

SOMATIC APPROACHES TO ANATOMICAL EDUCATION

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## **Dedication**

In loving memory of my grandfather, 穆惠民, whose spirit continues to guide and protect me.

Thank you 爷爷, we miss you.

## **Abstract**

(251/300 words)

Anatomical sciences in health professions education (HPE) often reduce the human body to a static object of mental contemplation. This disembodied approach isolates anatomical concepts from lived, somatic experiences, neglecting the dynamic interplay between theoretical learning, experiential practice, and sensory embodiment. Such disconnection undermines health professional students' ability to develop the somatic sensitivity and kinaesthetic awareness essential for patient-centred care.

This dissertation explores how anatomy educators across diverse disciplines integrate experiential somatic learning methods, which emphasize sensory-based exploration and awareness of the body. These methods aim to bridge the gap between theoretical anatomical knowledge and somatic understanding. In doing so, they also promote perceived intercorporeal connections, or shared bodily experience, in classroom settings. Drawing on multiple case study research methodology and cross-disciplinary comparative analysis, the study traces evolving practices in anatomical education across expressive (visual arts, dance), clinical (medicine, kinesiology), and technical (bioengineering) fields.

Guided by the Function2Flow (F2F) framework, this research examines how sensory and affective dimensions of the body are mobilized in educational practice. Findings reveal that educators intentionally integrate movement, gesture, touch, and lived anatomical experiences to cultivate somatic awareness, deepen anatomical exploration through intercorporeal learning, and inspire joy and curiosity in both teaching and learning.

This work contributes to the growing discourse on cross-disciplinary somatic pedagogy in anatomical sciences, offering actionable insights for anatomy educators. It advocates for a more experiential, humanized, and integrative approach to anatomy education, particularly one that honours the interconnectedness of mind, body, and environment, and reflects the lived complexity of being human.

*Keywords:* Somatic learning, anatomy education, interdisciplinary pedagogy, cross-disciplinary pedagogy, living anatomy

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### **List of Acronyms and Abbreviations**

OCADU	Ontario College of Art and Design University
HPE	Health Professions Education
CBL	Computer-based learning
VR	Virtual Reality
AR	Augmented Reality
CT	Computed Tomography
MRI	Magnetic Resonance Imaging
F2F	Function2Flow
RTA	Reflexive Thematic Analysis
EMG	Electromyography
POCUS	Point-of-Care Ultrasound
CCF	Common Coordinate Framework

## **Appendices**

Appendix A – Reflection on the Thesis Format Conversion

Appendix B – Letter of Invitation

Appendix C – Letter of Informed Consent (participants & students)

Appendix D – Interview practice and guide with F2F model's creator (R.L.)

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## Dissertation Overview and Format

The following outline is meant to help readers navigate this dissertation, understand its development, and ultimately how this research contributes to the field of human anatomy education.

This dissertation was originally written as a “Thesis by Articles” but was later revised into a “Monograph Thesis” to provide deeper levels of analysis. Certain elements of the “Thesis by Articles” version (article 1, narrative review) are kept but restructured into literature review to suit the structure of a monographic thesis. A reflection and outline of how the original thesis by articles in relation to research questions is found in Appendix A. This doctoral monographic thesis is structured into six chapters, a summary outline is shown in Table 5, Monograph Thesis Structure Overview (P. 163).

Chapter 1 introduces the study by outlining the personal motivations for exploring somatic and experiential approaches to anatomical education across disciplines. It establishes the research problem, contributions to the field (HPE, theoretically, methodologically, and practically), and this overview to guide readers through the entire dissertation.

Chapter 2 presents the literature review, which includes the findings dedicated to Article 1 of 3 from the “Thesis by Articles” version of this thesis. This article was titled “Balancing Innovation and Living Experience: The Role and Limits of Modern Technological Approaches to Anatomy Education Across Disciplines”, a narrative inquiry into the historical, pedagogical, and technological evolution of anatomy education across disciplines. The literature review in Chapter 2 can be organized into six main areas: (1) historical and pedagogical foundations, (2) narrative review methodology, (3) discipline-specific anatomical instruction, (4) the potential and limitations of technological tools in anatomy, (5) experiential somatic learning, and (6) the lack of cross- and interdisciplinary anatomy education.

Chapter 3 begins with framing of the inquiry by exploring the research questions, theoretical framework, philosophical assumptions, and researcher positionality statement. This section outlines the Function2Flow (F2F) model as the theoretical framework guiding this research. This model categorizes somatic learning into four interrelated dimensions: *Function* (kinetic awareness), *Form* (aesthetic awareness), *Feeling* (kinaesthetic awareness), and *Flow* (energetic awareness). The chapter explains how the F2F model sensitizes analysis of educators’ somatic teaching practices and offers a vocabulary for mapping their pedagogical approaches

across expressive, clinical, and technical disciplines. This section explains why the F2F model was selected and how philosophical assumptions (constructivist and interpretivist) and researcher positionalities (insider and outsider roles) guided this research study. Chapter 3 then outlines the research methodology used in this study and provides rationale for adopting Merriam's (2002, 2009) case study research methodology. This chapter also connects the research questions to study design, data collection methods (instrument development, interviews, classroom observations, artifact analysis, and co-reflection interview), data analysis methods (Braun and Clarke's (2006, 2022) Reflexive Thematic Analysis (RTA), ethical considerations, and trustworthiness (Lincoln and Guba, 1985).

Chapter 4 presents all empirical findings from visual arts and dance instructors (Niloo Inalouei and Danielle Denichaud) as expressive educators, kinesiology and medicine instructors (Tamara Maciel and Dr. Terry Li) as clinical educators, and engineering instructor (Dr. Kei Masani) as a technical educator. The findings from interviews, observations, artifacts, and co-reflections are navigated through the F2F model and emphasize how each educator interprets their somatic experiences when applying living anatomy to their distinct pedagogical contexts.

Chapter 5 presents the discussion section of this research project. The chapter begins by presenting key themes that emerged from the reflexive thematic analysis (RTA), explores the cross-case interpretations, integrating interpretations with existing literature and theoretical frameworks. This chapter directly addresses the research questions of this study and explores how the implications of the findings are applicable for curriculum design, interdisciplinary teaching, and somatically informed pedagogy.

Lastly, Chapter 6 presents a thesis conclusion, covering a research summary, the conversion from Thesis by Articles to Monograph Thesis, highlighting the contributions to anatomical education, theory, and methods. The chapter then outlines the implications for HPE anatomy education before exploring limitations of the study and offers recommendations for future research. The thesis concludes with personal insights and a final note.

## **Chapter One: Introduction**

Chapter One provides an overview of the entire research project through my personal motivations for this research, description of the research problem, and contributions to the field.

### **Personal Motivations**

According to qualitative research methodologist Sheran Merriam (2002), a defining characteristic of a successful qualitative researcher is a deep, genuine engagement with the research topic. This study, which explores the somatic experiential teaching methods of anatomy educators, is ultimately motivated by my desire to better understand my own body and to refine my pedagogical approach to anatomy education.

On May 20<sup>th</sup>, 2022, I took a pivotal step in my academic career when OCAD University recognized my commitment to embodied anatomy education and appointed me as the anatomy lecturer in their Faculty of Arts and Sciences. To clarify, the term ‘embodied’ is not monolithic, and in this thesis, I refer to ‘embodied’ as the direct, felt experience through movement, touch, posture, and sensory engagement. This is used to emphasize one’s active bodily participation in meaning-making. The term ‘embodiment’ conceptualizes the body as a site of sensory, kinetic, emotional, and energetic awareness (Husserl, 1989; Hanna, 1986).

While still completing my doctoral studies, I was given the opportunity to develop an anatomy curriculum that integrates somatic, cross-disciplinary and experiential learning approaches. Experiential learning in this thesis refers to learning methods through direct, lived engagement with the body, where one actively moves, senses, palpates, visualizes, and reflects upon experiences to make meaning, rather than only receiving information cognitively as a product or outcome (Kolb, 1984; Smyth, 2021). My teaching methods, grounded in movement, direct engagement with the living body, and visualization, have been well received by students and colleagues alike, earning positive course evaluations and formal recognition, including a faculty-wide teaching award and shortlisting for university-wide teaching awards. During my hiring process, my embodied approach to teaching anatomy stood out. In my teaching demonstration, I taught the function and location of facial muscles by drawing directly on my own face while pulling a plethora of facial expressions. This method effectively showcased the kind of hands-on, interactive learning I aimed to cultivate in my classroom and left a lasting impression on the hiring committee. Nearly three years later, faculty members still recall this

demonstration from my interview. My integration of somatic learning strategies has since contributed to enhancing student engagement and enriching anatomy education at OCAD University.

Since childhood, I have been fascinated by the human body and our beautiful physicality that effortlessly balances our form and function. My passion for exploring anatomy evolved so ferociously that I learned it (and continue to learn it) from three different disciplines: visual arts, science, and yoga/mobility. Most interestingly, each discipline offered unique pedagogical approaches, allowing me to experience similar anatomical concepts from multiple perspectives. Each discipline has shaped me into the avid learner I am today. My first exposure to human anatomy was through visual arts, a life drawing course where I studied the surface anatomy of nude models. I visually examined the shapes and sizes of muscles, the protrusion of bone under skin, the pockets of fat distribution, and the beautiful proportions of the human form across sexes. This training honed my ability to analyze surface anatomy, providing a strong foundation for understanding bodily structures.

My second pursuit of human anatomy was through scientific study in my undergraduate Health Sciences degree. In large lecture halls, I learned the names, structures, functions, cell biology, and pathologies of the human body. For three hours weekly, 300 students would sit in the anatomy lecture and listen to one professor talk. Occasionally, the professor pointed at a diagram. Unlike my struggling classmates, this didactic method of instruction further incentivized me as I loved listening to the theory of how the human body functions. But the class felt limited as we were simply expected to memorize everything the professor had to say about anatomical sciences. Reflecting on these classes, I now recognize the irony – despite sitting in a room filled with living, breathing human bodies, anatomy was taught exclusively through words and two-dimensional images.

My exploration of anatomical sciences deepened immensely throughout my Master of Sciences where I practiced experiential learning through human body donor dissections. Physically peeling through the layers of the human body was mind-boggling. One layer at a time, I exposed and studied the composition of the musculoskeletal system with my own senses. Instead of resorting to memorization, I began asking questions like “how?” and “why?” when I physically manipulated structures of the body. For example, I would pull at different forearm tendons to inspect the corresponding movement of each phalange. This marked a turning point in

my understanding of anatomy as embodied knowledge. I was finally using a body to learn more about human anatomy. The more I learned, the more interested I became in the functions of my own living body, which I so rarely thought about. It was not until I started using my living body that all the theoretical concepts I had previously memorized started to connect with my physical being.

My third discipline of anatomical sciences education was through my yoga teacher training. As a yoga and mobility educator, I physically learned the biomechanics of my musculoskeletal anatomy by feeling the strength and locations of my muscles, the elasticity of my tendons and ligaments, and the ranges of motion in my joints. Suddenly, my artistic observational skills and the theoretical anatomical concepts I learned through didactic lectures became grounded in my understanding of myself. When I combine my body donor experiential learning with my somatic self-reflective learning, I answered the “how?” and “why” questions by physically embodying the answers instead of drawing from my memorized facts.

Thomas Hanna (1970) was a prominent figure in the development of *somatics*, which was influenced by the philosophy of Edmon Husserl (1980, 1989)’s concept of *somatology* (original work published in 1912 and 1952). Somatics refers to the study of the soma, understood as the living, experiencing body from a first-person perspective through bodily awareness and intentional movement (Hanna, 1970, 1988). However, they differ significantly in purpose, method, and application. Husserl’s somatology, grounded in phenomenology, investigates how lived bodily experience (feeling, sensing, and movement) contributes and is inseparable from our consciousness. This distinction emphasizes the difference between the object physical body that can be measured and observed (also known as *Körper*) and the lived, subjective body (known as *Leib*) (Husserl, 1989; Zahavi, 2003). While foundational to the philosophy of embodiment, Husserl’s work remains largely theoretical and descriptive, aiming to understand how bodily awareness shapes perception and subjectivity. In contrast, Thomas Hanna’s somatics, inspired by phenomenology philosophers Husserl and Merleau-Ponty, shifts focus to practical application. Hanna defines somatics as “the field which studies the soma: namely, the body as perceived from within by first-person perception” (Hanna, 1986, p. 1). His work emphasizes internal bodily awareness, movement education, and self-regulation as essential to restoring and optimizing human function (Hanna, 1988). Somatics has since been widely applied in bodywork, movement therapy, dance, and anatomical education. As a yoga/mobility and anatomy educator, I have

personally applied somatics in my classes. The most common one being a kinetic awareness exercise guided through “listen to your body” to promote internal bodily awareness such as focusing on tension recognition in the body. This promotes an intuitive sense of one’s own anatomy, much like how professional dancers sense the power, motility, and even non-verbal cues from their partners (Lloyd, 2021b).

My thesis explores the somatic experiences of anatomy educators and how they teach through movement, sensation, and embodied awareness. To accomplish this, I draw on Hanna’s (1970, 1988) somatics because it aligns with my emphasis on experiential, first-person learning and its integration in pedagogical practice. While Husserl provides a philosophical foundation for understanding embodiment, Hanna’s approach offers tools and concepts that are better suited to the applied, educational context of my research. Examples of these tools include heightening interoception (awareness of internal bodily sensations), proprioception (awareness of body position and movement), voluntary sensory-movement awareness, and pandiculation (a method of contracting, slowly releasing, and sensing muscles to reset the nervous system and regain voluntary control).

Through my doctoral research at the University of Ottawa, I have had the privilege of further expanding cross-disciplinary learning of anatomy by engaging with post-secondary educators across visual arts, dance, medicine, kinesiology, and engineering. One of the most rewarding aspects of my research has been bringing these cross-disciplinary somatic explorations into my undergraduate anatomy courses. Inspired by the extraordinary educators I recruited for this doctoral research, I have developed and repurposed teaching methods from multiple disciplines to encourage my students in engaging with anatomy, not just as a subject to be memorized, but as an experience to be felt and embodied.

My research in somatic anatomical teaching, shaped by visual arts, anatomical sciences, and yoga/mobility studies, has deepened my personal and professional understanding of anatomy. This doctoral journey has allowed me to investigate the diverse ways anatomy educators across disciplines engage with somatic learning. By learning from educators who teach the body through the body, I have gained invaluable insights into how experiential somatic learning methods can transform cross-disciplinary anatomical education.

I am honoured to share the embodied lessons I have learned from these educators, whose expertise and dedication continue to inspire my own teaching, research, and advocacy for somatic pedagogy.

### **Description of Research Problem**

Human anatomical sciences are commonly known as the foundation of health and medical education (Seo et al., 2021; Ganguly, 2013, Chapter 1; Turney, 2007). Traditionally, health professions education (HPE) students first encounter the human body from a pathological standpoint, where their sensory perceptions, such as touch, sight, smell, and sound, are shaped by the physicality of embalmed bodies. Despite the somatic nature of practice where health professionals assess patients using their hands, eyes, noses, and ears in diagnosis and treatment, the experience working with body donors is far removed from a live patient's embodied reality, which can result in a disembodied and disconnected anatomical experience (Chang et al., 2018).

The tendency to disembody and disconnect from one's own body or the lived experiences of patients is a problem which results from traditional approaches to human anatomical education in HPE. When anatomy education is reduced to a practice of the mind, it assumes a mind/body dualism, depicting the body as an object and reasoning is understood as independent of bodily movement (Lakoff & Johnson, 1999, p.32). This is shown in HPE gross anatomy where the human body is studied by dividing it into systems, analyzing layer by layer the structures and functions of organs and cells (Kelly et al., 2019) while neglecting the potential dynamic interplay between theoretical learning, experiential practice, and sensory embodiment.

While there is growing recognition that somatic embodied learning methods bridge theoretical learning, experiential application, and sensory embodiment in language, mathematics, and spatial thinking (Macedonia et al., 2019), HPE anatomy education continues to rely heavily on didactic lectures and, where program funding permits, human body donor dissections. Both of these methods often do not fully engage students in living kinaesthetic and sensory experiences that can deepen understanding of the human body (Chimmalgi, 2018). Furthermore, there is a lack of exploration of how various disciplines are incorporating embodied learning methods to enhance anatomical comprehension and bridge the gap between theoretical knowledge and practical application. Rather than viewing the body as an object that houses the mind, I explore examples of anatomy education using the living body as a rich resource of experiential

comprehension (Kolb, 1984; Smyth et al., 2021) through the experience of current anatomy educators across post-secondary disciplines.

As an anatomy educator prioritizing somatic learning at an arts university, I hope to see more anatomy students from all disciplines embracing experiential learning methods that involve movement, proprioception, and a deeper connection to the living, breathing bodies within their classrooms. This would involve, for instance, more students dancing through anatomy lectures, holding planks to learn the abdominal muscles, painting and drawing on their bodies to observe how moving internal structures may change the surface of the skin, crafting patchwork clothing to physically flip through the organization of visceral organs, and more (Barmaki et al., 2019; Diaz & Woolley, 2021; Estai & Blunt, 2016; Noël, 2012)! To understand how somatic learning can successfully complement didactic methods of teaching, it is necessary to first explore the somatic experiences of the anatomy educators. Therefore, my thesis explores the somatic experiences of post-secondary anatomy educators across visual arts, dance, kinesiology, medicine, and engineering. Through this research, I uncover educators' experiences with somatic learning, and I explore how they practice somatic pedagogy in teaching anatomical concepts within their discipline. The research questions that guided this dissertation are:

1. How do anatomy educators across disciplines integrate experiential somatic learning methods to bridge the gap between theoretical anatomical knowledge and embodied understanding and thereby promote comprehension and intercorporeal connections?
2. How can these cross-disciplinary insights transform anatomy in HPE?

This thesis expands the theoretical and methodological understanding of anatomical education and calls for pedagogical approaches grounded in somatic and experiential learning. By drawing out the somatic, embodied, and experiential teaching experiences of anatomy educators across disciplines, this research provides insights into how somatic learning can be translated across disciplines and be adapted beyond their original contexts.

### **Contributions to the Field**

This dissertation contributes a novel, cross-disciplinary investigation into somatic experiential approaches in anatomy education from the educator's perspective. This is an area that has been critically underexplored despite growing calls for embodied pedagogy in HPE. As mentioned in Description of the Research Problem, while anatomy remains foundational across

disciplines such as visual arts, dance, kinesiology, medicine, and engineering, little is known about how educators in these diverse fields teach the body through the living body. My research addresses this gap by offering the first in-depth qualitative insights into how anatomy educators intentionally integrate somatic learning (through movement, gesture, visualization, and touch) to foster embodied understanding and promote intercorporeal connection in the classroom.

Theoretically, this study expands the field's understanding of experiential somatic learning by framing it through the Function2Flow (F2F) model. The F2F model is used to examine the continuum from functional to energetic body awareness during movement (Lloyd, 2016; 2022). In this thesis, I also use the F2F model as a coding and sensitizing framework (Blumer, 1954) that illuminates how educators transition from mechanical knowledge of anatomy (*Function* and *Form*) to embodied, affective, and intuitive awareness (*Feeling* and *Flow*).

Methodologically, this research uses multiple qualitative case studies and comparative cross-case analysis to triangulate findings from interviews, classroom observations, artifact analyses, and co-reflection interview sessions (Merriam, 2002, 2009). This approach centers the educator's voice and reveals the importance of educator somatic awareness in shaping pedagogical practice – an aspect often overlooked in the literature.

Practically, the findings offer actionable insights for anatomy educators, curriculum designers, and interdisciplinary institutions seeking to humanize anatomical education. The study provides real examples of different disciplined instructors using their own bodies as anatomical teaching tools, bridging theory and disciplinary practice through lived experience. In doing so, it encourages a shift away from disembodied, technocentric instruction toward inclusive, reflective, and embodied pedagogies that honor the complexity of being human.

In sum, this dissertation not only contributes to the evolving discourse on anatomy education but also reimagines what it means to teach and learn anatomy across disciplines. It advocates for somatic approaches that are grounded in awareness, curiosity, relationship, and joy – offering a model for more humanizing, inclusive, collaborative, and transformative anatomical education.

## **Chapter 2: Literature Review**

This literature review can be organized into six main areas: (1) historical and pedagogical foundations of the dualistic view in anatomy education, (2) narrative review methodology, (3) current HPE approaches and discipline-specific anatomical instruction, (4) the potential and limitations of technological tools in anatomy (the role of living anatomy in addressing the limitations), (5) experiential somatic learning (definitions, supplementing limits of technological approaches, current research in anatomy education, educator's perspective), and (6) the lack of cross- and interdisciplinary anatomy education (exploring the bridging of innovation and embodiment in anatomy education across disciplines).

A broad interpretive review of this literature, informed by best-evidence synthesis (Slavin 1995), enabled a comprehensive understanding of how anatomy pedagogy has and continues to evolve across disciplines.

### **Dominant Dualistic View in Anatomy Education**

The word 'anatomy' is derived from the Greek word 'anatome', which means dissection or cutting of the bodily structure in relation to its surrounding structures (Leonard, 1996). Anatomy is the foundation of health and medical sciences as a thorough understanding of the body's structures, functions, and their interrelations is needed when seeking the causes, effects, and treatments of pathologies that affect the body (Duffin, 2021). The study of anatomy in HPE typically consists of anatomical terminology, normality, variations, anomalies, three-dimensional relationships, functional / living / clinical anatomy, and imaging technology (Educational Affairs Committee, American Association of Clinical Anatomists, 1996; Matveeva et al., 2024). To understand the current pedagogical designs of anatomical sciences, we first must acknowledge the sub-disciplines and the most common approaches to teaching human anatomy. Human anatomical sciences are currently taught under the sub-disciplines: gross anatomy (the study and identification of structures that can be seen with the naked eye, including shape, size, function, location, and pathology), embryology (the study of prenatal development's structures and organization from conception until birth), neuroanatomy (the study of the relationship, organization, and function of the nervous system), and histology (the microscopic study of tissues and their structures). Although each sub-discipline of anatomy is equally important in health and medical sciences (Singh et al., 2015), this research study will focus on gross human

anatomy education because it is most directly relevant to the possibilities of somatic experiential education across multiple disciplines.

With gross human anatomy holding foundational significance as the bedrock of health and medical sciences, a multitude of teaching approaches have emerged. In the pursuit of effective anatomical education, it is crucial to recognize that no single approach reigns supreme. Instead, there exists a rich tapestry of pedagogical methods through various disciplines (Estai & Bunt 2016). Despite this multimodal approach, many contemporary anatomy education curricula remain rooted in a dualistic framework that prioritizes vision over other sensory engagements, often reinforcing a disembodied perspective of the human form. No matter the discipline, 2D static anatomical renderings tend to be most common (Chan et al., 2021; Triepels et al., 2019), even though they are inadequate for fostering the somatic, kinaesthetic, and experiential understanding central to embodied anatomy learning. Their abundance in HPE anatomy education is attributed to Western education's prioritization of vision over all other senses. This is known as 'ocularcentrism' (Classen, 2020; Classen & Howes, 2005; Kelly et al., 2019). The prevalent oculo-centric portrayal in Western anatomy education enforces a dualist view which segregates the human body from the human mind.

René Descartes, father of Cartesianism, believed "the mind has ontological priority over the body, where the body is subject to the causal relations to which other physical things are subject, and the body has no constitutive role in the relation to self" (Edwards, 1998, p. 47; Descartes, 1637, 1642). Descartes argues for a real distinction between mind (*res cogitans*) and body (*res extensa*) and grants the mind methodological priority in securing certainty through indubitable truths. He argued that the mind and body could not exist in unity because the mind was a substance of thought and the body was material (Descartes, 1942; Mehta, 2011). In present HPE, Cartesian ideology becomes apparent when anatomy students divide the body into systems, structures, cells, and tissues without regard to the connection with the human mind, but where the disembodied mind is scientifically contemplating the body. Ahlberg (1996) believed ocularcentrism promoted dualism as the disembodied gaze was "at the expense of the active and embodied look" (Ahlberg, 1996, p. 13). By reducing our bodily processes to machine-like components rather than living, complex entities, a major paradox has evolved in the field of anatomical sciences: the study of the human body becomes a practice of the mind, without considering the uses of our bodies and our subjective experiences (Kelly et al., 2019).

With present curricula striving to incorporate state-of-the-art technology to displace 2D with 3D imaging, medical imaging, virtual reality (VR) and augmented reality (AR), and even 3D printing, the emphasis on vision continues to fuel oculo-centric learning experiences. The neglect of supposedly ‘less reliable’ forms of sensory engagement, like touch and auscultation (Kelly et al., 2019) becomes conspicuous when HPE students learn human anatomy through embalmed human body donors, where their sensory experiences are constructed from pathological standpoints that are far removed from living realities. Ironically, these future health professionals are expected to eventually treat living patients with living embodied experiences. The oculo-centric educational strategies for anatomical sciences in Western HPE promote a sense of disembodiment (Poirier, 2006), where the subjective experiences of the body are often taken for granted and the body is an object in the background, only to be acknowledged when the corporeality is deviated from ‘dys-appearing’ silence (Leder, 1990; Wilson, 2012).

Body and medicine philosopher Leder (1990) explains that the body ‘dys-appears’ into the background when learners are productively unaware of their bodily functions. This is especially noted when learners deny their physical needs, such as sacrificing sleep and nutritious diets to achieve scholarly productivity. The physical and emotional consequences of neglecting the body push our physicality towards a moment of disruption, such as illness and/or pain. This is known as a “recessive mode of existence”, where one’s whole being is forcibly reoriented due to the fundamental changes caused by illness or declining health (Leder, 1990, p. 84). In doing so, the learner’s body is only ‘appearing’ or ‘speaking up’ in moments of exhaustion and distress. It is during moments of corporeal dysfunction, such as illness and/or pain, that we become acutely aware of our disrupted corporeality. The ‘absent’ body finally emerges into our explicit awareness, and we turn to health professionals to restore the normal absence of bodily experiences.

This philosophical divide has shaped anatomy pedagogy across disciplines. To better understand how somatic learning (to be explained in this chapter) diverges from traditional dualistic methods, it is important to first examine the dominant instructional strategies currently employed in HPE.

### **Narrative Review Research Methodology**

This literature review synthesizes how anatomical sciences education has evolved across disciplines, from its historical roots to modern applications in medicine, visual arts, engineering,

therapy, and dance. To accomplish this, a narrative review methodology was selected to be a part of this literature review. A narrative review offers the flexibility needed to critically explore diverse disciplinary traditions, theoretical orientations, and pedagogical trends that do not conform to narrowly defined research questions or homogenous data types (Basheer, 2022; Sukhera, 2022). Unlike systematic reviews, which rely on rigid protocols and narrowly defined inclusion criteria (Slavin 1995), narrative reviews allow for the integration of theoretical perspectives, historical developments, and practical insights across diverse fields (Green et al., 2006). The goal of this narrative review was to integrate diverse forms of knowledge rather than assess intervention effectiveness, which is more typical of systematic reviews (Green et al., 2006). Furthermore, scoping reviews aim to map the breadth of a field without engaging in critical synthesis, whereby a narrative approach enables interpretive depth, allowing the researchers to identify thematic patterns, philosophical divergences, and epistemological tensions across fields. The thematic patterns identified in this narrative review are the increased use of technology, marginalization of living anatomy education, and growing recognition that the living body is both subject and object of study in the arts. Philosophical divergences include arts disciplines emphasizing felt experience and embodiment of anatomical concepts while biomedical disciplines focus on the objectification and dissection of the body. The epistemological tensions explored across fields involve how clinical and technical fields privilege visual, measurable, and replicable anatomical knowledge while arts value kinaesthetic, subjective, and relational knowledge. Research in pedagogy demonstrate that expressive disciplines' teaching methods may be used in clinical education, but rarely goes the other way around.

The narrative review approach aligns with the interdisciplinary nature of the topic, as it allows for historical contextualization, theoretical integration, and reflective critique across domains that are often siloed in the literature. Grounded in the “best-evidence synthesis” framework proposed by Slavin (1995), this methodology enabled a critical exploration to answer the research question of how anatomy teaching methods have evolved somatically across expressive (visual arts and dance), clinical (kinesiology and therapy), and technical (engineering) domains. By drawing connections between pedagogical shifts, disciplinary values, emerging technological trends and limitations, this narrative review offers a panoramic analysis of how innovation intersects with long-standing educational challenges. Moreover, it provides a platform

to examine underlying pedagogical tensions, such as how embodied somatic engagement can supplement disembodied technological instruction (Asad et al., 2023; Bergman et al., 2011).

### **Data Collection for Narrative Review**

Following best practices for narrative reviews, data collection processes emphasized transparency and rigour by identifying key questions, selecting relevant literature through purposive sampling, and organizing insights thematically (Green et al., 2006; Basheer, 2022; Ferrari, 2015).

The goal of this narrative review was to synthesize literature to understand how modern technology is used to teach anatomy across multiple disciplines, how it overshadows the role of experiential somatic teaching approaches, and to determine associated trends, challenges, or innovations within anatomy education. This narrative review was also written to build a rich, integrative picture of the evolving landscape of anatomy education, its pedagogical shifts and disciplinary silos, while critically examining what is gained and what may be lost in the move toward increasingly digital modes of instruction. The disciplines in question were across medicine, allied health professions, the arts, and engineering. The technology examined were 3D visualization software, medical imaging, virtual and augmented and mixed reality, digital human body donors, 3D printing.

The data collection process was iterative, drawing upon a wide range of literature, including peer-reviewed articles, reviews, and grey literature were considered to ensure comprehensive coverage of the topic. The keywords searched across PubMed, Scopus, and Web of Science included "anatomy education", "3D visualization", "medical imaging", "virtual reality", "augmented reality", "3D printing", in addition to discipline-specific terms like "therapy", "visual arts", "dance", "kinesiology", "engineering".

Articles were selected and reviewed iteratively, with attention to both empirical findings and conceptual contributions. Attention was also given to works that emphasized living anatomy and somatic experience as essential components of meaningful anatomical learning (Snowber, 2016; Lloyd, 2011), even when such approaches are less represented in mainstream medical education literature. In alignment with the pragmatic paradigm underpinning this thesis, the review prioritized applicability and insight across disciplinary borders (Patton, 2015), helping to

frame subsequent qualitative inquiry into how anatomy is taught in movement-, design-, and health-oriented fields.

Titles and abstracts were screened for relevance, followed by full-text review of selected studies. A total of 7875 abstracts were considered for inclusion, with 52 (0.7%) papers being selected for inclusion in this review. See PRISMA flow chart (Figure 1) below.

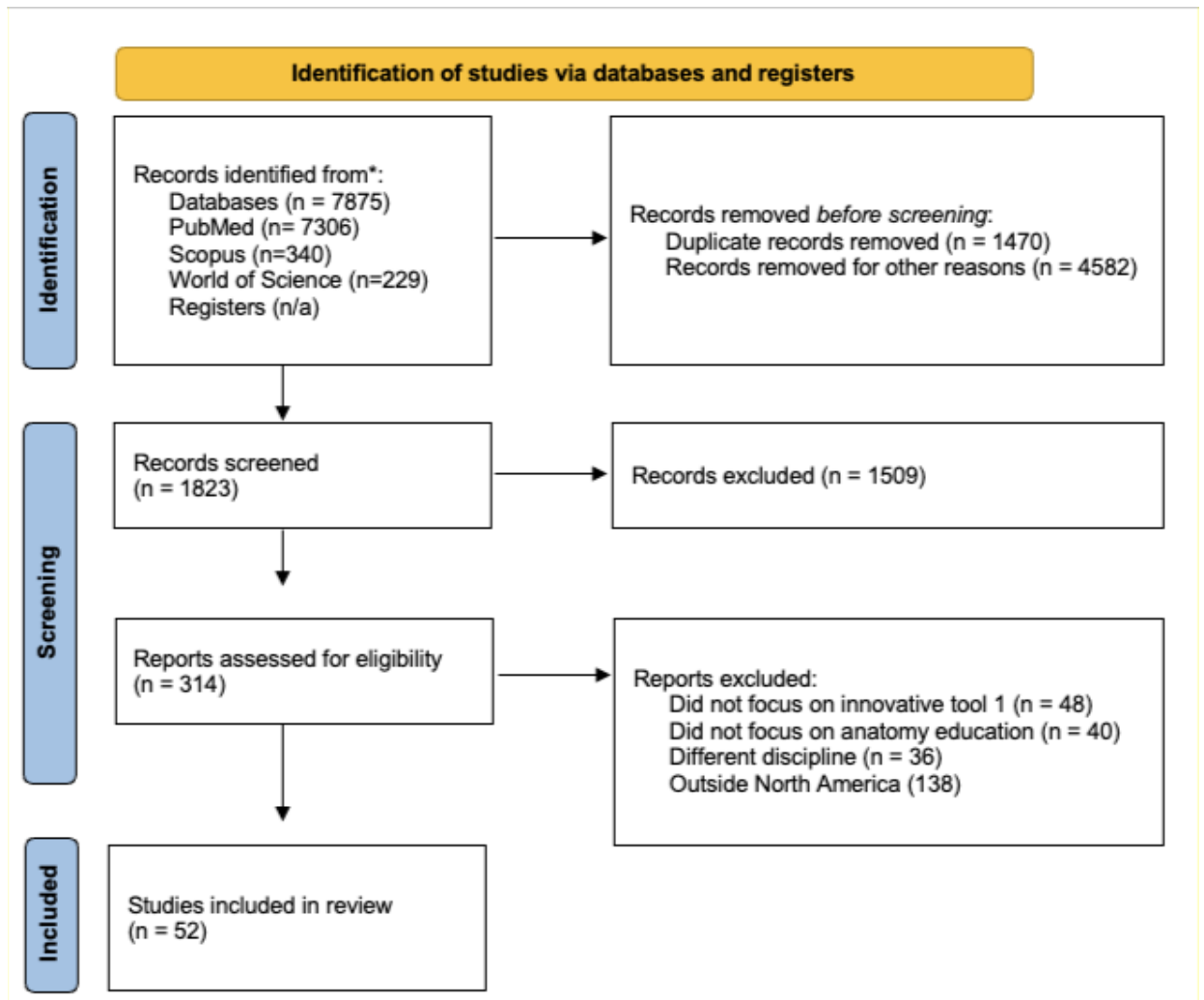


Figure 1. Prisma Flow Diagram for Narrative Review (now literature review)

The scope and inclusion criteria looked at studies that explored the use of technological tools anatomy education in at least one discipline, published within the last 20 years, and written in English. Studies pertaining to North American post-secondary institutions were prioritized. Purposive sampling was used to capture diverse perspectives rather than an exhaustive coverage.

Further sources, such as curricula, program structures, and syllabi were identified through specific programs in North American institutions' websites.

### **Data Analysis for Narrative Review in Literature Review**

Data analysis for this narrative review followed a best-evidence synthesis approach, as outlined by Green et al. (2006). Relevant literatures were critically examined for purpose, findings, and relevance to the research question, primarily focusing on discipline specificity and technological tools used for anatomical education. A total of 7875 abstracts were screened, with 52 full-text articles selected based on inclusion criteria. Selected studies were organized to identify recurring patterns, areas of consensus, and points of divergence amongst disciplines. The analysis emphasized patterns of pedagogical use, disciplinary relevance and preference, and reported benefits and limitations. Insights were synthesized into a narrative review intended for publication, then rearranged to be presented as literature review as part of this monographic thesis. This narrative review highlights disciplinary-specific trends, unique applications, and gaps in the literature. The interpretive process was iterative and reflexive, informed by my interdisciplinary background and advocacy for living anatomy education.

### **Current Common Approaches to Anatomy Education in HPE**

In most HPE programs, anatomy remains a foundational subject, traditionally taught through didactic lectures, human body donor dissection, and anatomical models. More recently, computer-based learning, such as 3D visualization systems, VR and AR, medical imaging, and 3D printing have been implemented into course curriculum (Bui et al., 2021; Urlings et al., 2023; Venkatesan et al., 2021). This section outlines the present most common approaches to gross anatomy education in HPE, setting the stage for a comparison with pedagogical practices in other disciplines.

*Didactic lectures.* Formal lectures have been key to anatomical education since before Ancient Greek (200 AD to 1700 AD) and remain a key part of present-day anatomical education. Anatomy education researchers criticize lectures as an ineffective, outdated, and passive form of learning (Anyanwu, 2014; Estai & Blunt 2016; Siwela & Mawera, 2017). However, this approach is used globally because lectures address the most information to a large audience at the lowest cost. Although an unengaging method of teaching, it is arguably necessary to impart

an anatomical foundation and medical vocabulary. Lectures are integral in a multimodal approach to anatomical learning.

*Human body donor dissections.* Human body dissections have been present since Ancient Egypt (3100 BC). Presently, we understand that hands-on dissection of human body donor promotes active learning, prepares students for clinical practice including encounters with death, team building, problem solving, self-directed learning, and development of manual skills to understand the relationship between structure, function, symptom, and pathology (Estai & Blunt, 2016; McBride & Drake, 2020; Parker, 2002). Dissection practice is an experiential learning method that promotes self-reflection of one's own anatomy, long-term comprehension, observation of bodily variations, experience with real body texture, pathology experience, and teamwork competency (Estai & Blunt 2017; McBride & Drake, 2020). It is important to note that body donor-based learning has long provided tactile experiences and direct interaction with human tissues and anatomical variation (Bolino et al., 2023). The virtual and digital tools that we experience in modern anatomy classrooms are created from data gathered from human donor material (Bartoletti-Stella et al., 2021). Therefore, we acknowledge that access to body donors for educational purposes is a privilege granted by the selfless and profound contributions of individuals who donate their bodies to scientific research. Without their generosity, the advancements we see in current anatomy education would not be possible (Iwanaga et al., 2021).

*Computer based learning (CBL).* CBL focuses on 3D representations of anatomical structures. For example, VR can mimic dissection, allowing students to visualize and interact with simulated objects in artificial 3D space (Estai & Blunt, 2016) while AR combines the real environment with additional virtual content to better display complex anatomical structures (Estai & Blunt 2016; Kamphuis et al., 2014). Studies have shown that CBL can be a successful supplementation to traditional anatomy lectures and dissection practice in multimodal learning environments (Estai & Blunt 2016; Peterson & Mlynarczyk, 2016).

*Medical imaging.* Anatomical medical imaging provides *in vivo* visualization of anatomical structures, physiology, and pathological processes (Estai & Blunt, 2016). Popular techniques such as computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound produce detailed, commonly 2D, images of internal anatomy (Binder et al., 2019; Estai & Blunt, 2016; Smith & Barfoot 2021). Students can correlate medical imaging with

clinical relevance while developing problem solving skills as it takes critical thinking to deduce abstract images from different perspectives (Estai & Blunt, 2016).

*3D printing.* 3D printing produces accurate, customizable and tangible models that enhance visuospatial and 3D understanding of anatomical structures (McMenamin et al., 2014). This has revolutionized anatomical education, particularly for anatomy-heavy specialties like surgery, histopathology, and radiology. These physical models allow students to examine anatomical structures in a tangible form, facilitating hands-on learning and promoting experiential learning. Recent research shows 3D printing in anatomy education is highly effective for enhancing student understanding and skill development. Students using 3D printed anatomical models reported greater engagement, deeper learning, and improved performance in assessments compared to traditional teaching methods. For example, a Tripodi et al., (2020) conducted a study and found the majority of students felt 3D printed models increased their academic confidence and positively impacted their learning experience and viva exam performance. These benefits are attributed to the tactile, kinesthetic nature of the models, which provide opportunities for independent study and hands-on exploration beyond traditional resources.

*Living anatomy.* Living anatomy is an active, tactile learning modality that reinforces self-awareness and comprehension of one's own anatomical structures through the sensory-motor system (Cherdieu et al., 2017; Estai & Blunt 2016; McMenamin, 2008). State-of-the-art technology overshadows the fact that our bodies are the original anatomical instructional tool. Rather than encountering anatomy from a pathological standpoint, living anatomy allows one to learn through feeling, movement, and self-reflection (Kelly et al., 2019). Studies have shown that living anatomy excels in linking theory with application of the nervous system and musculoskeletal anatomy (Soames & Palastanga, 2018).

Although HPE offers a useful baseline, anatomy is taught far beyond health and medical programs. This next section expands the discussion to explore how anatomy is approached across a range of disciplines including visual arts, dance, kinesiology, therapy, and engineering, and how each discipline brings its own anatomical pedagogy and curricular priorities.

### **Discipline Specific Approaches to Anatomy Education**

As mentioned, formal lectures are still the dominant instructional methods in today's HPE anatomy education due to the perception that large amounts of information can be

disseminated to a large audience at a low cost (Anyanwu, 2014; Estai & Blunt 2016; Siwela & Mawera, 2017). However, since anatomy education continues to play a crucial role in many disciplinary and professional programs within and outside of HPE, it begs the question: how do a variety of across and outside HPE teach human anatomy? This section of the literature review explores specific approaches to anatomy instruction and anatomical curricula visual arts, dance, kinesiology, physiotherapy and occupational therapists, and bioengineering.

*Visual Arts.* There is a symbiotic and inseparable bond between art and anatomy (Mitrousias et al., 2020). Visual arts students benefit greatly from studying anatomy, learning predominantly from observing the human body's structure, proportions, and movement of a live figure drawing model (known as life drawing). Anatomical comprehension enhances artistic realism and expressiveness in their work (Kermanian et al., 2023), therefore anatomy lessons or lectures are typically intertwined within life drawing classes (Inalouei, 2024).

*Dance.* Dancers predominantly learn musculoskeletal anatomical concepts through formal instruction coupled with living anatomy in dance class, where experience, experimentation, and proprioception of movement develop a profound understanding of the structure and function of their bodies (Denichaud, 2024). A dancer's thorough understanding of how to move their bodies enables them to optimize performance in their genre of dance, prevent injury, and refine their technique for full expressions of complex movements (Fraleigh, 2004; Rózsavölgyi 2021; Smith 2019). Dance instructor's teaching approaches emphasize that form is not fixed but shaped by movement and perception. This highlights a symbiotic relationship between spatial reasoning and geometry through physical movement is supported by Parsley & Soriano's (2009) study which used human motion as a medium for teaching geometry, while simultaneously using geometry to enhance movement amongst dance students.

*Kinesiology.* Kinesiology students learn the peculiarities of our locomotor apparatus that are essential to understanding body structure, movements, responses and adaptations to physical exercise. This is essential for optimizing athletic performance, preventing injuries, and enhancing rehabilitation strategies (Viana et al., 2019). Kinesiology students use traditional textbook readings and lectures for theoretical education and dissection laboratory sessions for practical applications of joint mechanics, biomechanical principles, movements, and the physiological responses of the body during exercise (Catena & Carbonneau, 2019; Downie & Burke 2023; Enoka & Duchateau, 2008). North American undergraduate kinesiology programs typically

begin anatomy education within the first two semesters, then require more advanced anatomy courses across the four years of the program (Brock University, 2024; Guelph University University of Toronto, 2024; University of Waterloo, 2024; York University, 2024).

*Physiotherapists and occupational therapy.* Physiotherapists and occupational therapists rely on their anatomical comprehension to improve a patient's ability to move their body and to perform daily activities. With their thorough understanding of musculoskeletal anatomy, they identify injury or dysfunction and prescribe targeted interventions or equipment to restore optimal movement and function (Cramer et al., 2005). Many North American therapy programs teach anatomy through lectures over one or two semesters within the first year, allowing students to select more specialized physical science courses later, including courses that offer human body donor dissection experience (Kurul et al., 2020; Milian et al., 2024; University of Toronto, 2024).

*Bioengineering.* Bioengineering combines anatomy, engineering, biomaterials science, cell biology, and medicine to create technological advancements aimed at enhancing human health (Bisht et al., 2019). This includes artificial organs, prosthetics, and drug delivery systems. Undergraduate bioengineering students in North America typically take one or two anatomy courses, with lectures often integrated into broader biomedical engineering classes such as biomechanics or biomedical systems. The emphasis on anatomy varies by institution, where some programs consider anatomy an elective (Northwestern University, 2024) while others incorporate medical lectures and gross anatomy laboratory sessions to improve anatomical quiz performance, reduce anxiety, increase appreciation and motivation, and direct application to research projects (Topping et al., 2018; University of Florida, 2023). Bioengineering programs teach anatomy through practical experiences, expert demonstrations, active learning activities, and long-term follow-up assessments (Singh et al., 2019).

Anatomy education thus serves as a foundational component across visual arts, dance, kinesiology, therapy, and bioengineering. Each field prioritizes certain anatomical concepts and instructional tools to meet its unique demands, whether guiding therapists in patient care, enhancing artistic realism for visual artists, supporting dancers' movement awareness and injury prevention, or propelling bioengineers to enhance quality of life. While the depth and delivery of anatomical education varies, the goal in each discipline is to build a comprehensive understanding of the human structure and function that aligns with the practical needs of each

discipline. This broad integration of anatomy highlights its enduring relevance and underscores the opportunities for cross-disciplinary collaboration.

### **The Potential of Preferred Modern Technological Tools in Anatomy Education Across Disciplines**

With technology evolving rapidly in the 21<sup>st</sup> century, a common thread across these diverse disciplines is the growing use of digital and immersive technologies to teach anatomy. This section explores this trend in greater depth, examining the potential and limitations of technological tools in anatomical education across fields. It is important to establish the current landscape modern technological approaches to human anatomy education across disciplines. Anatomy education within HPE is being confronted with increased class sizes and costs of human body donor dissections. There is a global trend of anatomy educators favoring or resorting towards more technologically advanced approaches to enhance lectures and/or to substitute costly and time-consuming full human body donor dissections (Dempsey et al., 2022; Gunderman & Wilson 2005; Nnaemeka & None 2024).

Recent scholarship in anatomical sciences education has increasingly examined the integration of modern technological tools, such as 3D visualization systems, VR and AR, advanced imaging, and 3D printing across disciplines. While these innovations offer new possibilities for visualization and access, they often lack the sensory and embodied dimensions essential to deep anatomical comprehension, especially in contexts where tactile engagement and somatic awareness are central (Asad et al., 2023; Bergman et al., 2011). These tensions reflect a broader challenge in anatomy education across disciplines: balancing innovation with the need to preserve the embodied and humanized aspects of teaching and learning.

*3D Visualization software.* 3D visualization software is a type of CBL that showcases complex structures from multiple angles. In anatomy education, 3D visualization has shown to be a successful tool in better understanding fine anatomical details in comparison to 2D images (Bertolini et al., 2021). Physical therapy students immensely benefit from 3D visualization methods that link theory with practice, facilitating long-term comprehension of complex anatomical concepts (Rezayi et al., 2022; Trelease, 2015). Linking theory from lectures with clinical practice in CBL has shown to develop critical thinking skills, clinical reasoning abilities, and provides therapy students the context of their future roles as healthcare professionals (Bergman et al., 2011; Estai & Bunt, 2016; Padulo et al., 2016). Visual arts students learn the

foundations of the human body's structure, proportions, and movement to aid in creating realistic and expressive artwork. Today, many art classes offer anatomy classes with live models, anatomy books, and digital resources. CBL programs like ZBrush, 3D Anatomy for Artists, and BodyViz showcase 3D anatomy for interactive exploration of the human form (Inalouei, 2024). Some dancers are fortunate enough to experience anatomical visualization software and motion capture systems to analyze and precisely refine movements (Tsampounaris et al., 2016). However, dance education mostly uses one's own living, experiential anatomy to foster deep understandings of the body's interconnectedness and functionality (Smith 2019). Bioengineering programs have varying emphasis on anatomy education. The bioengineering program of Newcastle University integrated anatomical lectures on joint replacement and biotribology (synovial joints and their artificial replacement). Students learned joint anatomy through a series of practical activities involving 3D anatomical software (Primal Pictures), models of human joints, and critiques of specific joint designs. Students submitted 3000-word projects on the in-depth analysis of joint anatomy and showed a substantial comprehension of joint anatomy based on the lectures and interactions with 3D software (Joyce 2012).

*Virtual Reality (VR) and Augmented Reality (AR).* Immersive VR consists of a virtual world, immersion, sensory feedback, and interactivity (Kurul et al., 2020; Sherman & Craig, 2019; Sinou et al., 2023). With either head-mounted devices or rooms that cover the user's 360-degree field of view, it provides an experience that completely isolates the individual from the external environment (Laver et al., 2017). These programs allow practical understanding through visualization and manipulation of 3D anatomical structures (Khot et al., 2013; Zhao et al., 2020). Dissection VR is popular in medical anatomy education as it mimics real dissection through multi-angled visualizations and interactions with simulated objects in this artificial 3D space (Estai & Blunt, 2016). It is also less expensive compared to real dissections and can be helpful for students with low spatial ability (Kurul et al., 2020). In fact, Zhao et al. (2020)'s meta-analysis found VR more effective than 2D methods when it comes to spatial anatomy comprehension. Zhao also found higher scores in learning satisfaction when VR learning tactics were employed. Furthermore, the average cost of immersive VR hardware and 1-year software license is \$4,900 USD. For comparison, the average cost of a single dissection laboratory is \$1,268.20 USD per resident (Crockatt et al., 2023).

AR combines 3D virtual content with real-world environments to display complex and difficult-to-show anatomical structures, allowing users to interact with both virtual and real environment (Estai & Blunt 2016; Jamali et al., 2015; Kurul et al., 2020). There are inconsistent findings on the efficacy of AR, for example, Bork et al. (2019) found minimal improvement in radiology anatomy test scores between students using AR versus traditional 2D atlases while Henssen et al., (2020) found a 10.6% improvement in test scores from students using a tablet-based AR. It is inconclusive if AR significantly impacts learning outcomes and spatial abilities.

VR systems are coveted in therapeutic and diagnostic fields due to their engagement, multiple perspectives, self-directed learning, and customizable learning experiences for clinical experience, such as complex anatomical processes and pathologies (Azuma et al., 2001). Kurul et al. (2020) investigated the effect of VR on anatomy education in 72 randomized undergraduate physical therapy students. They found that VR's pre-test to post-test results (107% increase) were significantly higher than the control group's (26% increase). Most students had positive perceptions on VR sessions, verbally expressing high rates of enjoyment and effectiveness in studying anatomy structures. High rates of enjoyment can be essential in self-directed learning. In a study by Telner et al. (2010), 90.5% of participants agreed or strongly agreed with the statement, "I learn more when I have fun", supporting the accomplishments and the positive reviews of the VR group. It's also important to note that McBain et al. (2023) found that although AR was often associated with improved learner engagement and performance in clinical anatomy, they concluded the underlying reasons for this improvement were often underexplored and lacked rigorous theoretical grounding.

Kinesiology scholars have consistently advocated for active learning approaches over traditional lectures, citing better learning outcomes (Knudson, 2019; Knudson & Wallace, 2019). VR and AR technology holds significant promise in enhancing anatomy student engagement of biomechanical concepts through immersive experiences showcasing the body and real-time changes during human movement (Keogh et al., 2024). Meyer et al. (2020) integrated Anatomage Table, a virtual 3D dissection program into undergraduate and graduate kinesiology anatomy classes. Virtual dissection activities are a cost-effective way for kinesiology students to actively explore anatomical structures and their 3D relationships in a stimulating learning environment. Students learned authentically rather than simply memorizing isolated facts about origins and insertions of muscles. For example, rather than simply listing muscles, origins,

insertions, and actions, students used VR to consider collective functions of muscle groups to describe the actions of someone pitching a baseball. This draws on theoretical knowledge while adding context to their learning.

*Medical Imaging.* Popular medical imaging techniques include computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound produce detailed, commonly 2D, images of internal anatomy (Binder et al., 2019; Estai & Blunt, 2016; Smith & Barfoot 2021). Educators may use medical imaging to present clinical experience, anatomical variation, and relation to pathology. The data collected from CT and MRIs can be extremely valuable in creating three-dimensional printed models.

Luetmer et al. (2018) found ultrasound to be a successful way to teach upper limb musculoskeletal anatomy to medical and physical therapy students. The increased exposure to medical imaging of anatomical content in an interprofessional context replicated their future professional workplace sparked by collaborative efforts. Students working in interprofessional teams scored higher than individual scores, suggesting that interprofessional team activities using medical imaging improves understanding, builds team skills, and increases clinical application of anatomy (Bergman et al., 2008; Luetmer et al., 2018).

Kinesiologists frequently integrate medical imaging in training and in professional settings. In fact, ultrasound has been described as the “sport medicine physician’s stethoscope” due to its diagnostic use in clinical practice (McCurdie, 2012). A strong foundation in imaging techniques allows for kinesiologists to accurately diagnose, investigate, and prescribe appropriate treatment of injuries (Bonab et al., 2023). Finnoff (2010) suggested sports medicine students learn basic physics principles of ultrasound; the history of ultrasonic medicine, how to optimize, capture, store, and transfer an ultrasound image. They also learned to describe ultrasonographic appearance of adipose, muscle, tendon, ligament, bone, fascia, vessels, nerve, and cartilage, and generate appropriate reports based on their anatomical findings.

Kinesiologists are expected to be familiar with other imaging modalities such as MRI, radiography, and CT to assess various types of injuries. Depending if the injury is soft-tissue, muscle damage, intra-articular lesions, or bony trauma (McCurdie, 2012), kinesiologists learn which techniques to use and how to use them depending on how the anatomical structures in question appear. Various studies examined students’ perception of imaging modalities and concluded that it enhanced the quality and efficiency of instruction in anatomy. These results

were reflected in higher test scores for students experiencing imaging modalities (Grignon et al., 2016). Overall, exposure of high-quality anatomical images puts their understanding into context, especially the relationships between structure and their function, or lack of function depending on the injury. The incorporation of medical imaging technology facilitates a more interactive and engaging learning environment for kinesiology students.

Bioengineering is a multidisciplinary science, where students tend to have backgrounds in physics, computer science, electrical engineering, or other physical sciences. Sometimes students arrive with limited anatomy education and are required to rapidly gain a thorough understanding of the intricacies of human anatomy and specialist terminology (Joyce 2012). Carmichael & Robb (2008) arranged for bioengineering students in the biomedical imaging tract to familiarize themselves with anatomy through dissections and interactive presentations of their dissected body donors. This was a hands-on approach to directly apply anatomical principles into their biomedical imaging degree, where students are tasked to improve image acquisition systems (image physics), advance image processing in CT scans, MRI, ultrasounds, develop systems for image feature analysis and more. When using medical imaging techniques, the students felt empowered by the professionalism associated with anatomy education, including accountability for actions, working with others (teamwork), respect for patients (confidentiality), and social responsibility (Swartz, 2006).

*Three-dimensional (3D) Printing.* 3D printing has revolutionized anatomical education by producing accurate and tangible models to enhance visuospatial and 3D understanding of anatomical structures (McMenamin et al., 2014). 3D printed models are customizable and easily reproduced, especially if educators share banks of datasets gathered from CT and MRI scans. The cost for 3D printing varies, with some printers ranging in price from 300 USD to 65,000 USD, and the cost per model ranging from 1.25 USD to 2800 USD (Brumpt et al., 2023). This has made them a popular alternative to traditional human body donor dissections as they are affordable, reproducible, and cover large ranges of anatomical variations and pathologies that body donors cannot. Body donors are an incredible learning tool but not every donor presents with the specific pathologies educators need to teach. In contrast, imaging-based 3D printing allows institutions to reproduce rare or clinically relevant variations repeatedly; once a pathology is captured in a shared CT/MRI dataset, identical models can be printed and distributed across multiple classes or programs, ensuring consistent and equitable exposure for all learners.

Plastic anatomical models are currently idealized in medical anatomy but do not include the anatomical variations found during human body dissection. Therefore, customized 3D printing models created from real patient data provides tactile experience and variation exposure for anatomy students. These 3D printed variations can be physically manipulated by students and preserved for future generations of students (Fasel et al., 2016; Moore et al., 2018). Surveys show medical students and educators resoundingly attest to the invaluable role of 3D models within the medical curriculum (AbouHashem et al., 2015; Garas et al., 2018; Lee et al., 2018; Young et al., 2019).

3D printed models serve as tangible learning aids for bioengineering students, allowing physical interaction with replicas of complex anatomical structures. This hands-on experience is invaluable for understanding the spatial relationships and intricate details of human anatomy that are often difficult to grasp through 2D images or textbooks alone. For example, Bertolini et al. (2021) explains that 3D printing in anatomy education for bioengineers can create accurate educational tools to illustrate complex cardiovascular anatomy and pathology. The 3D rendering guarantees a better understanding of fine anatomical details that may influence the management of disease in comparison to 2D images. As CT scans lead to the creation of whole-organ models through 3D printing, students can even reverse engineer printed models to enhance dimensional accuracy, ensuring digital and physical models match.

In artificial modeling, 3D bioprinting produces mesotissues, microtissues, and organoids to develop human disease models for drug discovery and toxicology. This intricate process requires the bioengineer to be familiar with several factors, such as morphology of anatomical structures, histology, biomaterials, cell biology, physics, engineering, and medicine to accurately select materials based on sensitivities of cell types, growth and differentiation factors, and technical challenges related to tissue being mimicked (Grignon et al., 2016; Morris, 2018). This multidisciplinary nature allows engineers to tackle surgical challenges such as knee joint replacement. By incorporating anatomical principles into computational models, bioengineers can simulate realistic physiological conditions and provide insights into the biomechanical behavior of the knee joint. This approach not only enhances our understanding of joint mechanics but also informs the design of orthopedic implants and rehabilitation strategies. Today's successful bioengineers and anatomists have bioprinted skin, bone, vascular grafts, tracheal splints, heart tissue and cartilaginous structures for surgical transplant (Morris, 2018).

Innovative technology continues to trend across disciplines and such coveted tools have undoubtedly enhanced visualization and accessibility to spatial learning and interactivity in anatomical education. However, certain challenges and limitations of these instructional methods suggest a need for renewed emphasis on living anatomical education, particularly the lack the tactile and embodied dimensions essential to deep anatomical understanding. To address these gaps, the following section considers how living anatomy can act as a vital supplement to modern technological approaches.

### **Living Anatomy Supplements the Limitations of Modern Technological Approaches**

Without doubt, modern technology provides interactive, engaging, and immersive learning experiences, resulting in expeditious advancements in anatomical education globally. However, these instructional tools bring inherent limitations, such as high implementation costs, lack of tactile and embodied learning experiences, insufficient anatomical variation, inconclusive learning outcomes (particularly for AR), and a limited theoretical grounding behind their effectiveness. These limitations hinder the development of a fully immersive and comprehensive curriculum. One method to address these limitations is to supplement technology with living anatomy. Examples of living anatomy education include live model examinations, palpation, body painting (where deep structures are painted on the surface of the skin), movement, and self-reflection. Movement and self-reflection in learners activate their sensory-motor systems. This consolidates anatomical comprehension, such as recalling structure names, localization, spatial recognition, and function (Cherdieu et al., 2017; Soames & Palastanga, 2018). These experiences offer students a holistic understanding that integrates abstract knowledge from technological tools with the practical, sensory-rich encounters necessary for their future professional roles. By blending technology with living anatomy, educators have an opportunity to create a comprehensive and balanced anatomy curriculum that prepares students for real-world demands.

Common limitations of VR and AR include cost and accessibility, as specialized equipment and yearly subscriptions for software can become costly, and side effects like motion sickness, eye fatigue, disorientation, and discomfort, which negatively impact learning experiences (Chang et al., 2020). Another limitation is the current lack of tactile stimulation, which decreases the face validity (degree to which reality is accurately represented) in anatomy students' immersive learning experience (Baniasadi et al., 2020; Meyer et al., 2020; Vaghela et

al., 2021). While haptic feedback is currently being developed for VR and AR, this is presently problematic as anatomy students in medicine, therapy and kinesiology require sufficient face-validity contexts that emulate their future professional settings to ensure preparedness. Living anatomy practices, such as movement analysis and self-directed exploration of one's own body can meaningfully supplement these technological limitations. Living anatomy engages learners in real-time with their own musculoskeletal systems and those of peers. This not only reinforces spatial and structural understanding but also fosters intercorporeal awareness, an essential skill in clinical, therapeutic, and artistic disciplines where touch, responsiveness, and somatic sensitivity are central.

Furthermore, due to lack of consensus on VR and AR efficacy, future studies should consider focusing on comparing different features of digital-based methods rather than just comparing digital-based to traditional methods. Considering the benefits of improved engagement, learning experiences, repeated use, versatility, the cost-benefit trade-off will vary based on institutional goals and resources.

Medical imaging is extremely useful in teaching anatomical variation, relation to pathology, and diagnostic familiarization through problem solving skills and critical thinking when deducing abstract images (Estai & Blunt, 2016). Similar to AR and VR, a limitation to medical imaging is the lack of the "feel" of tissue, which is a crucial aspect of learning human anatomy. For professions that must be well-versed in diagnostic ability, anatomy curricula could provide the missing tactile engagement with living anatomy education, such as palpation. Palpation examination is a procedure where a healthcare professional presses a specific region of a patient's body with fingers to detect the presence of features and abnormalities under the skin (Ribeiro et al., 2016).

3D printing has become an increasingly valued complement to traditional human body donor dissection, offering scalable, durable, and anatomically precise models that can represent rare or diverse pathologies. Limitations include concerns about color and texture realism compared to living bodies and donor bodies (Yuen, 2020). While 3D models hold great promise in anatomical curricula, they underscore the need for physical interaction with human living anatomy to develop a more nuanced understanding, especially for students preparing for clinical practice. Living anatomy offers the opportunity for students to interact with the dynamic, responsive qualities of the human body that static 3D models cannot replicate. Through guided

palpation, movement-based observation, and peer-based physical exploration, students gain insight into the subtle variations in tissue texture, tone, temperature, and responsiveness, qualities essential to clinical reasoning and somatic awareness. These embodied experiences enhance students' ability to interpret static anatomical models with greater depth, contextualizing anatomical structures within functional, living systems. In this way, living anatomy complements the visual-spatial strengths of 3D printing with the sensory-rich, intersubjective experiences necessary for professions grounded in human touch, movement, and care.

This integration of living anatomy with modern technological tools addresses the sensory limitations of digital tools while connecting theoretical knowledge with one's own living body. For example, physiotherapy and kinesiology students may experience living anatomy to emphasize the interactions between muscles, joints, and bones during movement (Rabattu et al., 2022), spatial orientation, natural variations, and insights to the applied aspects of our dynamic anatomy (Asad et al., 2023). Rabattu et al. (2022) found that kinesiology experimental participants with movement exercises throughout the semester demonstrated significantly higher scores on the final exam compared to the control participants. It was concluded that triggering one's own living body through movement enhances anatomical learning outcomes, especially when integrated into the curriculum deliberately.

Dancers use their experiential anatomical understanding to enhance awareness of their bodies, aiding in injury prevention and expressing authentic emotions through movement (Pengelly 2010). Salk (2005) shares how anatomy education for dancers involves tracing muscle lines, experiencing joint movements, and understanding functionality of joints to develop a comprehensive understanding of their bodies' capabilities and limitations. Concepts like “proximal stability for distal mobility” and “kinetic chains” empower performers to strike a balance between strength, flexibility, and artistic expression to convey narratives effectively, enriching their performances (Rózsavölgyi 2021; Salk 2005; Skotnicka et al., 2017). Experiential anatomy equips dancers with knowledge to make informed choices about their training, thereby promoting longer and healthier performance careers (Pengelly 2010; Rózsavölgyi, 2021; Salk 2005).

Visual artists also benefit from experiential anatomical education, which often includes gesture drawing, sculpting, and digital modeling to effectively study anatomy while catering to different student preferences. For example, life drawing sessions with nude models promote self-

reflection and help students understand the body's proportions and muscle structure, while sculpting allows for a tactile exploration of three-dimensional form (Inalouei, 2024).

Living anatomy education in bioengineering has played a pivotal role in developing detailed, customized prosthetics (Bisht et al., 2019). While bioprinting is a powerful tool that precisely places cells, biomaterials, and biomolecules in 3D space to build intricate anatomical structures, such as tissues and organs for organ transplantation, prosthetics, and surgical innovations (Seol et al., 2014), the success of these technologies heavily relies on a deep understanding of living anatomy. Bioprinting involves the technical aspects of printing biocompatible materials and cells and a nuanced comprehension of the functional and structural complexities of living tissues. For example, the design of a novel hand prosthesis by Dunai et al. (2020) underscores the importance of this knowledge. The prosthetic hand, fitted with sensors and actuators to allow motorized fingers to perform grasping movements, was developed with meticulous attention to the human hand's anatomy, including its dimensions, proportions, and functionality. The success of such devices hinges on an accurate replication of living anatomy, as even slight deviations can result in diminished functionality or user discomfort.

While modern technologies have brought significant advancements to anatomy education in spatial understanding and accessibility, their limitations underscore the enduring value of sensory-rich experiences in living anatomy. This is particularly significant in fields that need strong tactile understanding of human tissue, such as therapy, kinesiology, performing arts, and bioengineering. Technology alone cannot fully prepare students for practical, clinical settings, but sensory-rich encounters with the living body can complement technological approaches while creating foundation for experiential for experiential somatic learning.

### **What is Experiential Somatic Learning?**

Integrating living anatomy learning approaches into the classroom opens the door to more embodied, subjective, and somatic experiences of learning. To better understand these approaches, we must first define what is meant by experiential somatic learning and how it differs from traditional methods.

Experiential somatic learning, also known as embodied learning, is a learning process anchored in physical movement, proprioception, and body awareness (Emond, 2021; Lindgren & Johnson-Glenberg, 2013; Smyth et al., 2021). This means perceiving one's three-dimensional

movement not solely based on vision, but inherently spatially in the sense of kinaesthetically feeling the reality and the qualitative spatial dynamics of movement (Lloyd & Smith, 2021; Sheets-Johnstone, 2010). Experiential somatic learning in anatomy emphasizes the embodied integration of thought, perception, and movement, dissolving the traditional separation between mind and body in the learning process (Nielsen et al., 2013). As sentient learners, we harness an intrinsic connection with our corporeality. This aligns with Snowber's (2016) conception of embodied inquiry as a process of knowing through the body, where the felt experience of movement, presence, and reflection becomes central to learning and meaning making.

As Davis et al. (2008) highlights, knowledge is not merely an abstract entity but is deeply situated, embedded, and embodied; this suggests *not* that one learns *within* the body but rather that it is the body *itself* that learns. Learning through the body happens through a combination of feeling, acting, and reacting, which requires reflection of the experiential realities within us, with other bodies, and within our environment (Emond, 2021). This process of learning through feeling, acting, and reacting is also known as body pedagogics, which refers to principles and practices of education specifically through a multisensory experience (Johnson, 2007; Kelly et al., 2019). This approach is built upon Maxine Sheets-Johnstone's (1981, 2018) theory of movement, where she emphasizes the fundamental role of movement in the process of learning because cognition arises when the body interacts with its physical environment and our awareness of such movements forms our living experiences (Gallagher, 2014; Smyth, 2021). She argues movement is a vital aspect of human cognition and understanding as it allows us to make sense of our surroundings.

From a human anatomy education perspective, students would actively and kinaesthetically engage their bodies to deepen understanding of concepts taught in class. When students discover the human body through passive visuals and didactic lectures, they deny experiencing and embodying their corporeal reality, which leads students to disregard their own bodies as a site of knowledge construction. The body is sensate, full of somatic wisdom that connects the mind, body, and environment into a site of knowledge production (Kelly et al., 2019, p.973). "The experience of being embodied is... mediated by our continual interactions with other human and nonhuman bodies" (Weiss, 1999, p. 5), suggesting our existence in relation to others is something tangible and bodily (Csordas, 2008). For example, we can share and extend our bodily experiences (Merleau-Ponty, 1962) by seeing how our bodies function,

feeling the way our bodies move, or hearing the sounds our bodies make. The dualism in anatomy within HPE also limits the potential of ‘intercorporeal knowing’ (Kelly et al., 2019); this is social construction of knowledge, in the sense that human learning presupposes a specific social nature and a process by which learners grow into the intellectual life of those around them (Vygotsky, 1978, p.88), one that calls on the use of multiple sensory systems.

As discussed earlier in this chapter, embodied learning through living anatomy reinforces theoretical understanding, nurtures practical skills, and promotes a deeper understanding of the body’s structures and functions (Emond, 2021; Lindgren & Johnson-Glenberg, 2013). This immersive, sensory experience can reinforce the spatial orientation, proprioception, and anatomical variability learned from technological tools (Castro-Alonso et al., 2024). Through evidence-based approaches such as live model observation, palpation, body painting, self-reflection, and movement analysis (Petty et al., 2012; Meyer et al., 2020), students gain a physical, interactive understanding of anatomical structures that technology cannot currently replace. Therefore, integrating living anatomy with modern technological tools creates a balanced curriculum that bridges the gap between virtual representations and the physical realities of human anatomy.

### **Current Research on Experiential Somatic Learning in Anatomy Education**

Having established the core principles of experiential somatic pedagogy, this section introduces reports from dance and HPE programs that demonstrate the pedagogical impact of embodied approaches.

Research in experiential somatic learning seeks to explore how human bodies mediate, interpret, and interact with the experiences of everyday life (Smyth et al., 2021). Presently, a growth in quantitative research exploring experiential learning suggests that movements and gestures may provide a better understanding of educational subjects in young children, particularly in second language, mathematics, and spatial thinking (Macedonia et al., 2019; Macedonia & Knösche, 2011). Studies have shown that learning with the body helps students better visualize and understand the functions of anatomical structures for clinical relevance (Seo et al., 2021). Most undergraduate university dance departments incorporate experiential somatic anatomy as a first-year requirement (Denichaud, 2024; Green, 2002). Gross human anatomy in HPE tend to favour didactic lectures within the first few years of undergraduate studies (Ganguly

& Chan, 2008; Kelly et al., 2019). Depending on the institution and discipline, most commonly medicine, kinesiology, and nursing (MacPherson & Lisk, 2022; Lafave & Tomkins-Lane, 2014), universities may offer experiential learning through human body donor dissections in upper years of undergraduate study. As previously mentioned, although dissections are an experiential method of learning, it frames anatomical concepts from a pathological lens, far removed from HPE student's future patients. The somatic learning and teaching of anatomical concepts using the living, breathing body has massive potential to be further explored from a qualitative perspective.

### ***Somatic Pedagogy in Dance***

We see somatic experiential learning techniques predominate the dance disciplines as the body is the primary instrument for a dancer, and therefore understanding one's anatomy is a priority in dance education as it translates to accurate, expressive, and safe movement (Pengelly, 2010). The experiential and sensory awareness of complex anatomical concepts allows a dancer to holistically and personally learn human anatomy, viewing one's own body as a rich resource of anatomical comprehension (Smyth et al., 2021). This explains why most dance curricula, including K-12, offer direct knowledge of how the body moves. While younger dancers learn anatomy mainly through proprioception of particular body parts or feeling the breath and energy flow through the body, teen students employ more formal anatomical principles through movement exploration. University dance departments incorporate experiential anatomy and kinesiology as a basic requirement as many universities are supplementing dance education with separate somatic classes. Popular somatic training methods that require the active embodiment of human anatomy include the Alexander Technique, Feldenkrais Awareness through Movement, Kinetic Awareness, and Body-Mind Centering (Green, 2002).

Dancers and dance educators are connected to their anatomy in a way that HPE students would not likely deeply explore, especially given the time and resources constraints in scientific anatomical education. It is therefore especially valuable to analyze how dance anatomy educators employ their somatic techniques to lead students into appreciating how modalities of kinaesthetic awareness ground us and our social interactions (Sheets-Johnstone, 2010). This topic is explored in Chapters 4 and 5.

### ***Somatic Pedagogy in HPE***

As HPE evolves to meet the increasing complexity of patient care, there is a growing recognition that effective clinical training must go beyond technical knowledge to include embodied understanding. Somatic pedagogy offers a valuable lens through which to explore how movement, sensation, and bodily awareness can enhance anatomical learning. The following section explores the relevance and current somatic approaches across the broader context of curricular design and research methodology in HPE.

Physiotherapy services are continuously on the rise and their scope has spread to over 20 different specialties (CSP-Scope, 2022). This means physiotherapy students require greater anatomical training while its education continues to modernize. Physiotherapy licensing is achieved through a Master's degree in Canada (The Canadian Council of Physiotherapy University Programs, 2025), with applicants usually having an undergraduate degree in kinesiology or health sciences. Educational studies in kinesiology and physiotherapy education are profoundly dependent on quantitative research methodologies, with less than 4% of its literature employing qualitative approaches during the early 2000s (Gangata & Vigurs, 2023; Gibson & Marin, 2003; Petty et al., 2012). Most of these quantitative studies focus on student surveys and outcome-based measurements while the few qualitative studies offer valuable insights into student engagement, enriching clinical practice, and teaching with a deeper understanding of experiences, behaviors, and outcomes. These studies show that physiotherapy schools across North America tend to employ teacher-centred lectures throughout a typical three-to-four-year physiotherapy program (Abdur-Rahman, 2007; Latman & Lanier, 2001). This is unfortunately accompanied by an extensive amount of anatomical content, limited teaching time, challenges in transitioning towards student-centred learning, and a need to frequently revisit anatomical concepts (Gangata & Vigurs, 2023).

In this way, physiotherapy and kinesiology programs across the globe commence with an ocularcentric approach, a heavy focus on anatomical diagrams. Only later, typically from the second year onward, do programs introduce kinaesthetic anatomical skills and the clinical application (Gangata & Vigurs, 2023). This once again highlights the dualistic approach as visual and verbal information are assumed to be processed separately from experiential somatic comprehension of the body. Even in physiotherapy education, where health professionals are expected to restore movement and function of the living human body, there is a tendency to

undervalue non-visual learning, such as human actions, visceral sensations, and self-embodiment. Eventually, tactile and kinaesthetic approaches, such as palpating peers, using prosections, dissecting, physically assessing patients, and embedding anatomical concepts into clinical settings (Gangata & Vigurs, 2023) are introduced to complement the ocularcentric and dualistic teaching methods. This remains a common theme throughout education in North America, Japan, and UK physiotherapy schools (Kawashiro et al., 2009; Latman & Lanier, 2001; Reimer et al., 2013). Therefore, exploring how kinesiology or physiotherapy educators prioritize somatic and experiential comprehension in anatomy education will address the knowledge gap between theoretical anatomical knowledge and its practical application.

Nursing students, like kinesiology students, are required to become physically acquainted with skill application. For example, nursing students are expected to understand the science of palpation and sensory discrimination:

The finger pads facilitate fine because they are the most mobile parts of the hand. The palmar surface of the fingers and joints are best for assessing firmness, contour, position, size, pain, and tenderness. The back of the hand [dorsal] is most sensitive to temperature. Vibrations... are best felt with the ulnar, or outside surface of the hand (Jensen 2015).

Another example of using the living body in HPE clinical training is listening for the sounds from the heart and lungs: “repeated practice establishes body sounds as part of students’ perceptual repertoire. Deviation from these sounds can be the embodiment of pathology. Eventually these changes affect HPE student’s sensory judgements and diagnoses can become unconscious, intuitive, or habits of practice.” (Kelly et al., 2019, p.973). It is important for a health practitioner to be in contact with their bodily expertise when developing cognitive capacity (Erlandson, 2014; Kelly et al., 2019).

Although somatic learning is incorporated in some nursing lessons within lectures or during laboratory sessions, it comes second to the human anatomical concepts that are taught didactically (Kyte et al., 2023), segregated from the body, once again feeding into a dualistic perspective. Like physiotherapy, the body is incorporated into lessons later, which may cause potential confusion during the learning process. For example, it becomes easy to confuse similar concepts when disregarding the body as a primary learning resource, such as the concepts of arterial pulse versus heartbeat. To clarify, an arterial pulse is the abrupt expansion of an artery resulting from the sudden ejection of blood through the arterial system whereas a heartbeat is the contraction of the heart pumping blood to the lungs and body (Moran 1990). These concepts can

be studied using one's own living anatomy such as listening to one's own heartbeat or using ultrasound cameras. Nursing students are learning the fundamental principles within their first years to facilitate their understanding of concepts in later years (Kyte et al., 2023) whereas somatically inclined educators, like dancers, are reinforcing the mind and body connection by revealing information simultaneously. Using the body through a multisensory consciousness allows intuitive development of competence and motivates students in their educational progression (Kyte et al., 2023).

Research shows that somatically embodying one's anatomy and bodily function heightens subjective awareness of the body during movement. Conscious movement results in the development of efficient movement patterns, eventually becoming movement habits (Merleau-Ponty's, 1982; Shilling, 2017; Taylor et al., 2019). Habits enable us to "economize and simplify actions by storing fruits of past experiences so action can occur without having to devote heightened consciousness to every element" (Kelly et al., 2019). In HPE, repeated practice of physical examination skills reorganizes physicians' body schemas, a concept rooted in Merleau-Ponty's (1982) phenomenology of perception, allowing them to construct new learnings by integrating previous experiences with present environment. The practice of physical movement should thus be applied to anatomical studies in conjunction with verbal and visual cues so that a deep comprehension of the human body becomes experienced. This will encourage students to rely less on conscious recall of anatomical concepts and more on using the body intuitively and seamlessly to integrate anatomical knowledge into movement, enhancing the potential intercorporeal relations between students, teachers, and patients.

Experiential learning is increasing in popularity (Smyth et al., 2021) in various disciplines. Although HPE streams such as kinesiology and nursing incorporate experiential somatic learning techniques, they are often involved as an afterthought compared to the anatomical concepts that are first introduced as information dedicated to the mind. Forgoing the dominant dualistic approach to anatomy education provides an opportunity to examine the body's central place as a resource for anatomical comprehension in our interpretations and interactions with our physical and social environments (Kelly et al., 2019, p.968; Taylor et al., 2019). Through experiential somatic learning, the external environment eventually becomes an extension of corporeality and no longer demands conscious and explicit attention as students engage in daily health practice (Wilson, 2012). By being present in the lived body, students can

enhance and even accelerate learning by connecting and reflecting upon the internal and external aspects of desired learning (Emond, 2021).

These examples underscore the transformative potential of somatic learning, but how are such practices enacted by those who teach them? As qualitative experiential somatic learning is still an emerging area of research, there exists a gap in exploring anatomy educators' perspectives. This next section foregrounds educators' perspectives, emphasizing the importance of their lived experience in shaping anatomy curricula.

### **Educator's perspective**

This embodied approach is not only transformative for students, but also educators. This section explores how educators experience and apply somatic awareness in their teaching, shaping their pedagogy and fostering deeper connection with their students.

Experiential somatic learning is not limited to learners. Studies by Emond (2021) have shown that educators experiencing consciousness of their own bodies had dramatic positive effects on their teaching, such as improvements in self-perception and relations with students. Many teachers perceive and mobilize their bodies unconsciously when they teach, unless perceptions of teaching become negative, then teachers become more conscious. Somatic strategies push for a conscious bodily connection when teaching, no matter the perceptions. This helps educators by synthesizing internal and external sensations, intentions, and actions (Emond, 2021; Korthagen, 2004). When a teacher is actively aware of their internal (feelings and reflections) and external (actions, relationships, and environment) teaching coherence, their teaching becomes enhanced in quality and effectiveness, improving their overall practice and wellbeing (Emond, 2021).

Understanding the educator's perspective is essential when considering the impact of experiential somatic learning in anatomy education, especially across multiple disciplines. In every discipline, educators actively shape the learning environment through their own embodied presence, gestures, and engagement strategies. If educators themselves are disconnected from their own somatic awareness, they may unconsciously continue to perpetuate the traditional, dualistic, disembodied, and ocularcentric approach to their discipline-specific anatomical education. Conversely, when they cultivate somatic awareness in their teaching, they create more immersive, multimodal learning experiences that deepen student engagement and comprehension

(Hegna & Ørbæk 2021; Reeves & White 2021). Educators who cultivate somatic awareness teach not just with their minds but through the wisdom of their lived, expressive bodies, transforming pedagogy into a relational and reflective practice (Snowber, 2016).

Furthermore, educators often take on additional roles, such as facilitators and engagement designers. As facilitators, they support learners in developing more advanced and sophisticated understanding of the content by, for example, asking questions instead of explaining the concept (Bauersfeld, 1995). As engagement designers, they create intuitive situations to devote consciousness to the task at hand (Davis et al., 2015, p.166). This reinforces active learning, shifting the focus away from the educator and towards the learner and the learner's body as the centre of knowledge construction (Braun, 2018). To support and challenge a learner's thinking, the facilitator or engager "should provide rich environments, engaging experiences and activities for learning by incorporating opportunities for collaborative work, problem solving, and authentic tasks" (Ndon, 2011, p. 253). As previously mentioned, enriching somatic activities, such as body painting or creative patchwork modeling (Barmaki et al., 2019; Estai & Blunt, 2016; Noël, 2012), are some creative methods of experiential anatomy pedagogy. By recognizing and prioritizing the educator's own somatic experience and its relationship to learner's somatic experiences, anatomy education can shift from a dualistic, fragmented approach to a more holistic, embodied learning process that improve intercorporeal knowing.

While educators play a critical role in shaping pedagogy, they often remain siloed within their own disciplines – and this presents another research gap to address. The following section highlights the research on barriers that hinder cross-disciplinary collaboration in anatomy education.

### **The Lack of Cross- and Interdisciplinary Anatomy Education**

In addition to the gaps of literature addressed previously, there is also a marked lack of cross-disciplinary dialogue and collaboration between the many disciplines that teach anatomical concepts (Albert et al., 2020; He, 2025). While these disciplines each use anatomy extensively, they rarely exchange pedagogical strategies or epistemological perspectives, resulting in discipline-specific, siloed, and inconsistent anatomy curricula across institutions. This creates drastic missed opportunities for interdisciplinary learning and innovation, despite growing evidence of the benefits of collaborative anatomy learning (Mat Nawi & Hadie 2024).

Medical education, despite its frequent self-characterization as interdisciplinary, also demonstrates this siloed tendency. As Albert et al. (2020) show in their bibliometric analysis, 81% of references in top medical education journals come from within health-related research clusters, including applied health research and medical education itself, while only 19% draw from education, other disciplinary, interdisciplinary, or topic-centred sources. This calls into question the actual interdisciplinarity of medical education scholarship. It suggests that even within a field claiming interdisciplinary status, there is limited engagement with the arts, humanities, and social sciences, which are areas that could offer valuable insight into embodied, relational, or somatic approaches to education.

This issue becomes especially relevant in anatomical education, a subfield of medicine, that is equally if not more restricted in its theoretical and methodological collaborations with adjacent disciplines such as movement science, arts, or engineering (Albert et al., 2020). Many current technological tools, such as 3D modeling and VR/AR, prioritize form over felt experience and are developed within a technical or biomedical lens (He, 2025). Meanwhile, since visual arts and dance instructors engage deeply with the moving, sensing body, there are some examples of their anatomy education approaches integrated into HPE (Mukunda et al., 2019). Conversely, expressive disciplines like visual arts and dance rarely have access to clinical anatomical resources or educational partnerships that could deepen their practice with structural precision (He, 2025).

As Albert et al. (2020) argue, privileging a narrow range of epistemologies in anatomy creates a pedagogical imbalance: expressive and somatic knowledge is often dismissed in clinical settings, while clinical anatomy remains overly abstracted from lived bodily experience in expressive fields. A more integrated approach, where knowledge and practices flow freely across disciplines, could foster a richer and more humanizing anatomy education. Such integration also resonates with broader research on cross-disciplinary collaboration, which emphasizes the value of moving beyond isolated disciplinary silos. As Heitzmann et al. (2021) suggest, multidisciplinary, interdisciplinary, and transdisciplinary approaches each offer unique ways of linking, blending, or transforming disciplinary perspectives. Applying these frameworks to anatomy education underscores the need for collaborative problem solving and shared conceptual frameworks, ensuring that expressive, clinical, and technical fields can work together toward more holistic and humanizing pedagogies.

These institutional and philosophical silos have created a fragmented anatomy education landscape that fails to fully leverage and highlight the strengths of diverse disciplines. To move forward, anatomy education must embrace a more integrated, balanced approach that honours both technological innovation and embodied experience while promoting cross-disciplinary collaboration.

### **Bridging Innovation and Embodiment in Anatomy Education Across Disciplines**

By leveraging the strengths of both innovation and living bodily experiences, educators can create a balanced, comprehensive and dynamic learning experience where students become equipped with foundational theoretical knowledge and practical real-world competencies required in applied settings (Estai & Bunt, 2016; Joyce, 2012).

For educators inspired to integrate more anatomy into their curriculum, it is important to consider the costs and benefits of each teaching method, align them with course objectives, and determine the most suitable combination of teaching methods to meet their educational goals. This allows anatomical education to become a rich, multidimensional experience as one directly experiences the theoretical concepts on the physical structures and functions of a living body. While intellectual learning is valuable, the *felt sense* of one's own body comes through experience, experimentation, and proprioception (Hanna, 1988; Smith 2019).

In recognizing the preferences, successes, and limitations of various disciplines and how they apply modern technological instructional tools, this research study aims to address the knowledge gap in experiential learning in anatomy education across various disciplines. Learning how disciplines teach and apply anatomical concepts specific to their field paves the way for future interdisciplinary advancements in anatomical research (Bremner et al., 2023; Speed et al., 2024), technological education approaches (Estai & Bunt 2016; Bankar et al., 2024), and overall practice (Classen, 2020; Emond 2021; Weiss 1999).

This thesis addresses this critical gap by examining how anatomy is taught and experienced across expressive (visual arts and dance), clinical (kinesiology and medicine), and technical (engineering) disciplines. It aims to support more inclusive, embodied, and interdisciplinary approaches to anatomical sciences education. By synthesizing the somatic experiences of anatomy educators across disciplines, this research offers qualitative insights

alongside practical and transferable frameworks for integrating somatic approaches across disciplines.

Having reviewed the historical, disciplinary, and technological landscape of anatomical education, Chapter 2 highlighted both the limitations of current approaches and the potential of experiential somatic methods across disciplines. These insights set the stage for the present research study, which seeks to explore the lived experiences of anatomy educators who engage in somatic teaching. The next chapter frames this inquiry by presenting the central research questions, theoretical framework, philosophical assumptions, and researcher positionality statement.

### **Chapter 3: Methodology**

This chapter begins by framing the inquiry and presenting the research questions that emerged from the gaps in literature identified in Chapter 2. These questions explore how anatomy educators across disciplines integrate experiential somatic learning and how their insights can inform interdisciplinary approaches to anatomy education in Health Professions Education (HPE). The chapter then introduces the Function2Flow (F2F) model, which serves as the theoretical framework and sensitizing concept that shapes both data collection and analysis. This is followed by a discussion of the philosophical assumptions and researcher positionality statement that underpin the research. These segments explain how this thesis drew from constructivist and pragmatic traditions aligned with Merriam's approach to qualitative case study and how my background and evolving role as both insider and outsider shaped the research process and contributed to its methodological rigour. Finally, this chapter includes an exploration of case study methodology, the study design where I describe the context of my research, instrument development, data collection procedure, data analysis processes, and ethical considerations.

#### **Research Questions**

As explained in Chapter 2, anatomy is taught across a variety of disciplines, yet the educators rarely have opportunities to consider or experience how it is approached outside their own fields. As experiential somatic learning gains prominence, the insights of somatic anatomy educators are valuable in promoting and deepening bodily consciousness into anatomy lessons across all disciplines. The research questions that guide this research study are:

Research question 1: How do anatomy educators across disciplines integrate experiential somatic learning methods to bridge the gap between theoretical anatomical knowledge and embodied understanding and thereby promote comprehension and intercorporeal connections?

Research question 2: How can these cross-disciplinary insights transform anatomy in HPE?

#### **Theoretical framework: Function2Flow**

My research into the somatic experiences of anatomy educators is framed by the original F2F model (Lloyd, 2014, 2016, 2021b; Lloyd & Smith 2021). The original F2F model was developed by Lloyd and Smith (2009, 2010) and charts an individual progression through four

stages of movement consciousness: *Function, Form, Feeling, and Flow* (Lloyd, 2011). The model supports a deepening awareness of the body in motion, from mechanical understanding to aesthetic expression, sensory attunement, and finally, a felt sense of integrated flow (Lloyd, 2011). The model has since developed to reflect relational and interactive dynamics. Recent studies (e.g., Lloyd, 2021b; Lloyd & Smith, 2022) emphasize relational somatic interaction, especially in contexts like partnered dance, community-based aging programs, and collaborative movement inquiry. My focus in this research explores how each educator personally navigates and articulates their own somatic awareness as they move through the stages of *Function, Form, Feeling, and Flow* in the context of anatomy education. This emphasis on interiority supports a phenomenologically grounded exploration of how educators come to know, sense, and express the body through their teaching practice.

According to Lloyd (2015, p.5), “The purpose of the F2F model is to broaden how any physical activity may be understood and assessed in a way that blurs and integrates disciplinary boundaries”. This integrative vision aligns with Maxine Sheets-Johnstone's (1999) assertion that movement plays a fundamental role in the process of learning and is vital for making sense of the world while acknowledging the interconnectedness of mind, body, and environment. Sheets-Johnstone further believes in the value of kinesthetic learning, where learners actively engage their bodies and physical actions to deepen understanding of concepts. Examples of this include hands-on experiments, role-playing, artistic expression, and physical exploration, which are ways to enhance learners’ cognitive abilities and overall improve learning outcomes through a more holistic learning.

The F2F model, which draws on principles from exercise physiology, physical education pedagogy, somatic awareness, motivational psychology, and existential phenomenology (Lloyd, 2016; Lloyd & Smith, 2021), supports interdisciplinary inquiry from multiple perspectives to understand and enhance movement experiences. Recognizing the inherent relationship between movement, learning, and teaching, the F2F model guided how I observed and analyzed the somatic teaching practices of anatomy educators from visual arts, dance, medicine, kinesiology, and engineering.

To reiterate, since my thesis is rooted in an individual perspective, the F2F model best allows me to trace each educator’s somatic experiences when teaching anatomical concepts through their bodies. Drawing inspiration from Lloyd’s autobiographical and motion-sensitive

writings (Lloyd, 2011, 2016, 2021a), I focus on the somatic dimension of the educator's teaching as a deeply personal, embodied journey shaped by lived experience, disciplinary context, and internal awareness. Just as Lloyd (2011) explored her evolving relationship to movement through running with her dog, or how breastfeeding (Lloyd, 2012) became a curriculum of the body, I use the F2F model to investigate how educators from multiple disciplines transition from functional instruction to embodied flow states during teaching. To further clarify, my focus is not on the relational dynamics between educator and students, but rather on the educator's own somatic awareness, pedagogical embodiment, personal engagement with anatomy as lived knowledge, and their perceived intercorporeal connections during their teaching. When educators reflect on their students' engagement or describe intercorporeal connections, these are analyzed as part of the educator's own embodied perspective, rather than co-experienced phenomena. These transitions, which are expressed through gesture, sensation, emotion, and energy, resonate with the F2F model's emphasis on experiential, self-reflective, and body-based meaning-making. My research extends this lineage by applying the F2F model to the teaching body, highlighting how individual somatic awareness becomes a site of pedagogy.

The F2F model has the following four consciousnesses:

*Function* pertains to kinaesthetic consciousness, such as the way health-related fitness or movement is conceived. This pertains to a specific movement pattern like sitting, reaching, elongating, or twisting.

*Form* represents aesthetic consciousness, such as the outer shape and visible expression of bodily movement, including the process of movement maturation. This pertains to the shapes and positions specific body regions take to adapt to the environment and conditions.

*Feeling* emphasizes kinaesthetic consciousness, or the inner sensations and perceptions experienced during movement, such as musculoskeletal sensations. This includes examples such as rhythm of the breath, timing of movement, the force of movement, or even muscle exhaustion from the movement.

*Flow* highlights an energetic consciousness such as the existential dimension of movement, encompassing the long-term possibility of experiencing pleasurable connections between the motions, persons, and the world at large. Examples of Flow are a sense of effortlessness or where time seems to pass at a different rate.

The InterActive prompts for the F2F model is shown in Figure 2, taken from the Function2Flow website.

<b>INTERACTIVE WAYS TO CONNECT</b>	<b>RELATIONAL AWARENESS OF POSTURES, POSITIONS, GESTURES &amp; EXPRESSIONS</b>
<b>InterActive Function</b> (Actions & Interactions)	What motional dynamics characterize this situation, circumstance, event or encounter? Are you bending, crouching, lunging, walking, rolling, reaching, leaning, stretching, withering, expanding, swelling, lifting...?
<b>InterActive Form</b> (Postures & Positions)	What shapes, body positions, postures and movement patterns emerge in pivotal moments? Describe postural & positional twists, angles, and turns of optimal interaction, amplitude & direction.
<b>InterActive Feeling</b> (Sensations of Timing & Force)	What effort qualities (i.e., force + timing) do you feel in these moments? Is the movement heavy, light, grounded, floating, steady, slow, sustained, sudden, quick, fast, heavy, light, fleeting, smooth...?
<b>InterActive Flow</b> (Connecting Energies: Self-Other-World)	What energetic and synergistic registers of motional resonance do you sense with self/others/world? Do you feel connected, attuned, in synch, more than yourself...?

Figure 2. Application of Function2Flow Model from <https://function2flow.ca/the-interactive-for-life-project/interactive-function2flow-model/>

Examples of how the F2F model is applied to designing interview questions and observational protocols for this study is show in Appendices C and D.

It is important to consider that flow, as articulated in the F2F model, can also be understood alongside several complementary definitions that show how this phenomenon manifests in movement, motivation, relational energy, and cognition. Rudolf Laban was an Austro-Hungarian choreographer and movement theorist, conceptualized flow as a dynamic quality of movement itself, describing “free” and “bound” flow within his Effort system. This is

a framework that analyzes how weight, time, space, and flow shape the bodily control, qualitative feel, continuity, and rhythm of movement to express the mover's inner state and evolving relationship with space and time (Laban, 1950/1971). Mihaly Csikszentmihalyi was a psychologist known for founding flow theory in positive psychology. Csikszentmihalyi (1988, 1990) theorized flow as an optimal motivational state marked by deep absorption, intrinsic enjoyment, and a balance between challenge and skill. This construct has been widely applied in studies of sport, the arts, education, and creativity (Anuhamdeh, 2020; Beck, 1992). Building on somatic and phenomenological perspectives, Canadian scholars of movement education and phenomenology Rebecca J. Lloyd and Stephen J. Smith extend flow into an energetic, intercorporeal phenomenon, arguing that "interactive flow" emerges between partners, groups, and environments and can be traced through the Function2Flow model across function, form, feeling, and flow (Lloyd & Smith, 2021; Lloyd, 2022). From an extended-cognition viewpoint, philosopher Andy Clark proposes that intelligent activity unfolds through self-organizing loops that link brain, body, and world, such that "intellectual flow" names moments when these distributed systems coordinate seamlessly in adaptive, creative problem solving (Clark, 1996).

Taken together, these perspectives reinforce that while this study uses the F2F model, flow itself can appear as movement quality, psychological absorption, relational energetic exchange, or distributed cognitive organization, so the analysis must remain open to these diverse manifestations in educators' practices. Importantly, I therefore applied the F2F model not as a rigid or prescriptive framework, but as a sensitizing concept as described by Blumer (1954). Rather than offering definitive classifications with fixed empirical referents, the model provided a flexible lens that suggested directions for inquiry. In practical terms, the F2F dimensions oriented what I attended to in interviews and observations, such as moments of functional explanation, aesthetic shaping, kinaesthetic attunement, or sensed flow, without requiring that participants' accounts be forced into predetermined categories. During analysis, the model operated as a provisional guide that was continually adjusted in dialogue with the data, allowing new meanings and nuances to reshape how Function, Form, Feeling, and Flow were understood in context. Merriam (2002) describes qualitative researchers as interested in understanding individuals' experience of a phenomenon within a specific time frame and context. Understanding such experiences and their meaning requires interpretation (Merriam, 2002). As Blumer (1954) notes, sensitizing concepts give researchers "a general sense of reference and

guidance in approaching empirical instances” (p. 7). The F2F model allowed me to remain attuned to the distinctive, situated ways in which participants used movement, sensation, and relationality in their teaching. It also enabled a context-sensitive and iterative process of interpretation that stays grounded in the lived experiences of educators. This is important so that my inquiry remained responsive to the embodied realities of anatomy educators across visual arts, dance, medicine, kinesiology, and engineering. This orientation parallels Snowber’s (2016, p. 45) vision of embodied inquiry, where research is not only about bodies, but also conducted through the sensate, intuitive, and expressive body of the researcher. By mapping educator practices to this framework, this study captured both the structured and emergent qualities of embodied teaching and highlights how anatomy becomes lived and understood through dynamic interaction.

### **Philosophical Assumptions**

My philosophical assumptions as a researcher, educator, and student are deeply rooted in pragmatism and constructivism. I believe that knowledge is socially constructed, shaped by interactions and experiences, and best understood through methods that accommodate the evolving nature of inquiry. I will be using case study methodology and my philosophical assumptions aligning with Sharan B. Merriam’s pragmatic constructivist approach to case study research. Merriam’s (1998, 2009) approach integrates diverse research methods based on the nature of the research question rather than adhering strictly to a predetermined framework, like Yin’s post-positivist approach. Merriam (1998, 2009) emphasizes particularistic, descriptive, and heuristic understandings of a case, allowing for a dynamic and responsive methodology (Harrison et al., 2017; Yazan, 2015). Unlike Yin’s (2002) more rigid methodologies and Stake’s (1995) priority of intuition over protocol, Merriam’s (1998) approach permits progressive focusing and guidance in data collection and analysis, enabling me to refine my inquiry as new insights emerge. Her emphasis on triangulation and internal validity supports my commitment to methodological pluralism, reinforcing the depth and trustworthiness of my findings. Moreover, her constructivist analytical techniques, such as consolidation, reduction, and interpretation (Merriam, 1998), provide a structured yet adaptable way to make sense of complex qualitative data. By offering clear yet flexible guidance on data collection, ranging from conducting effective interviews to systematic document analysis (Merriam & Tisdell, 2016), Merriam (1998)

provided a practical roadmap that prioritizes understanding the case itself over rigid methodological adherence, a perspective that aligns with my holistic and interdisciplinary research on experiential somatic learning in anatomical education.

### **Researcher's Positionality Statement**

In designing and carrying out this multiple case study, I have explicitly situated myself within the continuum of insider and outsider roles first articulated by Aoki (1996) and later discussed by Corbin Dwyer and Buckle (2009). Insider researchers share relevant experiences or characteristics with participants, while outsiders enter the field with limited firsthand knowledge of the phenomenon. As Corbin Dwyer & Buckle (2009) propose, qualitative researchers cannot fully retreat into a distant “researcher role as we carry the stories of our participants. The intimacy of qualitative research empowers us to occupy the space in between, oscillating between insider and outsider positions depending on our perspectives and contexts. In practice, qualitative inquiry often unfolds in the “space-between,” where the investigator moves fluidly along an insider–outsider continuum in response to context and perspective.

Given that my professional background spans some of the disciplines under study, I approach some cases as a near-insider (e.g., arts-based anatomy) and others as a relative outsider (e.g., engineering applications). This shifting stance enriches data generation yet also introduces the potential for bias. To uphold methodological rigour consistent with qualitative case study principles (Stake, 1995; Yin, 2014), I engaged in continuous reflexive practice, including memo-writing, participant co-reflection, and maintenance of an audit trail.

Accordingly, my prior experiences and genuine interest in multidisciplinary anatomy education informed (but did not predetermine) my interactions with participants and my analytic decisions. Through systematic reflexivity, triangulation of data sources, and transparent reporting of analytic procedures, I sought to enhance credibility, dependability, confirmability, and transferability (Lincoln & Guba, 1985) (this is further elaborated in Chapter Four), thereby aligning my positional stance with established standards for trustworthy qualitative case study research.

### **Case Study Research Methodology**

In this research study, I am using case study as a research methodology to explain why specific research methods were used and how data analysis was conducted (Hamilton & Corbett-

Whitler, 2013). Specifically, I will employ Sheran Merriam's (1991, 2002) approach to multiple case study with individual focus to explore the somatic teaching practices of anatomy educators of various disciplines (this is further elaborated in the following section).

Case study research, as described by many contributors from various disciplines and epistemological underpinnings, must occur within a bounded system, be exploratory and explanatory in nature, take place within the case's real-life setting, and employ multiple comprehensive data collection methods (Creswell, 2014; Flyvbjerg, 2011; Harrison et al., 2017; Merriam, 2002, 2009; Stake, 2003; Takashi, 2020; Yin 2015; Adams et al., 2022).

Case study research intensively explores an individual "unit of interest", known as "case" within a "bounded system" over time. Common boundaries include participants, time, place, location, and/or activity to be explored. The boundaries are set by the researcher and are essential to focusing, framing, and managing data collection and analysis (Creswell, 2013; Brown, 2008; Harrison et al., 2017; Merriam, 2009; Stake, 2003; Stewart, 2014; Yin, 2014). With multiple participants, the boundaries of each case in my research are each individual participant teaching a specific anatomical concept in their real-life class as part of their overall curriculum. I set these boundaries to focus, frame, and manage data collection and analysis (Creswell, 2013; Brown, 2008; Harrison et al., 2017; Merriam, 2009; Stake, 2003; Stewart, 2014; Yin, 2014). Individual focus refers to the detailed examination of each distinct case within the study. This approach was selected as it allowed me to intensively explore and explain the unique aspects of each case to provide holistic descriptions and analysis, capturing the complexity and particularity of each case (Merriam, 2002; Merriam & Tisdell, 2016).

Case study aims to generate an in-depth, multi-faceted appreciation of the case to answer why and how research questions, rather than what questions (Creswell, 2013; Crowe et al., 2011; Flyvbjerg, 2011; Merriam, 2009; Stake, 2003; Stewart, 2014; Yin, 2014). The phenomena must be explored, explained, and/or described in its real-life setting, which is fundamental to understanding its contextual variables (Merriam, 2009; Stake, 2003; Yin, 2014). Successful case studies provide descriptions and are often used to test, refine, and/or generate theories or themes (Eisenhardt, 1989).

Multiple data collection and analysis methods are encouraged in case study research to provide a synergistic and comprehensive view of the phenomenon (Flyvbjerg, 2011; Harrison et al., 2017; Merriam, 2009; Stake, 2003; Yin, 2014). They triangulate and ensure the reliability of

data to circumvent errors and more accurately understand the case (Bhasin, 2019; Eisenhardt, 1989; Harrison et al., 2017; Lincoln et al., 2011; Takashi et al., 2020). Common data collection methods include interviews, focus groups, observations, surveys, and exploring artefacts (Eisenhardt, 1989; Harrison et al., 2017, Paul Vogt, 2011; Pope & Mays, 2006).

### ***Case Study Research Methodology - Epistemology***

A researcher's epistemological standpoint grounds and shapes the investigation process and governs the theories and methods employed (Furlong & Marsh, 2002; Stake, 2005). In case study research, there are three dominant voices and accompanying orientations that guide case study methodology: Robert Yin the methodologist, Robert Stake the interpreter, and Sharan Merriam the educator (Brown, 2008; Hamilton & Corbett-Whittier, 2013; Harrison et al., 2017; Rolfe, 2006; Yazan, 2015).

Yin (1994, 1999, 2002, 2014) adopts a post-positivist stance, emphasizing objectivity, validity, and generalizability. He views case study as a structured method of empirical inquiry designed to answer “how” and “why” questions in real-life contexts, requiring carefully pre-planned protocols, theoretical propositions, and strict data collection procedures (Yin, 2014; Yazan, 2015). While this design provides clarity and rigour, it offers limited flexibility once the study begins.

In contrast, Stake (1995, 2005) approaches case study as a constructivist and interpretivist, focusing on the richness and particularity of each case. He values intuition, researcher interpretation, and emergent design, preferring progressive focusing over rigid structure, and emphasizing the co-construction of meaning between researcher and participant (Harrison et al., 2017; Stake, 1995; Yazan, 2015).

Merriam (1998, 2009), a pragmatic constructivist, blends aspects of both. Like Stake, she believes knowledge is socially and experientially constructed and supports flexible, evolving research design. Yet, like Yin, she stresses the importance of careful planning, clear research questions, and systematic data analysis for generating trustworthy findings (Brown, 2008; Harrison et al., 2017; Yazan, 2015). Merriam offers a balanced approach that is interpretive yet methodologically grounded, making her framework particularly useful for researchers like myself who seek both flexibility and guidance.

As previously explained, my philosophical assumptions are deeply rooted in pragmatism and constructivism, aligning with Sharan Merriam, the educator and educational researcher (Brown 2008). Merriam believes “reality is not an objective entity; rather there are multiple interpretations of reality” (Merriam, 1998) that are socially and experientially constructed (Harrison et al., 2017; Merriam, 2009). She sees case study as a research methodology that provides “in depth description and analysis of the bounded system”. She emphasizes that case study research focuses on understanding the knowledge constructed by people within a case and that the investigation is particularistic, descriptive, and heuristic in nature (Harrison et al., 2017; Merriam, 2009; Yazan, 2015). She believes in multiple-layered, constructed perspectives and elucidates that researchers bring a construction of reality to the investigation that interacts with the reality of those being studied. The product of case study is “yet another interpretation by the researcher of the case subject’s view filtered through their own” (Merriam, 1998).

Merriam’s pragmatic approach encourages the use of solidified research questions and the use of qualitative and quantitative data collection methods. However, there must be careful planning to holistically generate inductive reasoning, to interpret results, and to triangulate data for quality assurance (Brown, 2008; Harrison et al., 2017; Merriam, 1998, 2009; Yazan, 2015). Merriam’s definition of data analysis involves “consolidation, reduction and interpretation... to make meaning of observations” (Merriam, 1998).

### ***Strengths and Limitations of Case Study Research Methodology***

One of the major strengths in case study research is its fluidity in accommodating various ontologies, epistemologies, and research methods, allowing researchers to study an array of phenomena and complex interactions. This advantage allows the tailored application of case study to the specific research problem (Flyvbjerg, 2011; Harrison et al., 2017; Merriam, 2009; Sandberg, 2005; Stake, 2005; Yin, 2014).

Despite being contested by researchers of varying backgrounds, case study is one of the most popular qualitative research methodologies today because of its methodological advantages. Case study allows for naturalism, where researchers can watch subjects in their own territory, interact with them in their own language, and on their own terms (Pope & Mays 2006). This advantage bolsters researchers' capability in understanding the many complex layers of human behaviour and social interaction (Crowe et al., 2011; Flyvbjerg, 2011; Harrison et al.,

2017; Pope & Mays, 2006). The explanations and descriptions of how phenomena in everyday contexts unfold are useful for finding causal links within the case. This is particularly advantageous when developing, refining, or disproving themes or theories. (Crowe et al., 2011; Yin, 1994). A case study's ability to "close in" on real-life situations allows a close collaboration between researcher and participant(s) where the researcher is able to explore the participants' reality and better understand phenomena from their perspective (Brown, 2008).

As with every qualitative research methodology, there are a few challenges and limitations (Creswell, 2013; Paul Vogt, 2011; Yazan, 2015). Foremost, there is not a full consensus on case study definitions, approaches, and applications because it has been convoluted by many contributors of various-disciplines and epistemological underpinnings (Brown, 2008; Creswell, 2013; Hamilton & Corbett-Whitler, 2013; Stewart, 2014). The on-going debates between researchers of varying disciplines and epistemic backgrounds hampers the full evolution of case study (Harrison et al., 2017; Merriam, 2009; Stake, 1995, 2005; Yin, 2002). According to some researchers, case study does not have legitimate status as a research methodology because it does not have agreed-upon definitions nor structured protocols (Yin, 2002). Seen more positively, this ostensible limitation can be viewed as an advantage: researchers can come up with combined perspectives and conditions to best serve their research question (Paul Vogt, 2011; Yazan, 2015).

A taxing challenge during the initial stages of case study is identifying the case to be studied (Baxter & Jack, 2008; Harrison et al., 2017). The researcher must dictate how this methodology will unfold, including how the system is to be bound, if there is more than one boundary, and if it is worthy of study, etc., all the while anticipating the unexpected. Cases have plenty of unexpected variables that are intricately wired into political, social, historical, and personal contexts (Baxter & Jack, 2008; Stake, 1995; Yin, 2002).

A major criticism of case study is its "lack of scientific rigour and compromised validity" due to its inability to generalize. I argue that this criticism is off target because the purpose of case study is particularization (Brown, 2008; Crowe et al., 2011; Harrison et al., 2017; Merriam, 2009; Stake, 1995; Stewart, 2014). Furthermore, scientific rigour can be addressed through respondent validation, data triangulation, and transparency throughout the research process (Crowe et al., 2011).

Lastly, researchers can lose sense of proportion when dealing with vivid, voluminous data. Qualitative research generally deals with words that are measured through taxonomy or classification. This means that data are organized into categories or themes based on their characteristics or meanings, rather than quantified numerically (Baxter & Jack, 2008; Merriam, 2009; Pope & Mays, 2006; Yin, 2002). Delineating the most important relationships from the idiosyncrasies of a particular case can be challenging; therefore, a researcher must enter the scene with sincere interest in learning how the case functions while putting aside any previous presumptions (Stake, 1995, 2003).

### **Study Design**

This thesis dissertation uses a multiple case study with individual focus across five disciplines (visual arts, dance, medicine, kinesiology, and engineering) to explore the living anatomy embodiment and pedagogy in anatomy education. This dissertation contributes to the discussions on bridging theoretical knowledge with embodied understanding in anatomical pedagogy. This study uses the F2F model as a comprehensive guide to understand the somatic experiences and intrinsic awareness of teaching anatomical concepts.

While this study includes educator insights and examples of practice, it extends beyond reporting best practices. I am synthesizing these accounts alongside my own embodied, somatic observations of educators in action, paying close attention to how anatomy is taught using the F2F model to analyze gestures, movements, perceived relational dynamics, intention, and spatial awareness. This direct engagement allows me to contribute original insights into how somatic anatomy is enacted across disciplines. This research investigates how anatomy educators across disciplines engage with somatic pedagogy in dynamic, embodied, and context-specific ways; a qualitative approach is therefore essential (Merriam & Tisdell 2016, p. 6). The study seeks to understand not only what educators say about their methods, but how their teaching unfolds through movement, gesture, and intercorporeal interaction. Therefore, I employ the F2F model as a theoretical framework to explore how educators transition from functional and formal anatomical instruction to deeper layers of feeling and flow. This model supports an embodied lens of analysis that aligns with the core values of somatic and intercorporeal learning. In tandem, the case study methodology allows for in-depth, situated exploration of teaching practices across multiple disciplines, capturing the complexity and richness of real-time experiences. Together, F2F and case study research provide a comprehensive and responsive

approach to studying somatic education in action, enabling a synthesis of layered insights that may inform anatomy instruction across traditionally siloed disciplines.

### **Data Collection**

Data were collected over 12 months using a multi-modal qualitative approach. The entire process of data collection progressed through interviews, artifact analysis, observations, and follow-up co-reflection interview sessions (Eisenhardt, 1989; Harrison et al., 2017, Pope & Mays, 2006). This process explored and revealed how gesture, touch, and movement deepen anatomical understanding while promoting perceived intercorporeal connection. Participants were interviewed about their experience using somatic learning approaches, focusing on teaching strategies, learning objectives, and embodied engagement. Through these methods, I uncovered and interpreted (Merriam, 2002) how anatomy educators – from visual arts, dance, kinesiology, medicine, and engineering – somatically experienced teaching anatomical concepts. Throughout this study, I progressively focused my research as I interviewed my participants on their somatic experiences in teaching anatomy, observed their educational methods, interactions, and activities as they happen in practice, studied class related artifacts, and co-reflected with my participants. This gave the participants and me further opportunities to discuss interview and in-class moments, ensuring their experiences are appropriately interpreted.

### ***Participant Recruitment***

The overall purpose of this research is to generate insights that are relevant across and between disciplines with varying degrees of engagement with somatic and anatomical content. I purposefully sampled (Patton, 1990) Canadian post-secondary educators from various disciplines who were committed to somatic experiential teaching strategies of gross human anatomical concepts. This purposive sampling was designed to illuminate both the depth of somatic anatomy teaching and the breadth of its application across diverse educational contexts. From an initial pool of 56 faculty members identified through faculty biographies, course syllabi, publications, and direct inquiry, 9 educators met the inclusion criteria – and were teaching during the investigator’s data collection period; they were invited to participate. Of these, 5 were ultimately selected to support cross-case comparability across expressive, clinical, and technical disciplines. Eligible participants received an email invitation to join the study (Letter of Invitation in

Appendix B; Letter of Informed Consent in Appendix C). Two educators were turned away because their teaching practices did not align with the inclusion criteria, one did not respond, and one initially consented but later withdrew due to time constraints.

### ***Instrument development & Data collection procedure***

#### **Initial interview.**

The development of data collection instruments was guided by the F2F model (Lloyd, 2011; Lloyd, 2012; Lloyd & Smith, 2009; 2022), which served as the primary sensitizing framework for inquiry. Interview guides, guided by Merriam's (1988) effective interviewing recommendations, were designed to explore how anatomy educators integrate sensory, spatial, affective, and energetic dimensions into their teaching practices. The interview guide was developed and tested with F2F model's creator (R.L.) before formal data collection to ensure clarity, relevance, and ability to yield meaningful data (Seidman, 2013). The initial interview guide explored participants' somatic teaching methods through F2F tailored questions. The questions encouraged reflection on specific teaching moments and is found in Appendix D. Participants were sent prompting questions 1-2 weeks before the initial interview, found in Appendix E.

Two semi-structured interviews (an initial interview and follow-up co-reflection interview session) (2-3 hours total per participant), guided by Merriam's (1988) effective interviewing recommendations, explored participants' somatic teaching methods. Each interview began with an introductory script thanking participants and reiterating the study's purpose. In the initial interview, participants were asked to confirm their academic affiliations, educational background, and the anatomy-related courses they had taught or were currently teaching. Initial interviews started with few predetermined questions to guide participants, while leaving time for flexibility in following up on interesting points. Questions remained open-ended to encourage detailed responses, and follow-up questions were participant-specific to promote clarification and reflection on specific moments. In alignment with hermeneutic phenomenological principles, the interviews aimed to keep open all possibilities (Gadamer, 1975; Van Manen, 1984). The guide was anchored by an overarching prompt, such as asking participants to describe a specific teaching moment in which they felt particularly connected to the sensation of their moving body. Semi-structured, open-ended questions followed, informed by the F2F categories of Function

(kinetic awareness), Form (spatial and visual attention), Feeling (somatic sensing), and Flow (energetic presence).

### **Artifacts.**

In alignment with Merriam's (1991, 2002) qualitative case study methodology, artifact analysis was employed to complement interviews and observations and to deepen contextual understanding of each case. Artifacts, such as syllabi, teaching tools, visual aids, and lecture slides, were selected based on their relevance to the research questions and their potential to illuminate the somatic and pedagogical practices under study. Each artifact was examined in relation to its origin, purpose, and use within the participant's teaching context, and analyzed for symbolic, cultural, and educational significance. Consistent with Merriam's guidance, artifacts were interpreted not in isolation, but through triangulation with other data sources to support trustworthiness and richer thematic insight. This process also involved critical reflection on how the artifacts embodied participants' values, teaching philosophies, and embodied understandings of anatomy. Reflexivity was maintained throughout to consider the influence of researcher interpretation and the broader context in which each artifact was situated.

### **Observations.**

Based on initial interview discussions and artifact analysis, such as lecture slides and syllabi, one to three relevant classes (3–6 hours per participant) were then collaboratively selected for non-participant observation – in which the researcher observed without engaging in the activity. The selected classes depended on the concepts being observed and the participant's preference. Observations were scheduled soon after the initial interview to immerse the researcher in the participants' lifeworld experiences (Van Manen, 2016). The observational field guides were developed iteratively following the first round of interviews (Creswell, 2013). Each guide was customized to the individual participant based on their interview responses, ensuring alignment with their pedagogical context and disciplinary focus. These guides echoed the F2F-informed interview structure, but were adapted to capture nonverbal gestures, pacing, tone, classroom dynamics, and instances of sensory or movement-based instruction.

I conducted direct, in-person classroom observations in participant's natural teaching environments, including a dance hall, art studio, lecture halls, and even faculty office. With participant consent, classroom sessions were audio and video recorded by camera and Teams, transcribed verbatim, and supplemented by detailed field notes to capture key instructional

moments, verbal and non-verbal cues, and environmental context. Only visual arts class observation was not video recorded because the class featured a nude male model. The descriptive and reflective field notes allowed me to compare observed behaviors with interview narratives and artifacts. This process enhanced methodological rigor by supporting triangulation and minimizing interpretive gaps (Bhasin, 2019; Eisenhardt, 1989; Harrison et al., 2017; Lincoln et al., 2011; Takashi et al., 2020). Rapport was built between participant and interviewer.

### **Follow-up co-reflection interview sessions.**

Upon completion of the observations, follow-up interviews (1–1.5 hours per participant) were scheduled as soon as possible. The follow-up interview, known as co-reflection sessions, was an opportunity to co-reflect and deepen the authenticity of participants' experience. Co-reflection is a collaborative and iterative process that enhances the depth of qualitative inquiry as participants are engaged in reflective dialogue on their teaching experiences. Merriam (1998) believed case studies benefit from multiple sources of data and participant engagement, ensuring findings are meaningful, trustworthy, and representative of lived experiences. In this study, the follow-up co-reflection sessions were meant to confirm my interpretations from interviews, observations, artifacts, and preliminary analysis of data. It also allowed me to further explore budding insights and better align my understanding of their real-life experience, enhancing overall validity of my study. These sessions specifically allowed for the participants and I to revisit key moments and deepen reflection for accurate interpretation of themes, notes, artifacts, and transcripts to enhance overall understanding (Creswell, 2013). This triangulated approach (Creswell & Poth, 2018) offered rich insight into both stated intentions and embodied practices.

This session ensured authentic and multifaceted interpretations of participants' teaching experiences. Probing questions were used selectively to invite deeper elaboration on embodied strategies, but care was taken not to lead participants or overly structure their responses (Van Manen, 1984). These questions were intended to draw participants into a process of reflective wondering, attuned to their own lived experience.

### **Data analysis for Multiple Case Study**

Data analysis of this study followed Braun & Clarke's (2006, 2022) six-phase Reflexive Thematic Analysis (RTA) process, a flexible and interpretative approach that aligned with my constructivist and interpretivist assumptions. An example of the data analysis procedure is shown

in Figure 3. This method allowed themes to emerge organically from the interviews, observations, artifact analysis, and co-reflections of each participant, rather than being imposed through predefined coding structures. NVivo v.14 was used to organize, code, and refine themes throughout the process. Coding was iterative and interpretive, with early codes grouped into broader patterns corresponding to the F2F model. Rather than forcing data into predefined categories, the F2F model acted as a sensitizing framework (Blumer, 1954), guiding the identification of moments of kinetic focus (Function), visual mapping (Form), tactile and sensory engagement (Feeling), and relational energy (Flow). This framework allowed for both convergence and divergence across cases to emerge organically through the data. Potential themes were reviewed multiple times to ensure rich interpretations of participants' experiences. Themes were named and co-reflected upon with participants to allow for authentic and collaborative meaning-making. The final themes interpretations are reported under "Co-reflection" of the Findings section of this dissertation.

As an anatomy educator with experience in experiential and somatic teaching approaches, I approached the data with sensitivity to embodied pedagogical practices while maintaining reflexivity throughout the analytic process, consistent with Braun and Clarke's (2019, 2022) approach to RTA. This treats the researcher's subjectivity as a valuable analytic resource because "meaning is not simply discovered but is constructed through the researcher's engagement with the data" (Braun & Clarke, 2019, p. 594).

### ***Reflexive Thematic Analysis Phase 1: Familiarization***

Transcripts, field notes, and artifacts were reviewed multiple times to capture early impressions and recurring patterns. During this phase, I actively listened to each interview and observation numerous times. I did not take any notes until the fourth listen to develop a solid understanding of the primary concepts addressed in each recording. This provided me an opportunity to revisit gestures and mannerisms that may have not been documented in my field notes. Throughout this process, I documented my thoughts and interpretations of what I was seeing and hearing to further explore during co-reflection sessions with my participants.

### ***Reflexive Thematic Analysis Phase 2: Generating initial codes***

To produce succinct, descriptive, and interpretive labels for my transcripts, I identified data that were interesting and informative in developing themes. Using NVivo v.14, initial coding was open-ended and exploratory: rather than applying a predefined codebook, I created

codes inductively to capture participants' language, actions, and somatic experiences (Byrne, 2021). Individual excerpts were often coded in more than one way when they spoke to multiple facets of experience. For example, the statement below, given by the dance participant, was coded under Feeling (kinaesthetic and affective attunement) and Flow (energetic, time-altering, integrative experience).

When I lean into an exercise, I feel that part of my body become enlivened with sensation. There's generally a sense of warmth... and it feels as though my body... is homing in on the area and it becomes much larger... I feel joy when... all these little bits are harmoniously working together in my movement

This practice of multiple coding preserved the complexity of the data and allowed connections to emerge later between the F2F dimensions and broader pedagogical processes. Focusing on sufficient depth meant prioritizing rich, recurrent patterns over an exhaustive list of superficial codes. I revisited each transcript several times, refining, collapsing, or expanding codes to ensure that they captured nuance, were supported by multiple instances across cases, and remained grounded in the original context. Codes were thus iteratively reviewed and revised throughout the analysis, forming a robust foundation for subsequent theme development.

### ***Reflexive Thematic Analysis Phase 3: Generating Themes***

I reviewed and analyzed my coded data to form themes and sub-themes by collapsing multiple codes that shared meaning and segregating themes that are distinctive. By interpreting the relationship between codes, I produced a thematic map that collates code and data items relative to their respective themes (Braun and Clarke 2006, 2020).

### ***Reflexive Thematic Analysis Phase 4: Reviewing Potential Themes***

When reviewing the themes that I articulated, I specifically reviewed the relationships between the data and the codes and the relationships between the potential themes and the data. Based on how well they provided rich interpretations related to my research question, themes that were strongly evidenced and offered rich interpretations in relation to the research questions were solidified. Themes that were too conceptually diffused or weakly supported were either demoted to subthemes or codes of more robust themes, or they were removed entirely from the final thematic map to avoid redundancy and over-fragmentation.

### ***Reflexive Thematic Analysis Phase 5: Defining and Naming Themes***

All themes and subthemes were named based on the consistent content of data and the contribution towards the research question. The names of themes were carefully considered to indicate to the reader what had been captured from the data. I strived to create memorable theme names to catch the reader’s attention while communicating the importance of the theme. Upon naming my solidified themes, I co-reflected with my participants to ensure their experiences were accurately reflected in my interpretations. This process allowed for collaborative meaning-making which resulted in some code modifications but overall solidified themes.

Cross-case analysis was carried out through iterative, interpretive engagement with coded data, thematic summaries, and illustrative quotes. A diagram depicting cross-case analysis is shown as Figure 4. Comparative insights were drawn by mapping similarities in pedagogical strategy and somatic emphasis, while attending to the ways in which disciplinary paradigms shaped the meaning and delivery of anatomical instruction. This recursive and interpretive process allowed for a nuanced understanding of how anatomy is taught through the body across diverse domains, in line with RTA’s emphasis on situated meaning-making, researcher reflexivity, and thematic depth (Braun & Clarke, 2022).

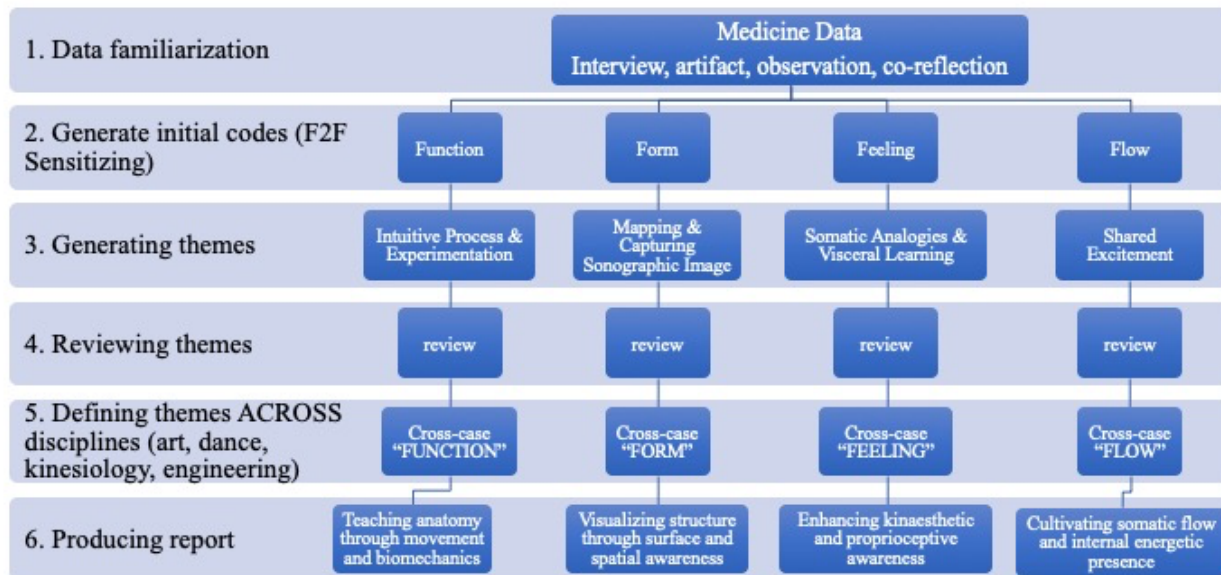


Figure 3. Example of data analysis procedure

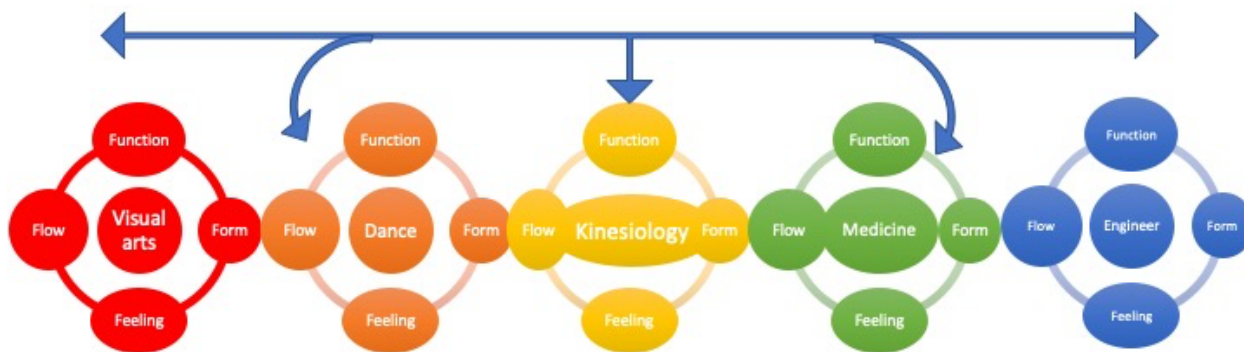


Figure 4. Depiction of cross-case analysis

### ***Reflexive Thematic Analysis Phase 6: Producing the Report***

The final writing and interpretations are presented in Chapters Five and Six. The reports present the themes in a logical and meaningful manner, building on the raw data itself to explain the experiences of my participants.

### **Ethical Considerations**

Ethics approval was granted by the University of Ottawa [ID: S-10-23-9255] and reviewed by OCAD University [File No. 102525 and 102522] (Appendix F). All participants provided informed consent before data collection, with the right to withdraw at any time without consequence. Confidentiality was maintained through de-identification of data, secure storage in locked laptop and locked office. Participants were then asked during co-reflections if they wanted to remain anonymous or be identified. Their wishes were respected. Ethical guidelines aligned with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS-2, 2022), ensuring respect for participant autonomy, privacy, and well-being throughout the study.

### **Research Validity and Trustworthiness**

To ensure validity and trustworthiness, I adopted Lincoln and Guba's (1985) trustworthiness criteria which assess four criteria to reinforce the integrity of findings: credibility, dependability, confirmability, and transferability. Additionally, it acknowledges the interpretative nature of thematic analysis (Braun & Clarke, 2006, 2022) and the active role of the researcher in meaning-making.

**Credibility**

Credibility was enhanced through triangulation of multiple data sources including semi-structured interviews, classroom observations, artifact analysis, and co-reflections. Comparing educators' self-reported experiences with observed teaching practices strengthened the validity of interpretations, preventing reliance on single accounts. Furthermore, co-reflections with participants allowed for any discrepancies between self-reported intentions, observed experiences, and my interpretations to be refined with the participants' input so that findings authentically represent their experiences and perspectives.

**Dependability**

During data analysis, I used NVivo v.14 for organization and tracking of codes, enabling transparency in how themes evolved over time. Regular memo-writing and critical reflections on coding helped refine interpretations and address potential biases. Additionally, I discussed coding frameworks and thematic insights with the co-founder of the F2F model and the F2F research unit to clarify analytical interpretations.

**Confirmability**

Recognizing that qualitative research is inherently interpretative, I actively engaged in researcher reflexivity throughout the analysis process (Varpio et al., 2016). This involved critically reflecting on how my prior experiences, theoretical orientation, and positionality shaped the construction of themes. Rather than treating themes as passively emerging from the data, I acknowledge that they were actively constructed through my interpretative lens. By inviting the perspectives of the participant through co-reflections, I strengthened the confirmability of the study.

**Transferability**

Transferability was enhanced through the rich, thick descriptions of the research context, participants, and findings found in Chapters Five and Six. Rather than claiming generalizability in the conventional sense, this study embraces the value of particularity by closely examining the specific practices of individual educators within their unique disciplinary and environmental contexts. By focusing deeply on a smaller number of thoughtfully selected cases, the research draws out insights that, while grounded in the particular, carry relevance beyond each case.

Through detailed accounts of how educators experience somatic anatomical teaching and learning within different disciplines, this study offers contextually rich insights that may inform and inspire other educators and researchers interested in experiential anatomy pedagogy across diverse fields.

### **Reflexivity**

As a researcher, with lived experience in visual arts, scientific anatomy, and yoga-based movement, I approached this study with a perspective shaped by both insider familiarity and outsider curiosity. This allowed me to connect meaningfully with some participants while learning across disciplinary boundaries. Consistent with Aoki (1996) and Corbin Dwyer & Buckle (2009), I acknowledge that this shifting positionality influenced my engagement with participants and interpretation of their practices.

To support analytical transparency and depth, I adopted Braun & Clarke's (2022) RTA, which acknowledges that meaning is actively co-constructed rather than passively discovered. I engaged with data iteratively, drawing connections through the F2F model while remaining critically attuned to how my assumptions shaped emerging themes. My commitment to reflexivity extended beyond analysis: I recorded memos, welcomed participant feedback, and continually re-evaluated my interpretive stance. Inspired by Merriam's (2002) recognition of the dual personal and scholarly nature of qualitative inquiry, I acknowledge that this research is deeply meaningful to me. The somatic insights I've gained from participants have already transformed my own teaching practice. I am extremely grateful to my wise participants who have been so generous in opening their classrooms, mind, and spirits to me. This dissertation is intended not only as an academic contribution but as a resource for anatomy educators across disciplines. The target audience for my dissertation are anatomy educators and learners of all disciplines and I hope the lessons that emerge from this research provide valuable perspectives for human anatomy educators in HPE and beyond, encouraging greater dialogue between disciplines and a more experiential, somatic approach to anatomical sciences.

### **Summary & Logical Flow of Dissertation**

This chapter outlines the methodological framework for my multiple case study on experiential somatic learning in anatomical sciences education. The study explores how five educators across expressive (visual arts, dance), clinical (medicine, kinesiology), and technical

(engineering) disciplines, integrate somatic and experiential methods, such as movement, gesture, touch, breath, and relational presence, to bridge theoretical anatomical knowledge and embodied understanding.

This chapter explained how the F2F model is used as both a theoretical (Lloyd, 2011; Lloyd & Smith 2009) and sensitizing framework (Blumer, 1954), which supports inquiry into the lived, embodied experiences of teaching and learning anatomy across disciplinary boundaries.

Grounded in Sharan Merriam's pragmatic constructivist approach to qualitative case study, this chapter explained the case study research methodology. I describe and justify my methodological alignment with Merriam, in contrast to alternative approaches by Yin and Stake. I also outline the philosophical assumptions, ethical considerations, and reflexive stance that shape my inquiry, building off Chapter Three.

Data collection involved four complementary methods: semi-structured interviews, classroom observations, artifact analysis, and collaborative co-reflections with each educator. Data were analyzed using Braun and Clarke's (2022) RTA, guided by the F2F model to examine how participants transition from functional and formal teaching to embodied states of feeling and flow.

Each case is presented in Chapter Five and Chapter Six presents a cross-case thematic discussion organized by expressive, clinical, and technical disciplines. Together, these chapters respond to my research questions by highlighting how diverse teaching approaches contribute to a more inclusive, embodied, and interdisciplinary future for anatomy education.

A logical flow diagram of the entire research study is shown in Figure 5.

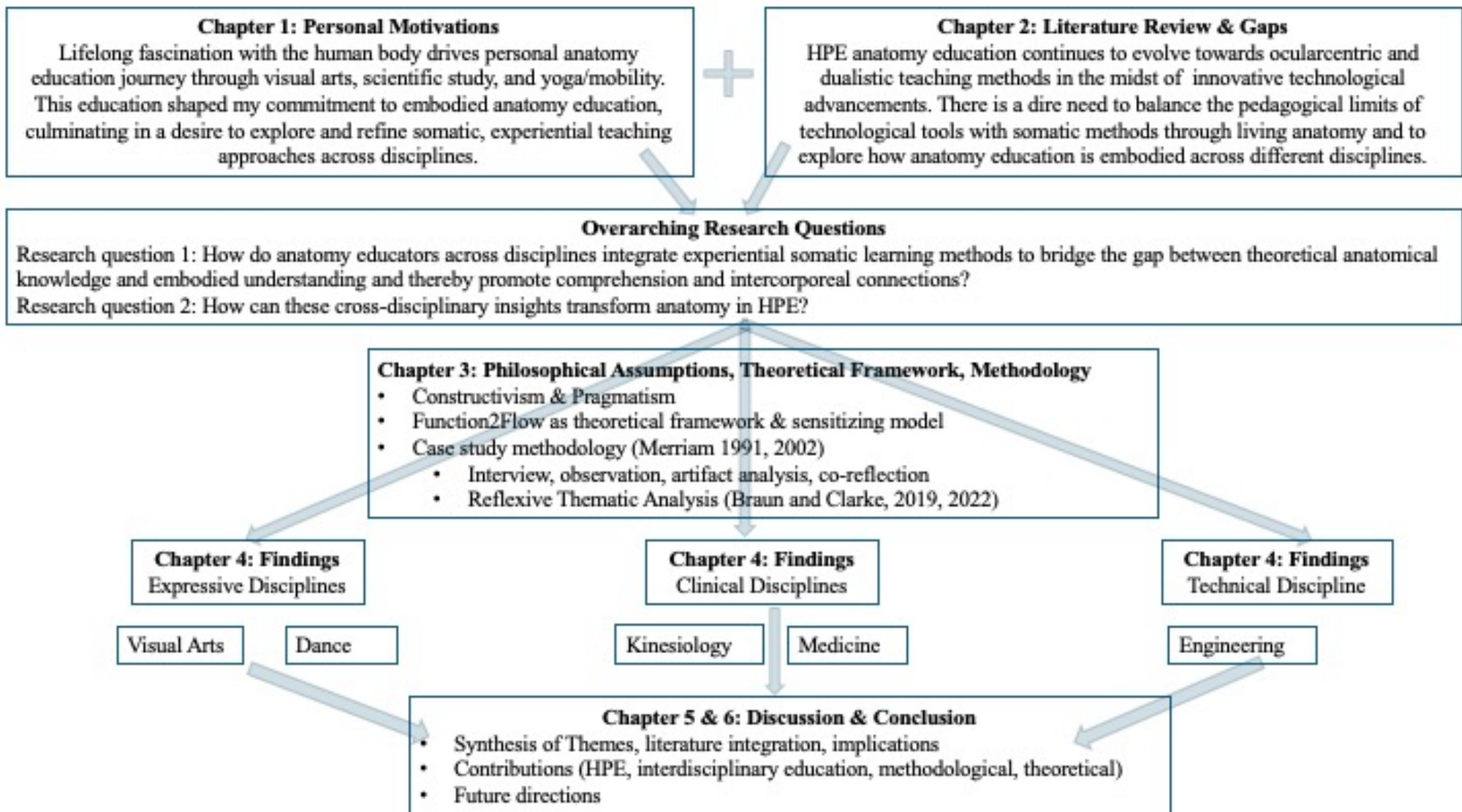


Figure 5: Logical flow diagram mapping research questions and monograph thesis

## Chapter 4: Findings

This chapter presents the findings from a multifaceted exploration of how anatomy educators across expressive, clinical, and technical disciplines employ somatic and experiential learning methods to teach anatomical concepts. Through a purposive sample of five Canadian university educators, representing visual arts, dance, kinesiology, medicine, and engineering, this study captures the diverse ways in which the living body is used as a pedagogical tool. Guided by the F2F model, data from semi-structured interviews, artifact analysis, classroom observations, and follow-up co-reflection sessions are presented. This section then offers these findings as they've been analyzed using Braun and Clarke's (2022) RTA. The chapter is organized into sections detailing participant profiles, in-depth findings from interviews, classroom observations, artifact analyses, and co-reflections. These findings illuminate how educators integrate *Function* (kinetic awareness), *Form* (spatial and visual attention), *Feeling* (somatic sensing), and *Flow* (energetic presence) to foster embodied anatomical understanding, revealing both discipline-specific approaches and convergent pedagogical themes that enrich Health Professions Education.

### Participants

The five participants, shown in Table 1, (all consented to being named) were purposefully selected (criteria explained in previous chapter) to represent a spectrum of disciplinary orientations:

Table 1: Purposively sampled participants in their anatomical disciplinary spectrum

Expressive	Clinical	Technical
<ul style="list-style-type: none"><li>• Danielle Denichaud (Dance)</li><li>• Niloo Inalouei (Visual Arts)</li></ul>	<ul style="list-style-type: none"><li>• Tamara Maciel (Kinesiology)</li><li>• Dr. Terry Li (Medicine)</li></ul>	<ul style="list-style-type: none"><li>• Dr. Kei Masani (Engineering)</li></ul>

Each participant taught anatomical concepts related to their respective disciplines at the post-secondary level, either as a central feature of their syllabus or in support of broader disciplinary learning objectives. Most participants showed inclination towards somatic learning. This sampling strategy ensured both variation and depth in how anatomy and potential somatic pedagogy manifested across fields.

## **Interview 1 & Artifact Findings**

This section presents findings from the first round of participant interviews and artifact analyses, offering insight into each educator's pedagogical philosophy, somatic practices, and curricular design. Each profile includes demographic context, teaching approaches, and an overview of course structure and assessment.

### ***Expressive: Visual Arts - Niloo Inalouei***

Inalouei is a dynamic visual artist whose work pulses with life, spanning acrylics, charcoal, textiles, and installations for over thirty years. As the visual arts educator for DRPT-2014 *Anatomy for Artists* at OCAD University, she guides twenty-five second-year students beyond proportion and musculature, challenging them to see anatomy as both a technical foundation and a deeply personal narrative.

The syllabus for this three-hour weekly studio-based course frames anatomy as both a technical and critical practice. Weekly classes move from skull structure to sustained full-figure studies, all anchored in direct observation of nude models, skeletons and *écorchés*. Learning outcomes stress the ability to “make informed observations of the human form,” translate structural insight into expressive drawing or painting, and critique the colonial and gendered histories of anatomical imagery. Scaffolded, iterative assignments (self-portrait, figure *écorché*, final sustained composition) require students to post work to an online critique board and provide peer feedback. A curated list of digital apps (e.g., 3D Anatomy for the Artist) and podcasts extends learning beyond class, while the engagement rubric links weekly preparation, critique participation and reflective writing directly to grades. Scaffolded, iterative assignments include a narrative self-portrait, analytic and schematic drawing of the skeleton, figure *écorché*, in-class drawing portfolio, and a final assignment

Inalouei's calm and nurturing teaching style intertwines live model drawing studies, digital imaging, and somatic exploration, encouraging students to feel their own anatomy during class. Through storytelling, she emphasizes the profound connection between anatomical observation and personal narrative, empowering students to draw from their own stories rather than adhering to Western conventions.

Her body is an essential teaching tool in demonstrating *Function* through movements, *Form* through deliberate gestures, *Feeling* through embodied awareness, and *Flow* through the joyful feel of motion captured on paper. She urges her students to learn with their own

physicality – “stand in front of the mirror naked when you are home. Try to realize your own muscles and what’s happening inside”. Inalouei’s somatic approaches nurtures artists to observe, feel, and express anatomy with meaningful intention and sensitivity.

### ***Expressive: Dance - Danielle Denichaud***

Denichaud is a seasoned dancer and movement educator with over 22 years of experience balancing anatomical precision and the art of somatic expression. At Toronto Metropolitan University, she teaches THF-100 *Anatomy of Movement and Lifestyle*, a first-year course for thirty dancers and twenty actors. To support their distinct artistic demands, she designed the curriculum to eclectically blend biomechanical anatomy, somatic practices, and holistic well-being to practice injury prevention and personalized warm-up and cool-down routines.

Her syllabus integrates functional anatomy with performer well-being. Lecture-based yet highly experiential classes combine palpation, movement analysis, breathing, meditation, journalling and nutrition tracking. By term’s end, students must “locate, identify and describe” musculoskeletal structures and design a personalized warm-up / cool-down protocol that reflects mind-body-heart principles. For twelve weeks, students meet for one and a half hours each week, progressing from breathing mechanics and active sitting to injury, immune intelligence, and anti-oppressive embodiment. Each session pairing pre-class readings and post-class reflective journals. Assessment evaluates participation, three journal installments, a “Movement Context” plan, a “Mind-Body-Heart Context” plan, peer review, and a final project regarding self-tailored warm up and cool down.

Denichaud’s teaching approach is deeply shaped by personal experience, having endured a debilitating four-year long subluxation and nutation of her sacrum, she underscores the importance of self-care and injury prevention. She now moves pain free, despite moderate arthritis in L5-S1, and treats her body as “wise friend rather than a hindrance”. This philosophy translates into her teaching, where she fosters somatic awareness, body autonomy, and accessibility to anatomical concepts.

Dancers in her class arrive with a technical mindset, used to fine-tuning their rotators or articulation, while actors often prioritize space, character, and expression. Through her empathetic and adaptive teaching style, Danielle guides all students to move with intention,

strength, and joy. Through somatic awareness, she empowers performers to make informed bodily choices in all contexts, ensuring long-term sustainability.

### ***Clinical: Kinesiology - Tamara Maciel***

Tamara Maciel is the Program Director of the School of Anatomy in Kinesiology and Health Sciences at the University of Waterloo. Maciel teaches *Regional Human Anatomy* (KIN100), blending theoretical anatomy instruction with movement-based, clinical application. Her classes integrate musculoskeletal anatomy with dynamic demonstrations of joint function and muscle activation, using real-world activities such as punching, lunging, or scapular stabilization drills.

Her syllabus signals a region-by-region approach to human anatomy for kinesiology students. Section headings specify a class schedule, learning outcomes, texts/materials, student assessment procedures and administrative policies. The inclusion of “Notice of Recording” and “Assignment Screening” sections indicates an emphasis on academic integrity and privacy. The structure of detailed weekly topics progress from the upper axial region and appendicular regions of the body to the lower axial and appendicular regions of the body. The course syllabus shows a traditional university anatomy course scaffolded by clear learning objectives and assessment criteria. Classes are one hour long, three times a week and dissection labs are two hours long, once a week. Assessments involve two midterm exams, one final exam, a bell ringer (dissection lab exam), and an optional iClicker in class participation tool.

With Maciel’s rich background in both classroom instruction and curriculum leadership, her teaching bridges theoretical knowledge and applied movement analysis, preparing undergraduate kinesiology students for clinical, research, and athletic careers. Maciel emphasizes that anatomy is not merely about memorization but about understanding the body in motion. She is passionate about helping students connect academic lecture content with active engagement through palpation, guided movement, and application in the dissection lab.

Maciel is deeply connected to her own physicality and maintains a regular gym routine to embody the anatomical principles she teaches. Her personal commitment to physical activity allows her to bring embodied knowledge into the classroom with authenticity. She uses her own awareness of movement, sensation, and muscular engagement to guide students through similar experiences, encouraging them to develop their own somatic awareness as part of their

anatomical literacy. In her lectures, she fosters a dynamic relationship with her students where peer learning, curiosity, and reflective practice are central, fostering anatomical literacy that is deeply connected to bodily autonomy and physical confidence.

### ***Clinical: Medicine - Dr. Terry Li***

Dr. Terry Li is a medical educator and researcher focusing on developing novel anatomy learning modules for undergraduate and postgraduate medical students at Max Rady College of Medicine, University of Manitoba. Dr. Li teaches a variety of anatomy courses to medical, dental, and undergraduate students. The course and lessons of interest in this thesis are from his *Respiratory Medicine I (RS1)*, where he integrates clinical anatomy with real-time sonographic imaging. His pedagogical approach emphasizes the tactile and visual exploration of living anatomy through ultrasound, guiding students to locate, interpret, and relate muscles, vessels, and nerves to surface landmarks. Dr. Li frequently demonstrates scans on his own body or student volunteers through interactive modules that combine foundational content with experiential tools such as point-of-care ultrasound (POCUS). Before lectures and labs, he often practices on student volunteers to ensure class demonstrations go smoothly. In his hands, handheld ultrasound becomes more than a diagnostic device, it becomes a pedagogical bridge that connects students to the living body in real time.

In labs, Dr. Li guides students to combine palpation, ultrasound imaging, and anatomical reasoning to explore structures in the neck. His lab outlines encourage learners to think about probe orientation, spatial relationships, and key anatomical landmarks. Dr. Li shows emphasis on experiential learning, where visual and tactile inputs reinforce one another. The labs are grounded in real-time anatomy, embodied logic, and intuitive understanding through hands-on exploration with ultrasound.

When he isn't using ultrasound for teaching, his classroom continues to emphasize spatial reasoning, tactile engagement, and direct visualization, allowing students to move beyond static 2D textbook representations toward real representations of anatomy. Although not the focus of his teaching observation in this thesis, an example of Dr. Li's spatial reasoning exercise without ultrasound is his demonstration of how the uterus is naturally "anteverted" meaning the uterus is tilted forward towards the abdomen, and "anteflexed" meaning the body of the uterus is bent forward at the cervix. He demonstrates anteversion of the uterus this by bending forward slightly

at the waist to mimic the angle of the uterus relative to the axis of the vagina. He demonstrates anteflexion by raising his arms as high as he can behind his back, each hand holding a balloon to represent an ovary, effectively showing and kinaesthetically demonstrating how the body of the uterus folds forward over the cervix. He continues to ground anatomical theory in spatial, embodied logic by asking for student volunteers to take his place as the uterus, and to represent the rectum (behind the uterus) and bladder (crouched down in front of the uterus) from a sagittal point of view. He drapes a large tablecloth over the three student volunteers standing in single file to orient the class to the peritoneum. Through his integrative teaching style, students learn to feel and interpret subtle anatomical landmarks that cannot be palpated beneath the skin, fostering both competence and clinical intuition.

Through ultrasound learning in his classroom, Dr. Li models *Flow* through the confidence and curiosity that emerge from mastering complex tools with embodied ease. Dr. Li's work reimagines what it means to teach anatomy in the digital age by grounding and increasing connection to the living human body.

### ***Technical: Engineering - Dr. Kei Masani***

Dr. Kei Masani is a researcher and educator in biomedical engineering at the Toronto Rehabilitation Institute and the University of Toronto. His work centers on human movement and movement variability through the lens of neuro-mechanical interaction and sensory-motor integration. He teaches *Human Whole Body Biomechanics (BME530)* at the University of Toronto, introducing engineering students to anatomical concepts within kinematics of human motion. Though not an anatomy educator per se, Masani's courses weave anatomical concepts, such as muscle origin-insertion relationships, joint moments, and gait dynamics, into biomechanical modeling and motion analysis.

The syllabus positions anatomy within an engineering framework. After introducing kinematics and kinetics, lectures trace the neuromuscular system from electromyography to neural control, culminating in applied modules on posture, gait and electrical stimulation. Two-hour weekly lectures are paired with three-hour weekly practical labs in the BME Design Space, where students first analyze provided datasets and later collect their own EMG, gait and force-plate data. Evaluations involve laboratory reports, mid-term, and final exam. Listed learning outcomes require students to “describe principles of human motion” and “use multiple

methodologies to analyze human motion” while linking biomechanics to neuromuscular rehabilitation. Suggested texts span biomechanics, neuromechanics and neural science, underscoring the interdisciplinary nature of the course.

In Dr. Masani’s classroom, anatomy is not taught in isolation but in tandem with practical contexts, such as analyzing walking patterns through gait observation or interpreting electromyography (EMG) signals to evaluate muscle activation. His students often begin with little prior exposure to anatomy, so he emphasizes functional relevance to build their confidence and engagement. Rather than overwhelming students with memorization, he focuses on key anatomical structures that support comprehension of movement, posture, and motor control. His pedagogical approach emphasizes experiential learning and technical experience as his students learn to apply anatomical concepts through project-based learning and physical testing procedures in his tutorial sessions, such as locating and placing sensors on surface muscles for EMG experiments.

Dr. Masani’s passion for human gait and balance is rooted in his early academic training, where he became fascinated by how complex motor actions emerge through unconscious processes. His curiosity now helps his students appreciate how seemingly simple acts, like walking or standing, reveal the body’s deep capacity for coordination and adaptability without conscious control.

### **Observations in the Classroom Findings**

Direct quotes and figures (recreated by the author) are presented in this section to illustrate how participants’ somatic and anatomical teaching philosophies come to life in real-time classroom settings. These embodied observations highlight how educators communicate anatomical knowledge through gesture, metaphor, physical demonstration, and dynamic interactions with students, revealing how *Function*, *Form*, *Feeling*, and *Flow* are enacted through live instruction.

#### ***Expressive: Visual Arts – Niloo Inalouei – Study of the Forearm and Hand***

At 6:30pm, students enter a brightly lit studio at OCAD University, arranging themselves in two rows of semi-circles facing a raised stage with a live nude male model. 6 students sit on donkeys in the first row, 9 students on easels and 5 students on donkeys in the second row. As the observer, I am seated in the corner furthest from the stage. I am aware my background in

anatomical sciences may inform my perceptions of her somatic teaching. Today's study was of the forearm and hands.

Inalouei warmly greets her students and the class begins with gesture drawings (30 seconds to 2 minutes) of the model to capture his movement. Inalouei introduces the anatomy of the forearm and arm, rolling her sleeve above her left elbow to demonstrate how *Form* changes in pronation and supination. She raises her left arm to eye level, elbow bent, wrist relaxed, fingers gently flexed (Figure 6a).

Inalouei guided her students to learn the art of careful observation and geometric interpretation of the body's changing shape. She explained how the planes and angles change the *Form* of the forearm, wrist, and hand in different movements.

See how it goes from round and egg-shaped... to more boxy because the bones are noticeable... then plane, plane, plane... Think about all the angles... at the joints, like round, boxy, one plane, one plane... they're all different angles... We're... constantly looking for change in form. Understand how form changes is your focus. It's not about getting it right the first time – it's about training your eye to see what's really happening... I believe that... everything we see... in the human body... we can describe... with geometry... Draw simply, geometry first, then details.

Slowly, her hand dips downward, interphalangeal and metacarpal-phalangeal joints leading the way as her fingers flex into her palm and her wrist flexes into her forearm (Figure 6b). The skin between her palm and wrist wrinkles deeply while the posterior side stretches longerrr, she *Feels* the compression versus the stretch. This fluid motion triggers her *Flow*, evoking a liveliness associated with a happy cat curling its paws to “knead dough”, or a gentle wave “letting go” into itself.

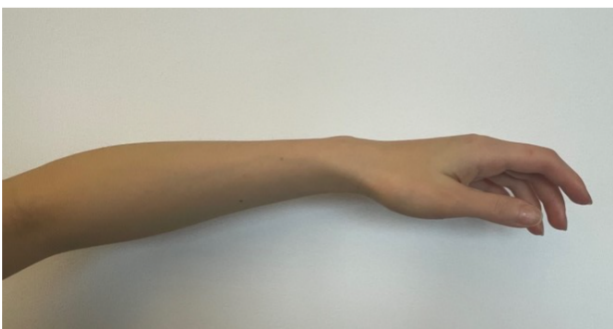


Figure 6a: Visual arts study of the forearm, wrist, and hand – Starting point: Parallel



Figure 6b: Visual arts study of the forearm, wrist, and hand – Mid point: Descending Flexion

Shadows on the anterior side creep in with increase flexion of the wrist and fingers. Her wrist comes into maximum flexion – the striking, almost 90 degrees angle between wrist and forearm looks uncomfortable, transforming the *Flow* from letting go, to a *Feeling* of recluse and hiding.

The odd shape and sharpness of the wrist (Figure 6c) sends a ripple of awareness through the room as students mimic her motions.



Figure 6c: Visual arts study of the forearm, wrist, and hand – Final point: Full Flexion

Inalouei identifies the bones from the radius and ulna to the distal phalanges, encouraging students to feel how *Form* in the body changes through movement as she compares structure to sensation. Her right hand curves and hovers over the egg-like roundness of the posterior proximal forearm, highlighting the forearms' muscle bellies. Distally, the posterior forearm becomes boxy and rectangular, her right hand gestures sharply, across the flatter surface, stopping at the wrist. Her right hand slants down the slope of the posterior metacarpals, crossing the minute roundedness of the wrist, and she finishes with three short, sharp strokes over each flat surface of the posterior phalanges. Each slope is a new plane, a new *Form* that interacts differently with the light around us, waiting to be captured on paper.

To truly capture the essence of the model, she explains artists must consider the subject's *Feeling*, especially in the hands, which can be so expressive. She explains:

Draw from your arm, not your wrist... It's hard to capture movement if you don't understand what bone is moving against what bone. The ulna? The radius? Where does movement... originate? If you understand how a joint moves, you'll know how to draw it in different positions. And it's not just about lines you draw... it's about capturing the essence in those lines... Like the palm feels different than the top of the hand... it's about capturing the feeling... the essence.

The *Feeling* of compression versus stretching of the skin will dictate the weight of her charcoal-holding hand against the newsprint. A light, thin, quick line captures the essence of

delicate stretched skin on the dorsal forearm. The anterior forearm is fleshier and compressed; a heavy, thick line captures the essence of deep wrinkles and the shadows in the groove of the skin. Lines become simple geometrical shapes, *Flowing* into the essence of her subject captured by charcoal on newsprint.

Students return to their newsprint, capturing these anatomical nuances. As they draw, Inalouei circulates, critiquing shading techniques and value transitions. She reminds them “drawing from observation is exhausting, but it refines how we see and feel anatomy.” The class concludes at 9:30pm.

### ***Expressive: Dance – Danielle Denichaud – The Joy of Safe Movement in the Hips and Abdominal Obliques***

At 9am, 48 students gather into an oval on the Marley flooring of a dance studio in Toronto Metropolitan University. As the observer, I am part of the oval, seated on the floor in the corner furthest from the entrance and I am aware my anatomical background may inform my perceptions while observing this class. Denichaud introduces the *Sacral Clock* and the *Abdominal Oblique Shift* exercises to achieve a true spiral – where the torso and pelvis dissociate, creating *Functional* oppositional reach in dramatic twisting motions while maintaining deep structural stability. Through grounding breath, she brings awareness to the pelvic floor, lumbar spine, ischia, iliac crests, pubis, and how the femurs sit in the acetabulum, supported by the tibias. Lying on her back, she demonstrates the *Sacral Clock*, inviting students to map their sacrum, using the imagery of a clock: 12 o'clock being the sacroiliac joints, 6 o'clock at the coccyx, 3 and 9 on either side. She rocks between 6 and 12, then 3 and 9, to *Feel* the sacrum's length and width. Her lumbar vertebrae subtly lift and lower to accommodate her sacral rocking, students watch intently but it's almost undetectable unless you stare directly at the changing distance between the floor and her spine (Figures 7a and 7b). Her *Sacral Clock* exercise made anatomical landmarks visually and spatially palpable

Here is near at the top near my iliac crest. OK, now we're going more to the coccyx and then we can go to the lateral sides. Feel... my neutral pelvis, where we... still have a little bit of our lumbar curve. *Sacral clock* is... Can I map it [sacrum] as if I... give someone details for a 3D printing?... Are there any bony nodules or is it smooth? What does it feel like to use my abdominals to rock my pelvis?

Deepening somatic awareness, she instructs students to sequentially press each number of the *Sacral Clock* onto the floor, first clockwise, then counterclockwise. Denichaud's exercises heightened somatic perception, enabling her to teach movement experience as a multi-dimensional event rather than only a mechanical action. She emphasized *Feeling* specific parts of the body through movement exploration and refinement:

Engage your active breath... Can you feel your clavicle and your shoulder blade widen against the floor? Can you root your shoulders down... towards your pelvis? Notice if you can maintain presence to... the weight in your ischium. Can I get as much sensation as possible of my sacrum?... I feel the dimensionality of my sacrum. I feel its breadth. I feel its attachment within my sacral iliac crest.

Pairing up, students attempt the exercise while Denichaud offers guidance throughout the room.



Figure 7a: Dance study of the sacrum morphology – Sacral Clock 6 O'clock



Figure 7b: Dance study of the sacrum morphology – Sacral Clock 12 O'clock

Next, Denichaud introduces the *Oblique Shift*. On her back, arms extended to her sides, core stabilized, she lifts her knees to 90-degrees, lower legs parallel to the floor, ankles together (Figure 7c). Pressing 3 o'clock of her sacrum into the floor, her right hip descends while her left hip and femur reach to the ceiling. Her legs cascade right, spiraling her spine as her shoulders and upper back maintain a *Functional* stability, pressed into the floor (Figure 7d).

If you don't understand the mechanics... you'll keep making compensatory movements. Notice if you can actually have a disassociation of the pelvis, or if your torso is wanting to move... with it... I feel myself, like I'm becoming a longer arch... and I can feel myself making architecture in space... I'm going to go into a dissociation. I maintain it as far as I can [Figure 7d].

She senses her joyful range of motion in her spiral and with a controlled exhale, her obliques ‘pulllllllll’ her legs back to her starting position, knitting her core back together harmoniously.

I’m going to have my oblique abdominus pull me back ... so I come back torso first and then I drag my legs, which is all obliques, and my legs are doing little. My core is knitting itself back together. Using the obliques to come back from the spiral to should feel like the spine behind the heart arrives first, then the middle back, then the sacrum.



Figure 7c: Dance study of the Abdominal muscles – Start and Final point: Oblique Shift

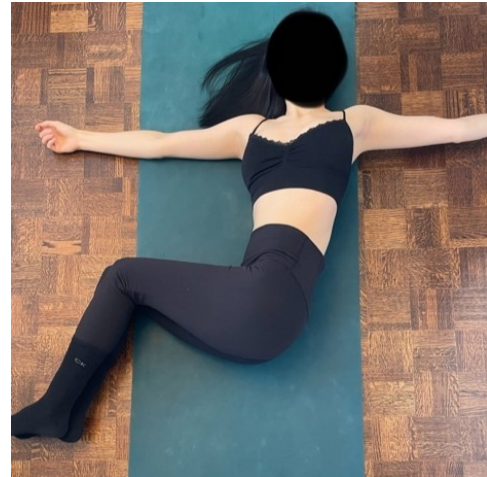


Figure 7d: Dance study of the Abdominal muscles – Mid point: Oblique Shift, full spiral

She explains the abdominals ‘draaaaag’ the torso to center so the spine behind the heart arrives first, then the middle back, then the sacrum, and the legs arrive last. She demonstrates this deliberate, dissociated movement against a twist / untwist, where the hips and torso move as a singular unit, legs and back arrive at the same time because of compensatory engagement of the psaos and back muscles, which leave the obliques under-engaged and the spine vulnerable.

Students attempt the exercise while Denichaud gives individualized feedback on enhancing functional strength to promote joyful, safe range of motion. The class concludes around 11am.

***Clinical: Kinesiology – Tamara Maciel – Axial-Appendicular and Scapulo-Humeral Muscles; Supraspinatus Injury***

At 8:30am, approximately 150 students continue to file into a massive lecture hall located at Waterloo University. In this bright and energized lecture hall, I observed Tamara Maciel guiding her kinesiology students through three-hour exploration of the musculoskeletal,

cardiovascular, and nervous systems of the axial-humeral compartment (shoulder). As the observer, I am seated at the right side of the front row in the lecture hall. This is the lowest tier of continuous desks that face the front of the room for visualization of any of the four projector screens (two at the very front, two in the middle of the room for those seated at the back of the lecture hall). I am aware my background in anatomical sciences may inform my perceptions of her somatic teaching.

Maciel begins her lecture by presenting the shoulder not just as a mechanical structure, but as a complex, clinical space. She begins with the axilla, the anatomical term for the armpit. She uses the axilla as a model to introduce students to how anatomical structures form walls, floors, and contents of functional spaces in the body. Maciel explains the biomechanical actions and injury mechanisms. Throughout the lecture, with each new musculoskeletal concept introduced, she would refer to and palpate her own body. She encouraged students to palpate and move their own bodies to locate surface landmarks, muscle groups, and fiber directions. She always began by identifying the shapes of key surface landmarks and tied this geometry into positioning of key muscles to orient students spatially:

Find your clavicle. Walk your fingers along when you get to this flat shelf. You found your acromion. Continue along the back. Your acromion is just an extension of your scapular spine. You just drew like a horseshoe shape on the top of your shoulder... So all the fibers of trapezius landed on that horseshoe shape and then deltoid fibers would pick up and leave from that horseshoe shape. They share this horseshoe shape.

She continued to explore the major muscles of the shoulder, including as the deltoid, trapezius, and rotator cuff muscles. Location, size, fibre directions, function, pathology, nerve innervation, and blood supply were discussed for each muscle. Throughout the class, she continues to a functional and somatic entry point into understanding shoulder mechanics and pathology.

Maciel guided students to feel muscular fiber lengthening and contraction. Her active movements reinforced anatomical sensation, helping students connect what they were learning to real sensations in their own bodies. This hands-on approach made anatomy more tangible and memorable, as she watches her students participate in mirroring her demonstrations, experiencing lessons firsthand.

Let's start abducted... Be careful. Don't hit your neighbor but show me abduction. We used our middle fibers of deltoid to contract to get us into abduction, like this... But what has now happened to our anterior and posterior fibers? You can actually feel it... Are they crunched up together or did they have to stretch themselves out?... Stretched out! So, what happens if we take fibers that are stretched out and we shorten them? It's gonna contract and bring me back to midline with some force.

Tamara Maciel shifts focus to the supraspinatus muscle, located in the superior posterior compartment of the shoulder. The supraspinatus becomes the anatomical anchor for a rich, layered investigation into abduction, compensation, and neuromuscular control. Maciel begins by reviewing the muscle's origin on the supraspinous fossa of the scapula and its insertion on the greater tubercle of the humerus. Rather than presenting this as static information, she demonstrates and invites the students to palpate the spine of their own scapulae, trace the supraspinous fossa with their fingers, and gently abduct their arms in the coronal plane. The first 15 degrees of shoulder abduction (Figure 8a), which is an action primarily initiated by the supraspinatus, is isolated through slow, deliberate movement. Maciel encourages the class to pay close attention to the moment the deltoid takes over, creating a transition that can be both felt and seen. She then demonstrates how kinesiologists can assess pathology to the supraspinatus muscle. She explains:

Supraspinatus does the first 15 degrees of abduction [Figure 8a]. That means a little away from your body. Once you've got a little away from your body, deltoid now has the right angle to pick up and finish the job [abduction]... Have you ever heard of anyone who's had a supraspinatus impingement? There's an easy clinical test that physiotherapists will do... They'll ask you to abduct the arm from this position [neutral]. And that would be painful if supraspinatus was damaged because the first 15 degrees is hard. So, what [patients] will do, is just tip the body over a little, laterally flex a little, and now you see my arm with gravity just hangs at 15 degrees away [Figure 8b], and deltoid can pick up and do the rest of the job. So, people will sort of cheat to avoid using supraspinatus because it feels easier, that's enough of a clue for clinicians.



Figure 8a: Kinesiology study of supraspinatus first 15 degrees of shoulder abduction



Figure 8b: Kinesiology clinical study of injured supraspinatus and compensated first 15 degrees of shoulder abduction through trunk lateral flexion

By the end of the segment, Maciel has taught the textbook anatomy of the supraspinatus, but also experienced and demonstrated its activation, limitations, and clinical significance through guided palpation, observation, and peer feedback. Maciel’s approach seamlessly merges anatomical knowledge with embodied sensation, reinforcing the idea that clinical understanding begins in one’s own somatic awareness. The class concludes at 9:30am.

### ***Clinical: Medicine – Dr. Terry Li – Valsalva Maneuver***

There were 3-hours of in person observations, however for this research, I have selected the 1-hour online observation due to elevated somatic teaching methods.

At noon, Dr. Li greets two of his anatomy student volunteers with easy humour about “not really being a morning person” and a lighthearted debate over the value of Costco poutine. His spacious office, located in the basement level of the medical building at the Health Sciences Centre building of Max Rady College of Medicine at The University of Winnipeg, is set up like a mini-studio: an ultrasound cart against the wall by the door, chairs for everyone, and multiple cameras set up so online observers can view both the ultrasound display monitor and the office.

As the observer, I am watching over Microsoft Teams and I am aware my background in anatomical sciences may inform my perceptions of his somatic teaching.

Today's 1-hour practice session focused on the anatomy of the neck and upper thorax, demonstrating vascular dynamics and surface-to-subsurface relationships through ultrasound. Dr. Li's practice lesson with his two volunteer students focused on the *Valsalva Maneuver* (a physiological technique involving forced exhalation against a closed airway) to illustrate physiological phenomena like venous distention (bulging of jugular vein in neck). This practice lesson was to familiarize himself with his student's upper neck and upper thorax anatomy so he may smoothly recreate this lesson for his usual larger audience.

Dr. Li begins by introducing his students to the equipment. He turns the large monitor toward them and explains the functions of the transducer or ultrasound probe, focusing on the linear probe selected for today's session. This type of probe, which emits high-frequency ultrasound waves, is ideal for capturing fine detail in superficial structures like blood vessels and muscles. He contrasts it with other types of probes, laying the groundwork for understanding probe selection based on anatomical depth and resolution needs.

He begins to scan his students, revealing the sternocleidomastoid muscle, the carotid artery, internal jugular vein. He explains how much pressure (he is gentle with his students and regularly asks how the pressure feels) is needed, and he demonstrates how the compressibility of the vein helps distinguish it from the artery, which remains round and pulsatile. After a few scans on his volunteers, he places the ultrasound probe to the lateral side of his neck. The sonographic image of his left internal jugular vein and common carotid artery appears on the screen for everyone to see and he re-highlights the ergonomic probe technique and sonographic anatomy. This time, on himself, he adds more explanation of his kinaesthetic feedback. begins guiding learners through efficient probe grip and posture during ultrasound:

[When you're using the ultrasound] You don't know... how hard you're pushing. You'll also slide around all the time [because of the ultrasound gel] ... We ask you to put your pinky or hypothenar to anchor yourself. So, this way you won't slip as much and... you also know relatively how much you're pushing. [When I do it on myself], I just push as hard as I can.

He sits relaxed, the probe on the lateral side of his neck, the display monitor showing how circular his carotid artery is and how the internal jugular vein almost looks deflated (Figure 9a is a recreation of Dr. Li's sonographic visualization of the internal jugular vein when in a

relaxed position). He prepares his students with an explanation of the *Valsalva maneuver*, explaining how it should feel like “you’re trying to [defecate]”. Then, he ‘bears down’, exhaling without letting air escape his body. His face becomes flushed. As intrathoracic pressure increases, the internal jugular vein visibly enlarges on the monitor, demonstrating venous distention (Figure 9b is a recreation of Dr. Li’s sonographic visualization of the *Valsalva Maneuver*).

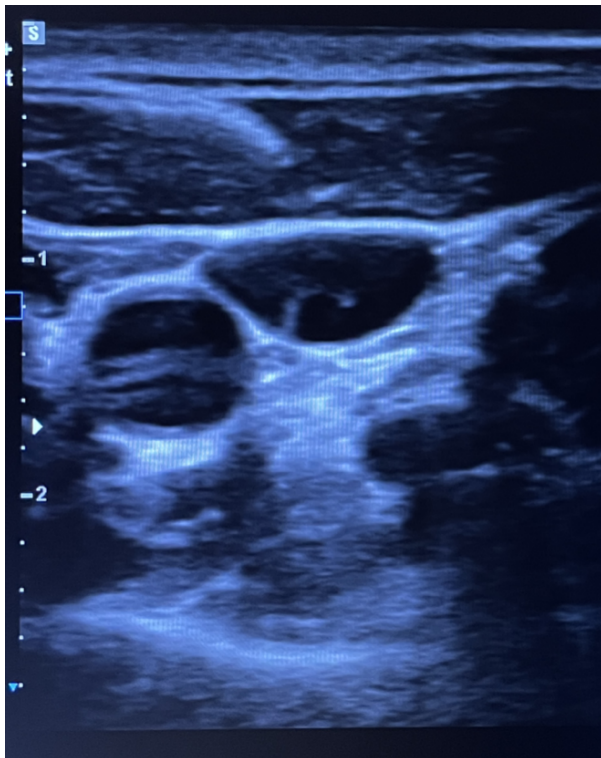


Figure 9a: Medical study of sonographic image of internal jugular vein in reclined position

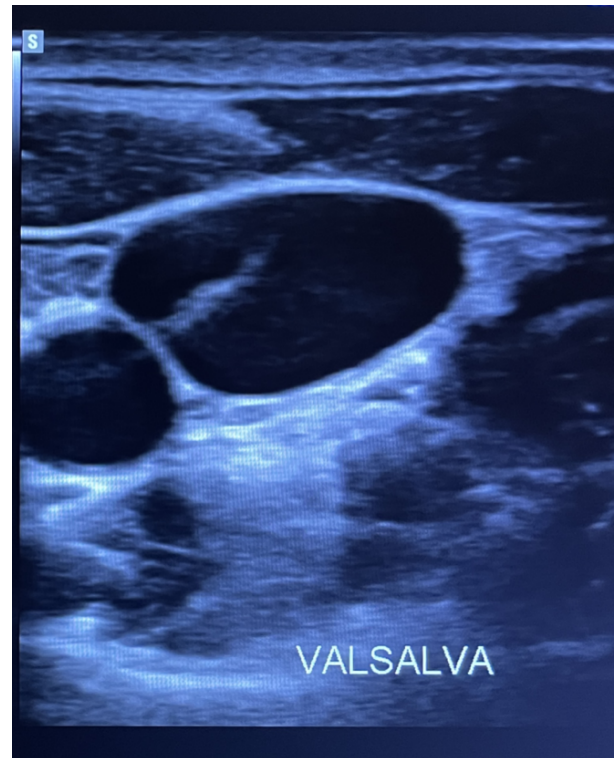


Figure 9b: Medical study of sonographic image of Valsalva Maneuver in reclined position

When you do the Valsalva Maneuver... you’re increasing the intra-abdominal, intrathoracic pressure... pull all the blood up and accumulate in there, right? Valsalva increases your intrathoracic pressure, reduce preload. Or reduce refill of the heart... you back the blood up and then it enlarges the veins.

He smiles at the students reactions and contextualizes the clinical relevance of this response in terms of cardiovascular function and central venous pressure assessment. His vivid demonstrations linked physiological function and pressure changes to the dynamic embodied experiences in the cardiovascular system.

The session wraps up with informal reflection, gel cleanup, and a sense of sparked curiosity in the room and online. Dr. Li’s approach integrates technical precision with embodied,

experiential learning, grounding anatomical knowledge in the dynamic and responsive landscape of the living body. The Teams meeting ends at 1pm.

***Technical: Engineering – Dr. Kei Masani – Kinetics: Joint Moment during Gait cycle***

At 1pm in a compact but brightly lit lecture room at the University of Toronto, approximately fifteen students are seated across four tiers of fixed, continuous desks. Dr. Masani stands at the front of the room, behind the podium, surrounded by a minimalist arrangement of lecture slides on a projector, and a chalkboard behind the screen. The sessions observed are part of a 4-hour Neuro-Musculoskeletal module, which focuses on the integration of anatomical structure, biomechanics, and motor control. These classes highlighted lower limb anatomy and its role in gait cycles, focusing on how unconscious self-organization of muscle and joint action underpins efficient human movement. A large portion of these lectures are framed specifically through the lens of human gait analysis.

From the outset of gait analysis, Dr. Masani's teaching involves experiential demonstration. Starting with joint moment curves plotted against a gait cycle, he explains why the graph illustrates the sinusoidal hip motion, the unpredictable "jump"-like knee torques, and the distinct push-off spike of the ankle plantarflexors.

He walks across the classroom, modeling and exaggerating each stage of the gait cycle, emphasizing how joint torques, muscle activations, and motor pattern coordination underpin each phase. His movements are purposeful, timed with his lecture content, and help better explain the theoretical graphs projected on the screen behind him. He looks at the joint moment graph in his lecture slides and begins his gait cycle. He shows the start of the gait cycle with his left heel striking the ground, the left hip flexed, left knee slightly bent (Figure 10a). Then he shows the stance phase, his left leg extended and supporting body weight as the right hip flexes, the right knee flexes too, and the right ankle shifts to plantarflexion (Figure 10b). As his left foot pushes off, the swing phase begins: the right hip and knee flex to move the leg forward, and the right ankle dorsiflexes to clear the ground (Figure 10c). The cycle ends when the left foot contacts the ground again, ready to repeat the motion (Figure 10d).



Figure 10a: Engineering study of left gait cycle start



Figure 10b: Engineering study of left gait stance phase



Figure 10c: Engineering study of left gait swing phase



Figure 10d: Engineering study of left gait cycle end

He returns to the joint moment graph in his lecture slides (Figure 11, graph retrieved from Robertson et al., 2014). This graph shows three-line for the ankle, knee, and hip moments over

the gait cycle. The Y-axis is Joint Moment (Nm/kg) and the X-axis is % Gait Cycle (0-100%).  
 He explains:

Hip is giant swing, see one sinusoidal [Figure 11, bottom graph] in the gait cycle... but knee is kind of weird, like jump... There are more peaks, not like nice one wave [Figure 11, middle graph]. Sometimes two or three peaks depending on the person or the stride. The ankle has small dorsiflexion torque early, and then a big plantarflexion torque later, like a big peak at push-off [Figure 11, top graph]. After push-off, it drops fast. So hip is big smooth wave, knee is messy with jumps, ankle has big push-off... Depending on participants, that show some variations, like stride lengths or the data within each joint. Hip is a giant swing... knee is kind of weird, like jump... ankle has big push-off.

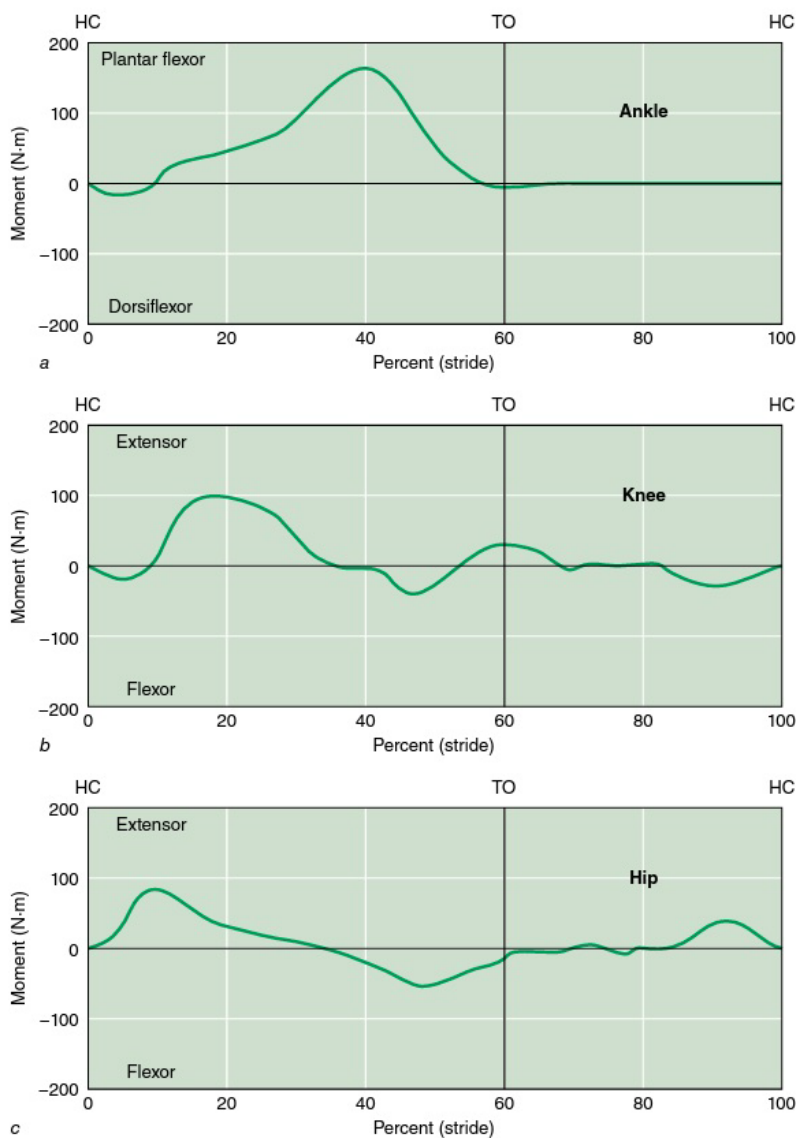


Figure 11: Joint Moment Graph retrieved from Robertson et al., 2014

Moments of force at the (a) ankle, (b) knee, and (c) hip during normal level walking. HC = Heel-contact, TO = Toe-off

He explains to students that gait, while seemingly intentional, is largely governed by lower-level neural systems and spinal pattern generators. This area of study exemplifies self-organization: “There’s no actual center telling all the details of the movement, but the movement [is] basically happening in a self-organized manner.”

### **Co-reflection Interview Findings**

This section presents findings from the follow-up co-reflection interview sessions conducted after the classroom observations. These follow-up conversations invited participants to revisit specific teaching moments and share how they experienced them somatically, emotionally, and pedagogically. Through this dialogic process, participants offered deeper insight into their intentions, sensations, and interpretations of embodiment during teaching. Their reflections revealed moments of *Function, Form, Feeling, and Flow*, offering a unique window into how anatomy educators make meaning of their bodily presence in the classroom. Guided by Braun & Clarke’s (2022) RTA and the F2F model, interconnected themes regarding embodied anatomical expressions were generated using excerpts from initial interviews, artifacts, observations, and co-reflections. While each participant expressed these themes in discipline-specific ways, the data also revealed convergent pedagogical practices. The data presented here includes direct quotes that illuminate the internal experiences of movement, gesture, and teaching, enriching and complicating the observational data with participants' own felt narratives.

#### ***Expressive: Visual Arts – Niloo Inalouei – Study of the Forearm and Hand***

##### **Subtheme 1: The Geometry of Gesture: Anatomical Form in Motion (Function).**

During the coreflection interview, Inalouei revisited a specific teaching moment in which she demonstrated the anatomy of the forearm and hand by using a fluid circular motion of her upper limb. She described the movement as a pedagogical tool and an aesthetic experience. She explained her process:

I make a circle with my arm and hand... My fingers in flexion, but inward... Descending circle of motion with the fingers leading... to show the planes and the shapes of the forearm versus the hand and fingers. If you see it as different angles, then you understand how to draw it, because when the light hits... all planes are affected differently... It’s not about getting it right the first time—it’s about training your eye to see what’s really happening... I believe that... everything we see... in the human body... we can describe... with geometry... Draw simply, geometry first, then details.

She likened the gesture to Hokusai's *The Great Wave*, noting the visual and kinesthetic parallels between art and movement:

Do you know Hokusai's painting, *The Great Wave*? This movement (flexion & inward circle) is like that painting for me. At first, it looks quite simple... But if you study the roundness, boxy, plane, plane, plane... there's so much more to study. Doing this motion... I feel content. It reminds me of my cat... a happy cat curling in its paws about to knead dough.

**Subtheme 2: Mapping and Capturing the Essence: Timing, Gesture, and Line (Form).**

Inalouei believes that gesture drawing is not only about accuracy but about capturing essence. She described how rapid observational drawing could distill an internal sense of motion:

Gesture is not about... drawing... to be perfect. I put a lot of focus on... capture the movement... like if you have two seconds and the model is posing, just imagine... what line can you just draw... to basically capture that movement... or feeling of the pose?

**Subtheme 3: Somatic Knowing (Feeling).**

Inalouei emphasized the importance of self-touch and sensory awareness in developing anatomical literacy and artistic sensitivity. She encouraged students to palpate their own bodies to inform artistic decisions, such as line weight, texture, and shading, based on tactile and visual impressions:

I want my students to feel it... I always want them to touch everything [self] as I'm talking... It's not only about the bones and muscles... it's about the skin too. How does the skin feel? Tight? Loose?... In this motion (deep flexion) (Figure 6c), I feel the pressure on both sides. There is a pressure of the stretch and pressure of compression. The palm feels different than the top of the hand. This is compressed... It's going to need thicker lines... You need some shading here in between the skin and tendons... This [dorsum of hand] feels more delicate. The lines drawn... should show... the skin is delicate.

**Subtheme 4: Storytelling Through the Body (Flow).**

Through her teaching, Inalouei creates a classroom space where students engage not only with anatomy but with the emotional and narrative dimensions of the body. She explained how figure drawing allows students to express unspoken parts of themselves:

My class is... about the stories... the voice can't say because you're looking at the body (of a model), but you're also very reflective of your own and how you feel on the inside. Conversation in class is... creating counter-narratives through the body. How to use the body to create different kinds of stories... alternative histories. Their stories... Basically what... is important to them. The importance of hands in figure drawing and painting are

just like facial features. We use them to express things... they tell a story.... Sometimes they (students) cry because it reminds them of their own story.

**Subtheme 5: Flow and Perceived Group Synergy (Flow).**

Finally, she described the joy, curiosity, total absorption in her teaching practice, and how she senses a group synergy that emerges during shared artistic exploration, especially when demonstrating complex motions alongside her students:

There's so much joy in experimenting... I'm learning... Anytime I'm drawing, I go into that zone, and it's a lot of joy... This movement [where she showed flexion of wrist, metacarpal-phalangeal, and interphalangeal joints]... it looks quite simple... but if you study the roundness, boxy, plane, plane, plane... there's so much more to study... It's a great energy going in the class, especially in those moments because they're all doing the same thing and there's something about doing the same thing together... they're so enthusiastic seeing how I draw... I'm seeing them learn, and I see myself as part of this group. We're experimenting something together.

***Expressive: Dance – Danielle Denichaud – The Joy of Safe Movement in the Hips and Abdominal Obliques***

**Subtheme 1: Postural Intelligence: Building Expressive Potential (Function).**

Denichaud structured her lessons to support movement efficiency, injury prevention, and performance excellence by teaching embodied postural analysis, proprioception, and functional dissociation. Her pedagogy enhanced bodily awareness to self-correct and to explore new expressive pathways somatic clarity. In revisiting her instruction of *Sacral Clock* and *Oblique Shift* exercises, she explained how anatomical understanding supports expressive choice:

The anatomy in class is functional based... I focus on postural analysis... to identify which... muscular engagement... may be already dominant... Can you move it as a large chunk or break it into smaller functional components? We want their body to be as... strong as possible so they can accomplish the full expression of their character. Same for a dancer, give them as much choice as possible. If you don't understand the mechanics... you'll keep making compensatory movements. This course is about having enough information so they can be aware of putting their body into space and... movement.

To guide students in anatomical dissociation, she described the spatial relationships and muscular control involved in the spiral. She mapped sacral motion through pelvic tilts (Figure 7a, 7b) and demonstrated rotational torque and oblique muscle action (Figure 7c, 7d).

If anyone has ballet training they lose their disassociation between the torso and their pelvic girdle... they lose this spiral in their body. So being able to get a true oblique without just having... the dorsal muscles is...important... To do this in class, we use *Sacral Clock* and *Oblique Shift*. For *Sacral Clock*, I lay down on the ground... and I put my hands on my back to indicate the sacrum and show that we're rocking up and down,

and... side to side. For Oblique shift, you're on your back with your legs at 90 degrees... feel the femur shifting superiorly towards the ceiling and... rotation in the hips... which is the initiation of a true spiral... Spiral's gonna involve an oppositional directionality... I'm going to go into a disassociation.

Danielle emphasized the role of internal feedback in activating somatic awareness and spatial clarity. Her explanation of the oblique return movement exemplifies how layered sensory input, from muscle engagement to fascial stretch, guides learning and performance:

I maintain it as far as I can, and have my oblique abdominus pull me back... so I come back torso first and then I drag my legs, which is all obliques, and my legs are doing little... I can feel my front body knitting, knitting, knitting myself back together and it relieves my pelvis... And it will also open up the fascia on the front of the body.

**Subtheme 2: Orienting the Body in Space: Visual Mapping and Postural Form (Form).**

Danielle emphasized the importance of external orientation and spatial mapping as foundational tools for building anatomical clarity in performances. Her teaching of movement involved sensation for efficiency, but also about understanding where the body is in space, how it stacks, and how form shapes intention. Danielle explained that training in dance often leads to ingrained movement biases, especially those shaped by aesthetic ideals, which can cause postural imbalances.

All dance styles are about an aesthetic form and very specific performative actions... Some dance styles are going to favor rigidity and mobility in very specific parts of the body that would likely not be overall balanced... In ballet, there is gonna be a tendency for an anterior position [of the pelvis] because of the external rotation of the leg... You will train your body as such... The muscles are trained to accomplish the aesthetic form and performative function... The wear and tear on your joints [needs you to] understand how your body likes to move... the balances and biases in training... so we need to teach... awareness to... mitigate and prevent injury and premature damage to the body... so that we can do more of what we want to do for longer and in peace.

To counteract these patterns, she used exercises that re-established a neutral sense of center and verticality:

In yoga, they say you're trying to come back to home, no matter what position you're going in... the crown of my head to be over the center of my jaw, which is going to be over the center of my diaphragm, which is over the center of my pelvis... If my femurs are shoved forward... what is my experience of center? So much of body awareness and body intelligence and body autonomy in terms of directing movement... is tuning the mind to hone in on a certain body part... and it's finding language that makes that accessible based on the things that are known to us.

Throughout her teaching, *form* was not simply a matter of correctness, but a visual for students to embody their structure with clarity, intention, and responsiveness.

### **Subtheme 3: Somatic Knowing & Expansion (Feeling).**

In describing the rhythmic repetition of these practices, Denichaud highlighted how breath, sensation, and muscular coordination contribute to a Flow state during instruction:

When I lean into an exercise, I feel that part of my body become enlivened with sensation. There's generally a sense of warmth... and it feels as though my body... is homing in on the area and it becomes much larger... I feel joy when... all these little bits are harmoniously working together in my movement. I can get swept up in my cycle of breathing, which is very pleasurable... It's an invitation to go into a body sensorial experience... My obliques pulling me into a true twist, then releasing back into center... It feels joyful for my body... I feel strong. Joy. Safety. Freedom...

### **Subtheme 4: Teaching as Healing and Embodied Presence (Flow).**

Danielle spoke of her personal connection to the course, shaped by her experiences with injury and illness as a dancer. She described teaching as a redemptive act, where pain and embodied learning could be shared with students through presence and relational care:

What does it mean to be an embodied human... who has a capacity to be creative and intentional and responsive to moving through space, doing an action, be an effective communicator and storyteller? I've been doing the same thing over and over again, but this particular course... represents a very special experience for me because I was a dancer and I was injured and sick for so many years. I went through so much suffering. The opportunity to share whatever knowledge, insights, and guidance has helped me recover. It's an absolute gift... I encounter an incredible amount of energy. I have a lot of presence and focus for them... This particular course... represents a very special experience for me because I was a dancer, because I was injured, because I was sick for so many years. Teaching makes my years of suffering OK...

## ***Clinical: Kinesiology – Tamara Maciel – Axial-Appendicular and Scapulo-Humeral Muscles; Supraspinatus Injury***

### **Subtheme 1: Anatomical Language - Movement and Biomechanics (Function).**

Maciel uses interesting language to describe locations of muscles. The co-reflection began by exploring how she has refined the anatomical terms she uses in lectures and labs, shifting from traditional “origin–insertion” language to phrasing that foregrounds attachment sites and shared anchor points:

[The language I use] is an evolution. I started out using ‘origin’ and ‘insertion’ and... I felt early on that language was a little bit problematic. And I... noticed one of our textbooks had switched to start using more descriptive proximal attachment or distal

attachment... So [I] switched to like one muscle landing somewhere, it's an anchor point, right?... Another muscle picking up and leaving from there. It almost looks like the bone interrupts a fiber that continues... but here it's more just a shared anchor point I guess. [That] is how I described trapezius and deltoid sharing that horseshoe shape on the top of the shoulder. So we want them to know... where roughly [origin] is because it helps dictate fiber direction... But when it comes to the distal attachment sites... we ask them to be very specific because it's tied to the function...

### **Subtheme 2: Somatic Knowing; Kinesthetic Palpation and Visualization (Form & Feeling).**

To help students sense underlying structures, Maciel repeatedly guides them through self-palpation and movement cues, pairing tactile feedback with mental imagery:

We palpated our clavicles, the acromion and the spine of the scapula... I do that twice... Find the horseshoe shape on the shoulder... I can feel that little tiny pulse, that little tiny bulge [of supraspinatus]... But I can feel that deltoid does this... When I tell students to, like, abduct your arm, I feel stretching through here. I feel pectoralis major and maybe my back muscles stretch.

She encourages students to imagine joint spaces and borders:

What shape is this space? And if it's a shape, what borders or boundaries do we need to consider that make this shape?... I wish we could get to the point where they could take a complex movement, like a push up and say in a push up these muscles are shortening and contracting and maybe these ones are isometric and maybe these ones are eccentric. That's very, very hard.

When demonstration alone is insufficient, she adds external aids:

I'll say to them: I can't demonstrate this for you... you won't be able to see me well enough. If they can't feel it, maybe they can at least visualize it [with] therabands in the lab... especially around the shoulder joint... [so students can make the bones move with therabands acting as muscles].

### **Subtheme 3: Storytelling and Joy of Teaching (Flow).**

Maciel described moments of fluency and comfort in her teaching practice where movement, communication, and content delivery feel naturally integrated. She emphasized her awareness of these rhythms as signs of confidence, which generated camaraderie across her class during applied anatomy sessions, enhancing a sense of community in her class:

I love teaching this lecture so much... I feel really energized and... like I've got a flow going on, the groove... I know I'm gonna be at that lecture hall by 8:00 in the morning... Then it starts and I don't think too much. I just feel really, really like happy there... I think [the class] is good flow and it's the right amount of content. My delivery is so

smooth, and it doesn't feel rehearsed. I'm just so comfortable and confident with the content, even if a student asked me a question, I can integrate the answer and you know, continue to move. Just have this smoothness for that [axiohumeral] area...

In reflecting on her pedagogy, Maciel described how clinical case stories and in-class anecdotes help her feel connected, present, and confident.

Because the story [lateral flexion of trunk to avoid using supraspinatus in the first 15 degrees of arm abduction] a little bit cheeky, isn't it? Like the way I tell the story. But the story is that the patient is cheating [by laterally flexing the trunk]... 'Oh, I'm fine. I can abduct.' ... No, you have a supraspinatus injury!

#### **Subtheme 4: Perceived Connection and Purpose in Challenging Contexts (Flow).**

Maciel described how her sense of connection to students emerges during moments of shared effort in demanding academic environments. In her perception, these physically engaged sessions generate a sense of collective investment and mutual recognition that supports her own sense of purpose and trust in the classroom. She reflected on how movement-based tasks, sustained engagement, and repeated exposure contribute to her feeling of closeness with students:

And they're [also] moving their bodies and they're feeling... I think they get a sense of community. What we're asking you to do is hard... and if you come at the other end with this cohort of students and you all did it together... it's like a group achievement... moving together in the class. I do try to engage them as part of that group. I feel connected to students in the room... I have their attention... I never feel embarrassed or worried... I know now that I have their trust... You see the same faces every week... the ones I feel that connection with are sitting nearer to the front... And I think too about the sense of community that we're trying to create, right? This course is hard. I mean, for some students who love it, it seems to come easy and they're able to be successful. But for a lot of students, this is a very challenging course, and they're working very hard to achieve their grades. And so I think that when you come out of it and especially, we think about... Bell Ringer exam, which is such a unique experience and a higher stress situation... I feel like they come out and as a cohort they can say like we did this thing we did this thing together and this binds us.

#### ***Clinical: Medicine – Dr. Terry Li – Valsalva Maneuver***

##### **Subtheme 1: Mapping and Capturing Sonographic Imaging (Form).**

Dr. Li incorporated ultrasound use in his clinical anatomy lectures to prepare medical students for clerkship. He described how scanning his own body helps him deliver more efficient and accurate demonstrations during ultrasound-based anatomy instruction. Relying on his own

bodily awareness and anatomical familiarity, he emphasized how somatic sensations help guide the probe placement:

It's... a brand new way of seeing the body. I just scan myself. It's also much easier to demonstrate with my body... Even if it's just a quick thing, I put the probe on my own neck to show them the carotid arteries, internal jugular, muscles, and nerves... I have a mental image to chase; I have a target that I need to hit. Part of it depends on the area of the body. The surface landmark is important, so... either with the probe or with my hand, I can feel the structures that are supposed to be underneath and where I should put the probe. You can also feel, you know, this is muscle, this is bone, and this is... cartilage... Once you've done enough of this, you get an idea of where to place the probe.

He reflected on how tactile feedback, personal sensation, and intuitive recognition guide his demonstrations:

I don't demonstrate like [the observation] during a whole lecture but more tutorial [settings]. Especially on myself, sometimes I do it on other people, but it could be harder to see... [I use my own body] and it's out of necessity or convenience... 'Cause, it's like you're touching yourself... my feelings also tells me where to put the probe. That's why I'm always more accurate on myself. Like I scan myself much faster than scanning other people... I know where everything is.

### **Subtheme 2: Intuitive Process and Experimentation (Function).**

Dr. Li shared that his ultrasound teaching process is driven by visual goals and intuitive sequencing. He compared it to other experiential learning methods like dissection, where an internal expectation precedes the external action:

I think ultrasound you almost have to... be working backwards because everyone starts looking at the image that you need to take first, so in that sense it's... similar to dissection. Everyone learns anatomy first before they dissect. You kind of have an expectation and then you go to cut it out. I think for the most part is intuitive. I just put the probe on myself. I have a mental image to chase.

Dr. Li reflected on his comfort with experimenting during teaching demonstrations, sharing that his actions are guided by an internal sense of mechanical cause and effect. His approach is rooted in bodily intuition and a willingness to explore somatic feedback in real time:

I've always been... intuitive with mechanical causality. When you do... this, [something else] will happen. If I have a concept of that, then I don't mind trying it to see the feedback. I'm not afraid of trying something, just to see what happens.

### **Subtheme 3: Somatic Analogies and Visceral Learning (Feeling).**

To explain complex internal mechanisms of Valsalva Maneuver, Dr. Li described using somatic analogies grounded in lived bodily experience. He shared his personal understanding of

the Valsalva maneuver and how he uses relatable metaphors to make internal pressure perceptible:

I just connect the ultrasound to the big screen and then show them, especially for people who've never... seen it, they always love the watching the vein. Just balloons like crazy!... I don't know exactly how to describe it, but it's very visceral... they know they can feel it. Everyone knows what it's like to hold their breath, or like try to take a hard poop, but being able to visualize it [Valsalva Maneuver], it's like trying to blow up a balloon from the inside

Dr. Li emphasized visual clarity and spatial relationships on the sonographic image. He highlighted the importance of anatomical orientation and image acquisition in developing diagnostic precision. His teaching centred on helping students identify key anatomical landmarks and understanding their relationships in real time using ultrasound.

The artery is round... it carries more pressure, has a stronger wall, so it stays more circular. But a lot of people like myself, the veins are very collapsed, or small, hard to see [Figure 9a]. You can't really see it, only during Valsalva [Figure 9b]. You can really show the vein and then you show the relationship between the vein and artery.

Dr. Li used visceral analogies to explain the feeling of internal pressure during the *Valsalva Maneuver* (forced exhalation against a closed airway).

The easiest description is just pretend you're trying to poop... like, have a really hard poop. And that's what we do. When you're constipated, you have to do a Valsalva maneuver, yeah... You can definitely feel the blood rushing to your head [Figure 9b]. I always tell students "Don't do it too frequently, you can pass out."

#### **Subtheme 4: Shared Excitement (Flow).**

Dr. Li described feeling energized when sharing ultrasound demonstrations, especially when his own bodily engagement triggers reactions that validate the immediacy and effectiveness of his approach. His comments reflect a personal sense of enjoyment and motivation when tactile-sensory techniques evoke visible attention. He is most excited about sharing excitement with his students, as he explains:

Because I spend like four months with the same group of students, I form a really good like relationship with them. I take a lot of pride in how they turn out. [At] the same time, what I personally find more interesting... is ultrasound and the actual procedures. I am more excited for... more procedure-oriented things... Like you want to demonstrate... *Valsalva*... make your internal jugular artery super big and everyone's like 'whoa.'

And... [it] always gets a good reaction out of the class. If they weren't paying attention before, they're paying attention now.

## ***Technical: Engineering – Dr. Kei Masani – Kinetics: Joint Moment during Gait cycle***

### **Subtheme 1: Technical Surface Mapping (Form).**

During his co-reflection, Dr. Masani emphasized the importance of anatomical familiarity for engineering students, particularly in relation to EMG (electromyography) data collection and interpretation. He reflected on why a foundational understanding of anatomy, such as naming and locating superficial muscles remains essential for engineers who design and test human-machine systems:

I want them [students] to have some fundamental understanding with the names... location of... the superficial muscles... [because] we often collect EMGs [electromyography] from them... These muscles... often show up in... [scientific] papers so they have to understand which part of the body [is being] discussed.

### **Subtheme 2: Demonstrating Automatic Gait (Function).**

Alongside the diagrams and gait graphs on his slides, he taught the gait cycle by walking across the room to show start of gait cycle (Figure 10a), stance phase (Figure 10b), swing phase (Figure 10c), and end of gait cycle (Figure 10d). Dr. Masani used real-time movement in coordination with his lecture slides to effectively teach core engineering concepts. Although Dr. Masani linked anatomy lessons concerning proprioceptive engagement to activities outside of class, such as baseball, he noted that performing gait does not evoke a sensory experience for him.

Whenever I train skill development, I'm deeply thinking about the body movement, stretching, everything factor... Currently I'm helping my son in baseball pitching and I'm always thinking about the mechanism of baseball pitching throwing motion. But... when I'm doing [gait] demonstration [in class], I don't feel. I explain that it's an unconscious movement.

Since gait is meant to be an automatic, unconscious movement, it often escapes our proprioceptive awareness during demonstration. Although Dr. Masani's classroom emphasized graphs, he valued proprioceptive feedback in his personal day-to-day life.

### **Subtheme 3: Self-Organization (Flow).**

Dr. Masani's fascination with unconscious, self-organizing bodily rhythms shaped both his research and pedagogy. He explained that gait emerges from automatic neural and mechanical systems, with minimal conscious control. These reflections underscore how the body's functional complexity continues to inspire his work:

This is my favorite topic actually... I was interested in how these complex actions emerge. This is related to my thesis, that's kind of my trigger for me to come into this field... How is gait action generated? It's mostly automatic... self-organization is... key... In spinal cord... central pattern generator makes rhythm. The musculoskeletal system is in segment pendulums, swinging, and they interact with the environment. This [sensory feedback] goes back to spinal cord... maybe small adjustments happen... If a complex task, for example, visual feedback or something where the knee buckles, then motor cortex becomes more involved. There's experiments showing the brain function burst in motor cortex during the task that has visual feedback. So, then the action is likely becoming more conscious. But we cannot do experiments to show that, it's subjective. It's difficult to define... But the movement is happening in a self-organized manner. So everything is kind of an unconscious process. Mostly automatic from the lower central nervous system... So basically everything is unconscious... automatic, self-organized. The body adjusts by itself... unless you add some complicated feedback, then motor cortex may be more activated.

This chapter has illuminated the rich, multifaceted ways in which anatomy educators across expressive, clinical, and technical disciplines employ somatic pedagogies to engage the living body as a teaching tool. Through the lens of the Function2Flow model, the findings from interviews, artifact analyses, classroom observations, and co-reflections reveal how educators integrate kinetic awareness, spatial attention, somatic sensing, and energetic presence to foster deep anatomical understanding. These discipline-specific yet convergent approaches highlight the transformative potential of embodied learning in HPE, offering insights into how educators cultivate attentiveness, confidence, and clinical intuition. The thematic connections across cases is presented in Chapter 5, Discussion.

## Chapter 5: Discussion

This chapter synthesizes the findings from the findings section, exploring and comparing the differences and similarities between how anatomy educators across expressive, clinical, and technical disciplines integrate somatic and experiential learning methods to bridge theoretical anatomical knowledge with embodied understanding. Guided by the F2F model and Braun and Clarke's (2022) RTA, this discussion reveals both disciplinary nuances and shared pedagogical strategies. Through a cross-case analysis of five educators' practices, this chapter directly addresses the research questions guiding this study, highlighting the body's role as a dynamic pedagogical tool in HPE. The thematic synthesis and comparative insights offer a deeper understanding of how embodied learning shapes anatomical education across diverse contexts.

This study revealed that while anatomy educators across expressive (visual arts, dance), clinical (medicine, kinesiology), and technical (engineering) disciplines approached somatic teaching through discipline-specific methods, there were shared underlying themes that transcended disciplinary boundaries. RTA (Braun & Clarke 2006, 2022) guided by the F2F model (Lloyd 2011; Lloyd & Smith, 2009), illuminated four interrelated themes:

1. Teaching anatomy through movement and biomechanics (*Function*)
2. Visualizing structure through surface and spatial awareness (*Form*)
3. Enhancing kinaesthetic and proprioceptive awareness (*Feeling*)
4. Cultivating Somatic Flow and Internal Energetic Presence (*Flow*)

Table 2 summarizes how each participant expressed the four core themes generated through RTA, highlighting both cross-case similarities and disciplinary nuances.

Figure 12 shows a bar chart on the Emphasis on F2F dimensions Across Participants. This chart illustrates the RTA coding results (0-100 codes) for each educator's emphasis on the F2F dimensions (*Function, Form, Feeling, Flow*) based on their somatic teaching practices, presented in color.

Table 2: Comparative summary of how participants expressed the four embodied anatomical themes across disciplines using the Function2Flow (F2F) Model.

Theme	Niloo Inaloeui (Visual Arts)	Danielle Denichaud (Dance)	Tamara Maciel (Kinesiology)	Dr. Terry Li (Medicine)	Dr. Kei Masani (Engineering)
1. Teaching Anatomy through Movement and Biomechanics ( <i>Function</i> )	Demonstrated wrist flexion to teach dynamic form in drawing.	Taught sacral and torso dissociation exercises for strength and awareness.	Explained shoulder abduction mechanics clinically and functionally.	Used ultrasound and <i>Valsalva Maneuver</i> demonstration to teach vascular function.	Taught gait cycle phases through live movement and EMG application.
2. Visualizing structure through Spatial and surface Awareness ( <i>Form</i> )	Emphasized geometric visualization of forearm, wrist, hand structures.	Mapped <i>Sacral Clock</i> and <i>Oblique Shift</i> to visualize pelvic-lumbar structure.	Taught students palpation of clavicle and scapular spine landmarks.	Used ultrasound to spatially map anatomical structures in the neck, particularly arteries and veins.	Explained joint moment graphs to visualize movement forces across gait cycle.
3. Enhancing proprioceptive and kinaesthetic Awareness ( <i>Feeling</i> )	Encouraged self-palpation to sense anatomical surface changes while drawing.	Cultivated internal sensing through breath, sacral proprioception.	Guided active feeling of muscular contraction and stretch.	Taught students to feel internal vascular pressure during <i>Valsalva Maneuver</i> .	Emphasized unconscious body awareness during gait; linked proprioception to skill training.
4. Cultivating Somatic Flow and Internal Energetic Presence ( <i>Flow</i> )	Described joyful, collective experimentation during gesture drawing.	Experienced somatic joy, strength, and relational presence through movement teaching.	Fostered sense of community and group energy through applied anatomy movement.	Created shared excitement with live ultrasound demonstrations.	Explored unconscious self-organization and flow during gait analysis and modeling.

## Emphasis on Function2Flow (F2F) Dimensions Across Participants

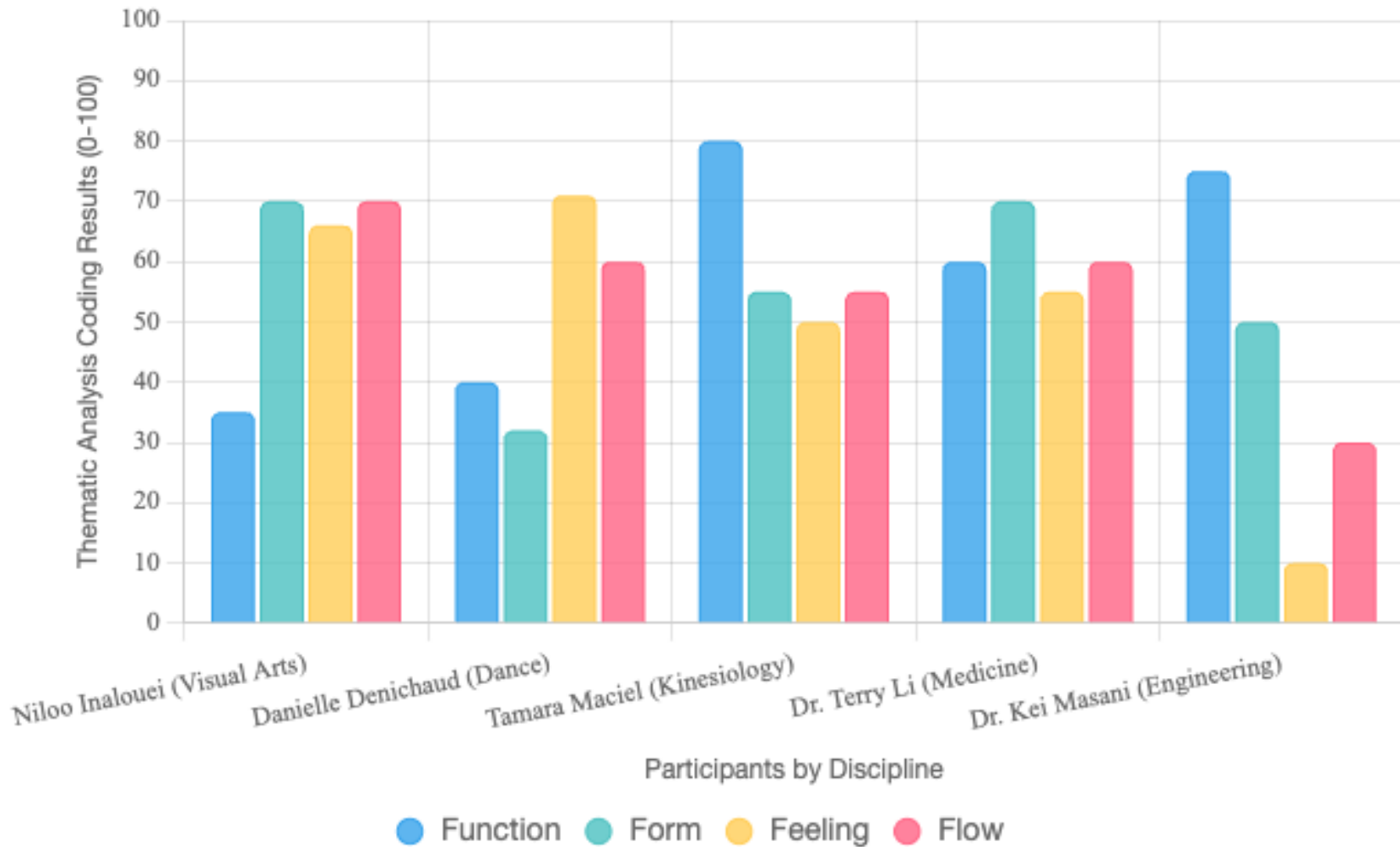


Figure 12. Bar Chart – Emphasis on F2F dimensions Across Participants; Cross case comparison of Reflexive Thematic Analysis (RTA) coding results (0-100 codes) for all educators

## **Theme 1: Teaching Anatomy through Movement and Biomechanics (*Function*)**

All participants taught anatomical concepts by physically modeling mechanical functions using their own bodies. However, the degree of complexity varied across disciplines. In expressive fields like visual arts and dance, functional movement was often taught through simple, accessible gestures (e.g. wrist flexion or pelvic tilts) to awaken kinetic understanding, proprioception, and expressive nuance in visual-motor coordination. These movements allowed educators to teach visual-motor skills and embodied expression, which are common objectives in creative, expressive practices (Denichaud, 2024; Green, 2002; Inalouei, 2024, Rózsavölgyi, 2021). In these contexts, *Function* is about biomechanical detail but also initiating sensory and expressive awareness by using motion as a mirror for internal experience.

For example, Inalouei guided her art students to “draw from your arm, not your wrist... If you understand how a joint moves, you’ll know how to draw it in different positions.” This quote shows how movement was used as anatomical language to train both perception and imagination in figure drawing. Similarly, Denichaud taught dancers to refine functional control through sacral tilts and abdominal spirals, explaining that “the anatomy in class is functional based... so they can accomplish the full expression of their character... If you don’t understand the mechanics... you’ll keep making compensatory movements.” Both educators used *function* to build anatomical accuracy and to enhance expressive choice, body literacy, and technical safety, a priority in performance education where the body is both instrument and message (Pengelly, 2010). Their approach suggests that *Function* can serve as a scaffold for creativity, linking physical mechanics with artistic expression and somatic agency.

In clinical fields like kinesiology and medicine, educators taught more complex mechanical processes (e.g. vascular pressure dynamics during the *Valsalva Maneuver*, or supraspinatus muscle activation when injured). These movements were used to emphasize clinical application or reasoning in injury diagnosis (Estai & Blunt, 2016; Li, 2025; Maciel, 2025; McBride & Drake, 2020; Viana et al., 2019). As Maciel explained, “Supraspinatus does the first 15 degrees of abduction... what patients will do [with an injury] is tip the body... so deltoid can pick up and do the rest of the job.” This example shows how functional anatomy becomes a tool for clinical observation and biomechanical reasoning. *Function* gives clinical educators and students the tools to assess dysfunction, identify compensations, and understand physiological cause-and-effect in real time (Ericsson, 2004).

The technical aspect of engineering framed function through biomechanics and the forces applied to different joints (e.g. how joints move during the unconscious, systemic motor patterns in gait), highlighting the analytical priorities of the field (Bisht et al., 2019; Masani, 2025). Masani emphasized that “when I’m doing [gait] demonstration, I don’t feel... it’s an unconscious movement... mostly automatic, self-organized.” This reinforces the idea that in technical education, bodily movements are taught less as felt sensation and more as a system to be modeled. This abstraction of *Function* points to a unique paradigm: in engineering, anatomical movement becomes a reproducible signal that is detached from experience but essential for designing responsive technologies.

This spectrum suggests that embodied functional anatomy teaching ranges from expressive simplicity to clinical precision. At one end, Inalouei’s wrist-flexion exercises cultivate gestural awareness to deepen artistic perception, while at the other, Maciel’s detailed shoulder-abduction demonstrations support accurate injury diagnosis. Together, these examples show that *Function* is not a fixed construct but a discipline-shaped mode of embodied knowing, spanning expressive fluency and highly patterned technical expertise. Whereas visual arts and dance foreground accessible, felt action, clinical and technical fields locate function within mechanistic detail or systems thinking, indicating that anatomy education must continually negotiate the balance between felt action and mechanical abstraction depending on learning goals (Barsalou, 2008; Lakoff & Johnson, 1999).

Across all five cases, *functional* anatomy served as a foundational entry point into embodied teaching, yet its delivery reflected each educator’s unique disciplinary lens. What unites these approaches is the use of movement as the language to learn anatomical concepts. All participants used movements such as expressive gesture, clinical modeling, or biomechanical demonstration. Dr. Li, for instance, described how “I just scan myself... with the probe or with my hand, I can feel the structures underneath... you get an idea of where to place the probe.” His movements, though technologically mediated, still relied on a somatic map grounded in personal sensation and experience.

These findings show that *Function* emerges as a dynamic, discipline-shaped construct that is moulded depending on the educator’s teaching philosophy, disciplinary goals, and somatic awareness. For some, it is about feeling a movement; for others, it is about observing its outcome or modeling it mathematically. The F2F model helps make sense of these differences by framing

*function* as more than mechanical, it is shaped by how teachers bring their own bodies, habits, and intentions into the learning space. In this way, teaching function becomes a kind of performance: both planned and embodied, precise yet alive.

Thus, across cases, function emerges as a living construct: mediated by movement, interpreted through intention, and enacted through distinct yet overlapping pedagogical logics.

## **Theme 2: Visualizing Structure through Surface and Spatial Awareness (Form)**

Participants used techniques to teach students how to develop surface awareness of underlying anatomical structures through external landmarks on the body, such as bony landmarks or muscle contours. All educators emphasized the importance of surface anatomy, geometric form, and spatial mapping. This kind of geometrical visualization can help students mentally map the body three-dimensionally. For educators, it seems to be a practical way to teach complex anatomy without advanced tools. For students, educators believe it helps them build spatial reasoning and deepens understanding by linking what they can see and touch relating to the anatomical structures that lie beneath the skin.

Interestingly, each discipline emphasized different aspects. In expressive disciplines, Inalouei and Denichaud taught students to interpret form dynamically through gesture drawing, mirror work, and shape recognition. This supports literature on visual-motor coupling in somatic and artistic education (Green, 2002; Franklin, 2013; Taverna et al., 2020). “Gesture is not about drawing to be perfect... just imagine what line you can draw to capture the feeling of the pose,” Inalouei explained, highlighting how quick anatomical sketching distills movement into essential spatial and emotional form. She further explained the change in *Form* by teaching how one should observe shapes, shadows, and planar transitions. “See how it goes from round and egg-shaped [proximal forearm] ... to more boxy [distal forearm]... then plane [metacarpals], plane [proximal phalanges], plane [middle phalanges], plane [distal phalanges].” Denichaud similarly focuses on the *Form* of the sacrum and asked, “Can I map [sacrum] as if... details for 3D printing?... bony nodules or... smooth? What does it feel like to use my abdominals to rock my pelvis?” Her phrasing links kinesthetic mapping with spatial accuracy, translating sensation into anatomical logic. This focus on form as felt structure reveals how expressive educators blur the line between visual, tactile, and spatial modalities, inviting students to “see” anatomy by embodying it.

In clinical contexts, both Maciel and Dr. Li integrated palpation and sonographic imaging to connect surface landmarks with subsurface anatomical structures. This aligns with research on procedural anatomical skill-building and surface anatomy palpation being critical for clinical practice (McBride & Drake, 2020; Papa et al., 2019). Maciel helped students palpate and visualize clavicle and scapular spine structures. She began by identifying the shapes of key surface landmarks and tied this geometry into positioning of key muscles to orient students spatially. She prompted students: “Find your clavicle... you just drew... a horseshoe shape on the top of your shoulder... trapezius landed there and deltoid picks up from there.” Her approach framed the body as a geometric and tactile map, reinforcing spatial comprehension through physical contact. Maciel showed that *Form* becomes diagnostic: a way to sharpen students’ spatial awareness for real-time problem-solving. Compared to expressive approaches, clinical form is more functionally tethered to action and interpretation.

Similarly, Dr. Li emphasized *Form* by seeking visual clarity and spatial relationships on the sonographic image. He highlighted the importance of anatomical orientation and image acquisition in developing diagnostic precision. His teaching centred on helping students identify key anatomical landmarks and understanding their relationships in real time using ultrasound.

The artery is round... it carries more pressure, has a stronger wall, so it stays more circular. But a lot of people like myself, the veins are very collapsed, or small, hard to see... You can really show the vein and then you show the relationship between the vein and artery.

Dr. Li noted, “I have a mental image to chase... the surface landmark is important... I can feel the structures underneath. This is muscle, this is bone, this is cartilage.” Even in high-tech instruction, spatial mapping remained grounded in somatic feedback. His approach underscores how tactile familiarity with the body remains essential, even when mediated by screens or sonographic images, suggesting that visualizing form still begins from the inside out.

When discussing the hip and knee during the gait cycle, Dr. Masani referenced the visual shape or *Form* of joint movements through plotted graphs (Figure 11, graph retrieved from Robertson et al., 2014). Although not on his own body, he used this graph to explain the pathway of three-lines for the ankle, knee, and hip moments over the gait cycle. The Y-axis is Joint Moment (Nm/kg) and the X-axis is % Gait Cycle (0-100%). “So hip is big smooth wave, knee is messy with jumps, ankle has big push-off... Depending on participants.” Dr. Masani further emphasized technical surface mapping to support EMG sensor placement and kinematic data

interpretation. “These muscles... often show up in... [scientific] papers so they have to understand which part of the body [is being] discussed,” he explained, underscoring that engineers require anatomical literacy not for expressiveness but for functional surface precision. In contrast to expressive and clinical teaching, technical anatomy reframes *Form* as data. The body is rendered as a series of coordinates and curves, where shape is meaningful when measurable or programmable. This aligns with current biomedical and computational anatomy efforts to construct a Common Coordinate Framework (CCF) for the human body, which seeks to map anatomical structures across individuals by assigning spatial addresses to tissues, organs, and even cells (Rood et al., 2019). In both technical cases, anatomical form is removed from expressive or tactile nuance and becomes a dataset to be analyzed, modeled, or engineered (Rood et al., 2019).

Although each discipline emphasized different aspects, such as expressive movement in the arts, diagnostic precision in clinical fields, or quantitative modeling in engineering, all participants used surface anatomy and/or spatial reasoning to help students visualize anatomical *Form*. Whether through drawing musculature on the body, identifying bony landmarks in a physical exam, or mapping joint angles using graphs, each educator translated abstract anatomical structures into visible, surface-based reference points that could be observed traced, or measured. Taken together, these findings show that *Form* operates differently across disciplines, yet in all cases, it is used to translate unseen complexity into observable or transition into *Felt* logic. All participants showed that anatomy education is reframed according to disciplinary needs (Anstey, 2017).

### **Theme 3: Enhancing Kinaesthetic and Proprioceptive Awareness (Feeling)**

Every participant engaged in sensory and tactile feedback to deepen anatomical engagement beyond visual observation. Participants visibly encouraged their students to pay close attention to their internal bodily sensations, such as muscle tension, balance, breath, and joint position, which is known as proprioceptive feedback. This means guiding learners to notice how their bodies *Feel* and move from within, rather than only focusing on what can be seen externally. The educators in this study believed this approach supported deeper engagement in classrooms by helping students connect theory to personal experience (Lindgren & Johnson-Glenberg, 2013; Emond, 2021). They believed that tuning into these internal cues can improve

body awareness and enhance understanding of anatomical concepts (Smyth et al., 2021; Kelly et al., 2019).

Expressive educators prioritized self-touch, breath, and myofascial awareness as creative and educational tools, echoing Husserl's (1980, 1989), Hanna's (1988) and Batson and Wilson's (2014) work on somatic pedagogy. Inalouei encouraged kinaesthetic sensitivity through self-touch and sensory feedback, guiding students to feel how one's own anatomy can inform artistic decisions, such as adjusted line weight and shading. Self-palpation was a key drawing aid. "How does the skin feel? Tight? Loose? This is compressed... need thicker lines... This [dorsum of hand] feels more delicate. The lines drawn... should show... the skin is delicate." For Inalouei, proprioception is a drawing aid that translates physical sensation into artistic nuance.

Denichaud, for instance, emphasized fascia, rhythm, and felt expansion during guided spiral movement, inviting students to "maintain presence to... the weight in your ischium", "feel the dimensionality of [your] sacrum", and "notice if you can... have a disassociation of the pelvis." These sensory invitations transformed anatomy into lived experience, positioning proprioception as a foundation for movement literacy and emotional connection. In both expressive cases, *Feeling* was a method of understanding anatomical concepts but also a medium of creation and expressiveness.

In clinical contexts, kinesiology valued palpation and muscular activation awareness, using guided movement and tactile exploration to reinforce functional anatomy. Maciel guided students to feel muscular fiber lengthening and contraction. Her active movements reinforced anatomical sensation, helping students connect what they were learning to real sensations in their own bodies. Maciel's interactive demonstrations invited students to mirror her movements and feel fiber tension. "Are they crunched up together or did they have to stretch?" she asked, prompting learners to interpret anatomy through the sensation of muscular contraction and lengthening. This hands-on approach framed anatomy as something that can be felt and not solely memorized, engaging the body as an instrument of inquiry. While Inalouei uses skin stretch tension to adjust line weight in a drawing, Maciel's students similarly use the sensation of stretch in muscle fibers to identify muscle recruitment. Both teaching methods root anatomical learning in the real-time stretch of bodily feedback.

In medicine, Dr. Li used somatic analogies and real-time ultrasound scanning to help students connect internal pressure and structural awareness. "Pretend you're trying to poop,"

when describing the feeling of *Valsalva Maneuver*. His playful analogy served a pedagogical purpose: making visceral sensations relatable and diagnostically meaningful. He frequently scanned his own neck to demonstrate vascular structures, relying on a deeply internalized body map: “I can feel the structures that are supposed to be underneath... This is muscle, this is bone, this is cartilage.”

Although Dr. Masani reported less proprioceptive focus in the classroom, his comments from co-reflections revealed an appreciation for sensory learning outside of his engineering classroom. “When... I’m helping my son in baseball pitching... I’m deeply thinking about the body movement, stretching, everything.” He emphasized that gait, the topic of his observed engineering class, is a largely unconscious process, “automatic, self-organized.” This reinforces the idea that in technical domains, function and feeling may be decoupled in pedagogy but remain linked in practice. Even when proprioception is not foregrounded, it remains relevant across contexts. However, during class, his teaching did acknowledge proprioception in related technical tasks such as EMG placement.

Whether open-ended or goal-oriented, across cases, *Feeling* emerged as a teaching method and a threshold concept. All disciplines leveraged somatic sensation to demonstrate that proprioception is pedagogically flexible and available from a multidisciplinary perspective (Kiefer & Trumpp, 2012; Proske & Gandevia, 2012; Skjaerven et al., 2010). Results demonstrated that all educators, whether in classrooms or in personal lives, use *Feeling* to activate anatomical understanding while personalizing it. Educators used touch, metaphors, motion, and kinaesthetic cues to bridge abstract knowledge with embodied knowing. This emphasis on internal sensation can be seen as a supplement to the limitations of traditional, ocularcentric, and dualistic ways of teaching. Their somatic approaches invited learners to develop an inner anatomical compass rather than relying solely on memorization of visual diagrams and static facts. In expressive fields, sensation served aesthetic intuition; in clinical fields, it supported diagnostic reasoning; and in technical fields, it grounded abstract modeling in somatic reference. This theme highlights how proprioception, while universal, is taught and understood through divergent disciplinary lenses.

#### **Theme 4: Cultivating Dynamic, Relational Learning Experiences (Flow)**

*Flow* is characterized by a deep sense of presence, internal coherence, and joyful absorption. Findings from this study showed how *Flow* manifested as individual and unique experiences across disciplines. This ranges from expressive kinetic flow in arts-based teaching to motivational and relational flow in clinical instruction and intellectually distributed flow in technical modeling (Clark, 1997; Csikszentmihalyi, 1990; Laban, 1950/1971). Participants consistently reflected energetic engagement to the material being taught, perceived sense of community with students, or joy through somatic exploration. Participants described moments of dynamic flow, where somatic engagement, group energy, and satisfaction merged (Lloyd 2011; Lloyd & Smith, 2009, 2022). In these moments, learning felt less like following instructions and more like an internally motivated and individualized embodied experience that generated a sense of community and engagement. For these educators, setting up their conditions for *Flow* fostered deeper perceived engagement and build a strong sense of connection in the classroom. These educators perceive *Flow* through confidence in teaching, creativity, and a sense of belonging, making learning feel alive and personally relevant.

In expressive disciplines, participants such as Inalouei and Denichaud described *Flow* as a feeling of clarity and vitality within their own bodies. Inalouei likened anatomical demonstrations to "a happy cat curling its paws in to knead dough" or flowing like Hokusai's Great Wave. These somatic metaphors emphasized internal rhythm and tactile resonance. Inalouei further expresses her passion and *Flow* when drawing or doing demonstration drawings "There's so much joy in experimenting... I'm learning... Anytime I'm drawing, I go into that zone, and it's a lot of joy." In her classroom, she's expressed a sense of belonging and community.

It's a great energy going in the class, especially in those moments because they're all doing the same thing and there's something about doing the same thing together... they're so enthusiastic seeing how I draw... I'm seeing them learn, and I see myself as part of this group. We're experimenting something together.

Denichaud similarly experienced *Flow* as an activation of vitality and purpose:

I encounter an incredible amount of energy. I have a lot of presence and focus for them... This particular course... represents a very special experience for me because I was a dancer, because I was injured, because I was sick for so many years. Teaching makes my years of suffering OK... I feel very privileged and honored to learn with and from them.

She further described experiences of *Flow* during certain exercises:

When I lean into an exercise, I feel that part of my body become enlivened with sensation. There's generally a sense of warmth... and it feels as though my body... is homing in on the area and it becomes much larger... I feel joy when... all these little bits are harmoniously working together in my movement. I can get swept up in my cycle of breathing, which is very pleasurable... It's an invitation to go into a body sensorial experience... My obliques pulling me into a true twist, then releasing back into center... It feels joyful for my body... I feel strong. Joy. Safety. Freedom...

These accounts illustrate how *Flow* in expressive education is tied to a felt integration of sensation, creativity, and purpose, which amplifies personal meaning and joy through movement. Inalouei's and Denichaud's experiences resonate strongly with Laban (1971) and Csikszentmihalyi's (1988) understandings of flow. Laban described flow as a qualitative, continuous modulation of movement dynamics and Csikszentmihalyi's description of flow was an optimal experience through deep absorption and intrinsic enjoyment (Csikszentmihalyi, 1988, 1990; Laban, 1950/1971). Inalouei and Denichaud's metaphors of a "happy cat kneading dough," and the warm expansion or harmonious coordination of "little bits" illustrate how free and bound flow qualities, rhythmic breath, and shifting effort factors generate a psycho-physical state in which movement, affect, and attention cohere into a pleasurable learning experience. At the same time, their emphasis on shared energy and mutual attunement with students reflects Lloyd and Smith's account of "interactive flow," where energetic presence emerges between mover, partners, and environment across the Function–Form–Feeling–Flow continuum (Lloyd & Smith, 2021; Lloyd, 2022).

In clinical contexts, both Maciel and Dr. Li reported experiences of *Flow* when their bodily confidence and ease allowed them to move beyond cognitive scripting into embodied spontaneity. Maciel described "getting into a groove" when teaching the axial-humeral region, reflecting a physical and cognitive fluency that emerged from sustained engagement with content. She states "[The class] is good flow and it's the right amount of content. My delivery is so smooth, and it doesn't feel rehearsed. I'm just so comfortable and confident with the content." She also feels that synchronous movement generated camaraderie across her class during applied anatomy sessions, enhancing a sense of community with her students, "I think they get a sense of community. What we're asking you to do is hard... it's a group achievement... I do try to engage them as part of that group." This shows that for Maciel, *Flow* was experienced internally and socially, anchored in her confidence of anatomical concepts and the rhythm of her teaching.

Dr. Li similarly found joy and excitement in the shock factor of visceral immediacy through ultrasound demonstrations, especially when the effects (e.g., vein distention during Valsalva) mirrored his own embodied understanding, “I am excited for... procedure-oriented things... make your internal jugular vein super big and everyone’s like ‘whoa.’ [It] always gets a good reaction out of the class.” He further explained how his *Flow* came from somatic alignment and performative spontaneity, “If they weren’t paying attention before, they’re paying attention now.” Like Maciel, Dr. Li also felt a sense of community with his students and was emotionally invested in their success, “Because I spend four months with the same group of students, I form a good relationship with them. I take a lot of pride in how they turn out.”

In clinical fields, collective discovery (e.g. student excitement at seeing vascular changes on ultrasound) and senses of community (e.g. moving together in class) emphasized the role of shared emotional engagement in clinical skill development (Sawyer et al., 2016, p.212). Maciel’s description of “getting into a groove” and Dr. Li’s excitement at the shock factor of embodied discovery exemplify Csikszentmihalyi’s (1988, 1990) account of flow as a balance between challenge and skill that produces focused absorption and intrinsic satisfaction. Their reflections on collective enthusiasm, humor, and relational pride in students’ progress also align with Lloyd and Smith’s (2022) notion of interactive flow, in which energetic resonance circulates through shared tasks and co-present bodies, turning clinical demonstrations into moments of intercorporeal discovery rather than one-way instruction (Sawyer et al., 2016).

In technical education, Dr. Masani’s concept of *Flow* was tied to his intellectual fascination with self-organizing systems, rather than a sensory-emotional state. He described teaching gait as a mechanical, automatic action that is “mostly unconscious” and attributed *Flow* to the aesthetic and theoretical appreciation of bodily complexity emerging without conscious control. His sense of *Flow* arose from his personal life’s interpersonal synergy and from his classroom’s internal satisfaction in watching a system work elegantly. He explained

“This is my favorite topic actually... This is related to my thesis... my trigger... to come into this field... How is gait action generated? It’s mostly automatic... [But] if a complex task, for example... where the knee buckles, then motor cortex becomes more involved. There’s experiments showing the brain function burst in motor cortex during the task that has visual feedback. But we cannot do experiments to show that, it’s subjective. It’s difficult to define”

Rather than deriving *Flow* from felt experience, Dr. Masani found it in the beauty of systems working without conscious control, appreciating bodily function as a kind of biomechanical art.

“So basically everything is unconscious... automatic, self-organized. The body adjusts by itself... unless you add some complicated feedback, then motor cortex may be more activated.”

Dr. Masani’s experience is closely aligned with Clark’s notion of “intellectual flow,” where cognition is distributed across brain, body, and external representations, and fluency emerges when these elements couple seamlessly in problem solving (Clark, 1997). His moments of satisfaction while physically modeling gait cycles, interpreting joint-moment graphs, and coordinating EMG traces illustrate how analytical immersion and system-level coherence can themselves constitute a form of embodied flow, even when proprioceptive feeling remains backgrounded.

These findings suggest that *Flow* in anatomy education can emerge as defined by multiple theorists and through multiple individualized somatic channels: through joyful immersion in expressive movement, through confidence in embodied demonstration, or through deep fascination and absorption in an abstract concept. They are grounded in the educator’s own somatic awareness, purpose, and pedagogical style. Each educator embodied *Flow* differently, shaped by their field’s values, such as creativity and expressiveness in arts, confidence in diagnostic immediacy, and understanding complex system modelling. These differences highlight how *Flow* is interpreted and enacted in alignment with disciplinary norms, values, and goals. Yet despite these differences, a common thread emerges: Flow tends to arise when the educator’s body, knowledge, and intention align in real time, whether that alignment is driven by artistry, diagnostic precision, or mechanical elegance.

Viewed together, these cases show that educators come into *Flow* through different gateways that mirror the complementary definitions outlined earlier: expressive teachers through Laban-style movement qualities and somatic absorption, clinical teachers through Csikszentmihalyian balance of challenge, skill, and shared excitement, and the technical educator through Clark’s intellectually distributed, system-focused engagement (Clark, 1997; Csikszentmihalyi, 1990; Laban, 1950/1971). This multiplicity reinforces the decision to treat Flow in the F2F model as a sensitizing construct rather than a single state, allowing the analysis

to remain open to movement-based, affective-relational, and cognitive-systemic manifestations of energetic coherence in anatomy teaching (Blumer, 1954; Lloyd, 2011).

This convergence across cases invites a deeper comparative analysis of how *Flow* supports the embodiment of disciplinary thinking and the cultivation of presence in anatomy education. These findings also suggest that educators across disciplines draw on *Flow* differently to achieve their pedagogical objectives. For some, *Flow* enabled creative risk-taking or somatic inquiry; for others, it facilitated calm precision or spontaneous modeling. *Flow*, therefore, may be understood a somatic phenomenon but also as a pedagogical tool that reflects and reinforces each discipline's embodied ways of knowing when the educator's body, knowledge, and intention are aligned. This aligns with literature supporting *Flow* as an outcome of challenging yet pleasurable activities that demand sustained attention, sensorimotor engagement, and intrinsic motivation (Ulrich et al., 2014; The F2F Model Approach, 2023).

While relational *Flow* has been emphasized in some somatic learning models (Lloyd & Smith, 2022), these cases show that individualized somatic *Flow*, rooted in sensation, confidence, and meaning, can be equally powerful for teaching and learning. *Flow*, in this study, showed that internal alignment between knowledge, presence, and purpose created conditions for the body to teach from within, embodying knowledge in ways that transcend verbal instruction and transforming movement and sensation into a site of meaning-making. This finding supports Emond's (2021) perspective that educators who are attuned to their own internal sensations, external actions, and relational dynamics are better equipped to foster embodied, multimodal learning environments (Korthagen, 2004). Furthermore, this echoes findings from neuroscience research, which show that interoceptive signals and internal bodily representations are critical for self-awareness, emotional coherence, and motor intentionality, factors that strongly influence how individuals engage with their own bodies in meaningful ways (Parma et al., 2024).

From a theoretical framework perspective, this also reinforces the fact that the F2F model supports a deepening awareness of the body in motion from mechanical understanding to aesthetic expression, sensory attunement, and finally, a felt sense of integrated flow (Lloyd, 2011). It is a fluid construct that adapts to both individual and collective experiences and it recognizes the pedagogical value of internally generated *Flow* across disciplinary contexts.

## **Cross-Case Interpretations**

To address the first research question that guided this dissertation, “How do anatomy educators across disciplines integrate experiential somatic learning methods to bridge the gap between theoretical anatomical knowledge and embodied understanding to promote intercorporeal connections?” this section of the discussion chapter presents a cross-case comparison of the five participants from this study. Guided by Braun and Clarke’s (2022) RTA, this is part of the fifth phase of RTA, defining and naming themes. This phase process involved identifying patterns of convergence and divergence across the five participant cases: visual arts, dance, kinesiology, medicine, and engineering. Subthemes within each core theme, *Function*, *Form*, *Feeling*, and *Flow* from the F2F model, were inductively generated to deeply explore the nuanced pedagogical and somatic differences of each participant. The F2F model, which was used as both a sensitizing and theoretical framework, guided how data were interpreted through the lens of somatic embodiment (Lloyd & Smith, 2009; Lloyd, 2011) while serving as the major axis of analysis. The four F2F dimensions were used to attune the analysis toward sensory, spatial, affective, and energetic aspects of teaching. A segment dedicated to addressing research questions follows the cross-case comparisons

The structure and presentation of this cross-case analysis follow Sharan Merriam’s (1998, 2009) approach to multiple case study reporting, which emphasizes the value of examining themes that cut across individual cases to generate deeper insights. Each core dimension of the F2F model is presented as a cross-case analytical category, with inductively developed subthemes used to highlight disciplinary nuance and pedagogical variation. This thematic, interpretive structure aligns with Merriam’s (2016) guidance to move beyond description and toward meaning-making through comparative synthesis, allowing for a richer understanding of how experiential somatic learning is enacted across expressive, clinical, and technical fields. By analyzing how each theme is embodied and articulated across disciplines, this cross-case approach reveals both convergences in embodied teaching strategies and divergences shaped by epistemological and curricular goals.

### ***Theme 1: Teaching Anatomy through Movement and Biomechanics (Function)***

*Function* pertains to kinaesthetic consciousness, such as specific movement pattern like sitting, reaching, elongating, or twisting. Educators use specific movement and gestures to teach anatomical dynamics to bridge theoretical anatomical knowledge with embodied understanding.

All participants employed movement as a primary pedagogical tool, but the purpose, complexity, and delivery varied by discipline, reflecting epistemological priorities (Eddy, 2009). These variations highlight how somatic methods foster perceived intercorporeal connections through shared movement experiences.

#### **Expressive Subthemes in Function: Geometry of Gesture & Postural Intelligence.**

Inalouei (visual arts) used simple forearm and hand movements to demonstrate changes in surface anatomy, guiding students to “draw from your arm, not your wrist” (Inalouei, 2024). Her approach linked biomechanical *function* to visual-motor coordination, fostering artistic representation through embodied movement. This method aligns with somatic pedagogy, emphasizing on gesture as a tool for sensory-motor integration (Green, 2002). Denichaud (dance) employed *Sacral Clock* and *Oblique Shift* exercises to teach functional dissociation, enhancing movement literacy and injury prevention (Denichaud, 2024). Her focus on postural intelligence encouraged students to sense musculoskeletal capabilities, reflecting somatic principles of proprioceptive awareness (Batson & Wilson, 2014). Both educators prioritized accessible movements, inviting students into a shared inquiry that made anatomy tangible and personally relevant, directly addressing the first research question by grounding theoretical knowledge in embodied experience.

#### **Clinical Subthemes in Function: Clinical Precision through Anatomy Language & Intuition.**

Maciel (kinesiology) demonstrated healthy activation of the supraspinatus muscle through shoulder abduction, then demonstrated how patients with injured supraspinatus muscles would compensate, emphasizing clinical reasoning through precise movement (Maciel, 2025). Her approach bridged theoretical biomechanics with practical application, fostering embodied understanding of injury dynamics. Dr. Li (medicine) used the *Valsalva Maneuver* and ultrasound imaging to illustrate vascular dynamics, noting, “Valsalva increases your intrathoracic pressure, reduce preload” (Li, 2025). This method linked movement and breath to diagnostic application, enhancing students’ ability to connect theoretical knowledge with clinical practice. This connection can give students a sense of intercorporeal comprehension and foster embodied empathy for when HPE students inevitably treat future patients (Gallagher, 2023; Leder, 1990; Weiss, 1999).

Both educators' focus on precision reflects HPE's emphasis on functional anatomy for procedural skills (Estai & Bunt, 2016; McBride & Drake, 2020). Their use of movement as a teaching tool fostered intercorporeal connections by modeling clinical scenarios, which bridges the gap between theoretical anatomical knowledge and embodied understanding.

### **Technical Subtheme in Function: Automatic Gait.**

In contrast to the other participants, Dr. Masani's engineering approach framed *Function* in terms of systemic modeling and unconscious movement patterns. Dr. Masani taught gait as a self-organizing system, using kinematic data and joint moment graphs to model unconscious movement (Masani, 2025). His approach detached *Function* from sensory awareness, prioritizing analytical clarity for technological applications (Bisht et al., 2019), such as kinematic information plotted on joint moment torque graphs or EMG data. While less focused on felt experience, Masani's personal engagement with proprioception (e.g., coaching baseball) suggests latent somatic awareness, which could be leveraged to foster embodied understanding. His methods are disciplinary focused, pedagogically aligned with biomechanical modeling research, where function of the human body is observed as a reproducible signal for system design, not a felt experience (Bisht et al., 2019).

### **Cross-Case Insights.**

The findings of this study show that *Function* serves as a universal entry point for embodied teaching, with movement acting as a shared language to bridge theoretical anatomical knowledge and embodied understanding across disciplines. Expressive educators Inalouei and Denichaud use simple, accessible gestures to foster sensory and creative awareness, making anatomy a lived, creative process. For instance, Inalouei's forearm demonstrations and Denichaud's Sacral Clock exercises encourage students to mirror movements, creating a learning environment that promotes intercorporeal connections within classrooms (Weiss, 1999). This aligns with Skulmowski and Rey's (2018) findings that gestures enhance spatial understanding, critical for expressive anatomy education.

Clinical educators Maciel and dr. Li employ complex movements to teach diagnostic precision, linking biomechanics to professional practice through shared clinical scenarios. Their methods reflect Kirk-Sanchez et al.'s (2022) concept of movement scripts, which utilize features

of the human movement system to facilitate clinical reasoning, enabling physical therapists to recognize, categorize, and substantiate clinical problems while fostering adaptive expertise in education and practice. This is also supported by Murphy and Eglseder's (2022) findings on the embodied nature of their Anatomy Glove Learning System, learning about the hand actively by wearing a cloth glove with imprinted bones, which positively impacted preparedness of entry level occupational therapists.

Technical educators, like Dr. Masani, abstract *Function* into systemic models, prioritizing computational clarity over sensory engagement. However, Dr. Masani's personal proprioceptive experiences suggest latent potential for kinaesthetic integration as Jang et al.'s (2017) evidence that active and direct manipulation with anatomy yields better understanding than passive viewing learning opportunities.

These variations align with Eddy's (2009) assertion that somatic education adapts to disciplinary epistemologies, from artistic expression to computational analysis. *Function*, in this study has shown itself to be a discipline-shaped construct. Expressive fields prioritize gestural fluency to mirror internal sensations, clinical instruction uses *Function* as a tactile and visual guide for diagnostic reasoning, and technical pedagogy translates it into mathematically coded systems. This tension between intuitive, sensory-driven action and precise, mechanistic approaches is supported by Abrahamson and Lindgren's (2014) research on embodied learning, which demonstrates how bodily engagement can bridge perceptual intuition and abstract conceptualization in STEM education. Their work illustrates how bodily engagement can serve as a bridge between perceptual intuition and abstract conceptualization, reinforcing the educational potential of somatic movement across diverse cognitive tasks.

### ***Theme 2: Visualizing Structure through Spatial and Surface Awareness (Form)***

*Form* represents aesthetic consciousness, such as the outer shape and visible expression of bodily movement, including the process of movement maturation. This pertains to the shapes and positions specific body regions take to adapt to the environment and conditions. Educators explore the *Form*, or visualization and spatial mapping of their specific movements used to teach anatomical structure. These methods demonstrated theoretical knowledge becoming visually and spatially accessible to learners. Each participant employed *Form* to render anatomy tangible, but

disciplinary priorities shaped their approaches, influencing how intercorporeal connections were fostered.

### **Expressive Subthemes: Mapping and Capturing the Essence (Visual Arts) & Orienting the Body in Space (Dance).**

Inalouei's forearm demonstrations emphasized surface anatomy's shifting planes, guiding students to capture anatomical essence through gesture and line (Inalouei, 2024). Her approach made anatomical structures visually accessible, fostering aesthetic awareness that aligns with visual arts' focus on observational accuracy (Kermanian et al., 2023). Denichaud's *Sacral Clock* and *Oblique Shift* exercises oriented students to spatial relationships, enhancing postural form through movement (Denichaud, 2024). Her method promoted proprioceptive mapping, reflecting dance's emphasis on spatial awareness (Fraleigh, 2004). Both educators used *Form* to enhance embodied knowing with theoretical understanding, fostering intercorporeal connections by inviting students to visualize and sense anatomy collaboratively.

### **Clinical Subthemes: Somatic Knowing & Kinesthetic Palpation (Kinesiology) & Mapping Sonographic Imaging (Medicine).**

Maciel combined palpation and visualization to teach shoulder musculoskeletal anatomy. She lead students deeper into their somatic knowing through self-touch to link surface landmarks to internal structures (Maciel, 2025). Her tactile-visual approach made *Form* clinically relevant, enhancing students' ability to connect theoretical anatomy showed in lecture slides with what students will experience in future practical application. Dr. Li integrated ultrasound imaging with surface palpation to map vascular structures, noting, "make your internal jugular vein super big" (Li, 2025). This method grounded theoretical knowledge of cause and effect, heightening somatic awareness and developing bodily intuition. Maciel and Dr. Li brought brought visual and tactile experiences together to foster intercorporeal connections through shared clinical observation (Estai & Bunt, 2016). Both educators' approaches reflect HPE's focus on visualization for diagnostic practice.

### **Technical Subtheme: Technical Surface Mapping (Engineering).**

Dr. Masani used gait cycle visualizations (e.g., joint moment graphs) to map anatomical structures as biomechanical systems (Masani, 2025). In his lectures, he highlighted various

muscles that were pertinent to the anatomical movements in gait cycle, such as the quadriceps for knee extension, tibialis anterior for foot dorsiflexion, etc. His approach prioritized computational accuracy over sensory engagement, aligning with bioengineering's focus on modeling (Bisht et al., 2019). While less focused on form and intercorporeal connection during gait demonstrations, his visualizations provided a theoretical framework for embodied understanding.

### **Cross-Case Insights.**

Expressive educators prioritize aesthetic mapping to foster creative visualization, while clinical educators use tactile-imaging integration for diagnostic precision, and technical educators employ computational models for analytical clarity. These approaches counter ocularcentrism by grounding anatomical visualization in sensory, tactile, or data-driven experiences, aligning with Kelly et al.'s (2019) critique of disembodied learning. Clinical methods, such as tactile-visual integration, enhance diagnostic relevance and intercorporeal connections through shared clinical scenarios, as supported by Manrique et al.'s (2024) findings on increased motivation and retention in medical students. In technical disciplines, computational mapping prioritizes analytical understanding but shows latent potential for somatic integration, as evidenced by Abrahamson and Sánchez-García's (2016) research on sensorimotor activities enhancing technical learning. These disciplinary nuances highlight how Form adapts to pedagogical goals, transforming anatomy into a lived, practical, or modeled experience that fosters embodied understanding across contexts. Abrahamson and Sánchez-García's (2016) showed that sensorimotor engagement can bridge abstract and embodied understanding in technical disciplines, offering a pathway to integrate more somatic opportunities into engineering education.

### ***Theme 3: Enhancing Proprioceptive and Kinaesthetic Awareness (Feeling)***

*Feeling* emphasizes kinaesthetic awareness, or the inner sensations and perceptions experienced during movement, such as musculoskeletal sensations. This includes examples such as rhythm of the breath, timing of movement, the force of movement, or even muscle exhaustion from the movement. Educators in this study were observed feeling the experiential somatic learning methods to bridge the gap between theoretical anatomical knowledge and embodied understanding. Between expressive, clinical, and technical educators, expressive and clinical

educators leaned into *Feeling*, while technical approaches showed less engagement with this dimension. This suggests there are disciplinary differences in fostering intercorporeal connections.

#### **Expressive Subthemes: Somatic Knowing and Expansion (Visual Arts & Dance).**

Inalouei's tactile explorations encouraged students to feel anatomical structures through self-touch and self-observation, fostering somatic knowing that deepened embodied understanding (Inalouei, 2024). Her approach aligned with Hanna's (1988) emphasis on interoception, promoting sensory awareness through direct bodily engagement. Denichaud's *Sacral Clock* and *Oblique Shift*, promoted kinaesthetic expansion, helping students sense musculoskeletal dynamics and enhance injury prevention (Denichaud, 2024). Her method reflects somatic pedagogy's focus on proprioceptive awareness (Batson & Wilson, 2014), fostering intercorporeal connections through shared sensory exploration.

#### **Clinical Subthemes: Somatic Knowing & Kinesthetic Palpation (Kinesiology) & Somatic Analogies and Visceral Learning (Medicine).**

Maciel used palpation to teach students to "feel" shoulder structures, linking kinaesthetic awareness to clinical reasoning (Maciel, 2025). Her approach bridged theoretical anatomy with practical application, fostering embodied understanding through sensory engagement. Li's ultrasound-guided palpation and analogies (e.g., vein distention as "super big") fostered visceral learning, connecting sensory experience to clinical observation (Li, 2025). These methods reflect HPE's emphasis on sensory integration for diagnostic skills (Chang et al., 2018). Both educators' approaches promoted intercorporeal connections by modeling sensory-rich clinical scenarios, aligning with Puentedura and Louw's (2012) findings that kinaesthetic learning enhances clinical empathy and diagnostic accuracy.

#### **Technical Subtheme: Lack of Feeling (Engineering).**

Masani's focus on biomechanical modeling did not explicitly engage *Feeling*, prioritizing analytical over sensory awareness (Masani, 2025). However, his personal proprioceptive experiences (e.g., coaching baseball) suggest latent potential for kinaesthetic integration and implicit embodiment in technical fields.

### **Cross-Case Insights.**

Feeling shifts anatomical learning from theoretical knowledge to embodied understanding, fostering an inner compass that transcends traditional, ocularcentric approaches. While expressive and clinical educators prioritize somatic awareness as a pedagogical tool, technical education remains more distanced from this internal sensing, focusing instead on data, models, and externalized forms of learning. Expressive educators Inalouei and Denichaud use *Feeling* to foster creative and sensory awareness, making anatomy a lived, tactile experience that promotes intercorporeal connections through shared sensory inquiry. For example, Inalouei's self-touch exercises and Denichaud's movement sequences align with Hanna's (1988) concept of somatics, emphasizing interoception as a pathway to embodied learning. Clinical educators Maciel and Dr. Li leverage *Feeling* for diagnostic precision, empathy, and student engagement by using palpation and visceral analogies to connect theoretical knowledge with clinical practice. Their methods reflect Wagner's (2014) discovery that kinaesthetic learning enhances engagement, clinical problem solving, communication skills, and critical thinking in nursing students. In this study, Wagner aimed to decrease the well-known classroom-clinical gap through feeling to enhance engagement, provide deeper understanding of cardiac function and disorders, and improving clinical application. Dr. Masani's limited engagement with *Feeling* in his classrooms highlights disciplinary differences, but his proprioceptive awareness through activities like baseball coaching suggests that somatic awareness is not absent in technical fields, but underarticulated and undervalued. Incorporating proprioceptive exercises, such as guided movement analysis, could enhance engineering pedagogy by connecting biomechanical models to embodied experience. This further suggests the potential for somatic integration, as supported by Barsalou's (2008) theory of grounded cognition, which posits that sensory experiences underpin technical understanding.

This disciplinary contrast points to broader implications for anatomical education. *Feeling* enhances anatomical learning by inviting students to listen inwardly, move with intentionality, and sense the connections between parts and whole. Integrating *Feeling* as a pedagogical strategy may not only improve individual learning outcomes but also foster deeper intercorporeal connections between educators, students, and their future patients. As Hanna (1988) and Batson and Wilson (2014) suggest, somatic awareness nurtures a sensitivity that is both inward and relational, allowing anatomy to be experienced as a living, expressive system

rather than a static map. This study reveals that *Feeling* can be used as a shared learning tool that has the potential to humanize technical disciplines, deepen clinical empathy, and cultivate presence, confidence, and agency in expressive education. When integrated across disciplines, this somatic dimension can transform anatomy education into a multi-sensory, multi-perspectival practice, rooted in the intelligence of the body itself.

#### ***Theme 4: Cultivating Somatic Flow and Internal Energetic Presence (Flow)***

*Flow*, as defined in this study, reflects an energetic consciousness and embodied coherence, where movement, attention, and intention align to produce a sense of ease, clarity, or even temporal distortion. It includes the existential dimension of movement, where teaching becomes more than task execution and transforms into a personally meaningful and affective (Husserl, 1980, 1989) experience. For some participants, *Flow* manifested as a sense of effortlessness or absorption. While each participant experienced *Flow* differently, their expressions were shaped by disciplinary values, pedagogical goals, and the somatic qualities of the content they were teaching. Notably, *Flow* often emerged when their bodies, interests, and instructional intentions were in alignment, whether through spontaneous demonstration, guided movement sequences, creative expression, or deep interest in the topic. These findings highlight *Flow*'s adaptability through anatomy pedagogy, showing how it can emerge through internal resonance rather than external synchronization, and how it contributes to immersive, embodied learning environments across diverse educational contexts.

#### **Expressive Subthemes: Storytelling Through the Body & Group Synergy (Visual Arts) & Teaching as Healing and Embodied Presence (Dance).**

Inalouei's storytelling through movement cultivated an internal sense of *flow*, characterized by focused attention, intuitive gesture, and somatic pleasure. As she demonstrated anatomical concepts through drawing and gesture, she entered a personal state of absorption and satisfaction, what she described as feeling "like a happy cat kneading dough." This experience of *flow* appeared to deepen her own anatomical awareness as she became immersed with her drawing. While simultaneously inviting students into their own explorations, she prompted spontaneous mirroring of her movements. Her approach aligns with somatic pedagogy's emphasis on internal energetic coherence and expressive autonomy (Lloyd & Smith, 2022),

where *flow* is understood as a meaningful and embodied connection to the material, the motions, persons, and the world at large. Similarly, Denichaud described *flow* as a sense of vitality, confidence, and embodied clarity that emerged as she engaged in structured anatomical movement sequences. For her, teaching became an act of transformation, where personal history, physical strength, and anatomical exploration merged into a state of heightened focus and ease. She described specific physical cues, such as her obliques “knitting her body back together”, as gateways into somatic *flow*. This pedagogical embodiment reflects Fraleigh’s (2004) view of dance as a transformative, introspective practice, where movement and sensation become vehicles for self-knowing. Both educators demonstrated how anatomy can be taught through the body in ways that support *flow* and intercorporeal ways of knowing across the classroom. Their *flow* was rooted in personal meaning, sensory clarity, and embodied purpose.

#### **Clinical Subthemes: Storytelling and Joy of Teaching & Perceived Connection (Kinesiology) & Shared Excitement (Medicine).**

In clinical disciplines, moments of perceived intercorporeal learning or shared energy often emerged through spontaneous demonstration, humor, and performative clarity, allowing students to witness anatomy as a living, responsive system. Maciel’s dynamic teaching style, marked by active modeling, palpation prompts, and storytelling, sparked a personal sense of joy that she described as “getting into a groove.” Her confidence and ease created an atmosphere of engaged attention that, while individually experienced, appeared to ripple outward into the classroom. Dr. Li similarly described a sense of somatic alignment and pedagogical satisfaction during live ultrasound demonstrations. His comment, “If they weren’t paying attention before, they’re paying attention now,” reflects his awareness of a turning point in engagement, often prompted by a visually striking physiological response like jugular vein distention during the *Valsalva Maneuver*. These moments align with Sawyer et al.’s (2016) exploration of collective discovery in clinical education, where improvised interactions and unplanned demonstrations enhance learning by activating curiosity and embodied attention. While the experience of *Flow* remained individually situated for both educators as this study did not have students as participants, educator’s spontaneous, emotionally invested approaches suggest that *Flow* can be amplified by the perceived responsiveness of learners. In both cases, *Flow* served as a bridge between theoretical knowledge and embodied understanding, allowing educators to immerse themselves in the act of teaching while modeling anatomy as a dynamic, lived process.

### **Technical Subtheme: Self-Organization (Engineering).**

In the technical domain, Dr. Masani's experience of *Flow* stemmed not from sensory immersion but from intellectual alignment with the biomechanics of gait as a self-organizing system. As he explained during his co-reflection section, his fascination with the elegant, patterned nature of unconscious motor control, what he called "mostly automatic, self-organized" movement, reflected a cognitive-somatic engagement that valued complexity, precision, and systemic coherence. Rather than focusing on felt experience, Dr. Masani's *Flow* emerged through conceptual clarity and analytical immersion, particularly when physically modeling gait cycle phases while interpreting joint moment graphs in real time. His use of live demonstration to embody system behavior exemplifies what Clark (1996) describes as extended cognition, wherein external tools and representations, such as graphs and EMG data, become integrated into the cognitive process. While Masani's classroom instruction emphasized modeling over feeling, these moments conveyed a subtle but embodied alignment between body and concept, suggesting an individualized experience of *Flow* rooted in intellectual coherence. His approach aligns with Koskinen et al.'s (2011) perspective on design thinking, where deep analytical engagement with systems fosters experiential insight and creative problem framing, often leading to a state of intellectual flow. Though less relational or sensory in nature, Masani's teaching demonstrates how *Flow* can also arise through synchronization of cognitive focus, pedagogical intention, and theoretical elegance, addressing the first research question by showing how anatomical concepts can be embodied through system-oriented thinking.

### **Cross-Case Insights.**

Across all five disciplines, *Flow* was described as a meaningful experience of internal coherence, where teaching anatomy transcended routine instruction and became an immersive, embodied experience. However, the way *Flow* was cultivated and experienced varied significantly across disciplines, revealing how different pedagogical paradigms shape educators' access to and expression of somatic *Flow*.

Expressive educators (visual arts, dance) experienced *Flow* as emotionally charged and deeply somatic, emerging through intuitive movement, aesthetic focus, and personal narrative. In contrast, technical and clinical educators reached *Flow* through structured frameworks, embodied precision, or spontaneous demonstration tied to content expertise. This disciplinary divergence

reflects what Fraleigh (2004) describes as the difference between movement as a creative, expressive act in dance, fostering embodied experience, and movement as an instrumental function, such as in technical or clinical applications, aligning with the disciplinary variations observed in this study.

Despite these differences, a common thread across all cases was that *Flow* emerged when the educator's personal bodily awareness aligned with their pedagogical purpose. For expressive educators, this alignment occurred through improvisation and sensory attunement; for clinical educators, through diagnostic immediacy and confidence in teaching anatomical concepts; and for technical educators, through conceptual clarity and system-based thinking. This supports Lloyd and Smith's (2022) framing of *Flow* as an energetic presence. This *Flow* is not limited to affective or relational modes, but can also be intellectual and procedural (Clark, 1997), as seen in Dr. Masani's modeling of gait as a self-organizing system.

Another key point of comparison is how tactile versus abstract engagement shaped *Flow*. Expressive and clinical educators tended to experience *Flow* during physical movement or touch. This was observed during Inalouei's drawing session, Denichaud's somatic exercises, Maciel's palpation techniques for her favorite lecture topic, and Dr. Li's excitement in procedural scanning. These forms of engagement encouraged internal somatic feedback loops, what Husserl (1980) might describe as kinaesthetic self-affection. In contrast, the technical educator's *Flow* was less grounded in bodily sensation and more in analytical immersion, arising from a seamless coupling between internal focus and systematic abstraction, where fluency in theoretical and presentational models became the medium of embodied experience (Clark, 1997; Koskinen et al., 2011).

Finally, across all disciplines, educators described *Flow* as individually experienced but sometimes perceived as contagious or mirrored. For example, when students responded visibly to demonstrations or began to mirror movements, which was perceived across all disciplines. While this study focuses only on educators' experiences rather than student perspectives, these moments suggest that *Flow* can be perceived intercorporeally even when it is cultivated intrapersonally, echoing themes in Sawyer et al.'s (2016) work on performative teaching and spontaneous discovery.

This supports Lloyd and Smith's (2022) framing of *Flow* as an energetic presence. This *Flow* is not limited to affective or relational modes, but can also be intellectual and procedural

(Clark, 1997), as seen in Dr. Masani's modeling of gait as a self-organizing system. Dr. Masani's intellectual *Flow*, rooted in modeling gait as a self-organizing system, reflects an embodied cognitive process that could be enhanced by integrating sensory feedback (Clark, 1997). Another key point of comparison is how tactile versus abstract engagement shaped *Flow*.

In sum, *Flow* was a unifying yet flexible concept: somatically rich in expressive fields, performatively activated in clinical settings, and cognitively driven in technical education. Across disciplines, *Flow* operated as a pedagogical amplifier, deepening presence, engagement, and clarity when teaching aligned with bodily knowing. This suggests that *Flow*, though shaped by disciplinary context, functions as a cross-cutting pedagogical phenomenon, enabling anatomy to be taught through the body in ways that foster immersive, somatically grounded learning across diverse educational environments.

Table 3 presents a cross-case comparison of the subthemes that emerged from each educator's teaching practices, organized according to the F2F model dimensions: *Function, Form, Feeling, and Flow*. This table synthesizes how the five anatomy educators of this study brought somatic teaching strategies to life while aligning with these dimensions. This comparative view illustrates both the shared values and disciplinary nuances in how educators use their own bodies to teach anatomical concepts through movement, touch, perception, and presence.

Table 3. Cross-Case Comparison of Somatic Teaching Subthemes by Discipline and Function2Flow Dimension

Theme	Niloo Inaloeui (Visual Arts) Subthemes	Danielle Denichaud (Dance) Subthemes	Tamara Maciel (Kinesiology) Subthemes	Dr. Terry Li (Medicine) Subthemes	Dr. Kei Masani (Engineering) Subthemes
1. Teaching Anatomy through Movement and Biomechanics ( <i>Function</i> )	Subtheme 1: The Geometry of Gesture: Anatomical Form in Motion (Function)	Subtheme 1: Postural Intelligence: Building Expressive Potential (Function)	Subtheme 1: Anatomical Language - Movement and Biomechanics (Function)	Subtheme 2: Intuitive Process and Experimentation (Function)	Subtheme 2: Demonstrating Automatic Gait (Function)
2. Visualizing structure through Spatial and surface Awareness ( <i>Form</i> )	Subtheme 2: Mapping and Capturing the Essence: Timing, Gesture, and Line (Form)	Subtheme 2: Orienting the Body in Space: Visual Mapping and Postural Form (Form)	Subtheme 2: Somatic Knowing; Kinesthetic Palpation and Visualization (Form & Feeling)	Subtheme 1: Mapping and Capturing Sonographic Imaging (Form)	Subtheme 1: Technical Surface Mapping (Form)
3. Enhancing proprioceptive and kinaesthetic Awareness ( <i>Feeling</i> )	Subtheme 3: Somatic Knowing (Feeling)	Subtheme 2: Somatic Knowing & Expansion (Feeling)	Subtheme 2: Somatic Knowing; Kinesthetic Palpation and Visualization (Form & Feeling)	Subtheme 3: Somatic Analogies and Visceral Learning (Feeling)	Subtheme 2: Lack of Feeling (Feeling)
4. Cultivating Somatic Flow and Internal Energetic Presence ( <i>Flow</i> )	Subtheme 4: Storytelling Through the Body (Flow) Subtheme 5: Flow and Perceived Group Synergy (Flow)	Subtheme 3: Teaching as Healing and Embodied Presence (Flow)	Subtheme 3: Storytelling and Joy of Teaching (Flow) Subtheme 4: Perceived Connection and Purpose in Challenging Contexts (Flow)	Subtheme 4: Shared Excitement (Flow)	Subtheme 3: Self-Organization (Flow)

## Addressing the Research Question 1

The first research question that guided this study was “How do anatomy educators across disciplines integrate experiential somatic learning methods to bridge the gap between theoretical anatomical knowledge and embodied understanding to promote intercorporeal connections?”. To address this question, this study examined the teaching strategies of five anatomy educators across expressive, clinical, and technical domains. Using the F2F model as a theoretical model and sensitizing framework (Lloyd & Smith, 2009; Lloyd, 2011), educators' practices were interpreted through the dimensions of *Function*, *Form*, *Feeling*, and *Flow*. Despite disciplinary differences, a unifying finding was that all participants used the body as a pedagogical instrument to support anatomical learning. This was completed through gestures, movements, sensory engagement, and cognitive modeling at varying levels of somatic engagement and awareness. Each of these methods reflected the educator’s discipline and their epistemological priorities (Eddy, 2009; Merriam, 2016).

In the *Function* dimension, all educators taught anatomy through movement, but the complexity and intent of that movement varied. Expressive educators, visual arts instructor Inalouei and performance instructor Denichaud emphasized accessible, somatically grounded gestures to build creative awareness and postural literacy, aligning with Green’s (2002) and Batson and Wilson’s (2014) descriptions of somatic proprioception. Clinical educators, including Kinesiology educator Maciel and medical educator Dr. Li, emphasized biomechanical precision through demonstrative palpation, ultrasound imaging, and storytelling, cultivating embodied clinical reasoning and empathy (Gallagher, 2023; Weiss, 1999). Meanwhile, engineering educator Dr. Masani from the technical domain approached *Function* through the lens of systems modeling, using EMG and gait graphs to demonstrate the self-organization of human gait. This showed detachment from felt sensation while engaging cognitively with embodied mechanics during lectures (Bisht et al., 2019).

In terms of *Form*, participants employed spatial and surface awareness techniques to make anatomical structures visually and tactically accessible. Expressive educators leveraged drawing, mirroring, and spatial orientation to enhance students’ internal visualizations of anatomy (Kermanian et al., 2023), expanding on what Kelly et al. (2019) describe as body pedagogics, moving away from the disembodied focus of ocularcentrism. Clinical educators combined tactile palpation with imaging (e.g., ultrasound) to map anatomy in real time,

enhancing diagnostic relevance and fostering somatic intuition (Manrique et al., 2024). Even in the technical domain, Dr. Masani's gait demonstration to explain joint moment graphs and torque data illustrated a form of computational mapping that visually externalized internal anatomy, aligning with Abrahamson and Sánchez-García's (2016) sensorimotor theories of embodied design.

In the *Feeling* dimension, expressive and clinical educators prioritized interoceptive awareness and kinaesthetic feedback. Tactile self-exploration, somatic analogies, and muscle activation exercises enabled students to sense anatomy from within, supporting a deeper affective and embodied connection to the material (Hanna, 1988; Batson & Wilson, 2014; Wagner, 2014). Inalouei's and Denichaud's work especially emphasized internal sensation as a mode of knowing, while Maciel and Dr. Li used palpation and visceral imagery to cultivate embodied empathy and diagnostic fluency (Chang et al., 2018; Louw & Puentedura, 2012). In contrast, Dr. Masani of the engineering discipline did not explicitly emphasize *Feeling* in his pedagogy. But his personal background in baseball coaching suggests latent somatic insight, in line with Barsalou's (2008) theory of grounded cognition. Barsalou (2008) proposes that cognition is rooted in sensory and motor experiences, rather than being purely abstract or symbolic. Grounded cognition suggests that knowledge, even in abstract domains like engineering, is built on sensorimotor interactions with the environment. For example, understanding biomechanical concepts (e.g., gait) involves mental simulations of movement, which are grounded in bodily experiences like those Dr. Masani encounters in baseball coaching.

Finally, *Flow* emerged as a flexible pedagogical amplifier across disciplines. Expressive educators described *Flow* as sensory and aesthetic absorption, often catalyzed by movement, gesture, or story. Their experiences reflect Fraleigh's (2004) interpretation of *Flow* as an introspective, transformational state. Clinical educators reported experiencing *Flow* during high-engagement moments, such as successful demonstrations or humorous interactions, which fostered shared energy and spontaneous focus (Sawyer et al., 2016). Even in the technical domain, Dr. Masani experienced *Flow* through intellectual clarity and system-level alignment, demonstrating that *Flow* can also arise through cognitive somatic integration (Clark, 1997; Koskinen et al., 2011). Across all disciplines, *Flow* appeared to deepen educators' presence and enhance learning environments, and while it was described as a personal experience, it was often mirrored or amplified by student engagement.

This study reveals that somatic pedagogy bridges theoretical and embodied anatomical understanding, fostering intercorporeal connections through discipline-specific strategies (Weiss, 1999). The F2F model highlights shared principles – movement as a universal language and the body as a teaching instrument – while revealing adaptations for expressive fluency, clinical precision, and technical clarity (Lloyd, 2011). Moreover, the study highlights the transformative potential of teacher presence. Participants did not merely deliver content, they modeled it through their own bodies, cultivating a learning environment where vulnerability, attention, and mutual exploration were central. In doing so, they reframed anatomy teaching as a dynamic encounter rather than a one-way transmission of static knowledge. This reframing is particularly valuable in HPE, where clinical relationships depend not just on knowledge, but on empathy, responsiveness, and attunement, all of which can be nurtured through somatic teaching approaches (Frenk et al., 2010). This somatic approach challenges Cartesian dualism, re-centering the lived body as a site of inquiry and connection (Classen, 2020; Weiss, 1999). These findings demonstrate that experiential somatic strategies are adaptable across diverse contexts, enriching anatomical comprehension and promoting inclusive, humanized learning.

What distinguishes this study is its ability to illuminate common pedagogical threads across divergent disciplines. While each educator brought distinct disciplinary objectives, they all leveraged somatic strategies to make anatomy tangible, memorable, and meaningful. This demonstrates that embodied pedagogy is not only compatible with, but also enriching for, diverse anatomical teaching contexts. These findings suggest that experiential somatic strategies can significantly broaden anatomy education’s pedagogical repertoire, fostering not only anatomical comprehension but also relational, reflective, and embodied modes of knowing.

### **Addressing the Research Question 2**

To address the second research question that guided this thesis, “How can these cross-disciplinary insights transform anatomy education in HPE?”, this section expands on the practical and transferable strategies explored in this study, illustrating how cross-disciplinary somatic methods can be implemented across HPE through the lens of *Function, Form, Feeling, and Flow*.

This study demonstrates that somatic teaching strategies drawn from visual arts, dance, kinesiology, medicine, and engineering offer a highly adaptable and impactful pedagogical framework for enriching anatomy education. When educators model anatomical concepts

through movement, gesture, self-touch, breathwork, or dynamic demonstration, they engage learners in embodied meaning-making, allowing theoretical concepts to be internalized through lived experience (Vygotsky, 1978). Expressive educators such as Inalouei and Denichaud employed tactile mapping, gesture-based sketching, and somatically guided movement sequences to enhance spatial and proprioceptive awareness, fostering a sensory dialogue between student and structure. Clinical educators like Maciel and Dr. Li demonstrated that diagnostic palpation, movement-based clinical analogies, and ultrasound-guided scanning can deepen kinaesthetic understanding and cultivate embodied clinical reasoning. Even in technical domains, Dr. Masani's modeling of gait as a self-organizing system reveals how biomechanical principles can be communicated through movement, aligning analytical clarity with the motor intuition potential (Barsalou, 2008; Masani, 2025). These varied approaches reveal that somatic pedagogy is both discipline-specific and widely transferable, offering multiple modalities to bridge the gap between theoretical anatomical knowledge and embodied understanding.

In curriculum terms, these findings suggest that HPE programs can be enriched by intentionally weaving in embodied pedagogies from dance, visual arts, and technical fields alongside advances in digital and visual technologies (Smyth et al., 2021; Macedonia et al., 2019; Seo et al., 2021). Integrating movement analysis, somatic awareness, and spatial exploration into existing lecture, lab, and simulation formats allows anatomy teaching to move beyond didactic or pathology-focused approaches toward more holistic and humanizing curricula that honour students' living bodies as central learning resources.

What distinguishes these cross-disciplinary insights is their shared emphasis on learning anatomy *through* the body rather than merely *about* the body, reframing anatomy education as an intersubjective, multi-sensory, and meaning-rich encounter. Using the F2F model (Lloyd & Smith, 2009; Lloyd, 2011) as a theoretical and analytical tool, this study provides a structured yet flexible recommendation in integrating movement, through the lens of *Function, Form, Feeling,* and *Flow*, into curriculum design.

*Function*-based teaching techniques from kinesiology can be scaffolded into gross anatomy labs to develop clinical reasoning through postural cueing, injury demonstration, compensatory movement analysis, and functional testing. Instructors might begin a musculoskeletal lab by demonstrating shoulder abduction and internal rotation, followed by compensatory patterns observed in rotator cuff injuries, like Maciel's pedagogical approach. This

helps students not only memorize anatomical structures but recognize how dysfunction presents in real bodies, preparing them for clinical assessment. Students could even take turns mimicking “healthy” and “injured” movement patterns to internalize the functional anatomy involved in movement pathology, a practice that is typically done in physiotherapy anatomy courses (Turhan, 2020).

*Form*-based strategies, such as gesture-based sketching and anatomical visualization techniques borrowed from visual arts, could be implemented during dissection labs or ultrasound interpretation. Before dissecting the forearm, for instance, students could be asked to draw their own hand and wrist in motion, paying attention to bony landmarks and superficial veins. A step further is to body paint, where deep structures are painted on the surface of the skin, which has shown positive comprehension results (Diaz & Woolley, 2021). This primes both observation and palpation skills, enhancing their ability to visually and tactically recognize structure during dissection or sonographic imaging. Incorporating live imaging techniques as Dr. Li’s ultrasound-guided lessons could foster deeper bodily knowing through surface-to-depth thinking and spatial mapping, both crucial for diagnostic precision and procedural accuracy. These strategies counter the dualistic, ocularcentric tendencies in HPE (Kelly et al., 2019), promoting a more embodied, relational approach to anatomy education that aligns with Weiss’s (1999) concept of intercorporeality.

*Feeling* and *Flow* dimensions, which are often underutilized in HPE, can be integrated through guided breathwork, palpation exercises, and embodied storytelling that foster attentiveness, confidence, and affective presence, essential for patient care (Gallagher, 2014; Hanna, 1988; Kelly et al., 2019). For example, Denichaud’s sacral clock and breath-initiated movement sequences could be adapted for pre-surgical training, helping learners recognize how breath and muscle activation affect posture and proprioception (Kelly et al., 2019). *Feeling* can also be embedded into simulation training by inviting students to place their hand on their own sternum or diaphragm to feel respiratory mechanics before practicing CPR or auscultation, deepening kinesthetic empathy. *Flow* might be supported through narrative-based patient case demonstrations, where instructors model not only clinical knowledge but also emotional and energetic alignment, such as performing a bedside ultrasound with intentional pacing and attuned presence, inviting students to absorb both technical skill and affective cues.

These are only some examples that have been inspired by the participants from this study. The implementation of such strategies has wide-ranging implications for curricular innovation and faculty development. Programs that cultivate educators' own somatic awareness, as advocated by Emond (2021), could help embed embodied approaches more broadly within HPE institutions. These practices can also support decolonial and anti-oppressive teaching by validating non-textual, non-ocular modes of knowing, particularly important for diverse learners with different sensory, movement, and cultural orientations (Kelly et al., 2019; Weiss, 1999). Moreover, the affective and intercorporeal dimensions of these methods enhance student engagement and empathy, qualities increasingly recognized as central to clinical competence. As Georgiou and Ioannou (2019) note, bodily engagement in learning strengthens cognitive retention but also nurtures communication, emotional awareness, and an ability to take different perspectives, all skills foundational to patient-centred care.

At the same time, adopting somatic and experiential approaches offers a concrete way to redress the mind–body dualism that continues to shape much anatomy instruction. Traditional pedagogy often disengages students from their own bodies in the classroom, even though clinicians are later required to re-engage the whole body when examining and caring for patients (Kelly et al., 2019; Kyte et al., 2023). When learners practice palpation, respiratory awareness, postural analysis, or movement-based reasoning on themselves and peers, the “classroom skills” they develop more readily translate into “clinical skills,” rendering anatomy personally meaningful and directly relevant to their future roles in patient-centred care.

Ultimately, these findings call for a broader reconceptualization of anatomy education as an embodied practice, one that centers lived experience, sensory intelligence, and interpersonal learning. By embracing a cross-disciplinary, somatically informed approach, HPE can move beyond static representations of the body toward dynamic, embodied pedagogies that prepare students not only to understand anatomy but to *feel* and *live* it. This will transform how HPE students relate to themselves, their patients, and the human condition.

To embed these cross-disciplinary insights into HPE, several practical steps are recommended. First, anatomy educators and curriculum developers should consider how their somatic approaches to anatomical concepts can be perceived through the F2F dimensions. As this study explained, *Flow*, the desired experience during somatic instructional approaches, tends to emerge when the educator's body, knowledge, and intention are aligned. Examples provided

from the participants of this study include *Function* through dynamic movement demonstrations and postural or self-analysis; *Form* through visual-spatial exercises like gesture drawing and palpation-based mapping; *Feeling* through guided breathwork, touch, and kinaesthetic reflection; and *Flow* through embodied storytelling and spontaneous demonstration. These approaches can be scaffolded across the curriculum, from introductory anatomy to advanced clinical practice, offering students repeated opportunities to connect knowledge with lived experience. It's important to reiterate that the participants of this study were purposively sampled for their expertise in education within their respective disciplines. Therefore, without the proper experience in teaching, it may be challenging to develop somatic methods. It is therefore recommended for those wishing to integrate more somatic teaching practices within their HPE curriculum to draw inspiration and to personally explore how expressive disciplines teach concepts found in HPE syllabi.

Second, this study recommends that faculty development programs include somatic awareness workshops, allowing educators to first explore conscious bodily awareness, which is associated with improved self-perception, stronger relational engagement with students, and enhanced teaching quality (Emond, 2021). From there, workshops can further explore how participant's own bodies can become instruments of teaching, and how sensory engagement can enhance student learning. This is especially relevant for technical and clinical instructors who may not have prior training in somatic or arts-based education.

Finally, this study provides good reasons why institutions should support interdisciplinary collaboration between HPE, fine arts, and movement disciplines, fostering a culture of pedagogical experimentation and embodied inquiry. These efforts can expand anatomy education beyond passive memorization, cultivating more reflexive, engaged, and empathetic future practitioners.

## **Chapter 6: Conclusion**

To my knowledge, this is the first time experiential somatic anatomical learning methods were studied across expressive (visual arts and dance), clinical (medicine and kinesiology), and technical (engineering) disciplines. Drawing on decades of disciplinary teaching practices and theoretical contributions from movement studies, phenomenology, and HPE, this dissertation originally presented three interrelated articles that collectively explore how somatic pedagogies reimagine anatomy teaching from the educators' perspective (Emond, 2021; Sheets-Johnstone, 1999; Gallagher, 2014; Smyth et al., 2021). The articles have been rewritten into a monographic thesis to offer a cohesive and progressive examination of how educators across fields bring the body into the center of anatomical learning, challenging the dominant ocularcentric and dualistic traditions in HPE (Kelly et al., 2019; Classen, 2020; Classen & Howes, 2005). Specifically, this dissertation was guided by two overarching research questions:

1. How do anatomy educators across disciplines integrate experiential somatic learning methods to bridge the gap between theoretical anatomical knowledge and embodied understanding to promote intercorporeal connections?
2. How can these cross-disciplinary insights transform anatomy education in HPE?

### **Research Summary**

This study investigates how anatomy educators across disciplines integrate somatic learning methods to supplement traditional anatomical instruction and promote embodied understanding. It begins by contextualizing the evolving landscape of anatomical education through an interdisciplinary review of modern technological approaches in fields such as visual arts, dance, medicine, physiotherapy, and engineering. While innovations like human body donor dissection, digital simulations, and virtual anatomy tools offer pedagogical advantages, they often rely on disembodied modes of engagement. This study critiques these limitations and proposes that living anatomy, which is taught through movement, touch, and sensory awareness, holds immense potential to complement and humanize technological instruction.

Building on this foundation, a comparative case study was conducted with five anatomy educators from expressive (visual arts and dance), clinical (medicine and kinesiology), and technical (engineering) disciplines. This cross-disciplinary multiple case study is the first of its kind to compare how educators teach anatomical concepts through the four dimensions of the

F2F model, *Function, Form, Feeling, and Flow*, in diverse pedagogical contexts. Using the F2F model as a sensitizing framework (Blumer, 1954) and Braun and Clarke's (2022) RTA, data were collected through multiple interviews, classroom observations, artifact analysis, and co-reflections. The resulting themes reveal how educators use gesture, breath, movement, and storytelling to cultivate somatic awareness, foster intercorporeal connection, and create immersive and joyful anatomy learning environments. Findings demonstrate both shared strategies and discipline-specific adaptations. While expressive arts educators emphasize narrative, sensory perception, and movement exploration, clinical and technical educators incorporate somatic practices through palpation, gait analysis, muscle activation, and applied biomechanics. This study points to the value of somatic engagement in experiences of *Flow* during teaching and suggests that educators across disciplines should strive to align their bodily presence, intention, and knowledge to facilitate intercorporeal learning, emotional resonance, and somatic comprehension of anatomical concepts.

Together, these findings demonstrate that anatomy education can be a deeply somatic, affective, and intercorporeal experience (Gallagher, 2014; Weiss, 1999; Lloyd, 2016). By illuminating the lived teaching practices of somatically attuned educators, this dissertation invites HPE to reconsider traditional pedagogical approaches, positioning anatomy not merely as a body of knowledge to be memorized, but as a living, breathing experience to be felt, expressed, and shared (Csordas, 1994; Sheets-Johnstone, 1999, 2010).

### **Contributions to Knowledge**

This study makes several important contributions to the literature on anatomy education and somatic pedagogy. It offers one of the first comparative analyses of how experiential somatic learning strategies are applied across expressive (visual arts, dance), clinical (medicine, kinesiology), and technical (engineering) disciplines from the educator's perspective. It demonstrates that movement modeling, tactile exploration, kinaesthetic feedback, and reciprocated engagement are widely adaptable pedagogical strategies that can enhance anatomical comprehension across fields when tailored to specific professional goals. As previously discussed, while anatomy education is foundational across many professional fields, prevailing approaches in Western HPE often privilege visual, disembodied methods, a limitation addressed more fully in the section on *Theoretical and Practical Implications for HPE Anatomy*.

This research investigated the experiences of Canadian educators of various disciplines who engage with experiential somatic learning approaches, multisensory and embodied pedagogies to support deeper anatomical understanding and intercorporeal knowing. This study contributes to HPE and anatomical education by exploring how educators across disciplines integrate experiential somatic learning and how these methods reshape anatomical knowledge construction. Drawing from interviews, observations, artifacts, and co-reflection in multiple case study research methodology (Merriam 2002, 2009), this research examines how anatomy educators engage learners through movement, touch, gesture, and embodied experience, offering a kinaesthetic alternative to traditional didactic instruction. This thesis offers thick, context-rich insights into how these practices reshape anatomical knowledge construction and foster intercorporeal learning. With integration of participant insights and my own first-hand observations, the research draws from and contributes to existing practices while also synthesizing broader themes of pedagogical innovation. The study contributes to a broader reconceptualization of anatomy education. By emphasizing intercorporeal engagement and sensory-rich approaches, it challenges the dominance of ocularcentric and disembodied methods and positions anatomy as a relational, affective, and lived domain of knowledge. This reconceptualization not only revitalizes anatomy education but aligns with broader shifts in HPE toward relational competence, empathy, and embodiment.

Importantly, this study expands the landscape of gross anatomical education by bridging kinaesthetic, artistic, clinical, and technical approaches. It offers practical, transferable strategies for anatomy instruction that can inform body pedagogics (Kelly et al., 2019), curriculum development, and faculty training in HPE. By advocating for cross-disciplinary collaboration, it fosters dialogue between disciplines such as visual arts, dance, kinesiology, medicine and engineering, thereby enriching HPE's approach to anatomy education with somatic pedagogy.

### **Methodological Contributions**

This dissertation advances methodological approaches in anatomy education research by integrating RTA (Braun & Clarke 2006, 2022) with the F2F model, facilitating a nuanced exploration of embodied pedagogical practices across diverse disciplines.

RTA, as developed by Braun and Clarke (2006, 2022), allowed for deep engagement with participants' narratives, centering meaning-making between participant and researcher. This

approach acknowledges the researcher's active role in interpreting data, moving beyond mere categorization to uncover latent themes that reflect the complexity of somatic teaching practices. By engaging in iterative cycles of coding and theme development, the analysis captured the multifaceted nature of embodied learning experiences. By integrating the F2F Model (Lloyd, 2011; Lloyd & Smith, 2009), which encompasses *Function, Form, Feeling, and Flow*, it served as a sensitizing framework rather than a rigid coding scheme. In line with Blumer's (1954) construct of sensitizing concepts, the F2F model offered a flexible lens to guide attention toward key dimensions of somatic teaching without imposing strict analytic categories. This approach supported an open, context-sensitive interpretation of each participant's embodied pedagogical practices, allowing themes to emerge organically while remaining grounded in the core principles of exploring of how educators incorporate kinetic Function, aesthetic Form, kinaesthetic Feeling, and energetic Flow dimensions into their teaching. By allowing themes to emerge organically within this framework, the study preserved the integrity of participants' experiences while providing a structured lens for analysis.

This research adopted Merriam's (2002, 2009) constructivist case study design with individual case boundaries, enabling both within-case depth and cross-case synthesis. I explored themes across expressive (visual arts, dance), clinical (medicine, kinesiology), and technical (engineering) disciplines. This cross-disciplinary approach illuminated both shared and unique embodied pedagogical strategies, highlighting the adaptability of somatic teaching methods across varied educational contexts. Such a design underscores the potential for interdisciplinary learning and the transferability of embodied teaching practices.

Data collection incorporated semi-structured interviews, classroom observations, artifact analysis, and co-reflective dialogues. This process follows the methodological best practices outlined by Merriam (1998) as triangulation of data to enhance the credibility and depth of the findings, allowing for a comprehensive understanding of the educators' embodied teaching practices. By converging multiple data sources, the study ensured a robust and nuanced portrayal of somatic pedagogy.

Lastly, the methodological integration demonstrated in this study offers a replicable model for future research in anatomy education and beyond. By combining multiple comparative case study, RTA, and the F2F model as a sensitizing framework within a cross-disciplinary design, this study provides a replicable model for future research on embodied pedagogy. This

holds the door open for researchers to explore embodied learning in a manner that honors the complexity of human experience. This approach encourages the development of pedagogical strategies that are both contextually relevant and theoretically informed.

### **Theoretical Implications and Contributions**

This dissertation contributes to the growing body of research on embodied learning and experiential somatic pedagogy by extending theoretical discussions across disciplines not traditionally linked to embodied approaches. Literature shows that experiential somatic learning is gaining recognition in education research (Emond, 2021; Lindgren & Johnson-Glenberg, 2013; Smyth et al., 2021). My research builds on these foundations by demonstrating how somatic awareness, tactile engagement, and dynamic movement practices can bridge the gap between theoretical anatomical knowledge and lived bodily understanding in post-secondary education.

Firstly, this work reinforces the principle that the body itself is a central site of learning. Knowledge is not only constructed cognitively but is fundamentally learned through the body (Davis et al., 2008). My findings expand on this concept by illustrating how anatomical knowledge is constructed through the body's interactions with its environment, through sensing, moving, and relational attunement, consistent with Gallagher's (2014) and Smyth's (2021) assertion that bodily awareness forms the foundation of our living experiences.

Secondly, by integrating participants' teaching practices with the F2F model, this study contributes to the field of body pedagogics (Kelly et al., 2019), emphasizing that teaching and learning anatomy is not simply about transmitting information but about mobilizing multisensory, relational, and affective dimensions of the body. Across all cases, my purposively selected anatomy educators demonstrated that incorporating multisensory and relational methods enhanced their feelings of class engagement and interpersonal connections with students in ways that purely visual or didactic approaches could not.

Thirdly, this dissertation engages directly with Maxine Sheets-Johnstone's (1981, 2018) theory of movement, affirming that movement is not only a medium through which anatomical concepts are learned but is itself a generator of meaning. Participants' teaching practices confirmed that anatomy education is enriched when they and their students feel, trace, and move through anatomical relationships rather than solely observing or memorizing them. These

findings validate the experiential role of movement in cognition and challenge the persistent dualistic divides in anatomy education (Pandey & Zimitat, 2007; Wang et al., 2023). This advocates instead for pedagogical shift that affirms the role of the living body as a source of knowledge (Sheets-Johnstone, 1999; Kelly et al., 2019).

Fourthly, this research reflects Weiss's (1999) concept of intercorporeality, highlighting how learning anatomy is mediated through our continual interactions with human and non-human bodies. Anatomy educators in this study modeled and facilitated moments of intercorporeal connection; whether through tactile palpation, modeled gestures, partnered exploration, or kinaesthetic empathy, they made the relational nature of embodied learning explicit. Rather than isolating the anatomical body as an object of detached study, participants fostered environments where bodies, movements, and spaces dynamically informed learning processes.

Beyond these student-centred implications, this dissertation makes a critical theoretical contribution by emphasizing the importance of the educator's somatic awareness in experiential anatomical education. As Emond (2021) observed, educators who cultivate conscious bodily awareness experience improved self-perception, stronger relational engagement with students, and enhanced teaching quality. This study confirms that anatomy educators who are attuned to their own internal sensations, external actions, and relational dynamics are well equipped to foster embodied, multimodal learning environments (Emond, 2021; Korthagen, 2004). Conversely, when educators are disconnected from their own bodily presence, they risk perpetuating traditional, disembodied, ocularcentric methods of teaching (Hegna & Ørbæk, 2021; Reeves & White, 2021).

By exploring how educators across disciplines engage their own bodies in pedagogical practice as facilitators and designers of embodied engagement (Bauersfeld, 1995; Davis et al., 2015; Brau, 2018), this research extends experiential somatic learning theory into the realm of educator embodiment. It supports the view that shifting from teacher-centred didacticism to learner-centred, body-centred pedagogy requires the educator's own somatic participation and reflection. When educators design rich, experiential environments through tactile modeling, dynamic movement, body painting, or anatomical mapping activities (Barmaki et al., 2019; Estai & Blunt, 2016; Noël, 2012), they promote deeper intercorporeal knowing and foster intuitive, situated learning.

Overall, this dissertation advances theoretical understandings of embodied anatomical education by showing that learning is not merely a cognitive or visual process but an interwoven somatic, sensory, intercorporeal, and dynamic experience. It offers a model where all educators can engage in embodied meaning-making, thus providing a strong theoretical foundation for reimagining anatomy education in HPE and beyond.

### **Theoretical and Practical Implications for HPE Anatomy Education**

Overall, this dissertation offers critical implications for the future of anatomy education in HPE, particularly in challenging entrenched pedagogical norms that prioritize visual, disembodied, and compartmentalized models of instruction. Traditionally, anatomy in HPE is often introduced through human body donor dissection and 2D visuals, reinforcing Cartesian dualism and promoting an ocularcentric culture of learning. While these methods offer foundational knowledge, they often neglect the lived, dynamic nature of the human body – a gap that somatic pedagogy is uniquely positioned to address.

Findings from this research show that anatomy educators across disciplines who intentionally integrate experiential somatic methods including gesture, touch, breath, posture, and movement, can enhance student engagement, deepen intercorporeal anatomical comprehension, and foster embodied empathy (Gallagher, 2023; Leder, 1990; Weiss, 1999). These educators model anatomy as an ongoing lived experience, not simply a body of facts. Their pedagogies blur the boundary between learner and content, inviting students to become active, sensing participants in their own anatomical learning.

For HPE, this means rethinking how anatomy is taught, not only in what content is delivered, but in how it is embodied, experienced, and applied. Integrating somatic learning practices into clinical anatomy courses could better prepare future healthcare practitioners to attune to their patients intellectually, physically, and relationally (Chang et al., 2018). Tactile-based activities such as palpation, embodied movement sequences, and functional assessments could be incorporated earlier in training to foster kinaesthetic understanding and diagnostic intuition (Turney, 2007; Papa & Vaccarezza, 2013). Teaching strategies that promote reflective somatic awareness, such as breath-led scanning, mirroring exercises, or relational anatomy tasks, could also support the development of intercorporeal sensitivity, an essential skill in patient-centred care.

This research also highlights the importance of supporting anatomy educators in developing their own somatic awareness. Faculty development initiatives that center the educator's embodied experience could improve teaching effectiveness and educator well-being (Emond, 2021), while modeling the very pedagogical shifts HPE seeks to foster in learners (Korthagen, 2004; Van Manen, 1999).

Ultimately, this dissertation calls for a more humanized, embodied approach to HPE anatomy education. An approach that values the body not just as content to be dissected, but as a relational, living source of anatomical knowledge. By bridging theoretical learning with sensory, experiential engagement, somatic anatomy education holds the potential to transform how future clinicians think, feel, and interact with themselves, their patients, and the world (Csordas, 1994; Reid, 2011).

### **Limitations & Future Research**

While this dissertation offers important insights into experiential somatic learning in anatomical education, several limitations suggest room for future inquiry. Like most qualitative multiple case studies (Yin, 2014), it offers rich disciplinary diversity, but this limits the generalizability of findings (Creswell & Poth, 2018). Although the cross-disciplinary design strengthened the richness of findings, the small sample size (five educators across expressive, clinical, and technical fields) limits the broader applicability of conclusions. Expanding the participant pool across additional institutions, educational levels, or geographic regions would further refine and test the F2F model's cross-contextual relevance.

Furthermore, participants were selected based on their openness to experiential learning, which may introduce bias toward somatic approaches (Palinkas et al., 2015). Observations captured only a portion of each educator's practice and may not reflect the full range of their teaching strategies.

Additionally, this research focused exclusively on the educator's perspective. While this lens was deliberately focused on the embodied pedagogy and somatic self-awareness of educator's teaching practices, future studies could integrate student perspectives to triangulate how somatic anatomical instruction is experienced, embodied, and applied in learner contexts. Investigating how students experience and internalize somatic anatomy teaching would provide a

more holistic picture of intercorporeal knowledge construction and validate the transformative potential suggested by this study.

Given the exploratory nature of the F2F model in cross-disciplinary settings, future research could pursue the development of assessment tools to measure the embodiment of anatomical knowledge in both educators and students. Mixed-methods studies combining RTA with pre- and post-intervention assessments could illuminate how somatic approaches influence anatomical comprehension, diagnostic reasoning, clinical skills, and relational competencies over time.

Moreover, longitudinal studies tracking how somatic pedagogies influence clinical practice, artistic expression, or technical design after graduation would extend current findings into professional application contexts. For instance, a question I currently ponder after writing this thesis is “How does early exposure to somatic anatomy education impact the tactile diagnostic skills of physicians, the spatial awareness of artists, or the ergonomic design thinking of engineers?” These forward-looking questions connect embodied pedagogy to professional practice, suggesting that experiential learning may impact future clinical reasoning in medicine, spatial and compositional sensitivity in the arts, and user-centred design thinking in engineering (Norman, 2005). As Koskinen et al. (2011) suggest, design thinking is not purely abstract but emerges through embodied interaction with tools, space, and context. This principle parallels how somatic anatomy education could influence ergonomic awareness and creative application in disciplines like engineering

Additionally, research should investigate how novice educators develop embodied teaching practices and whether professional development programs in somatic learning can enhance instructional quality. Studies could also examine the institutional conditions that enable or hinder the adoption of somatic pedagogy, helping to design supportive frameworks for broader implementation across educational settings (Moffat & Cross, 2024; Charon, 2001). Further future research could explore faculty development models that promote educator somatic awareness, addressing a gap highlighted by this dissertation. Action research projects that invite anatomy educators to cultivate their own experiential learning practices and then examine how this shift transforms their teaching. This would provide pragmatic pathways for institutional change.

Overall, while this dissertation lays an important foundation for integrating somatic experiential learning into anatomy education, further work is needed to extend, test, and adapt these approaches across diverse educational environments. Future research that amplifies student voices, tracks long-term impacts, and experiments with faculty development initiatives will be essential to building more embodied, relational, and humanized approaches to anatomy education in Health Professions and beyond.

### **Personal Insights**

As the human anatomy educator at OCAD University for the past three years, I have made a firm commitment to engage my students with embodied anatomical education. Through the lessons I have learned from this research study, I have enhanced how interdisciplinary anatomical concepts are taught in my course – *SCTM2002 - Human Form and Function: Introduction to Anatomy* – by integrating experiential somatic learning methods across a range of activities. Inspired by the strategies observed among my study participants, I have incorporated movement, tactile exploration, and visual mapping into my lessons to foster deeper anatomical comprehension.

For example, drawing from Niloo Inalouei’s approach to observing anatomical form through shifting planes and geometric structures, I now guide students through in-depth tactile exploration exercises where we palpate the contours of our musculoskeletal system, highlighting the difference between bony landmarks for attachment and insertions of muscles, and the roundness that comes from the muscle belly. In the spirit of Danielle Denichaud’s somatic movement pedagogy, I have introduced breath-led postural exercises, such as sacrum mapping, and spinal articulation drills, like physically exploring which segments of the vertebral column have more range of motion versus more stability. This has helped students kinaesthetically embody musculoskeletal relationships before visualizing them in their drawings or answering exam questions. Inspired by Dr. Terry Li’s integration of living anatomy through ultrasound and surface landmark palpation, I now bring my own ultrasound, CT, and X-ray scans from my previous pathologies to share with my students. Although they are not live scans in that very moment, this process has encouraged students to locate, feel, and trace anatomical landmarks on themselves or partners during comparative anatomy studies. Tamara Maciel’s functional demonstrations of joint mechanics and pathology have influenced my use of dynamic movement drills, where I challenge my students to analyze functional, or the-lack-of, actions in regions of

the body that are subject to injury. We have explored the potential functional limits and feelings associated with pathologies such as frozen shoulder, herniated vertebral discs, ligament tears in the knee, bursitis, joint dislocation, and many more. Finally, following Dr. Kei Masani's biomechanical modeling, I have incorporated basic gait cycle analysis exercises to encourage movement in the class. It is a pleasure to watch students walk around the room, feeling the unconsciousness of our human gait cycle and how it may relate to movement and changes in surface anatomy.

By weaving these interdisciplinary, somatically informed strategies into my anatomy courses, I have enforced anatomical literacy while promoting a sense of intercorporeal connection, relational learning, and embodied curiosity among my students. This research has profoundly shaped my teaching philosophy, affirming that anatomy is not merely to be seen or memorized but to be lived, felt, and dynamically understood (Davis et al., 2008; Lindgren & Johnson-Glenberg, 2013; Lloyd, 2011). I am proud to share that these efforts have been recognized through both faculty- and university-wide teaching awards, reflecting the impact and value of somatic, student-centred anatomical education.

### **Concluding Note**

This dissertation invites a fundamental rethinking of how we teach, learn, and embody human anatomy. By centering somatic awareness and experiential engagement across expressive, clinical, and technical disciplines, this work moves anatomy education beyond static content delivery toward a more dynamic, relational, and humanized practice. Guided by the Function2Flow (F2F) model and the perspectives of educators who teach the body through the body, this study illuminates the depth of understanding that emerges when anatomy is lived, felt, and enacted rather than merely observed or memorized. Embodied inquiry calls us to live into our research, embracing the vulnerability, creativity, and vitality of the body as a source of insight and transformation (Snowber, 2016, p.16).

These findings contribute to a growing interdisciplinary dialogue that situates the body not only as the object of anatomical inquiry, but as its most immediate, accessible, and intuitive source. In doing so, this research expands the scope of anatomical sciences education, offering a cross-disciplinary framework that is as pedagogically rigorous as it is experientially rich. For educators, it underscores the importance of cultivating somatic presence and reflective teaching practices; for institutions, it offers a pathway to curricular renewal that aligns with holistic and

patient-centred care; and for learners, it affirms the body as a site of knowledge, connection, and transformation.

As an anatomy educator, researcher, and lifelong student of the body, I conclude this dissertation with the belief that the future of anatomy education lies not only in technological innovation or disciplinary specialization, but in the capacity to return to the body – our breath, movement, sensations, presence, and connection to self – as our most powerful pedagogical tool. In bridging theoretical knowledge with lived experience, this work lays the groundwork for more embodied, inclusive, and compassionate approaches to teaching anatomy in Health Professions Education and beyond.

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## Appendices

### Appendix A – Reflection on the Thesis Format Conversion

This doctoral research was initially written in a Thesis by Articles format, comprising three publishable studies that collectively explore how experiential somatic learning methods are applied by anatomy educators across expressive, clinical, and technical disciplines. However, in collaboration with my committee, and in light of deeper data analysis and synthesis of findings, I made the difficult decision to convert my work into a Monograph Thesis format.

This decision was not taken lightly. Transitioning from article-based research to a monograph involved a complete reconceptualization of structure, argumentation, and narrative flow. It demanded a cohesive synthesis of methods, findings, and theoretical frameworks across all three studies. This process required time, intellectual endurance, and deep reflection. What made this process especially challenging was the urgency of time: the extensive revisions needed for this monograph format placed me at risk of not completing my PhD before the renewal of my first full-time faculty contract at OCAD University – my dream job. The prospect of losing this position, which aligned so deeply with my professional goals and pedagogical values, weighed heavily on me throughout the final stages of this project.

Despite the immense pressure, what sustained me was my unwavering belief in the value of this research and the stories of the remarkable educators who participated in it. Their voices, practices, and somatic wisdom continually reminded me why this work matters in the field of anatomy education and in the broader conversations about how we teach, learn, and connect through the body.

I am deeply grateful to my committee for their encouragement, trust, and insightful feedback. Their guidance allowed me to reimagine this project not as a set of discrete articles, but as a cohesive narrative that progressively builds a case for somatic pedagogies in anatomical sciences education. This monograph structure enabled more robust reflexive engagement with my dual role as researcher and educator, and ultimately enriched the rigor, transparency, and interdisciplinary impact of the dissertation.

As outlined in Table 4, I still intend to publish the following three articles:

Article 1: Balancing Innovation and Living Experience: The Role and Limits of Modern Technological Approaches to Anatomy Education Across Disciplines

Article 2: Teaching the Body Through the Body: Somatic Experiences of Anatomy Educators in Visual Arts and Dance

Article 3: Bridging the Gaps: Somatic Awareness in Expressive, Clinical, and Technical Anatomy Education

These forthcoming publications will ensure that the insights gained from this work continue to support educators, researchers, and students committed to embodied approaches to teaching and learning. The restructured chapters are detailed in Table 5, and the original plan for publication remains a core goal.

Despite my best efforts, I was unable to complete my PhD in time to meet the eligibility requirements for contract renewal at my first full-time faculty position. I lost the job I loved but I did not leave empty-handed. After five years, I am completing my doctorate with three years of full-time teaching experience, having designed and led anatomy education at a national art and design university. I have grown as a researcher, educator, and person. I am proud of the work I've done and grateful for the perseverance this journey demanded. Most of all, I remain deeply committed to honouring the voices of my participants, whose stories continue to inspire me. I am walking forward into the next chapter of my career as a stronger and wiser scholar who is ready to bridge disciplines, honour lived experience, and reimagine anatomy education through somatic and experiential ways of knowing.

Table 4. Original thesis by articles breakdown: Article contributions mapped to overarching research questions

Research Question	Article 1: Narrative Review	Article 2: Case Study (Visual Arts & Dance)	Article 3: Cross-Disciplinary Comparative Study (5 disciplines)
How do anatomy educators integrate experiential somatic learning to bridge theoretical knowledge and embodied understanding?	Identifies a lack of embodied engagement in modern technology-driven approaches; proposes living anatomy as an essential counterbalance to disembodied methods.	Educators in visual arts and dance use gesture, movement, and tactile modeling to personally and expressively embody anatomy comprehension; somatic awareness is central to student engagement.	Educators across all disciplines incorporate somatic strategies such as modeling, palpation, real-time movement analysis, and tactile feedback. Pedagogical patterns mapped to F2F model show that embodied understanding is cultivated through multisensory engagement.
How can cross-disciplinary insights transform anatomy in HPE?	Advocates for integrating somatic strategies with technological innovation to create more holistic and multimodal anatomy education frameworks.	Highlights transferable strategies from arts-based disciplines, such as guided breathwork and body-based storytelling that could enrich anatomy education across other fields.	Demonstrates that somatic methods are already being adapted within medicine, kinesiology, and engineering, though often unconsciously. Proposes a cross-disciplinary pedagogical model grounded in F2F to support embodied learning across HPE contexts.

Table 5. Monograph Thesis Structure Overview

Chapter	Title	Key Content	Function2Flow (F2F)	Reflexive Thematic Analysis (RTA)	Research Question(s)	Cases Featured
1	Introduction	<ul style="list-style-type: none"> <li>• Introduction</li> <li>• Personal motivation</li> <li>• Research problem</li> <li>• Contributions to the field</li> <li>• Overview of Dissertation</li> </ul>	N/A	N/A	RQ1 & RQ2	N/A
2	Literature Review	<ul style="list-style-type: none"> <li>• Dominant dualistic view in anatomy</li> <li>• Current common approaches to anatomy in HPE</li> <li>• Discipline specific approaches to anatomy education</li> <li>• Potential and limitations to preferred modern technological tools in anatomy education across disciplines</li> </ul>	N/A	N/A	RQ1	Visual arts, dance, kinesiology, physiotherapy, bioengineering

		<ul style="list-style-type: none"> <li>• Living anatomy supplements modern technology</li> <li>• Experiential somatic learning</li> <li>• Current research on experiential somatic learning in anatomy education</li> <li>• Educator's perspective</li> <li>• Lack of cross- and interdisciplinary anatomy education</li> <li>• Bridging innovation and embodiment in anatomy education across disciplines</li> </ul>				
3	Framing the Inquiry & Methodology	<p>Framing the Inquiry</p> <ul style="list-style-type: none"> <li>• Dominant dualistic view in anatomy</li> </ul>	Function, form, feeling, flow	<ol style="list-style-type: none"> <li>1. Familiarization</li> <li>2. Generating initial codes</li> </ol>	RQ1 & RQ2	N/A

		<ul style="list-style-type: none"> <li>• Current common approaches to anatomy in HPE</li> <li>• Discipline specific approaches to anatomy education</li> <li>• Potential and limitations to preferred modern technological tools in anatomy education across disciplines</li> <li>• Living anatomy supplements modern technology</li> <li>• Experiential somatic learning</li> <li>• Current research on experiential somatic learning in anatomy education</li> <li>• Educator's perspective</li> </ul>		<ol style="list-style-type: none"> <li>3. Generating themes</li> <li>4. Reviewing potential themes</li> <li>5. Defining and naming theme</li> <li>6. Producing report</li> </ol>		
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		<ul style="list-style-type: none"> <li>• Lack of cross- and interdisciplinary anatomy education</li> <li>• Bridging innovation and embodiment in anatomy education cross disciplines</li> </ul> <p>Methodology</p> <ul style="list-style-type: none"> <li>• Narrative review <ul style="list-style-type: none"> <li>• Data collection</li> <li>• Data analysis</li> </ul> </li> <li>• Case study research methodology <ul style="list-style-type: none"> <li>• Strengths and limitations</li> </ul> </li> <li>• Study design</li> <li>• Data collection for multiple case study <ul style="list-style-type: none"> <li>• Participant recruitment</li> <li>• Interviews &amp; co-reflections</li> </ul> </li> </ul>				
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		<ul style="list-style-type: none"> <li>• Artifacts</li> <li>• Observations</li> <li>• Data analysis <ul style="list-style-type: none"> <li>• Reflexive thematic analysis phase 1 – 6</li> </ul> </li> <li>• Ethical considerations</li> <li>• Research validity and trustworthiness <ul style="list-style-type: none"> <li>• Credibility</li> <li>• Dependability</li> <li>• Confirmability</li> <li>• Transferability</li> <li>• Reflexivity</li> </ul> </li> <li>• Logical flow of dissertation</li> </ul>				
4	Findings	<ul style="list-style-type: none"> <li>• Participants sampling</li> <li>• Instrument development</li> <li>• Data collection procedure</li> <li>• Data analysis</li> </ul>	Function, form, feeling, flow	<ol style="list-style-type: none"> <li>3. Generating themes</li> <li>4. Reviewing potential themes</li> <li>5. Defining and naming theme</li> </ol>	RQ1 & RQ2	<ol style="list-style-type: none"> <li>1. Niloo Inalouei</li> <li>2. Danielle Denichaud</li> <li>3. Tamara Maciel</li> </ol>

		<ul style="list-style-type: none"> <li>• Interview 1 and artifact findings</li> <li>• Observations findings</li> <li>• Co-reflections findings</li> <li>• Theme 1 – 4</li> </ul>		6. Producing report		<ol style="list-style-type: none"> <li>4. Dr. Terry Li</li> <li>5. Dr. Kei Masani</li> </ol>
5	Discussion	<ul style="list-style-type: none"> <li>• Theme 1 – 4</li> <li>• Cross-case interpretations</li> <li>• Addressing research question 1</li> <li>• Addressing research question 2</li> </ul>	Function, form, feeling, flow	<ol style="list-style-type: none"> <li>5. Defining and naming theme</li> <li>6. Producing report</li> </ol>	RQ1 & RQ2	<ol style="list-style-type: none"> <li>1. Niloo Inalouei</li> <li>2. Danielle Denichaud</li> <li>3. Tamara Maciel</li> <li>4. Dr. Terry Li</li> <li>5. Dr. Kei Masani</li> </ol>
6	Conclusion	<ul style="list-style-type: none"> <li>• Research summary</li> <li>• Thesis by articles conversion</li> <li>• Research contributions</li> <li>• Methodological contributions</li> </ul>	Function, form, feeling, flow	6. Producing report	RQ1 & RQ2	<ol style="list-style-type: none"> <li>1. Niloo Inalouei</li> <li>2. Danielle Denichaud</li> <li>3. Tamara Maciel</li> <li>4. Dr. Terry Li</li> </ol>

		<ul style="list-style-type: none"><li>• Theoretical contributions</li><li>• Implications on health professions anatomy education</li><li>• Limitations and future research</li><li>• Personal insights</li><li>• Concluding note</li></ul>				5. Dr. Kei Masani
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## Appendix B – Letter of Invitation

Université d'Ottawa | University of Ottawa

February 20th, 2024

Marie-Hélène He, PhD (Candidate)  
Faculty of Education  
University of Ottawa  
Ottawa, Ontario, K1N 6N5  
Email: [REDACTED]

Supervisor:  
Dr. Angus McMurtry  
Faculty of Education, University of Ottawa  
Email: [REDACTED]

Co-supervisor:  
Dr. Doug Archibald  
Faculty of Medicine, University of Ottawa  
Email: [REDACTED]

### Letter of Invitation: Somatic Approaches to Anatomical Education

Dear [REDACTED]

I hope my letter finds you well. My name is Marie-Hélène and I am a PhD Candidate at the University of Ottawa. I am conducting a research study titled "Somatic Approaches to Anatomical Education: A Qualitative Interpretive Study". The ultimate objective of this research project is to explore how anatomy educators of various disciplines connect with their living body to teach anatomical concepts and how these experiences may inspire other disciplines within Health Professions Education. The ethical aspects of this study have been reviewed and approved by the University of Ottawa Research Ethics Board.

You were selected as a potential participant because of your experience in teaching anatomy for artists. I would like to invite you to participate in my research study to better understand how you embody teaching and learning in your anatomy classes.

For this research project, I will interview you to better understand your experiences with teaching anatomical sciences. General interview questions will be provided to you one week in advance. After our initial interview, we

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will decide on 1-3 of your anatomy classes for me to quietly observe and record in person. I will review the documents pertaining to the observed and recorded classes (syllabus, textbooks, worksheets, lecture slides, etc). Upon completion of observations, I will follow-up interview you where we can discuss my interpretations of my observations.

As previously mentioned, you were selected based on your expertise within anatomical sciences. I would be delighted to learn about your experiences as an anatomy instructor and your participation in my study will be much appreciated.

If you are interested, please complete and return the attached *Informed Consent Form*.

Please do not hesitate to contact me should you have any questions or concerns.

Thank you for your time and consideration,

Sincerely,  
Marie-Hélène He

BHSc, MSc, PhD Candidate - Health Professions' Education  
Faculty of Education, University of Ottawa  
Telephone: [REDACTED]  
Email: [REDACTED]

## Appendix C – Letter of Informed Consent (Participants)

Université d'Ottawa | University of Ottawa

February 20th, 2024

Marie-Hélène He, PhD (Candidate)  
Faculty of Education  
University of Ottawa  
Ottawa, Ontario, K1N 6N5  
Email: [REDACTED]

Supervisor:  
Dr. Angus McMurtry  
Faculty of Education, University of Ottawa  
Email: [REDACTED]

Co-supervisor:  
Dr. Doug Archibald  
Faculty of Medicine, University of Ottawa  
Email: [REDACTED]

### **Somatic Approaches to Anatomical Education: A Qualitative Interpretive Study**

**Invitation to Participate:** I am invited to participate in the Doctoral research study entitled “Somatic Approaches to Anatomical Education: A Qualitative Interpretive Study” conducted by Marie-Hélène He. The ethical aspects of this study have been reviewed and approved by the University of Ottawa Research Ethics Board

**Purpose of the Study:** I understand that the purpose of the study is to explore how anatomy educators of various disciplines connect with their living body to teach anatomical concepts and how these experiences may inspire other disciplines within Health Professions Education.

**Participation:** My participation will consist of 2 interviews (initial and follow-up) and 1-3 of the researcher’s video-recorded observation of my whole classes. Data to be collected encompass my teaching methods, my engagement, pedagogical strategies, the learning environment, non-verbal cues, assessment techniques, movements, placement, etc. I will also provide the researcher with any student-accessible documentation pertaining to the anatomy course. The interviews will be scheduled on a convenient date and time for me. Prior to the interview, I will be given general interview questions, I will have provided the researcher with relevant course-related documents, and asked to provide verbal consent for participation and recording of the conversations and observations for research purposes. The

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observation sessions will be scheduled for dates and times that are convenient for me. The researcher will not interfere with class content, merely silently participate and observe.

**Risks:** I understand that since my participation in this study will entail that I respond to questions about my somatic experiences teaching anatomy, it may cause me to feel that I am sharing personal reflections and insights. I have received assurance from the researcher that every effort will be made to respect these responses and personal reflections in the writing and reporting of the research.

**Benefits:** My participation in this study will provide information to a research team doing Health Professions Education research at the University of Ottawa and will not have direct benefits for myself. However, I acknowledge the sharing of my experiences may improve educational practices of other anatomy educators.

**Confidentiality and Anonymity:** I have received assurance from the primary investigator that if I decide to remain anonymous, the information I share will remain strictly confidential. I am aware that identifiers will be removed from the reporting of research findings and analyses will only be performed with de-identified data. I am also aware that complete anonymity cannot be guaranteed because of the possibility that information regarding my expertise and individualized answers may be enough to become identifiers. I am aware that recordings or photographs might be used in presentations/conferences/publications and that I may request against the use of such recordings and photographs or my anonymization (such as blurring any identifying features/location) in recordings or photographs for presentations/conferences/publications.

I have been assured that if I request anonymity, all identifiable information will be kept confidential, and data will be reported in a way that prevents direct identification. I have been informed of the researcher's commitment to protecting my privacy.

**Conservation of data:** The audio and/or video recordings, and transcripts will be kept in a secure manner on a password-protected computer. Hard copies of research documents will be kept in a locked filing cabinet. The length of data retention will be up to 5 years.

**Voluntary Participation:** I am under no obligation to participate and if I choose to participate, I may withdraw from the study at any time and/or refuse to answer any questions. If I choose to withdraw from the interview, all interview data gathered until the time of withdrawal will be destroyed.

**Acceptance:** I, \_\_\_\_\_, agree to participate in the above research study conducted by Marie-Hélène He (PhD Candidate of the Faculty of Education), which research is under the supervision of Drs. Angus McMurtry and Douglas Archibald. I understand that by accepting to participate I am in no way waiving my right to withdraw from the study.

I AGREE to be interviewed for this study.

I also AGREE to allow researcher to observe my embodied learning anatomy classes.


I will AGREE to either being anonymized or identified by the second / follow-up interview (after all observations).

Please indicate email contact here: \_\_\_\_\_

If I have any questions about the study, I may contact the study investigator at the numbers mentioned above.

If I have any ethical concerns regarding my participation in this study, I may contact the Protocol Officer for Ethics in Research, University of Ottawa, 550 Cumberland Street, Room 154, (613) 562-5387 or [ethics@uottawa.ca](mailto:ethics@uottawa.ca).

Participant's signature: \_\_\_\_\_ Date: \_\_\_\_\_

Researcher's signature:  Date: Feb 19, 2024

Please print/save a copy of this consent page for your records.

## Appendix C – Letter of Informed Consent (Students)

Université d'Ottawa | University of Ottawa

March 20th, 2024

Marie-Hélène He, PhD (Candidate)  
Faculty of Education  
University of Ottawa  
Ottawa, Ontario, K1N 6N5  
Email: [REDACTED]

Supervisor:  
Dr. Angus McMurtry  
Faculty of Education, University of Ottawa  
Email: [REDACTED]

Co-supervisor:  
Dr. Doug Archibald  
Faculty of Medicine, University of Ottawa  
Email: [REDACTED]

### Student Information and Consent to be Video and Audio Recorded

**Invitation to Participate:** Your anatomy instructor has accepted to participate in the Doctoral research study titled "Somatic Approaches to Anatomical Education: A Qualitative Interpretive Study," conducted by Marie-Hélène He, under the ethical approval of the University of Ottawa Research Ethics Board. As a student in this class, you are also invited to participate in this study.

**Purpose of the Study:** The study seeks to explore how anatomy educators of various disciplines connect with their somatic being to teach anatomical concepts using the living body and how these methods may be applied to other disciplines within Health Professions Education.

**Participation:** Please note that the primary focus and research participant of the study is your anatomy instructor. While you are not the primary focus of the study, if you choose to volunteer with demonstrations, speak in class, or situate yourself close to your instructor, you may be within the frame to be observed and recorded as a secondary aspect of the research. Your participation involves being present in the video-recorded observations of the classes. Data collection covers teaching methods, engagement, pedagogical strategies, the learning environment, non-verbal cues, assessment techniques, movements, and placement of the instructor.

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**Risks:** Please be aware that you may be visible or audible in the recorded observations as a secondary aspect of the study.

**Benefits:** While participation offers no direct benefits, it contributes to Health Professions Education research, potentially enhancing educational practices for anatomy educators.

**Confidentiality and Anonymity:** Your identity will remain confidential, and any identifiers will be removed from research reporting. You may request anonymization or non-use of recordings or photographs featuring you.


**Data Conservation:** Recordings will be stored securely, and data will be retained for up to 5 years.

**Voluntary Participation:** Your participation is voluntary, and you may choose to be withdrawn from any recordings and observations at any time.

**Acceptance:** By accepting, you agree to be recorded should you be visible or audible in class. If you are recorded, you may choose to be anonymized.

**Acceptance:** I, \_\_\_\_\_, agree to be recorded should I be visible or audible in the class that is being observed during the research study conducted by Marie-Hélène He (PhD Candidate of the Faculty of Education), which research is under the supervision of Drs. Angus McMurtry and Douglas Archibald. I understand that by accepting to participate I am in no way waiving my right to withdraw from the study.

Student signature: \_\_\_\_\_ Date: \_\_\_\_\_

Researcher's signature:  Date: March 28, 2024

If I have any questions about the study, I may contact the study investigator at the numbers mentioned above.

If I have any ethical concerns regarding my participation in this study, I may contact the Protocol Officer for Ethics in Research, University of Ottawa, 550 Cumberland Street, Room 154, (613) 562-5387 or [ethics@uottawa.ca](mailto:ethics@uottawa.ca).

## **Appendix D – Interview practice and guide with F2F model’s creator (R.L.)**

How long have you been teaching anatomy education?

How many classes are you teaching now? Which ones do you find have the most movement or somatic awareness involved?

Have you taught it before? Where and to who?

I'm very interested in how instructors are experiencing our own bodies when we teach. Is this something that you've thought about before? The use of your body when you're educating?

The body & what you're teaching & how you're communicating it with other bodies in the room

I'm going to ask questions about the anatomy body, the living body, so I'll ask about movement and our awareness of our bodies when we teach. Are those 2 areas ok with you?

How many lessons do you have in a semester? Are there certain lessons where the body living body is more involved than others?

The one you think of first, but are there any other specific lessons?

In terms of movements of students, does their participation or enthusiasm change over the semester? Is it more so you demonstrating?

I'd like to imagine what it looks like in the room, can you describe the room? Is it moveable so students can reallocate themselves in the room?

What does the room look like, where were you, what was the day, what was the moment, describe everything how it emerged and how it became a moment, its a vignette. Laughter, sound effect, as if you're telling a story for someone

When you get into different moments, do you ask them to move things around or do they have agency to do it themselves?

Do you think some are more ready than others to move?

Do you reach out to the ones that aren't as ready to move? Or leave them be?

Focus on a specific lesson

How long ago did this lecture happen? How many sessions? Do you remember this lecture very well? When will the next lecture happen? May I attend this lecture?

Could you close your eyes and bring it back to life? Is there a particular moment where the movement was very connected to the learning

Can you give me an example?

What would you call this movement?

“Just send it!!!”

Dive deeper in this one moment, not the breadth of knowledge but the specificity of the moment

Could you tell me a particular moment where you saw a student felt interested or paid attention, how was it received?

“Sassy finger wag” is a name,

Can you see the faces in the room? What was happening in the room? How did the students react?

How long did that last? Can you give me a sense of how long that moment lasted?

Take me into that moment. How did you introduce that movement? How did they react? Did reaction increase over the class?

When did it become more of a moment? Rather than just a movement

What do you associate that sound with? How was the timing of the finger wag? Was it fast slow?

Heavy? Light? What was the mood of it? Was there a flavor?

If you thought of your class like a music score, how does the score look like? Sometimes its monotonous but there are pockets of moments that erupts to catch everyones attention.

Why do you think people connected with it?

Don't talk about self reflection - thats internal

Tell me how the students reacted? Were they moving with you? Sitting? Performing? Were all students doing it? What was the rhythm of pace of the movement trial? Did their posture change? Did their attention span change? Was it playful?

Did you feel like hte moment took on a life of its own? Do you think its something they'd remember in the long run out of all the lectures?

Can you describe the moment? Eye contact? Laughter?

In terms of your own awareness, did something shift in the moment for you? Did you feel lighter if they kind of understood it deep?

Tell me more, go deeper, what else did you see? What else did you feel?

Observation; look for when the moments where the body is present. Describe it

They might have a different moment, ask them to describe it via form, function, feeling, flow

Get the sense it was more than the objective body, it was a relational body moment with a meaning. What is the meaning? They're not just body parts, they're part of a whole living breathing body, and the moment of it coming to life. What does it mean to sit or stand or lift in the world. Gestures and communications

Want the interview person to bring you into that moment, how are they feeling in their body before i observe it.

Can you describe the specific postures, positions, gestures, and expressions involved in your partnered practice?

What are the somatic features of your practice, such as the motional sense of requisite functions and forms?

What inner sensations of breath, balance, muscular tension, extension, and alignment manifest in your practice?

Function: what action/motion is key to this moment

Form: Describe the posture, positional angles, gestural shape of this motion

Feeling: describe the amplitude, direction, force, and timing of this motion

Flow: describe the synergistic sensation that emerge in this motion

## **Appendix E – Prompting questions sent to participants**

- What course do you teach?
- Can you describe the room you teach in?
- Can you recount a specific moment where you felt connected or aware of your own body during your teaching?
- How do you use your body when you teach? Do you walk around the room? Gesture? etc.
- What were you doing at the time? How long did this activity last?

# Appendix F – Ethics Approval

09/10/2024

**Université d'Ottawa**

Bureau d'éthique et d'intégrité de la recherche

**University of Ottawa**

Office of Research Ethics and Integrity

## CERTIFICAT D'APPROBATION ÉTHIQUE | CERTIFICATE OF ETHICS APPROVAL


<b>Numéro du dossier / Ethics File Number</b>	S-10-23-9255
<b>Titre du projet / Project Title</b>	Somatic Approaches to Anatomical Education: A Qualitative Interpretive Study
<b>Type de projet / Project Type</b>	Thèse de doctorat / Doctoral thesis
<b>Statut du projet / Project Status</b>	Renouvelé / Renewed
<b>Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)</b>	06/11/2023
<b>Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)</b>	05/11/2025

### Équipe de recherche / Research Team

<b>Chercheur / Researcher</b>	<b>Affiliation</b>	<b>Role</b>
Marie-Helene HE	Faculté d'éducation / Faculty of Education	Chercheur Principal / Principal Investigator
Angus MCMURTRY	Faculté d'éducation / Faculty of Education	Superviseur / Supervisor
Douglas ARCHIBALD	Département de médecine familiale / Department of Family Medicine	Co-superviseur / Co-supervisor

### Conditions spéciales ou commentaires / Special conditions or comments

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	File No	Project Title	Principal Investigator	Application Type	Status Snapshot
<a href="#">View</a> <a href="#">Clone</a> <a href="#">Events</a> <a href="#">Latest Workflow</a>	102525	Somatic Approaches to Anatomical Education: A Qualitative Interpretive Study	Miss Marie-Hélène He (Faculty of Arts & Science)	Application for Ethical Review of Research Involving Human Participants (Certification/Human Ethics)	<b>Project Status:</b> Active <b>Workflow Status:</b> Approval Decision Made
<a href="#">View</a> <a href="#">Clone</a> <a href="#">Events</a> <a href="#">Latest Workflow</a>	102522	Somatic Approaches to Anatomical Education: A Qualitative Interpretive Study	Marie-Hélène He (Faculty of Arts & Science)	Grants Authorization Form (GAF) (Awards/Awards)	<b>Project Status:</b> Active <b>Workflow Status:</b> Approval Decision Made

## Appendix G – Rich descriptions of research context

- Visual arts – Niloo Inalouei
- Niloo is a dynamic visual artist whose work pulses with life, spanning mediums as varied as acrylics, charcoal, textiles, and installation. For over thirty years, she has poured her creativity into drawing, painting, and constructing pieces that transform materials like fabric, wood, and even industrial chalk powder into expressive art. Her journey began in childhood, and for the past three years, she has shared her passion as the visual arts instructor for DRPT-2014 Anatomy for Artists at OCAD University. In this intimate, second-year course of 23 students, Niloo inspires budding artists to deepen their understanding of human anatomy and use it as a foundation for capturing the human figure. With her professional expertise and fine arts education, Niloo infuses her teaching with calm and nurturing energy, encouraging students to see beyond proportion and musculature. She emphasizes the profound connection between observation and personal narrative, challenging students to draw from their own stories rather than adhering to Western conventions. Her classes weave live model studies, digital imaging, and somatic exploration, guiding students to feel anatomy through their own bodies. By intertwining technical precision with creativity, Niloo nurtures artists to transform their anatomical understanding into vivid, authentic expressions that resonate beyond the canvas.
- Visual arts – Niloo Inalouei – Descriptive Writing of Observations
- At 6:30pm on a Monday evening in the Winter semester of 2024, students enter a brightly fluorescently lit art studio / classroom at OCAD University, which is thoughtfully arranged to encourage creativity and focus on where the figure drawing model will be. The walls are white, brightly reflecting light in every corner of the room. On the right side of the entrance is a model change room, a stage up in the center of the room, pressed up against the wall across from the entrance, two rows of easels and donkeys form a semi-circle around the stage, paint splattered masonite boards and canvases of varying sizes are chaotically organized on the outskirts of the room. Special lighting equipment is secured to the tall ceiling, which can create dramatic effects or specific moods, especially during sessions involving color or different materials. Students pick their boards and use clips to secure affordable newsprint paper for weekly drawing exercises. 6 students sit on donkeys in the first row, closest to the stage. 9 students on easels and 5 students on

donkeys in the second row, closer to the entrance at the back of the room. Today's study was of the forearm and hands.

- Niloo welcomes her students warmly into her studio classroom. The class begins with a warmup; gesture drawings (30 seconds, 1 minute, and 2 minutes) of a live nude male model on stage to quickly capture his movement and form. Once the students are warmed up, Niloo introduces the anatomy of the forearm and arm. She begins her lecture by using her own body as a demonstration. She hastily rolls up the sleeve of her grey sweater to expose just above her left elbow explaining the notable change in form from proximal to distal forearm to tips of the finger. Facing her students, she raises her left arm, elbow bent, so her forearm comes directly in front of her face, just below her eye level and parallel to the floor. Her wrist is relaxed, but not floppy, there is some minor muscle contraction in her forearm's posterior compartment to gently prop her hand leveled. Her fingers are relaxed and gently curled, tilting towards the floor. She pivots on the spot to demonstrate the shape of her forearm, wrist, and hand. Then, very slowly, her hand dips towards the floor, sinking, her interphalangeal joints and metacarpal-phalangeal joints (knuckles) leading the way down. Her fingers curl deeper into her palms, back of her wrist elongating as her hand curls inwards towards her forearm, still descending as her elbow rises above the level of her shoulder, compromising the downward slope of her forearm's trajectory. The skin between her palm and wrist wrinkle deeply as her forearm, wrist, and hand continue to curve in on itself. At the same time, the skin on the posterior side of the forearm, back of the wrist, exposed to the light above us, stretches longer, longer. She comes into this position, slowly, this slow movement, as if a feeling of "letting go", or a happy cat curling in its paws about to "knead dough", or a gentle wave curving, before crashing into itself.
- 
- The bright light above us reflects off the skin of her arm, but the light hits differently with every slow, intentional, descending, curving motion. The shadows creep differently with more and more compression resulting from deeper flexion of the wrist and fingers. As her wrist comes into maximum flexion, it becomes an odd, unusual and uncomfortable-looking position for the hand; the back of the wrist reaches almost 90 degrees, almost a sharp angle against the forearm. The sensation changes from relaxed, content, and letting

go, to recluse and hiding. The odd shape of the wrist, the sharpness of the angle, which she loves seeing in art, increases everyone's awareness of their own wrist as students begin to look at themselves.

- She introduces the bones of the forearm, wrist, and hand with anatomical language, still indicating on her own body. From the radius and ulna, she progresses distally towards the carpals, to the metacarpals, and finally the phalanges. She retrieves the classroom's well-loved skeleton so students can observe the skeleton the forearm, wrist, and hand, pointing to each structure on the skeleton while encouraging students to feel their own bodies. The students explore the connection between their physical form and what they see on their plastic skeleton, eyes darting up to the skeleton, and back down to their own bodies.
- 
- Niloo's left arm is still raised and her right hand begins to gesture and motion, mimicking the contours of her left forearm. At the proximal end of the forearm, by the elbow, the forearm appears egg-shaped. There is roundness. Her right hand curves slowly and gently over the egg-shaped region, highlighting the muscle bellies and originating points of the forearms muscle. Distally, closer to the wrist, the forearm appears boxy and rectangular, her right hand gestures sharply, across the flatter surface of the back of her distal forearm, stopping at the wrist. Her right hand slants down the slope of the dorsum of her hand, crossing the minute roundedness of the back of the wrist, and she finishes with three short, sharp movements of her right hand, hovering over each flat surface of the dorsal phalanges found between the joints of the fingers. From rounded egg shape, to boxy and rectangular, to a gentle roundness of the wrist which leads to elegant flat surfaces found between the sharpness of joints. Each slope is a new plane, interacting differently with the light around us, to capture on paper.
- 
- Her demonstration continues as she orients herself in front of her easel equipped with newsprint while her students gather around, watching intently. She explains how the artist must consider their subject's feeling to capture their essence, even if it's a segmented part of the body such as the forearm, wrist, and hand, on paper. And this applies especially to the hands, which can be so expressive. She recreates the motion of her wrist and fingers

curling into flexion, the dorsum of the hand stretching, which naturally leaves the palmar side to compress. This dictates the weight of her charcoal-holding hand against the newspaper. Thin, elegant lines to represent the stretched, dorsal side forearm, exposed to the ceiling, white light reflecting off. The dorsum of the forearm, she explains, gives an essence of delicacy when the skin is stretched. A light, thin, quick line. The anterior of the forearm, fleshier, compressed, merits a heavy, *t h i c k e r*, line to represent the grooves of the wrinkles, the shadow creeping from each curve of the skin. Lines on her newspaper become simple geometrical shapes. Geometrical shapes become more detailed as shading is added. The essence of her forearm and hand is slowly brought to life on her easel.

- With this demonstration in mind, the students migrate back to their donkeys and easels, prepared to capture the essence of the model's forearm, wrist, and hand. The model sits on a chair surrounded by drapery on stage as students finger frame (using index finger and thumb of both hands to make a rectangle and looking through it) to determine their preferred composition. The model sits very still as Niloo encourages students to observe negative spaces and proportions surrounding the forearm and hand. Soft and relaxing music fills the room as the students begin their life drawing study. Niloo walks around the room to give each student individual suggestions and critiques. She emphasizes shading techniques, values, and the transition from general to specific details in their work. Towards the end of class the students are visibly tired, "drawing sessions can be demanding, especially the long poses that require intense focus... Drawing from observation is exhausting" Niloo explains. As the lifedrawing session concludes, students get out of their seats, stretch, and take a walk around the classroom to study their peers creation. The class concludes by 9:30pm.
- Niloo's classes focus on integrating anatomy with storytelling and creating counter-narratives through the body. She challenges students to use the living body to tell different kinds of feelings and stories—not just those represented dominantly across Western history, but from underrepresented backgrounds who create multiple histories, ensuring inclusivity in the narratives shared in class. Her goal in teaching anatomy to art students is to foster a deep connection between anatomical knowledge and creative expression by observing the feelings that emerge through changes in bodily form.

Through her pedagogical approach, she uses somatic awareness as a cornerstone, encouraging students to explore anatomy through their own bodies and physical sensations by “Stand in front of the mirror naked when you are home. Try to realize your own muscles and what’s happening inside”. By integrating storytelling with anatomical studies, Niloo empowers her students to challenge traditional narratives and create inclusive representations. Her body becomes an essential teaching tool, demonstrating function, form, feeling, and emotion through deliberate movements and gestures to be captured on paper. Her deep familiarity with her own somatic experiences allows her to draw from her body, not from the wrist to bring different weighted lines, tones, values to life on paper. This dynamic method inspires students to observe, feel, and express anatomy with intention and sensitivity, blending science with art in their own meaningful ways.

- Dance & Drama Performance – Danielle Denichaud
- Danielle is a seasoned dancer and experienced movement instructor. For over 22 years, she has navigated the intricate balance between anatomical precision and the art of somatic expression. At Toronto Metropolitan University, she teaches THF 100 - Anatomy of Movement and Lifestyle, a first-year course designed for thirty dancers and twenty actors embarking on their respective artistic journeys. The course is an eclectic mix of technical anatomy, somatic practices, biomechanical principles, and holistic well-being, tailored to meet the distinct needs of these two groups. Danielle carefully redesigned the curriculum to breathe life into what had once been a strictly anatomy-heavy syllabus. Her class allows students to explore activities that intertwine knowledge with experience: learning anatomical terms, practicing injury prevention, and crafting warm-up and cool-down plans tailored to their unique artistic demands. For Danielle, it's not just about teaching anatomy but fostering a deeper relationship with the body. She understands the contrasting ways dancers and actors approach movement. Dancers arrive with a technical focus, used to fine-tuning their rotators or articulation, while actors often prioritize space, character, and expression. Through her empathetic and adaptive teaching style, Danielle creates a bridge, encouraging all her students to connect with their bodies in ways that enhance their artistry and self-care.
- Dance and Drama Performance – Danielle Denichaud – Descriptive Writing of Observations
- At 9am on a Thursday morning during the Winter Semester of 2024, a rectangularly-shaped dance studio at Toronto Metropolitan University allows the soft, morning refracted light to enter through the long, double-paned windows near the ceiling of the room. The softness of natural light is complemented by fluorescent ceiling lights, both absorbed by the black Marley panels that cover the floor, offering a durable and smooth surface for movement. Floor length mirrors line the back and side walls, with ballet bars installed along two sides. Black curtains are draped on the side with the window, which can be adjusted for staging purposes. Students begin to enter the comfortable and dimly lit dance studio, removing their outside shoes and leaving them by the short side of the rectangular room. 48 students in their socks make their way deeper into their familiar studio. There are chairs arranged around the perimeter, though not enough for all

students, who have mostly seated (some have sprawled or laid) themselves on the floor in a large oval. A piano and sound system occupy one corner, facilitating musical accompaniment for the class. There is space for Danielle to move around the room comfortably to demonstrate exercises, ensuring all students can see clearly. She stands on the North side of the room as a member of the oval, her back towards the windows, and warmly greets her students. Today's exercise was finding mobility in the hips and torso by experiencing the joy of safe movement in the abdominal obliques.

- Danielle begins the class with prompted self-reflection for all students; one by one through the oval of students, each person presents a word or phrase to describe how they are feeling in that moment. This leads to her announcement that today's movement exercises will focus on achieving the true spiral of the body, where the torso and pelvis dissociate to achieve oppositional reach in dramatic twisting motions. She stands tall in front of the class and explains while demonstrating the oppositional reach in a spiral, which maintains the stability of deep structures in deep twists. She twists for everyone to see, then explains how her spiral allows the body to come back to center safely without unbalancing deep muscles and bony structures in the body, which could potentially throw out one's back. She introduces these exercises the Sacral Clock and the Abdominal Oblique Twist.
- She begins the exercises with a review of anatomical concepts that were taught in a previous class. Through grounding breathing where one anchors oneself in the present moment, breathing deeply into the belly, and inflating the relaxed chest and shoulders, Danielle brings students' focus to their pelvic floor, lumbar spine, ischia, iliac crests, pubis, and femurs sitting in the acetabulum. She then invites students to join her on the ground, flat on their backs, a neutral pelvis (slight lumbar curve), knees bent, soles of feet on the floor, arms relaxed to the sides. She then cues for active breathing on the floor by guiding students to breathe deeply into their back and ribs, blooming across the shoulder blades while engaging the pelvic floor and navel. On the exhale, the pelvic floor and navel are engaged, a dance between expansion of breath into the the three dimensionality of the torso and then a dynamic engagement of the deep abdominals. This serves as the foundation for all subsequent movements, fostering a sense of internal stability and alignment. She revisits the morphology, the natural convex curvature, of the sacrum and

provides the imagery that the sacrum is a clock. 12 o'clock being the sacroiliac joint (just below your lumbar spine before it becomes your sacrum), 6 o'clock at coccyx (tailbone), 3 o'clock on one's right side and 9 o'clock on one's left side. She instructs her students to rock the pelvis between 12 and 6 a few times to find the length of the sacrum. Then rock from 3 to 9 while feeling the lateral movement, almost like a boat tilting from side to side, to find the width of the sacrum. She demonstrates this extremely nuanced and subtle movement as the students gather for a better view. Students watch intently but it's almost undetectable unless you stare directly at the subtle changing distance between the floor and her lumbar spine. She adds to the exercise, instructing and demonstrating to gradually press every number on the Sacral Clock onto the floor starting from 12 o'clock, then repeat going in the opposite direction. She lets the students pair up and conduct the Sacral Clock exercise while she makes her way around the room, guiding and supporting her students.

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After the students have familiarized themselves with the Sacral Clock, Danielle introduces the Abdominal Oblique Twist. She returns to the floor, flat on her back, arms out to the sides, palms facing the ceiling. She takes a deep grounding breath to engage and stabilize her core. She lifts her hips and knees to a 90-degree angles, so the lower legs are parallel to the floor, keeping her ankles together. The right side of her sacrum (3 o'clock) presses into the floor, her right hip and right femur follow the descent to the floor while her left hip and femur reach to the ceiling. Her legs begin to lower, cascading to her right side, her spine coming into a spiral to accommodate her legs' reach while her shoulders and upper back remain stable, pressed into the floor beneath her. She maintains the 90-degree angles in her hips and knees, resisting engagement of the psoas which would bring the needs into the chest. She lays there, her torso wrung as if she was a towel holding too much water. With deep focus, she explains and demonstrates to isolate the obliques means to understand how we tend to compensate untwisting motions with our back and psoas muscles, which are commonly solicited to untwist, leaving the obliques under-engaged and the spine more vulnerable. She takes a moment to breathe, to assess her range of motion in her spiral. With a powerful and controlled exhale, she engages her abdominal obliques muscles and pulls her legs back to center, ~~her core knitting itself~~

back together. She explains that engaging the obliques to come back from the spiral to center should feel like the spine behind the heart arrives first, then the middle back, then the sacrum. The engagement of the obliques on the exhale begins with engaging the rectus abdominis superior to soften the sternum down to the ground, and then bring the spine to the ground which will eventually drraaaaag the pelvis and legs back to the original position of 90 degrees over the hips should feel like the sacrum comes back to center first, then the left hip, and lastly the rest of the torso. She emphasizes that upon return to center, the legs should not arrive at the same time as the back, therefore maintaining the 90-degree angle in the hips and knees. Students are invited to pause and reflect on their sensations after each sequence, fostering somatic mindfulness.

- She further emphasizes the importance of dissociation between the pelvis and torso. Through proprioception and experimentation, Danielle explains the isolation and activation of specific abdominal muscles. She continues to explain, by twisting deeply while elongating the body, the spine enters a spiral. The spiral is what allows the oblique and transverse abdominal muscles to guide the body's return to center. This deliberate focus on segmental movement contrasts with our tendency to use the entire body as a singular unit. Danielle highlights and demonstrates the nuanced distinction between superficial, singular unit twisting and a true spiral motion, where the torso leads and the legs follow. Achieving this controlled movement requires coordinated breath, intentional engagement of the transverse abdominis, internal and external oblique muscles, and the pelvic floor. Her goal in class is to cultivate a clear awareness of individual muscle contributions, enabling her students to refine their movement patterns and enhance functional strength during warm up, performances, and cool downs. Danielle's cues are precise, inviting participants to feel the weight of their legs being pulled by their abdominals, creating a moment of effortful realization as they transition from ease to active engagement. The class concludes around 11am.
- As someone who has suffered a debilitating subluxation and simultaneous nutation of her sacrum – both remaining frozen for four years – Danielle underscores the importance of self-care and injury prevention, encouraging students to develop their own warm up and cool down practices to sustain their physical and artistic pursuits. She has been in active regenerative recovery for six years, an ongoing journey. Her approach to movement

practice respects her body as a wise friend, living pain free and experiencing minimum restriction despite her diagnosis of moderate arthritis in L5-S1. This translates into her somatic teaching style, emphasizing adaptability and accessibility with a focus on long-term holistic health and functionality. She acknowledges natural variations in mobility and encourages participants to explore their limits without judgment, providing adjustments and modifications when needed. Her openness is especially important in a mixed cohort of dancers and actors, who may have differing experiences with anatomical comprehension and physicality. Danielle's methodology is deeply rooted in fostering body autonomy, using accessible language and relatable metaphors, such as the Sacral Clock, to demystify complex anatomical concepts. By guiding participants to hone their awareness of individual muscle actions and joint movements, she empowers them to make informed choices about their bodies in both performative and everyday contexts so they may move with intention, strength, and joy.

**Appendix H – Function2Flow transcript tables**

Table S1. Additional *Function* excerpts Niloo Inalouei and Danielle Denichaud

	Niloo Inalouei (Visual Arts)	Danielle Denichaud (Dance)
Anatomical education	<ol style="list-style-type: none"> <li>1. It's hard to capture movement if you don't understand what bone is moving against what bone. Where does movement... originate?</li> </ol>	<ol style="list-style-type: none"> <li>1. The anatomy in class is functional based.</li> <li>2. I focus on postural analysis... to identify which... muscular engagement... may be already dominant... Can you move it as a large chunk or break it into smaller functional components?</li> <li>3. We want their body to be as... strong as possible so they can accomplish the full expression of their character. Same for a dancer, give them as much choice as possible. Are you aware of the different ways that your body can accomplish this movement?</li> </ol>
Demonstration/exercise	<ol style="list-style-type: none"> <li>1. I make a circle with my arm and hand... My fingers in flexion, but inward... Descending circle of motion with the fingers leading... to show the planes and the shapes of the forearm versus the hand and fingers.</li> </ol>	<ol style="list-style-type: none"> <li>1. (Sacral Clock) I lay down on the ground... and I put my hands on my back to indicate the sacrum and show that we're rocking up and down, and... side to side.</li> <li>2. (Oblique shift) on your back with your legs at 90 degrees... feel the femur shifting superiorly towards the ceiling and... rotation in the hips... which is</li> </ol>

		<p>the initiation of a true spiral...  Spiral's gonna involve an  oppositional directionality... I'm  going to go into a  disassociation. I maintain it as  far as I can, and have my  oblique abdominus pull me  back... so I come back torso  first and then I drag my legs,  which is all obliques, and my  legs are doing little</p>
<p>Practical  application</p>	<p>1. Draw from your arm, not your  wrist.</p> <p>If you understand how a joint moves,  you'll know how to draw it in different  positions. It's not just about lines you  draw... it's about capturing the essence  in those lines.</p>	<p>If anyone has ballet training they lose their  disassociation between the torso and their  pelvic girdle... they lose this spiral in their  body. So being able to get a true oblique  without just having... the dorsal muscles  is...important.</p>

Table S2. Additional *Form* excerpts Niloo Inalouei and Danielle Denichaud

	Niloo Inalouei (Visual Arts)	Danielle Denichaud (Dance)
Anatomical education	<ol style="list-style-type: none"> <li>1. There are different planes, see how it goes from round and egg-shaped because of the muscles into more boxy because... the bones are more prominent. We're... constantly looking for change in form. Understand how form changes is a focus in our class.</li> <li>2. And depending on how the light hits it, we simplify it first, then we act on it.</li> </ol>	<ol style="list-style-type: none"> <li>1. Here is near at the top near my iliac crest. OK, now we're going more to the coccyx and then we can go to the lateral sides.</li> <li>2. Feel... my neutral pelvis, where we... still have a little bit of our lumbar curve.</li> </ol>
Demonstration /exercise	<ol style="list-style-type: none"> <li>1. Think about all the angles... at the joints, like round, boxy, one plane, one plane, one plane, one plane, they're all different angles... connecting these planes into shapes.</li> <li>2. This angle (wrist) is almost 90 degrees. And look at the compression that is created (anterior wrist). This is a really odd shape... It's not sharp... kind of round... But the angle is almost 90 degrees.</li> </ol>	<ol style="list-style-type: none"> <li>1. Sacral clock is... Can I map it (sacrum) as if I... give someone details for a 3D printing?</li> <li>2. Are there any bony nodules or is it smooth? What does it feel like to use my abdominals to rock my pelvis?</li> </ol>
Practical application	<ol style="list-style-type: none"> <li>1. If you see it as different angles, then you understand how to draw it, because when</li> </ol>	<ol style="list-style-type: none"> <li>1. Engage your active breath... Can you feel your clavicle and your shoulder blade widen</li> </ol>

<p>ion &amp; guidanc e</p>	<p>the light hits... all planes are affected differently</p> <p>2. It's not about getting it right the first time—it's about training your eye to see what's really happening... I believe that... everything we see... in the human body... we can describe... with geometry... Draw simply, geometry first, then details.</p>	<p>against the floor? Can you root your shoulders down... towards your pelvis?</p> <p>2. (Oblique Shift) I wanna be in disassociation. I'm gonna breathe... and on the exhale, I'm going to bring the spine behind the heart back to the ground. And then I bring my legs back... My legs should not arrive at the same time as my back.</p>
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Table S3. Additional *Feeling* excerpts Niloo Inalouei and Danielle Denichaud

	Niloo Inalouei (Visual Arts)	Danielle Denichaud (Dance)
Anatomical education	<ol style="list-style-type: none"> <li>1. I want my students to feel it... I always want them to touch everything (self) as I'm talking.</li> </ol>	<ol style="list-style-type: none"> <li>1. Notice if you can maintain presence to... the weight in your ischium.</li> <li>2. I feel the dimensionality of my sacrum. I feel its breadth. I feel its attachment within my sacral iliac crest.</li> </ol>
Demonstration/exercise	<ol style="list-style-type: none"> <li>1. In this motion (deep flexion), I feel the pressure on both sides. There is a pressure of the stretch and pressure of compression. The palm feels different than the top of the hand.</li> </ol>	<ol style="list-style-type: none"> <li>1. Sacral Clock is focusing on... Can I get as much sensation as possible of my sacrum?</li> <li>2. Notice if you can actually have a disassociation of the pelvis, or if your torso is wanting to move... with it.</li> </ol>
Practical application	<ol style="list-style-type: none"> <li>1. It's not only about the bones and muscles... it's about the skin too. How does the skin feel? Tight? Loose? This feels compressed. It's going to need thicker lines... you need some shading here in between the skin and tendons.</li> <li>2. This feels more delicate (dorsum of hand). The lines drawn... should show... the skin is delicate.</li> </ol>	<ol style="list-style-type: none"> <li>1. (Oblique Shift) I can feel my front body knitting, knitting, knitting myself back together and it relieves my pelvis... And it will also open up the fascia on the front of the body.</li> <li>2. When I lean into an exercise, I feel that part of my body become enlivened with sensation. There's generally a sense of warmth... and it feels as though my body... is homing in on the area and it becomes much larger.</li> </ol>

	<p>3. Gesture is not about... drawing... to be perfect. I put a lot of focus on... capture the movement... like if you have two seconds and the model is posing, just imagine... what line can you just draw... to basically capture that movement... or feeling of the pose?</p>	
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Table S4. Additional *Flow* excerpts Niloo Inalouei and Danielle Denichaud

	Niloo Inalouei (Visual Arts)	Danielle Denichaud (Dance)
Teaching	<ol style="list-style-type: none"> <li>1. My class is... about the stories... the voice can't say because you're looking at the body (of a model), but you're also very reflective of your own and how you feel on the inside.</li> <li>2. Conversation in class is... creating counter-narratives through the body. How to use the body to create different kinds of stories... alternative histories. Their stories... Basically what... is important to them.</li> </ol>	<ol style="list-style-type: none"> <li>1. What does it mean to be an embodied human... who has a capacity to be creative and intentional and responsive to moving through space, doing an action, be an effective communicator and storyteller?</li> <li>2. I've been doing the same thing over and over again, but this particular course... represents a very special experience for me because I was a dancer and I was injured and sick for so many years. I went through so much suffering. The opportunity to share whatever knowledge, insights, and guidance has helped me recover. It's an absolute gift... This course makes my years of suffering OK... I'm so grateful for... these classes I have.</li> </ol>
Demonstration/exercise	<ol style="list-style-type: none"> <li>1. Do you know Hokusai's painting, The Great Wave? This movement (flexion &amp; inward circle) is like that painting for me. At first, it</li> </ol>	<ol style="list-style-type: none"> <li>1. Sacral Clock is about going as slow as you're aware to stay present with the sensations of your body... it's an invitation to</li> </ol>

	<p>looks quite simple... But if you study the roundness, boxy, plane, plane, plane... there's so much more to study.</p> <p>2. Doing this motion... I feel content. It reminds me of my cat... a happy cat curling in its paws about to knead dough.</p>	<p>go into a body sensorial experience.</p> <p>2. Obliques pulling me into a true twist, then releasing back into center... there's joy in knowing my body is working in harmony.</p> <p>3. I feel wrung... in like a relief way. Like you have too much water that you were holding</p>
Inspiration & story telling	<p>1. The importance of hands in figure drawing and painting are just like facial features. We use them to express things... they tell a story.</p> <p>2. Sometimes they (students) cry because it reminds them of their own story.</p>	<p>1. Joy is like... when you get the harmony, it's like a symphony where all parts tune together.</p> <p>2. Performers... focus on authentic and excellent expression to be effective communicators and storytellers.</p>
Energy & joy in practice	<p>1. There's so much joy in experimenting... and every time... I feel like ohh, I'm learning.</p> <p>2. Drawing brings a lot of joy... anytime I'm drawing, I go into that zone.</p> <p>3. It's a great energy going in the class, especially in those moments because they're all doing the same thing and there's something about</p>	<p>1. I can get swept up in my cycle of breathing, which is very pleasurable.</p> <p>2. I feel joy when I know all these little bits are harmoniously working together in my movement.</p> <p>3. (Oblique Twist) I feel myself... becoming a longer arch... And... I can feel myself making architecture in space and the feeling of the tensegrity, like the connection between the toes</p>

	<p>doing the same thing together.</p>	<p>and the hands is really pleasurable. And feeling like... I can come back... to center... It's fun.</p>
<p>Connection &amp; engagement</p>	<ol style="list-style-type: none"> <li>1. I love how students love to come to watch the demos... they're so enthusiastic seeing how I draw, then they also wanna go start doing their own.</li> <li>2. I'm seeing them learn, and I see myself as part of this group. We're experimenting something together.</li> </ol>	<ol style="list-style-type: none"> <li>1. I encounter an incredible amount of energy. I have a lot of presence and focus for them... I feel very privileged and honored to learn with and from them.</li> </ol>
<p>Beyond the classroom</p>	<ol style="list-style-type: none"> <li>1. We start with very simple shapes, geometry, and then adding the details, values, and shading... Eventually the focus goes from observation to intuition on paper.</li> <li>2. Mistakes are common because we get too close to the sketch... I encourage them to step back and look again... to capture the essence.</li> <li>3. The lines you use for... compression areas need... thicker... stronger lines. Stretching... might not need</li> </ol>	<ol style="list-style-type: none"> <li>1. I really enjoyed the oblique exercise because... it feels joyful for my body.</li> <li>2. I feel strong. Joy. Safety. Freedom. We want to make sure all the joints can maintain their joyful movement for everything and anything else.</li> </ol>

	<p>that. But it's not just thick or thin, it's how much pressure you put on that line. And it also depends on the direction of the light. So... the quality of the lines... is going to change dramatically based on the environment.</p>	
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