INTRODUCTION

Human dissection has been a prominent teaching method in anatomy education for centuries (Ghosh, 2015). While many recognize dissection as a critical method for teaching and learning anatomy in health professions education, the number of hours dedicated to in-person dissection has substantially declined over the years, and in some cases, it has been completely removed from curricula (Sugand et al., 2010; McBride & Drake, 2018). The ongoing discourse on whether human dissection is essential within health professions training continues and it has been accentuated by the Coronavirus disease 2019 (Covid-19) pandemic as several institutions have incorporated or developed effective remote learning opportunities for students (Evans & Pawlina, 2021).

Beyond health professions education, human anatomy is also an important component of non-professional undergraduate programs, such as kinesiology and life sciences as it is a foundational basic science and a common course required for entry into professional programs (Finnerty et al., 2010). Since the onset of the Covid-19 pandemic, the delivery of undergraduate anatomy education has been significantly impacted, including the offering of in-person dissection courses (Evans et al., 2020; Harmon et al., 2021). The pandemic has also altered students’ learning methods, and the degree of student interactivity between both peers and instructors, while also presenting educators with the challenge of creating novel learning experiences through remote instruction and safe in-person learning opportunities (Evans et al., 2020). Despite these challenges, the
The pandemic has also spurred several promising innovations in anatomical teaching that have led to the creation of new online learning opportunities for degree-bound students (Evans & Pawlina, 2021; Harmon et al., 2021). For example, in-person laboratory activities have been subsidized using web-based interactive images, e-modules, scanned three-dimensional (3D) models, and specimen displays on the internet (Cheng et al., 2021; Flynn et al., 2021).

Although many promising and successful adaptations have been made to current pedagogical approaches for remote teaching, in-person teaching methods, such as dissection, continue to be considered the gold standard for teaching and learning anatomy (Böckers et al., 2010; Ross et al., 2021). Thus, as institutions and programs evaluate how best to move forward post-pandemic, the value of dissection for undergraduate learners should be thoroughly considered amongst new pedagogical options. In this commentary, a human dissection course at the University of Toronto is used as an example to highlight the value that dissection offers to undergraduate learners in non-professional programs and how this opportunity can be provided among evolving anatomy curricula.

UNDERGRADUATE DISSECTION OPPORTUNITY DURING COVID-19

Throughout the 2020–2021 academic year, most undergraduate courses in the Faculty of Arts and Science at the University of Toronto were delivered online; however, two laboratory-based undergraduate anatomy courses were permitted to run, with only one course incorporating dissection. This selection of courses was based on the premise that the course learning outcomes could not be achieved through remote delivery and that in-person delivery could follow strict public health guidelines. All other undergraduate anatomy courses at the University of Toronto, excluding professional programs, were delivered online. For additional perspective, Toronto, Ontario also entered a mandated government lockdown starting in late November of 2020 and remained in lockdown until June 2021. Thus, amidst the ongoing pandemic, selected undergraduate students at the University of Toronto had the opportunity to enroll in a full-body dissection course during the Winter semester of 2021. A total of 11 undergraduate and five post-graduate (pathology assistant) learners participated in this course. Four additional undergraduate students were initially enrolled; however, they withdrew before the course began due to the pandemic. Undergraduate learners were selected based on a competitive application process that considered prior experience and academic history, including a minimum 77.0% (B+) average in a full-year systemic anatomy course.

Dissection course set-up and safety protocols

Throughout the dissection course, local public health guidelines along with safety protocols set by the University were followed. This protocol enforced a maximum of 10 learners within a laboratory at a time and maintained physical distancing whenever possible. Anyone entering the University campus was also required to complete a Covid-19 symptom assessment check online prior to accessing the campus each week. Based on the safety protocols in place, two separate laboratories were utilized for dissection. Personal protective equipment was worn in the laboratory spaces, including masks, goggles or face shields, nitrile gloves, laboratory coats, long pants, and closed-toed shoes.

During the 12-week semester, students participated in a weekly two-hour synchronous online seminar via Zoom video conferencing platform (Zoom Video Communication Inc. San Jose, CA) followed by a dissection laboratory later in the week, with the exception of one week, where the laboratory time was used for the midterm bell-ringer examination. Each seminar included reciprocal teaching as student pairs presented an in-depth review of the anatomical region relevant to the upcoming dissection, followed by a journal club, and small group discussions. The journal club covered a variety of topics including, body donation and the Ontario Anatomy Act, ethics of using cadaveric specimens on social media, anatomical variation, and eponyms in anatomy education. The dissection component of the course utilized Grant’s Dissector (Detton, 2020) and was formally two hours in length; however, all students had access to the laboratory for an additional two hours to complete any dissection tasks. Throughout the course, students were evaluated on a variety of assessments, including a peer lecture presentation, participation in weekly seminars, completion, and accuracy of assigned dissection tasks, and midterm and final bell-ringer examinations.

For dissection, the majority of students were assigned into groups of three. All groups had their own designated donor by which all dissections were completed. For the dissections to be completed effectively and efficiently, roles were suggested to the students, including the lead dissector, task director, and station rotator. The lead dissector performed the dissection and was assisted by the task director who was also responsible for reading aloud the dissection steps. The station rotator was incorporated into the laboratory practice to abide by Covid-19 protocols and physical distancing. This student made use of the opportunity to review relevant models and prosections set out in the laboratory. Students switched roles throughout the two hours and, therefore, all students within each group participated in each role. Prior to certain dissections, a technician aided in cadaver preparation to help ensure that the dissections were time efficient. This preparation included completing the sagittal cut of the pelvis, opening the thoracic cage, and incising the calvaria.

DEVELOPMENT OF CONCEPTUAL KNOWLEDGE AND SPATIAL AWARENESS

The value of participating in dissection as an undergraduate learner is supported by the opportunity to gather a deep understanding of the interrelationship of anatomical structures present in the human body (Estai & Bunt, 2016; Bogomolova et al., 2020; Thompson &
Further, through the unveiling process of dissection, learners can retract and remove a variety of structures to examine human anatomy in its constituents and as a complete unit. This exploratory process involves direct observation and manipulation of structures and supports the development of rich conceptual knowledge of human anatomy (Bogomolova et al., 2020). Such conceptual knowledge can be relied upon over time and can positively impact learners’ future anatomy-related academic performance (Thomas et al., 2021).

Dissection is also an experiential learning opportunity that supports critical reflection and an educational context where undergraduate students’ metacognitive skills can be practiced and developed (Finn et al., 2019). As an example, as students uncover structures through dissection they may be challenged to “make sense” of what they see through manipulation, by following pathways and relating unknown anatomical structures to known surrounding structures. This discovery process supports critical reflection and provides learners with the opportunity to integrate new knowledge with their prior knowledge, which can result in restructuring one’s mental model and better conceptual understanding (Davis, 2003). Thus, dissection offers an opportunity to promote learners’ metacognitive awareness, which is recognized as an essential skill needed to succeed at higher levels of science education, such as medicine (Schraw et al., 2006; Paul et al., 2009).

Due to its multidimensional approach, dissection also affords learners an opportunity to improve their visual–spatial awareness (Estai & Bunt, 2016; Bogomolova et al., 2020). In essence, students can improve their ability to mentally depict 3D anatomical structures from all planes and angles of view accurately, which supports deep learning (Chytas et al., 2021). Furthermore, it is suggested that the development of undergraduate learners’ spatial ability can contribute to future achievement and success within science, technology, engineering, and mathematics (STEM) education (Steff & Uttal, 2015). Two and 3D simulations do not provide the same level of complexity as cadavers nor do they incorporate natural stereopsis which is important for understanding the interrelationship of complex structures (Estai & Bunt, 2016; Wainman et al., 2020). For example, Wainman et al. (2020) have shown that when learning bony features of the pelvis, physical models resulted in superior learning in comparison to using 3D virtual technology. Cognitive overload and lack of true stereopsis experienced with the use of 3D virtual technology are factors not encountered when learning from physical models, such as cadavers (Bogomolova et al., 2020; Wainman et al., 2020).

Learners’ visual–spatial awareness can be further enhanced by harvesting the organs from a cadaver to visualize all sides of the viscera and body cavities (Bogomolova et al., 2020). For instance, students in the dissection course were able to manipulate specimens from all angles after extracting a variety of structures from the donor, including the brain, lungs, heart, and abdominal organs. Being able to remove sections of the donor to view underlying layers also allowed students to appreciate the complexity of the human body, size of structures, and anatomical variation encountered in vivo.

NONTRADITIONAL DISCIPLINE-INDEPENDENT SKILL DEVELOPMENT

Participating in an undergraduate cadaveric dissection course also provides an opportunity to broaden students’ situational awareness and to develop professional skills, including communication, collaboration, and problem-solving abilities (Rizzolo & Stewart, 2006; Böckers et al., 2010; Nicolaides et al., 2018; Evans & Pawlina, 2020). These skills are often referred to as nontraditional discipline-independent skills (NTDIS) and they are increasingly recognized as essential skills required for success and growth within changing work environments (Evans et al., 2018).

The implementation of specific “roles” in the undergraduate dissection course granted students ample opportunities to hone and practice several NTDIS. For example, effective communication, time management, and active collaboration were required to ensure that the dissection tasks were distributed and that a clean procedure was completed in the time allotted. Group dissection also fostered an environment where students could develop leadership skills as they were evaluated on the outcome of their team’s dissection and thus required to work collaboratively during each laboratory session.

A dissection laboratory also naturally supports active problem-solving and peer-teaching (Rizzolo & Stewart, 2006; Youdas et al., 2008). As student groups dissect, they are required to continue applying their current knowledge of structural relationships to identify and distinguish structures from one another. Further, as variations and pathologies are encountered, students are presented with an opportunity to innovate and problem-solve as they try to make sense of what is visible and navigate dissection tasks (Rizzolo & Stewart, 2006). This process may also involve seeking help from surrounding peers and making use of available resources, such as atlases and teaching staff.

Cadaver dissection also provides learners with an opportunity to develop practical skills, such as manual dexterity (Older, 2004). Within the dissection course, students learned how to use a variety of small tools, including a scalpel, probe, scissors, and forceps to complete their dissection tasks. To support skill development, students received formative feedback during each laboratory regarding hand and tool placement and they were also formally assessed on the completion and accuracy of each dissection.

PROFESSIONAL IDENTIFY FORMATION

Direct involvement with dissection during undergraduate training provides a unique opportunity for students to observe and practice professional behaviors, such as empathy, respect, compassion,
and self-regulation (Hodges, 2004; Abrams et al., 2021). The dissection laboratory also presents several opportunities for students and faculty to uphold and discuss ethical principles and behaviors (Ghosh, 2020). For example, within the dissection course, the ethics of body donation was discussed and respectful handling and maintenance of the donors was a requirement within each session. These professional behaviors are essential skills required for entry into the caring professions (Koenig et al., 2013), and opportunities to observe and practice such skills are important in fostering students’ professional identity formation (Evans & Pawlina, 2020; Abrams et al., 2021).

The initial student-cadaver relationship also supports the development of students’ professional identity formation and can provide insight into potential career aspirations related to anatomy and the health professions (Coulehan et al., 1995; Abrams et al., 2021). Moreover, dissection encompasses a strong element of socialization, discussion, and self-reflection all of which can influence a student’s professional identity formation (Hafferty, 1988). Within the dissection laboratory, students can also learn to confront and process difficult emotions, including death and grief, which may help to prepare them for emotionally challenging clinical experiences in the future (Böckers et al., 2010; Abrams et al., 2021).

**DISCUSSION**

The value of human dissection for undergraduate learners is multi-fold. Dissection is a practical, hands-on experience that supports learners in developing rich conceptual knowledge of human anatomy (Thompson & Marshall, 2020). Participating in dissection also offers a unique opportunity for undergraduates to develop their metacognitive awareness of their current understanding or misunderstanding of important anatomical relationships (Finn et al., 2019). Thus, a dissection course offers learners an opportunity to develop deep knowledge of human anatomy through self-discovery, critical reflection, and collaboration with peers and teachers. The acquisition of such knowledge is key in supporting the development of adaptive expertise and thereby preparing undergraduate students for future learning and novel problem-solving tasks (Mylopoulos & Woods, 2014). As an example, Thomas et al. (2021) have shown that participation in undergraduate dissection has a positive effect on practical assessments completed during medical training. Based on the framework of adaptive expertise, it is also suggested that a deep understanding of the human body can be applied to future work contexts, such as interpreting radiographic images or formulating clinical diagnoses.

A dissection laboratory is also a unique learning environment that can naturally support the development of professional behaviors (Evans et al., 2018). Purposeful integration and assessment of activities that support the development of NTDIS within undergraduate curricula are recognized as important in preparing well-rounded, career-ready graduates (Idrus, 2014; Hart Research Associates, 2015; Wan Husin et al., 2016). Further, while current and future work environments rely heavily on technology, such as medical imaging, there is an unparalleled value in learning anatomy from the physical body rather than through technology alone (Marom, 2020). For example, within medicine, simply relying on representations of the body (e.g., diagnostic imaging) may shift a clinician’s focus from the physical presentation of their patient to merely their medical image (Marom, 2020).

Participating in an undergraduate dissection course can also play an important role in professional identity formation and career trajectory (Hodges, 2004). Since dissection promotes the development of professional attributes within learners, its inclusion within curricula can also help to address the loss of empathy that is observed during clinical training (Hojat et al., 2020). Furthermore, real-life application of anatomy and involvement in dissection can stimulate undergraduate student’s interest in related future occupations. For instance, several students from the dissection course at the University of Toronto have pursued further studies related to the anatomical sciences.

**Limitations of the study**

While this viewpoint has highlighted the value of dissection for undergraduate learners it is recognized that not all institutions have the physical resources necessary to facilitate dissection and thus undergraduate dissection courses may not be possible. The rising cost associated with obtaining donors and running such laboratories may further limit the offering of dissection to undergraduate learners (Evans & Pawlina, 2021). It is also reported that some institutions, in lieu of the pandemic, now have access to emerging teaching tools and have decreased access to cadavers (Onigbinde et al., 2021). In addition, the ongoing global shortage of qualified anatomy educators may also contribute to limited offerings of human dissection courses for undergraduate students (Wilson et al., 2020).

**CONCLUSIONS**

As anatomical education shifts to incorporate more technological modalities (Marom, 2020), including the many innovations which have been sparked by the onset of the Covid-19 pandemic, it is crucial to acknowledge the unparalleled value of undergraduate dissection in anatomical sciences education. In-person dissection allows for real life anatomical variation while supporting the advancement of students’ conceptual knowledge of the human body and visual–spatial abilities, which cannot be fully achieved through technology (Bogomolova et al., 2020). Human dissection also provides a unique opportunity for students to develop and hone NTDIS, while simultaneously broadening students’ interest in the field (Evans et al., 2018). Therefore, while the Covid-19 pandemic has spurred several innovative pedagogical options for undergraduate anatomy learners, this commentary demonstrates that institutions and educators should continue to consider dissection as a
valuable mode of curricular delivery for undergraduate anatomy learners.

ACKNOWLEDGMENTS

The authors would like to acknowledge the families of the donors who generously donated their bodies to the Division of Anatomy at the University of Toronto.

ORCID

Emily MacPherson https://orcid.org/0000-0002-7933-7540

Kristina Lisk https://orcid.org/0000-0002-7905-3783

REFERENCES

Abrams MP, Eckert T, Topping D, Daly KD. 2021. Reflective writing on the cadaveric dissection experience: An effective tool to assess the impact of dissection on learning of anatomy, humanism, empathy, well-being, and professional identity formation in medical students. Anat Sci Educ 14:658–665.

Böckers A, Jerg-Bretzke L, Lamp C, Brinkmann A, Traue HC, Böckers TM. 2010. The gross anatomy course: An analysis of its importance. Anat Sci Educ 3:3–11.

Bogomolova K, Hierck BP, van der Hage JA, Novius SE. 2020. Anatomy dissection course improves the initially lower levels of visual-spatial abilities of medical undergraduates. Anat Sci Educ 13:333–342.

Cheng H, Esmonde-White C, Kassay AD, Wunder ML, Martin C. 2021. Developing a hybrid four-prong approach to anatomical education during the COVID-19 pandemic. Med Sci Educ 31:1529–1535.

Chytas D, Plagkou M, Salmas M, Johnson EO. 2021. Three-dimensional digital anatomies in anatomy education: Better than traditional methods, but are they better than cadaveric dissection? Clin Anat 34:1122–1123.

Coulehan JL, Williams PC, Landis D, Naser C. 1995. The first patient: Reflections and stories about the anatomy cadaver. Teach Learn Med 7:61–66.

Davis EA. 2003. Prompting middle school science students for productive reflection: Generic and directed prompts. J Learn Sci 12:91–142.

Detton AJ. 2020. Grant’s Dissector. 17th Ed. Philadelphia, PA: Wolters Kluwer. 336 p.

Estai M, Bunt S. 2016. Best teaching practices in anatomy education: A critical review. Ann Anat 208:151–157.

Evans D, Bay BH, Wilson TD, Smith CF, Lachman N, Pawlina W. 2020. Going virtual to support anatomy education: A STOPGAP in the midst of the Covid-19 pandemic. Anat Sci Educ 13:279–283.

Evans D, Pawlina W, Lachman N. 2018. Human skills for human(istic) anatomy: An emphasis on nontraditional discipline-independent skills. Anat Sci Educ 11:221–224.

Evans DJ, Pawlina W. 2020. The role of the anatomist in teaching of nontraditional discipline-independent skills. In: Chan LK, Pawlina W (Editors). Teaching Anatomy: A Practical Guide. 2nd Ed. Cham, Switzerland: Springer Nature Switzerland AG. p 459–471.

Evans DJ, Pawlina W. 2021. Effects of Covid-19: The need to assess the real value of anatomy education. Anat Sci Educ 14:129–131.

Finn K, Benes S, FitzPatrick K, Hardway C. 2019. Metacognition and motivation in anatomy and physiology students. Int J Learn High Educ 31:476–490.

Finnerty EP, Chauvin S, Bonaminio G, Andrews M, Carroll RG, Pangaro LN. 2010. Flexner revisited: The role and value of the basic sciences in medical education. Acad Med 85:349–355.

Flynn W, Kumar N, Donovan R, Jones M, Vickerton P. 2021. Delivering online alternatives to the anatomy laboratory: Early experience during the COVID-19 pandemic. Clin Anat 34:757–765.

Ghosh SK. 2015. Human cadaveric dissection: A historical account from ancient Greece to the modern era. Anat Cell Biol 48:153–169.

Ghosh SK. 2020. The practice of ethics in the context of human dissection: Setting standards for future physicians. Anat Anz 232:151577.

Hafferty FW. 1988. Cadaver stories and the emotional socialization of medical students. J Health Soc Behav 29:344–356.

Harmon DJ, Attardi SM, Barremkala M, Bentley DC, Brown KM, Dennis JF, Goldman HM, Harrell KM, Klein BA, Ramnanan CJ, Richtsmeier JT, Farkas GJ. 2021. An analysis of anatomy education before and during Covid-19: May–August 2020. Anat Sci Educ 14:132–147.

Hart Research Associates. 2015. Failing Short? College Learning and Career Success. 1st Ed. Washington, DC: Association of American Colleges & Universities (AAC&U). 14 p. URL: https://dmg81phhvh63.cloudfront.net/content/user-photos/Research/PDFs/2015employerstudentsurvey.pdf [accessed 27 March 2022].

Hodges B. 2004. Medical student bodies and the pedagogy of self-reflection, self-assessment, and self-regulation. J Curr Theor 20:41–52.

Hojet M, Shannon SC, DeSantis J, Speicher MR, Bragan L, Calabrese LH. 2020. Does empathy decline in the clinical phase of medical education? A nationwide, multi-institutional, cross-sectional study of students at DO-Granting medical schools. Acad Med 95:911–918.

Idrus H. 2014. Developing well-rounded graduates through integration of soft skills in the teaching of engineering courses. In: Proceedings of 2014 IEEE Frontiers in Education Conference (FIE 2014); Madrid, Spain, 22–25 October 2014. p 835–843. Institute of Electrical and Electronics Engineers (IEEE), Piscataway, NJ.

Koenig TW, Parrish SK, Terregino CA, Williams JP, Dunleavy DM, Volsch JM. 2013. Core personal competencies important to entering students’ success in medical school: What are they and how could they be assessed early in the admission process? Acad Med 88:603–613.

Marom A. 2020. The birth, death, and renaissance (?) of dissection: A critique of anatomy teaching with or without the human body. Acad Med 95:999–1005.

McBride JM, Drake RL. 2018. National survey on anatomical sciences in medical education. Anat Sci Educ 11:7–414.

Mylopoulos M, Woods NN. 2014. Preparing medical students for future learning using basic science instruction. Med Educ 48:667–673.

Nicolaides M, Cardillo L, Theodoulou I, Hanrahan J, Tsoufas G, Athanasiou T, Papalois A, Sideris M. 2018. Developing a novel framework for non-technical skills learning strategies for undergraduates: A systematic review. Ann Med Surg 36:29–40.

Older J. 2004. Anatomy: A must for teaching the next generation. Surgeon 2:79–90.

Onigbinde OA, Chiat, Oyeniran AO, Jagabe, AO. 2021. The place of cadaveric dissection in post-COVID-19 anatomy education. Morphologie 105:259–266.

Paul G, Hinman G, Dottl S, Passon J. 2009. Academic development: A survey of academic difficulties experienced by medical students and support services provided. Teach Learn Med 21:254–260.

Rizzolo LJ, Stewart WB. 2006. Should we continue teaching anatomy by dissection when …? Anat Rec 289B:215–218.

Ross CF, Pescitelli MJ, Smith HF, Williams JM. 2021. Teaching anatomy with dissection in the time of COVID-19 is essential and possible. Anatom Rec 292B:151–157.

Schraw G, Crippen KJ, Hartley K. 2006. Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. Res Sci Educ 36:111–139.

Steff M, Uttal D. 2015. How much can spatial training improve STEM achievement? Educ Psychol Rev 27:607–615.

Sugand K, Abrahams P, Khurana A. 2010. The anatomy of anatomy: A review for its modernization. Anat Sci Educ 3:83–93.

Thomas R, Yancey T, Skidmore C, Ferrin N, Zapata I, Williams J, Mason NL. 2021. The effects of pre-medical anatomy and clinical experiences on medical school anatomy-related academic performance. Med Sci Educ 31:1839–1849.
Thompson AR, Marshall AM. 2020. Participation in dissection affects student performance on gross anatomy practical and written examinations: Results of a four-year comparative study. *Anat Sci Educ* 13:30–36.

Wainman B, Pukas G, Wolak L, Mohanraj S, Norman GR. 2020. The critical role of stereopsis in virtual and mixed reality learning environments. *Anat Sci Educ* 13:398–405.

Wan Husin WN, Mohamad Arsad N, Othman O, Halim L, Rasul MS, Osman K, Iksan Z. 2016. Fostering students’ 21st century skills through project oriented problem based learning (POPLB) in integrated STEM education program. *Asia Pac Forum Sci Learn Teach* 17:3.

Wilson AB, Notebaert A, Schaefer AF, Moxham BJ, Stephens S, Mueller C, Lazarus MD, Katrikh AZ, Brooks WS. 2020. A Look at the anatomy educator job market: Anatomists remain in short supply. *Anat Sci Educ* 13:91–101.

Youdas JW, Hoffarth BL, Kohlwey SR, Kramer CM, Petro JL. 2008. Peer teaching among physical therapy students during human gross anatomy: Perceptions of peer teachers and students. *Anat Sci Educ* 1:199–206.

**AUTHOR BIOGRAPHIES**

**Emily MacPherson,** B.Kin., is currently a Master of Science student in anatomical sciences in the Department of Biomedical and Molecular Sciences, Faculty of Health Sciences at Queen's University in Kingston, Ontario, Canada. She is a recent graduate of the Bachelor of Kinesiology at the University of Toronto.

**Kristina Lisk,** B.Sc.H., M.Sc. Ph.D., is an assistant professor in the Division of Anatomy, Temerty Faculty of Medicine at the University of Toronto in Toronto, Ontario, Canada. She also teaches anatomy at Humber College Institute of Technology and Advanced Learning, Toronto, Canada. Her research interests focus on examining strategies to optimize learning of the anatomical sciences and exploring the impact of innovative teaching tools on student learning.