

## University of Groningen

### Anatomy 3.0

de Carvalho Filho, Marco Antonio; Hafferty, Frederic W.; Pawlina, Wojciech

*Published in:*  
Anatomical sciences education

*DOI:*  
[10.1002/ase.2130](https://doi.org/10.1002/ase.2130)

**IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.**

*Document Version*  
Publisher's PDF, also known as Version of record

*Publication date:*  
2021

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

de Carvalho Filho, M. A., Hafferty, F. W., & Pawlina, W. (2021). Anatomy 3.0: Rediscovering Theatrum Anatomicum in the wake of Covid-19. *Anatomical sciences education*, 14(5), 528-535.  
<https://doi.org/10.1002/ase.2130>

#### Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

#### Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

*Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.*

# Anatomy 3.0: Rediscovering Theatrum Anatomicum in the wake of Covid-19

Marco Antonio de Carvalho Filho<sup>1,2</sup>  | Frederic W. Hafferty<sup>3,4</sup>  | Wojciech Pawlina<sup>5</sup>

<sup>1</sup>Life and Health Sciences Research Institute, School of Medicine, University of Minho, Braga, Portugal

<sup>2</sup>Center for Education Development and Research in Health Professions (CEDAR), Lifelong Learning, Education and Assessment Research Network (LEARN), University Medical Centre Groningen, Groningen, The Netherlands

<sup>3</sup>Division of General Internal Medicine, Department of Medicine, Mayo Clinic College of Medicine and Science, Mayo Clinic, Rochester, Minnesota, USA

<sup>4</sup>Program in Professionalism and Values, Mayo Clinic, Rochester, Minnesota, USA

<sup>5</sup>Department of Clinical Anatomy, Mayo Clinic College of Medicine and Science, Mayo Clinic, Rochester, Minnesota, USA

## Correspondence

Dr. Marco Antonio de Carvalho Filho, Life and Health Sciences Research Institute, School of Medicine, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal.  
Email: macarvalho@med.uminho.pt

## Abstract

The Covid-19 pandemic has challenged medical educators internationally to confront the challenges of adapting their present educational activities to a rapidly evolving digital world. In this article, the authors use anatomy education as proxy to reflect on and remap the past, present, and future of medical education in the face of these disruptions. Inspired by the historical Theatrum Anatomicum (Anatomy 1.0), the authors argue replacing current anatomy dissection laboratory (Anatomy 2.0) with a prototype anatomy studio (Anatomy 3.0). In this studio, anatomists are web-performers who not only collaborate with other foundational science educators to devise meaningful and interactive content but who also partner with actors, directors, web-designers, computer engineers, information technologists, and visual artists to master online interactions and processes in order to optimize students' engagement and learning. This anatomy studio also offers students opportunities to create their own online content and thus reposition themselves digitally, a step into developing a new competency of stage presence within medical education. So restructured, Anatomy 3.0 will prepare students with the skills to navigate an emergent era of tele and digital medicine as well as help to foreshadow forthcoming changes in medical education.

## KEYWORDS

anatomy laboratory, anatomy studio, Covid-19, gross anatomy education, medical education

## INTRODUCTION

The recent Covid-19 pandemic has been widely characterized as having a “forever altering” impact on health care (Fontanarosa and Bauchner, 2020; Mehrotra et al., 2020; Zhang et al., 2020), medical education (Kim et al., 2020; Rose, 2020; Thakur et al., 2021), and sociopolitical life in general (Papakyriakopoulos et al., 2020; Wagerman et al., 2021). One key element in this ongoing turbulence has been the shift in the language of interactions from face-to-face and “real” to one alternatively characterized as “virtual” and “distanced.” In an equally epistemic shift, early and more optimistic “back-to-normal” incantations have been replaced by an unsettlingly undefined “new-normal” (d’Orville, 2020; Sá and Serpa, 2020).

In this article, the gaze is narrowed to the world of medical education and a signature footprint within that disrupted landscape, anatomy

education, and cadaver dissection. The focus of this perspective article is more on the fate of the traditional laboratory experience rather than the particulars of emerging new pedagogical strategies. The authors argue that the “new anatomy” being reformulated in the wake of Covid-19 requires faculty and students alike to become more “media savvy” and that this digital/technical sophistication will require new ways of thinking about the production, delivery, consumption, and purposes of both anatomy and, in turn, medical education writ large. In exploring these emergent reimagination, arguments were structured across three portals: (1) How anatomy teaching and assessment already has been impacted by the pandemic's arrival (Present); (2) how this reshaping returns us to an important epoch in anatomy's pedagogical past—the anatomy theater (Past); and (3) what pedagogical steps should be considered going forward as anatomy seeks to move into a yet-to-be fully charted studio-esque future (Future).

## THE PRESENT: ANATOMY 2.0

The arrival of the Covid-19 pandemic has fueled a flood of articles, commentaries, and even a few empirical studies detailing changes across the full scope and trajectory of health sciences education (Jiménez-Rodríguez et al., 2020; Srivastava et al., 2020; Camargo et al., 2020; Frankl et al., 2021). Anatomy is no exception (Pather et al., 2020; Harmon et al., 2021; Nguyen et al., 2021; Owolabi and Bekele, 2021). One of the most dramatic identity-shifts for anatomy during this time was the large-scale suspension of body donation program (Ravi, 2020; Manzaneres-Céspedes et al., 2021) and anatomy laboratory activities including cadaver dissection (Lim, 2020; Longhurst et al., 2020; Smith and Pawlina, 2021). Traditional anatomical materials and practices were strategically reimaged and reinvented in real time as they joined a plethora of technologies ranging from not-so-new imaging tools [e.g., digitized sections of cadavers (Van Dijck, 2000; Tang et al., 2010; Ackerman, 2016), three-dimensional (3D) printing (McMenamin et al., 2014; Li et al., 2017; Smith et al., 2018)] to more avant-garde examples of technologized pedagogies [e.g., virtual, augmented, mixed reality and stereoscopic immersive 3D systems (Bork et al., 2019; Erolin et al., 2019; Kurul et al., 2020; Duncan-Vaidya and Stevenson, 2021; Moro et al., 2021)]. Less visible within this adaptive flurry was the fate of nontechnical skills—also known within anatomy circles as NTDIS or nontraditional discipline-independent skills (Evans et al., 2018; Evans and Pawlina, 2020). These skills, including elements of humanism, professionalism, teamwork, ethics, and leadership, had helped to redefine contemporary (Anatomy 2.0) anatomy training in the opening decades of the 21st century (Escobar-Poni and Poni, 2006; Gregory et al., 2009; Johnson et al., 2012; Hildebrandt, 2016; Goss et al., 2019; Chan and Pawlina, 2020). However, discussions of how anatomy might move forward in the wake of Covid-19 have been relatively silent (with few exceptions; see Jones, 2021) on how to preserve, or even grow, these seemingly “core” curricular elements.

Within this highly fluid and sometimes phrenetic interplay of disruptions and redeployments, three rather formative tensions began to emerge. The first centers on student performance and outcomes, but at an organizational level. Whatever else the anatomists may have seen as core to their assessment responsibilities, administration wanted to know how their Covid-disrupted learners were performing compared with previous years (Tucker and Anderson, 2021). The bellwether here was standardized test scores with a primary—sometimes singular—gauge being the National Board of Medical Examiners® (NBME®) subject examinations. “Trivial” slippages, no change, or the ecstatically received increase in test performance spelled “!!SUCCESS!!” Anything else invited scrutinous eyebrows. Nonetheless, and whatever the actual outcome, a potential trap was taking shape—just off-stage. Formed by the interlocking jaws of academic performance versus cost, and driven by longstanding concerns about the relatively high budgets of anatomy instruction, lurked the administratively attractive siren-call that a shortened, online, dissection-free, and less-expensive anatomy course might indeed be impervious to academic “downsides”

(Evans and Pawlina, 2021; Jones, 2021; Maloney et al., 2021). This possibility, in turn, raised for anatomists a disquieting uneasiness that test scores would show little to no impact via board performance metrics and thus little to no threat to a school's academic reputation—or ranking (Hafferty et al., 2020) all of which would give administration the ammunition it needed to preemptively cut anatomy instructional budgets.

The second tension was more enigmatic. The abrupt (in some cases) shift to online-virtual instruction brought a shocked awareness to some in medical academia that the uploading of talking-head videos via outdated curriculum management platforms in an age of Facebook, Twitter, Instagram, YouTube, WhatsApp, or TikTok was stop-gap at best and an embarrassment of digital unsophistication at worse. If anatomy education was to have a cutting-edge digital presence within this ever-evolving era of media sophistication, than something other than traditional knowledge/skills-mastery and related assessment practices would need to occupy center stage.

The third tension was related to technology, but more about culture than content. Other educational arenas have long courted both the parlance and practices of teaching as a “performance art” (Rives, 1979; Redington, 1983; Dawe, 1984; Pineau, 1994; Whatman, 1997; Brent, 2005; Hart, 2007; Schmenner, 2013), and with education as functioning within a “performance culture” (Gleeson and Husbands, 2004). Elsewhere, classrooms have been reimaged as “theaters” with teachers encouraged to develop new “acting skills” in service to their learners (Griggs, 2001; Tauber and Sargent Mester, 2007). Meanwhile, medicine, long ensconced within a cultural identity of science, fact, and objectivity, (Taylor, 2003) seemed relatively sympathetic to viewing content as king and context experts as the chief drivers of any educational engine. Although there is a nascent literature on the intersections of medicine/medical education and the performing arts (Hobson et al., 2019), most target-specific topics such as empathy (Dow et al., 2007; Eisenberg et al., 2015; Gao et al., 2019), conflict resolution (Wolfe et al., 2018), racism (Manzi et al., 2020), or more general curricular competencies such as humanism, ethics, or communication skills (e.g., Shapiro and Hunt, 2003; Coleman and Dick, 2016; Hoffmann-Longtin et al., 2018) and with particular theateresque vehicles such as improvisation and readers theater (Savitt, 2010; Watson, 2011) commanding a starring role. Alternatively, broader framings depicting clinical medicine as theater, (Gormley and Murphy, 2018) or physicians as actors, (Larson and Yao, 2005) are rare. Nonetheless, within this overall thematic space, and with a certain degree of historical irony, anatomy stands as a significant historical touchpoint given its cultural roots within the *Theatrum Anatomicum*.

## THE PAST: ANATOMY 1.0

If nothing else (but it was indeed so much more), early anatomical teaching was a highly scripted interplay of performance as pedagogy (Davison, 1969; Winkler, 1993; Beecher, 2006; Klestinec,

2011). The first documented public dissection was performed in Bologna in 1315 by Mondino de' Liuzzi, a University of Bologna professor in which de' Liuzzi, perched on a large, elevated chair above the dissection table, provided instructions to a demonstrator who performed the actual dissection, (Papa et al., 2019) while an ostensor (an exhibitor) pointed out the specific organs being examined for the attendees (Di Matteo et al., 2017). The earliest temporary anatomical theatres originated from Italy in the 16th century, where the term "Theatrum Anatomicum" was coined (Schumacher, 2007). In 1594, the first permanent anatomical theatre was opened in Padua (Macchi et al., 2014; Papa et al., 2019), and it quickly became the architectural blueprint for many anatomical buildings, some of which are still in existence today. As a social practice, dissections often were sanctioned by the crown, open to the public, dramatic in dialogue (lectures in Latin), dramatically role specific (dissection by a barber/surgeon under the direction of the professor/speaker), and sometimes accompanied by food, music, and related "distractions" to mask the odor of the decomposing body. Outside, street vendors competed with jugglers, minstrels, and dancing bears for the attention and patronage of those additionally gathered (Brockbank, 1968; Davison, 1969; Schwarte, 2005; Schumacher, 2007; Bleeker, 2008). Over time, these theaters also took their architectural form and performance cues from the emerging popularity of more "lay" theatrics (e.g., drama, comedy, music) with the rise of the Elizabethan era's London's Rose theater (1587) and the Globe (1599); along with Renaissance Europe's Teatro Olimpico in Vicenza (1580) and the Teatro all'Antica in Sabbioneta (1590). Also contextually important was the emergence of poet/playwrights (e.g., Shakespeare 1564–1616) as public figures. In short, anatomical dissection-as-theater, its sensationalistic and taboo elements notwithstanding, was less a back-street oddity than a socially sanctioned staple of 16th- and 17th-century European urban life (Sawday, 1995; Schumacher, 2007). By the 18th century, with advances of medical sciences in France (with its nucleus in Paris), the "Parisian manner" of student participation with hands-on dissection of human bodies had begun to revolutionize the way dissection was performed in medical teaching institutions worldwide (Gelfand, 1972). By the 19th century, anatomy began to disappear behind closed doors with access restricted to a privileged few, with instruction "reduced" to targeting anatomical form and body morphology (Anatomy 1.0), and with the anatomy laboratory itself becoming a more sanctified rite of medical school passage (Hafferty, 1991; Bender, 2002).

## THE FUTURE: ANATOMY 3.0

Although anatomy educators have long faced both external and internal pressures to reconceptualize the role of anatomy within the medical curriculum (Pawlina, 2009; Smith et al., 2016; Klement et al., 2017), Covid-19 did trigger more of a survivor mode for both faculty and students. Faced with the prospect of limited to

no dissection, along with the deployment of "distanced" learning and balky technologies, students felt both socially isolated and pedagogically abandoned (Sokolovskaya, 2020; Hamza et al., 2021). Meanwhile, faculty, with little time for strategic planning or even considered decision-making, felt equally overwhelmed and estranged (Evans et al., 2020).

Although the particulars moving forward remain understandably opaque, over the past year, anatomy educators worldwide have begun to anticipate calls both to reduce anatomy's curricula footprint and to transfer content to more specialized training venues (e.g., surgery) (Moxham, 2021). Within this space, they imagine a more digital-based anatomy laboratory grounded in a high-quality, real-time, live-feed learning and with digital technologies extending far beyond videotaping lectures or providing 3D anatomical schemas. These live-feed sessions will mimic the experience students might have of being present in the anatomy laboratory to participate in a dissection and communicate in real time with the anatomist (Bailey and Dean, 2020; Bhute et al., 2021). They also foresee students as more engaged partners, and curricula co-creators as educators push previously deployed team-based learning, blended learning, and flipped classroom strategies into these reimaged studio-based learning encounters.

These shifts in anatomy teaching will demand structural and cultural reconfigurations of the anatomy laboratory as we know it. In its most general form, the anatomy laboratory will need to be re-born as the "anatomy studio," ready to welcome the anatomist and student as co-performers capable of both receiving and delivering live content. This anatomy studio must be well equipped with audiovisual equipment, flexible in connectivity to records from multiple specialized sources (i.e., operating room laparoscopic cameras, radiological and microscopic images, etc.), and prepared to accommodate onsite and synchronous or asynchronous online learning activities (Stewart, 2017). In comparison with the traditional anatomy laboratory, the anatomy studio will offer medical students their first opportunity to investigate the human body from vantage points (multiple cameras capturing different angles, magnifications, hard to see locations) not available in traditional dissection-focused settings. Meanwhile, virtual reality technologies will allow anatomists to supplement students "dissection activities" while integrating in a ludic way the subjects of anatomy, radiology, embryology, histology, and physiology (Zorzal et al., 2019; Uhl et al., 2021). In a not-to-distant future, 3D printers will enable medical students not only to emulate their supervisors in performing home-based dissections of "plastic" specimens but also with "tissue" mimicking the tactility of human tissue (Bezek et al., 2020; Miramini et al., 2020).

This modern anatomy studio will be more than just a technologized hive of exotic mechanizations. It will demand the collaboration among an expanded range of experts. Designers, mathematicians, computer engineers, information technologists, visual artists, directors, basic scientists, and health professionals will co-create this new learning studio. Faculty will need to reach out to web-designers and editors to better understand what has been learned about internet users over the last 30 years (Amaral

and Brites, 2019). Knowing how internet users from different generations engage with online content will inform the development of interactive, synchronous, and asynchronous learning activities. Meanwhile, artificial intelligence and machine learning experts will help to generate algorithms to scaffold and evaluate students' performance in real time, which can be used to create individual learning trajectories and to provide help in assessment of students' performance to optimize students' and teachers' time (Roll and Wylie, 2016; Zawacki-Richter et al., 2019). Such collaborations will demand open minds and active imaginations to create and innovate in designing this studio of the future. The educational "team" will be reimagined. The modern anatomists, who must be knowledge experts, will need to reinvent themselves as cool, web-based masters-of-communication who wield magic wands of virtual engagement. Similar to its conceptual cousin, the architectural design studio (Dutton, 1991; Koch et al., 2002), Anatomy's 3.0 must undergo a similar reimagination of learning in an age of social media (Wang, 2010; Vyas et al., 2013; Güler, 2015).

One important step in this direction will be to imagine an expanded partnership between anatomy and theater. Although successful anatomy teachers already know how to "read" the body language and gaze of their trainees, and thus consequentially modulate and improve their performance in real time (Chan and Pawlina, 2020), teaching online is different. There is a delay in facial expressions. Eye contact with "the audience" is problematic. Students turn off their cameras. Following chat dialogues is an extra burden. Most importantly, both faculty and students face the challenge of reconciling verbal and nonverbal communication, the latter accounting for 70% of all messaging (de Carvalho Filho et al., 2020).

In the face of these challenges, anatomists can greatly benefit from interacting with and learning from actors who are used to perform in front of the cameras as well as with audiences at-a-distance. Actors can teach them how to read (and adapt to) ever more indirect and distant audience cues—something the theater world calls "scenic intelligence" (de Carvalho Filho et al., 2020). Directors, in turn, can help teachers to find other forms of gathering feedback and regulating their performance (Grotowski, 2010) nurturing their reflection-in-action skills (Schön, 1984, 1987). However, the most important lesson to take from the scenic arts is its culture of creativity, imagination, collaboration, and flexibility. A "theater world" nurtures a mindset that is capable of improvising and adapting "scripts" that are being modified in real time in response to changing environmental inputs including "audience" receptivity (Spolin, 1999; Boal, 2002). Going online to lead this transformation will be easier if anatomists learn how to grow this mindset. Actors and related expertise from the theater arts can help. Faculty development activities based on arts, especially theater, while not a novelty in medical education, can be adapted to target the development of these qualities and mindsets.

This new anatomy studio also will generate new anatomy students. In addition to the challenges of co-creating learning, students also will need to master novel presentation-of-self. Regardless of the telemedicine realities that await them as practitioners (Frankl

et al., 2021; Muntz et al., 2021), today's anatomy students may (and perhaps should) be called upon to demonstrate competencies and deliver performance metrics virtually. In doing so, memorization will give place to creation and application of knowledge. In these respects, the online environment not only will challenge teachers to create various "scripts," with different levels of engagement and with different opportunities to develop students' decision-making skills but also will challenge learners to design their own "proofs" of mastery.

The new anatomy student also will join the effort to create new online materials to nurture their own learning. This atmosphere of online collaboration will prepare students to strive as team players (Huitt et al., 2015). Moreover, the creation of online learning communities based on trust and solidarity feeds the students' identities with values that are important for becoming good doctors.

Students will also have the opportunity to reflect on their present and future digital identities and the nuances of online interactions that must be considered when dealing with peers, superiors, and patients. Learning how to be respectful and trustworthy online is one of a range of new professional competencies that needs to be mastered (Reinhart et al., 2021). Understanding how to protect patients' and body-donor privacy and interests within the cacophony of digitized exchanges that will dominate both classroom and clinic is critical. Online interactions, like online learning, while functionally necessary, are still only proxies for the intensely interpersonal and literally face-to-face engagements that have-long dominated medicine's learning environments. As but one example, digitized role models can be both literally present and easily distanced with the click of a keystroke. In addition, anatomy, with its oft-cited identity entrée into the world of medical education, will need to both address and newly identify many of these challenges.

So reimagined, the new anatomy studio can help not only to reformulate anatomy's long cherished identity as a rite-of-passage into the larger educational enterprise but also to serve as a harbinger for how that broader educational milieu may reimagine its own digitized, distanced, and virtual future. In doing so, the anatomy studio will continue to mark students' trajectories of identity and expertise within an educational milieu where imagination and reality are interdependent and emergent, and where learning is at one challenging, meaningful, and fun.

## CONCLUSIONS

Covid-19 has triggered cataclysmic change across society, health care, and medical education. The fact that medicine faces a sharply divided political landscape, as well as a deeply distrustful public (Young, 2021), means that the future training of physicians must reimagine itself both to the task of professional preparation and to its social contract with society. One piece of this new pedagogical order will consist of converting the old (*Theatrum Anatomicum*) into the new Anatomy 3.0 as the anatomical science seeks to move

beyond “the laboratory” and into “the studio.” Within this emergent future, anatomy faculty, students, and administrators must imagine new technologies and partnerships, including that we envision, the theater and theater arts to help bring both anatomy and medical education into the ellipsoidal (a.k.a. “Leko”) spotlight of center stage (Kennedy Center, 2021). In rising to this challenge, Anatomy 3.0 will launch students into the new era of tele and digital medicine as it also helps to usher in a new era of medical education.

## ORCID

Marco Antonio de Carvalho Filho <https://orcid.org/0000-0001-7008-4092>

[org/0000-0001-7008-4092](https://orcid.org/0000-0001-7008-4092)

Frederic W. Hafferty <https://orcid.org/0000-0002-5604-7268>

## REFERENCES

- Ackerman MJ. 2016. The Visible Human Project<sup>®</sup>: From body to bits. In: *Proceedings of the 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC 2016)*; Orlando, FL, 2016 August 16–20. Paper 3338. Institute of Electrical and Electronics Engineers, Piscataway, NJ.
- Amaral I, Brites MJ. 2019. Trends on the digital uses and generations. In: *Proceedings of the 13<sup>th</sup> International Technology, Education and Development Conference (INTED 2019)*; Valencia, Spain, 2019 March 11–13. p 5109–5115. International Academy of Technology, Education and Development (IATED), Valencia, Spain.
- Bailey SK, Dean M. 2020. Remote solution for immersive surgical mentoring. *Med Educ* 54:485–486.
- Beecher D. 2006. Mind, theaters, and the anatomy of consciousness. *Philos Lit* 30:1–16.
- Bender J. 2002. From theater to laboratory. *JAMA* 287:1179.
- Bezek LB, Cauchi MP, De Vita R, Foerst JR, Williams CB. 2020. 3D printing tissue-mimicking materials for realistic transeptal puncture models. *J Mech Behav Biomed Mater* 110:103971.
- Bhute VJ, Inguva P, Shah U, Brechtelsbauer C. 2021. Transforming traditional teaching laboratories for effective remote delivery—A review. *Educ Chem Eng* 35:96–104.
- Bleeker M (Editor). 2008. *Anatomy Live: Performance and the Operating Theatre*. 1st Ed. Amsterdam, The Netherlands: Amsterdam University Press. 272 p.
- Boal A. 2002. *Games for Actors and Non-Actors*. 2nd Ed. Abingdon, Oxon, UK: Routledge. 301 p.
- Bork F, Stratmann L, Enssle S, Eck U, Navab N, Waschke J, Kugelmann D. 2019. The benefits of an augmented reality magic mirror system for integrated radiology teaching in gross anatomy. *Anat Sci Educ* 12:585–598.
- Brent D. 2005. Teaching as performance in the electronic classroom. *First Monday* 10:4. URL: <https://firstmonday.org/ojs/index.php/fm/article/view/1221/1141> [accessed 26 July 2021].
- Brockbank W. 1968. Old anatomical theatres and what took place therein. *Med Hist* 12:371–384.
- Camargo CP, Tempski PZ, Busnardo FF, Martins MA, Gemperli R. 2020. Online learning and Covid-19: A meta-synthesis analysis. *Clinics (Sao Paulo)* 75:e2286.
- Chan LK, Pawlina W (Editors). 2020. *Teaching Anatomy: A Practical Guide*. 2nd Ed. Cham, Switzerland: Springer Nature Switzerland AG. 558 p.
- Coleman JJ, Dick TK. 2016. Nursing and theater: Teaching ethics through the arts. *Nurse Educ* 41:262–265.
- d’Orville H. 2020. COVID-19 causes unprecedented educational disruption: Is there a road towards a new normal? *Prospects* 49:11–15.
- Davison D. 1969. The oldest anatomical theatre. *Med Biol Illus* 19:72–76.
- Dawe HA. 1984. Teaching: A performing art. *Phi Delta Kappan* 65:548–552.
- de Carvalho Filho MA, Ledubino A, Frutuoso L, da Silva Wanderlei J, Jaarsma D, Helmich E, Marcia Strazzacappa M. 2020. Medical education empowered by theater (MEET). *Acad Med* 95:1191–1200.
- Di Matteo B, Tarabella V, Filardo G, Mosca M, Lo Presti M, Viganò A, Tomba P, Marcacci M. 2017. Art in science: Mondino de’ Liuzzi: The restorer of anatomy. *Clin Orthop Relat Res* 475:1791–1795.
- Dow AW, Leong D, Anderson A, Wenzel RP, and Theater-Medicine Team VCU. 2007. Using theater to teach clinical empathy: A pilot study. *J Gen Intern Med* 22:1114–1118.
- Duncan-Vaidya EA, Stevenson EL. 2021. The effectiveness of an augmented reality head-mounted display in learning skull anatomy at a community college. *Anat Sci Educ* 14:221–231.
- Dutton TA. 1991. The hidden curriculum and the design studio: Toward a critical studio pedagogy. In: Dutton TA (Editor). *Voices in Architectural Education: Cultural Politics and Pedagogy*. 1st Ed. New York, NY: Bergin & Garvey. p 165–194.
- Eisenberg A, Rosenthal S, Schluskel YR. 2015. Medicine as a performing art: What we can learn about empathic communication from theater arts. *Acad Med* 90:272–276.
- Erolin C, Reid L, McDougall S. 2019. Using virtual reality to complement and enhance anatomy education. *J Vis Commun Med* 42:93–101.
- Escobar-Poni B, Poni ES. 2006. The role of gross anatomy in promoting professionalism: A neglected opportunity! *Clin Anat* 7:461–467.
- Evans DJ, 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 DJ, Pawlina W. 2021. Effects of Covid-19: The need to assess the real value of anatomy education. *Anat Sci Educ* 14:129–131.
- 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 459–472.
- Evans DJ, Pawlina W, Lachman N. 2018. Human skills for human[istic] anatomy: An emphasis on nontraditional discipline-independent skills. *Anat Sci Educ* 11:221–224.
- Fontanarosa PB, Bauchner H. 2020. COVID-19—Looking beyond tomorrow for health care and society. *JAMA* 323:1907–1908.
- Frankl SE, Joshi A, Onorato S, Jawahir GL, Pelletier SR, Dalrymple JL, Schwartz AW. 2021. Preparing future doctors for telemedicine: An asynchronous curriculum for medical students implemented during the COVID-19 pandemic. *Acad Med* (in press; doi: <https://doi.org/10.1097/ACM.0000000000004260>).
- Gao L, Peranson J, Nyhof-Young J, Kapoor E, Rezmovitz J. 2019. The role of “improv” in health professional learning: A scoping review. *Med Teach* 41:561–568.
- Gelfand T. 1972. The “Paris manner” of dissection: Student anatomical dissection in early eighteenth-century Paris. *Bull Hist Med* 46:99–130.
- Gleeson D, Husbands C. 2004. *The Performing School: Managing Teaching and Learning in a Performance Culture*. 1st Ed. London, UK: RoutledgeFalmer. 256 p.
- Gormley GJ, Murphy P. 2018. Teaching clinical skills in the theatre of medicine. *Perspect Med Educ* 7:226–227.
- Goss AL, Viswanathan VB, DeLisser HM. 2019. Not just a specimen: A qualitative study of emotion, morality, and professionalism in one medical school gross anatomy laboratory. *Anat Sci Educ* 12:349–359.
- Gregory JK, Lachman N, Camp CL, Chen LP, Pawlina W. 2009. Restructuring a basic science course for core competencies: An example from anatomy teaching. *Med Teach* 31:855–861.
- Griggs T. 2001. Teaching as acting: Considering acting as epistemology and its use in teaching and teacher preparation. *Teach Educ Q* 28:23–37.
- Grotowski J. 2010. O diretor como espectador de profissão. In: Flaszen L, Pollastrelli C (Editors). *O Teatro Laboratório de Jerzy Grotowski*.

- 1959-1969. 1st Ed. São Paulo, Brazil: Editora Perspectiva/SESC. p 212-225.
- Güler K. 2015. Social media-based learning in the design studio: A comparative study. *Comput Educ* 87:192-203.
- Hafferty FW. 1991. *Into the Valley: Death and the Socialization of Medical Students*. 1st Ed. Haven, CT: Yale University Press. 234 p.
- Hafferty FW, O'Brien BC, Tilburt JC. 2020. Beyond high stakes testing: Learner trust, educational commodification, and the loss of medical school professionalism. *Acad Med* 95:833-837.
- Hamza CA, Ewing L, Heath NL, Goldstein AL. 2021. When social isolation is nothing new: A longitudinal study psychological distress during COVID-19 among university students with and without pre-existing mental health concerns. *Can Psychol* 62:20-30.
- 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 R. 2007. *Act like a teacher: Teaching as a performing art*. University of Massachusetts Amherst: Amherst, MA. Doctorate of Philosophy Dissertation. 328 p.
- Hildebrandt S. 2016. Thoughts on practical core elements of an ethical anatomical education. *Clin Anat* 29:37-45.
- Hobson WL, Hoffmann-Longtin K, Loue S, Love LM, Liu HY, Power CM, Pollart SM. 2019. Active learning on center stage: Theater as a tool for medical education. *MedEdPORTAL* 15:10801.
- Hoffmann-Longtin K, Organ JM, Helphinstine JV, Reinoso DR, Morgan ZS, Weinstein E. 2018. Teaching advocacy communication to pediatric residents: The efficacy of applied improvisational theater (AIT) as an instructional tool. *Comm Educ* 67:438-459.
- Huitt TW, Killins A, Brooks WS. 2015. Team-based learning in the gross anatomy laboratory improves academic performance and students' attitudes toward teamwork. *Anat Sci Educ* 8:95-103.
- Jiménez-Rodríguez D, Torres Navarro MD, Plaza Del Pino FJ, Arrogante O. 2020. Simulated nursing video consultations: An innovative proposal during Covid-19 confinement. *Clin Simul Nurs* 48:29-37.
- Johnson EO, Charchanti AV, Troupis TG. 2012. Modernization of an anatomy class: From conceptualization to implementation. A case for integrated multimodal-multidisciplinary teaching. *Anat Sci Educ* 5:354-366.
- Jones DG. 2021. Anatomy in a post-Covid-19 world: Tracing a new trajectory. *Anat Sci Educ* 14:148-153.
- Kennedy Center. 2021. Ellipsoidal reflector spotlights: Lighting up the stage. The Kennedy Center, Washington, DC. URL: <https://www.kennedy-center.org/education/resources-for-educators/classroom-resources/media-and-interactives/media/theater/ellipsoidal-reflector-spotlights/> [accessed 26 July 2021].
- Kim JW, Myung SJ, Yoon HB, Moon SH, Ryu H, Yim JJ. 2020. How medical education survives and evolves during COVID-19: Our experience and future direction. *PLoS One* 15:e0243958.
- Klement BJ, Paulsen DF, Wineski LE. 2017. Implementation and modification of an anatomy-based integrated curriculum. *Anat Sci Educ* 10:262-275.
- Klestinec C. 2011. *Theaters of Anatomy: Students, Teachers, and Traditions of Dissection in Renaissance Venice*. 1st Ed. Baltimore, MD: Johns Hopkins University Press. 257 p.
- Koch A, Schwensen K, Dutton TA, Smith D. 2002. *The Redesign of Studio Culture: A Report of the AIAS Studio Culture Task Force*. 1st Ed. Washington, DC: The American Institute of Architecture Students. 31 p. URL: [https://www.aias.org/wp-content/uploads/2016/09/The\\_Redesign\\_of\\_Studio\\_Culture\\_2002.pdf](https://www.aias.org/wp-content/uploads/2016/09/The_Redesign_of_Studio_Culture_2002.pdf) [accessed 21 July 2021].
- Kurul R, Ögün MN, Neriman Narin A, Avci Ş, Yazgan B. 2020. An alternative method for anatomy training: Immersive virtual reality. *Anat Sci Educ* 13:64-56.
- Larson EB, Yao X. 2005. Clinical empathy as emotional labor in the patient-physician relationship. *JAMA* 293:1100-1106.
- Li KH, Kui C, Lee EK, Ho CS, Wong SH, Wu W, Wong WT, Voll J, Li G, Liu T, Yan B, Chan J, Tse G, Keenan ID. 2017. The role of 3D printing in anatomy education and surgical training: A narrative review. *MedEdPublish* 6:31.
- Lim M. 2020. Educating despite the Covid-19 outbreak: Lessons from Singapore. Times Higher Education. 20 March 2020. THE World Universities Insights Limited, London, UK. URL: <https://www.timeshighereducation.com/blog/educating-despite-covid-19-outbreak-lessons-singapore> [accessed 26 July 2021].
- Longhurst GJ, Stone DM, Dulohery K, Scully D, Campbell T, Smith CF. 2020. Strength, weakness, opportunity, threat (SWOT) analysis of the adaptations to anatomical education in the United Kingdom and Republic of Ireland in response to the Covid-19 pandemic. *Anat Sci Educ* 13:301-311.
- Macchi V, Porzionato A, Stecco C, De Caro R. 2014. Evolution of the anatomical theatre in Padova. *Anat Sci Educ* 7:487-493.
- Maloney S, Pather N, Foo J, Lazarus MD. 2021. Spending wisely: The role of cost and value research in the pursuit of advancing anatomical sciences education. *Anat Sci Educ* 14:263-269.
- Manzanares-Céspedes MC, Dalmau-Pastor M, Simon de Blas C, Vázquez-Osorio MT. 2021. Body donation, teaching and research in dissection rooms in Spain in times of Covid-19. *Anat Sci Educ* 14:562-571.
- Manzi J, Casapulla S, Kropf K, Baker B, Biechler M, Finch T, Gerth A, Randolph C. 2020. Responding to racism in the clinical setting: A novel use of forum theatre in social medicine education. *J Med Humanit* 41:489-500.
- McMenamin PG, Quayle MR, McHenry CR, Adams JW. 2014. The production of anatomical teaching resources using three-dimensional (3D) printing technology. *Anat Sci Educ* 7:479-486.
- Mehrotra A, Chernew M, Linetsky D, Hatch H, Cutler D. 2020. The impact of the COVID-19 pandemic on outpatient visits: Practices are adapting to the new normal. The Commonwealth Fund, 25 June 2020. The Commonwealth Fund, New York, NY. URL: <https://www.commonwealthfund.org/publications/2020/jun/impact-covid-19-pandemic-outpatient-visits-practices-adapting-new-normal> [accessed 26 July 2021].
- Miramini S, Fegan KL, Green NC, Espino DM, Zhang L, Thomas-Seale LE. 2020. The status and challenges of replicating the mechanical properties of connective tissues using additive manufacturing. *J Mech Behav Biomed Mater* 103:103544.
- Moro C, Birt J, Stromberga Z, Phelps C, Clark J, Glasziou P, Scott AM. 2021. Virtual and augmented reality enhancements to medical and science student physiology and anatomy test performance: A systematic review and meta-analysis. *Anat Sci Educ* 14:368-376.
- Moxham B. 2021. Looking into the crystal ball. In: Proceedings of the First Virtual Trans European Pedagogic Anatomical Research Group Meeting (TEPARG 2021); Online, 2021 March 6. The Trans European Pedagogic Anatomical Research Group, Cardiff, Wales, UK.
- Muntz D, Franco J, Ferguson CC, Ark TK, Kalet A. 2021. Telehealth and medical student education in the time of COVID-19 - and beyond. *Acad Med* (in press; doi: <https://doi.org/10.1097/ACM.00000000000004014>).
- Nguyen VH, Spears RD, Warner RL, Joy-Thomas AR. 2021. Transitioning the anatomy curriculum to an online platform: Lessons learned. *J Dent Educ* (in press; doi: <https://doi.org/10.1002/jdd.12394>).
- Owolabi J, Bekele A. 2021. Implementation of innovative educational technologies in teaching of anatomy and basic medical sciences during the COVID-19 pandemic in a developing country: The COVID-19 silver lining? *Adv Med Educ Pract* 12:619-625.
- Papa V, Varotto E, Vaccarezza M, Ballestriero R, Tafuri D, Galassi FM. 2019. The teaching of anatomy throughout the centuries: From Herophilus to plastination and beyond. *Med Hist* 3:69-77.
- Papakyriakopoulos O, Medina Serrano JC, Hegelich S. 2020. Misinformation Review, 18 August 2020. The spread of COVID-19

- conspiracy theories on social media and the effect of content moderation. The Harvard Kennedy School (HKS), Cambridge, MA. URL: <https://misinfoforeview.hks.harvard.edu/article/the-spread-of-covid-19-conspiracy-theories-on-social-media-and-the-effect-of-content-moderation/> [accessed 17 July 2021].
- Pather N, Blyth P, Chapman JA, Dayal MR, Flack N, Fogg QA, Green RA, Hulme AK, Johnson IP, Meyer AJ, Morley JW, Shortland PJ, Štrkalj G, Štrkalj M, Valter K, Webb AL, Woodley SJ, Lazarus MD. 2020. Forced disruption of anatomy education in Australia and New Zealand: An acute response to the Covid-19 pandemic. *Anat Sci Educ* 13:284–300.
- Pawlina W. 2009. Basic sciences in medical education: Why? How? When? Where? *Med Teach* 31:787–789.
- Pineau EL. 1994. Teaching is performance: Reconceptualizing a problematic metaphor. *Am Educ Res J* 31:3–25.
- Ravi KS. 2020. Dead body management in times of Covid-19 and its potential impact on the availability of cadavers for medical education in India. *Anat Sci Educ* 13:316–317.
- Redington C. 1983. *Can Theatre Teach?: An Historical and Evaluative Analysis of Theatre in Education*. 1st Ed. New York, NY: Pergamon Press Inc. 264 p.
- Reinhart A, Malzkorn B, Döing C, Beyer I, Jünger J, Bosse HM. 2021. Undergraduate medical education amid Covid-19: A qualitative analysis of enablers and barriers to acquiring competencies in distant learning using focus groups. *Med Educ Online* 26:1940765.
- Rives FC Jr. 1979. The teacher as a performing artist. *Contemp Educ* 51:7–9.
- Roll I, Wylie R. 2016. Evolution and revolution in artificial intelligence in education. *Int J Artif Intell Educ* 26:582–599.
- Rose S. 2020. Medical student education in the time of COVID-19. *JAMA* 323:2131–2132.
- Sá MJ, Serpa S. 2020. COVID-19 and the promotion of digital competences in education. *Univers J Educ Res* 8:4520–4528.
- Savitt TL. 2010. Medical readers' theater as a teaching tool. *Camb Q Healthc Ethics* 19:465–470.
- Sawday J. 1995. *The Body Emblazoned: Dissection and the Human Body in Renaissance Culture*. 1st Ed. Abingdon, Oxon, UK: Routledge. 372 p.
- Schmenner RW. 2013. Teaching as theater. *Decis Sci J* 11:213–219.
- Schumacher GH. 2007. Theatrum anatomicum in history and today. *Int J Morphol* 25:15–32.
- Schön DA. 1984. *The Reflective Practitioner: How Professionals Think in Action*. 1st Ed. New York, NY: Basic Books Inc. 374 p.
- Schön DA. 1987. *Educating the Reflective Practitioner: Toward a New Design for Teaching and Learning in the Professions*. 1st Ed. San Francisco, CA: Jossey-Bass Publishers. 384 p.
- Schwarte L. 2005. Anatomical theatre as experimental space. In: Schramm H, Schwarte L, Lazardzig J (Editors). *Collection, Laboratory, Theatre: Scenes of Knowledge in the 17th Century*. 1st Ed. Berlin, Germany: DeGruyter. p 75–102.
- Shapiro J, Hunt L. 2003. All the world's a stage: The use of theatrical performance in medical education. *Med Educ* 37:922–927.
- Smith CF, Finn GM, Stewart J, Atkinson MA, Davies DC, Dyball R, Morris J, Ockleford C, Parkin I, Standring S, Whiten S, Wilton J, McHanwell S. 2016. The Anatomical Society core regional anatomy syllabus for undergraduate medicine. *J Anat* 228:15–23.
- Smith CF, Pawlina W. 2021. A journey like no other: Anatomy 2020! *Anat Sci Educ* 14:5–7.
- Smith CF, Tollemache N, Covill D, Johnston M. 2018. Take away body parts! An investigation into the use of 3D-printed anatomical models in undergraduate anatomy education. *Anat Sci Educ* 11:44–53.
- Sokolovskaya IE. 2020. Socio-psychological factors of student satisfaction in the context of digitalization of education during the COVID-19 pandemic and self-isolation. *Digit Sociol* 3:46–54.
- Spolin V. 1999. *Improvisation for the Theater: A Handbook of Teaching and Directing Techniques*. 3rd Ed. Evanston, IL: Northwestern University Press. 412 p.
- Srivastava V, Pandey V, Tiwari P, Patel S, Ansari MA, Shukla VK. 2020. Utility of real-time online teaching during COVID era among surgery postgraduates. *Indian J Surg* 82:762–768.
- Stewart P. 2017. *The Live-Streaming Handbook: How to Create Live-Video for Social Media on Your Phone and Desktop*. 1st Ed. Abingdon, Oxon, UK: Routledge. 388 p.
- Tang L, Chung MS, Liu Q, Shin DS. 2010. Advanced features of whole body sectioned images: Virtual Chinese Human. *Clin Anat* 23:523–529.
- Tauber RT, Sargent Mester C. 2007. *Acting Lessons for Teachers: Using Performance Skills in the Classroom*. 1st Ed. Westport, CT: Greenwood Publishing Group. 240 p.
- Taylor JS. 2003. Confronting “culture” in medicine's “culture of no culture”. *Acad Med* 78:555–559.
- Thakur A, Soklaridis S, Crawford A, Mulsant B, Sockalingam S. 2021. Using rapid design thinking to overcome Covid-19 challenges in medical education. *Acad Med* 96:56–61.
- Tucker RP, Anderson H. 2021. Dissection experience and performance on a human gross anatomy written examination: Lessons learned during the Covid-19 pandemic. *Anat Sci Educ* 14:169–170.
- Uhl JF, Jorge J, Lopes DS, Campos PF (Editors). 2021. *Digital Anatomy: Applications of Virtual, Mixed and Augmented Reality*. 1st Ed. Cham, Switzerland: Springer Nature Switzerland AG. 399 p.
- Van Dijk J. 2000. Digital cadavers: The visible human project as anatomical theater. *Stud Hist Philos Sci C Stud Hist Philos Biol Biomed Sci* 31:271–285.
- Vyas D, van der Veer G, Nijholt A. 2013. Creative practices in the design studio culture: Collaboration and communication. *Cognit Technol Work* 15:415–443.
- Wagerman SA, Bedikian A, Ross BS. 2021. Psychodynamic and sociopolitical predictors of COVID distress and gravity. *Pers Individ Differ* 171:110506.
- Wang T. 2010. A new paradigm for design studio education. *Int J Art Des Educ* 29:173–183.
- Watson K. 2011. Perspective: Serious play: Teaching medical skills with improvisational theater techniques. *Acad Med* 86:1260–1265.
- Whatman J. 1997. Teaching is performing: An alternative model of teacher education. *Res Drama Educ* 2:173–184.
- Winkler MG. 1993. The anatomical theater. *Lit Med* 12:65–80.
- Wolfe AD, Hoang KB, Denniston SF. 2018. Teaching conflict resolution in medicine: Lessons from business, diplomacy, and theatre. *MedEdPORTAL* 14:10672.
- Young D. 2021. Racism makes me question everything. I got the vaccine anyway. Surviving in an anti-Black society requires some personal negotiations. This was one of them. *New York Times*. 9 April 2021. The New York Times Company, New York, NY. URL: <https://www.nytimes.com/2021/04/09/opinion/racism-covid-vaccine.html> [accessed 26 July 2021].
- Zawacki-Richter O, Marín VI, Bond M, Gouverneur F. 2019. Systematic review of research on artificial intelligence applications in higher education—Where are the educators? *Int J Educ Technol High Educ* 16:1–27.
- Zhang SX, Wang Y, Rauch A, Wei F. 2020. Unprecedented disruption of lives and work: Health, distress and life satisfaction of working adults in China one month into the COVID-19 outbreak. *J Psych Res* 288:112958.
- Zorzal ER, Sousa M, Mendes D, dos Anjos RK, Medeiros D, Paulo SF, Rodrigues P, Mendes JJ, Delmas V, Uhl JF, Mogorón J. 2019. Anatomy studio: A tool for virtual dissection through augmented 3D reconstruction. *Comput Graph* 85:74–84.



## AUTHOR BIOGRAPHIES

**Marco Antonio de Carvalho Filho**, M.D., Ph.D., is an associate professor of emergency medicine in the Life and Health Sciences Research Institute (ICVS), School of Medicine at the University of Minho in Braga, Portugal. He is also a senior researcher in medical education in the Center for Education Development and Research in Health Professions (CEDAR) at the University Medical Center Groningen in Groningen, the Netherlands. He teaches clinical reasoning, point-of-care ultrasound, and supervises students in the clinics and simulation laboratories. His research focuses on professional identity development, clinical reasoning, and faculty development.

**Frederic W. Hafferty**, Ph.D., is a professor of medical education, in the Division of General Internal Medicine, Department of Medicine, Mayo Clinic College of Medicine and Science at Mayo Clinic in Rochester, Minnesota. He is an Associate Director of the Program for Professionalism and Values at Mayo Clinic. He teaches a variety of professionalism and ethics courses and his research interests include the evolution of medicine's professionalism movement, medicine's hidden curriculum, the application of complexity theory to medical training, and issues of medical socialization and professional identity formation.

**Wojciech Pawlina**, M.D., is a professor of anatomy and medical education in the Department of Clinical Anatomy Mayo Clinic College of Medicine and Science at Mayo Clinic in Rochester, Minnesota. He teaches anatomy and histology to first-year medical students, residents, fellows, graduate students, and other health professions students and his research interest in medical education.

**How to cite this article:** de Carvalho Filho MA, Hafferty FW, Pawlina W. 2021. Anatomy 3.0: Rediscovering Theatrum Anatomicum in the wake of Covid-19. *Anat Sci Educ* 14:528–535. <https://doi.org/10.1002/ase.2130>