervention applications.</li> <li>Vestibular progress monitoring</li> </ul>	<ul style="list-style-type: none"> <li>OT will report an increased perceived value of vestibular knowledge and applications through shared reflections in 1 of 2 opportunities.</li> </ul>	<ul style="list-style-type: none"> <li>Flipped classroom learning module 2</li> <li>Video examples of intervention and outcomes</li> <li>Vestibular intervention videos</li> <li>Didactic instruction</li> <li>Collaborative case study within breakout session</li> <li>Shared lived experiences with evaluation methods</li> </ul>
<p>Learning Session Three</p> <ul style="list-style-type: none"> <li>Reflections of vestibular evaluation and interventions.</li> <li>Reflections of teacher collaboration</li> <li>Collaborative problem solving</li> <li>Discuss outcomes observed.</li> </ul>	<p>By the conclusion of the learning series,</p> <ul style="list-style-type: none"> <li>OT will identify 5+ preferred vestibular activities for classroom or home applications and share those with 2+ teachers or parents to support children’s development.</li> <li>OT will report an increased perceived value</li> </ul>	<ul style="list-style-type: none"> <li>Flipped classroom learning module 3</li> <li>Video examples of intervention &amp; outcomes (change over time)</li> <li>Collaborative case study within breakout session</li> <li>Shared lived experiences with vestibular evaluation &amp; interventions applications</li> <li>Research articles</li> </ul>

<ul style="list-style-type: none"><li>• Discuss teacher observations of perceived change (if any)</li></ul>	<p>of vestibular knowledge and applications through shared reflections in 2/2 opportunities.</p> <ul style="list-style-type: none"><li>• OTs will report observations of children's improved outcomes they attribute to learned vestibular interventions in 2/2 opportunities.</li></ul>	<ul style="list-style-type: none"><li>• Dialogue or Q&amp;A with field expert in vestibular interventions.</li></ul>
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**Curriculum Vitae**

