

Enhancing Neuroanatomy Education for Medical Students Through the Development of Online Modules

Fatima E Al-Kubaisi , Soha R Dargham , Mange F Manyama 

Medical Education Division, Weill Cornell Medicine – Qatar, Doha, Qatar

Correspondence: Mange F Manyama, Medical Education Division, Weill Cornell Medicine – Qatar, Doha, Qatar, Email mfm2003@qatar-med.cornell.edu

Purpose: Neuroanatomy is a cornerstone of medical education, yet its complexity often leads to student apprehension, termed “neurophobia.” This quantitative study evaluated the effectiveness of online Functional Neuroanatomy modules in enhancing second-year medical students’ understanding of neuroanatomy at Weill Cornell Medicine-Qatar during the 2024–25 academic year.

Participants and Methods: Four functional neuroanatomy modules were developed: Brainstem Anatomy, Sensory Pathway, Motor Pathway, and Cranial Nerves. Each module featured a 15 to 20-minute animated video and accompanying pre- and post-module quizzes. Each module included 5–10 multiple-choice questions and labeling exercises targeting structure, function, and clinical correlation relationships through distinct clinical scenarios. Thirty-six students participated in this study by completing one or more modules. A survey was administered at the end of the final module to assess student perceptions of the modules’ effectiveness, utility, and overall satisfaction. Quantitative data were analyzed using paired samples t-tests to compare pre- and post-quiz performance and independent t-tests to compare weekly quiz scores between participants and non-participants.

Results: Statistical analysis showed significant improvement in post-module quiz scores across all modules ($p < 0.001$), indicating short-term learning gains. No significant difference was observed in official weekly neuroanatomy quiz scores between participants and non-participants ($p > 0.05$), possibly attributable to students’ already strong baseline performance and access to multiple learning resources. Survey responses reflected high satisfaction, with students praising the modules’ clarity, interactivity, and flexibility.

Conclusion: These findings support the effectiveness of neuroanatomy modules as a supplementary digital tool that enhances comprehension and addresses neurophobia. However, limitations, including small sample size, lack of long-term retention assessment, and reliance on quiz-based evaluation, warrant caution and suggest the need for more rigorous future studies.

Keywords: medical education, neurophobia, interactive learning, clinical correlations, student engagement

Introduction

Human anatomy, which include functional neuroanatomy (FNA), has historically represented a core educational discipline among the basic sciences that develop foundational medical understanding.¹ Neuroanatomy, the study of the structure and organization of the nervous system, provides the foundation for understanding the functional relationships between these structures and their roles in the body. It is a cornerstone of medical education, essential for disciplines such as neurology, psychiatry, and neurosurgery. Neurological disorders are among the leading causes of disability and mortality worldwide. Over the past three decades, their prevalence has increased significantly, a trend projected to continue as the global population ages.² This rising burden underscores the pressing need for comprehensive and effective neuroanatomy training in medical education.³

Despite its central importance, neuroanatomy remains one of the most difficult subjects for medical students to master.^{4,5} The nervous system represents one of the most challenging components of systemic anatomy education, given its sophisticated knowledge requirements and the inherent difficulty of demonstrating internal structures like fiber bundles and nuclei through gross specimens.⁶ Unlike other anatomical systems that possess more easily recognizable

features, the nervous system, particularly its central component, consistently proves difficult for students to master.⁷ These difficulties are often attributed to the complexity of the subject matter, challenges in visualizing three-dimensional structures, and a disconnect between basic science concepts and their clinical applications.^{8,9} This challenge is exemplified by the term neurophobia, introduced by Jozefowicz in 1994, which reflects the anxiety and confusion many students experience when engaging with neuroscience, neuroanatomy, and clinical neurology.¹⁰ Moreover, depicting pathological specimens and interpreting their functional consequences and clinical relevance presents additional challenges.¹¹

Traditional pedagogical strategies such as lectures, textbooks, and cadaver dissection have long been foundational in medical training, but they have notable limitations, including high costs, ethical concerns, and logistical constraints, particularly in resource-limited settings.¹² There is mounting awareness among anatomy educators that traditional instructional approaches may obstruct the cultivation of students' spatial reasoning abilities, which are vital for both anatomical knowledge acquisition and academic achievement.^{13,14} Current research in anatomical education establishes that effective neuroanatomy learning hinges on comprehending the sophisticated three-dimensional relationships that exist between neural structures.¹⁵

In recent decades, neuroanatomy educators have experimented with a wide array of teaching innovations aimed at enhancing comprehension, engagement, and fostering students' spatial perception of anatomical structures, with some success. These include three-dimensional simulations, computer-assisted learning, virtual reality, and integrated clinical case-based instruction.^{16–18} Nevertheless, the significant costs and technical expertise required have limited the widespread implementation of these innovations across medical education programs.¹⁹ Alternatively, online modules have gained traction for their flexibility, scalability, and potential to foster active learning.²⁰ Prior research has demonstrated that such modules can improve student interactivity, conceptual understanding, and satisfaction, especially when combined with formative assessments and video-based demonstrations.³ Nonetheless, there remains a gap in the literature regarding the impact of functional neuroanatomy-specific online learning tools on students' ability to form meaningful structure-function associations, an essential component for clinical reasoning.

In this context, there is a critical need for neuroanatomy curricula that are pedagogically sound, inclusive, cost-effective, and adaptable to institutional and student-specific needs. We sought to meet this need by developing a series of Functional Neuroanatomy online modules. These modules are designed to support second-year medical students during the Brain and Behavior unit by integrating multimedia content, clinical correlations, and self-assessment questions. The FNA modules were designed to reinforce core structure–function–clinical correlation concepts through digitally enhanced content that is accessible flexibly and can be revisited as needed.

This study aimed to evaluate the effectiveness of these FNA modules in enhancing student learning outcomes and satisfaction. Specifically, we sought to: (1) assess students' perceptions of the modules as a learning tool; and (2) compare the academic performance of students who engaged with the modules to that of the overall class cohort. In doing so, we aim to contribute to the ongoing discourse on how best to teach neuroanatomy in a rapidly evolving educational and clinical landscape, one that increasingly demands innovation, adaptability, and a student-centered approach.

Materials and Methods

Study Design and Population

This study involved second-year medical students at Weill Cornell Medicine-Qatar (WCM-Q) enrolled in the Brain and Behavior unit during the 2024–25 academic year.

Module Development and Platform

Four online FNA modules covering Brainstem Anatomy (module 1), Sensory Pathway (module 2), Motor Pathway (module 3), and Cranial Nerves (module 4) were developed. Each module included a 15–20-minute animated video accompanied by pre- and post-assessment quizzes. The FNA video modules were created using Clipchamp, an online video-editing platform. Clipchamp was selected for its intuitive interface, ease of use, and robust editing features, which

made it well-suited for quickly producing engaging and polished educational videos without requiring advanced technical skills. For each module, a script was developed and followed to ensure consistency and alignment with educational goals. The content of each video covered the basic neuroanatomy of a structure, relevant neural pathways and connections, associated functions, and key clinical correlations. The development of the modules was guided by the established learning objectives of our institutional neuroanatomy course, ensuring curricular alignment and relevance to students' ongoing coursework. The modules were initially developed by a fourth-year medical student (Fatima Al Kubaisi) who had previously completed the neuroanatomy course during the second year of the curriculum. Each module was independently reviewed and approved by Dr. Mange Manyama, an anatomy professor with over 15 years of experience teaching neuroanatomy, prior to deployment. This served as expert validation to ensure the educational and scientific integrity of the content.

Deployment and Module Format

Modules were uploaded to a dedicated Canvas course site, separate from the main neuroanatomy course page. Students were instructed to complete each module in a structured sequence

- Pre-module quiz
- FNA video
- Post-module quiz.

Modules were released weekly, running concurrently with the core neuroanatomy curriculum, allowing students to integrate the material with their ongoing studies.

Assessment Design

Each quiz included 5–10 multiple-choice questions and an equal number of labeling exercises, both addressing the same neuroanatomical concepts but using distinct clinical scenarios or anatomical perspectives. An additional file shows sample of questions for module 1 and 2 ([Supplementary Material 1](#)). The pre- and post-module quizzes were time-limited and allowed only one attempt, discouraging extensive external searching. Majority of the questions were designed to assess the application of concepts rather than simple recall, requiring knowledge integration that would be difficult to quickly search online. The Canvas learning management system was configured to present questions one at a time without allowing backtracking. A neuroanatomy expert reviewed all questions to ensure comparable difficulty levels between assessments.

Implementation and Data Analysis

Students were invited to participate in the study via email. The Email included a link to the Canvas page containing four supplementary online FNA modules and their associated self-assessment quizzes. Participation in the study was entirely voluntary, and students were assured that they could withdraw at any time without any consequences affecting their performance or grades. Students were encouraged to complete all four modules, though they could choose to complete any individual module if they preferred. Pre- and post-quiz scores were collected from Canvas and analyzed after removing identifiers. To assess the effectiveness of the FNA online modules, comparison of students' performance in pre- and post-module quizzes were analyzed. Survey results were analyzed descriptively and presented using tables and visual representations. The average scores of the Brain and Behavior unit's weekly quizzes were also compared between students who participated in the study and those who did not. Following last module completion, students completed a 5-point Likert scale survey assessing the modules' perceived effectiveness, utility, and overall satisfaction. Paired samples t-tests were employed to compare pre- and post-quiz scores. Independent t-tests were used to compare the average scores of the neuroanatomy weekly quizzes between students who participated in the study and those who did not. The level of significance was set at 5%. Data analysis was conducted using IBM SPSS Statistics.

Results

A total of 36 students participated in this study. Of these, 32 completed Module 1, 31 completed Module 2, and 30 completed both Module 3 and Module 4. Following module completion, 32 students completed a survey assessing perceived effectiveness, utility, and satisfaction with the FNA modules.

Canvas metadata revealed that 88.3% of students completed the post-module quiz within 2 hours of viewing the module, while 11.7% did so between 2–24 hours later. Notably, the average post-module quiz scores were comparable between these two groups, suggesting that the timing of quiz completion within this range had minimal influence on performance.

To evaluate learning gains, paired-samples *t*-tests comparing pre- and post-module scores showed statistically significant improvements across all four modules, with the largest gains observed in Module 3 and the smallest in Module 2 ($p < 0.001$) (Table 1).

Additionally, we compared official weekly neuroanatomy quiz scores between students who participated in the study and those who did not. These quizzes were administered on a fixed schedule to all students as part of the course. A two-sample *t*-test revealed no significant difference in performance between the two groups ($p > 0.05$; Table 2). Given the small sample size and the absence of controls for external learning variables in the asynchronous format, these findings should be interpreted with appropriate caution.

Student perceptions of the modules were largely positive. Survey responses indicated that most students agreed or strongly agreed that the FNA modules enhanced their understanding of neuroanatomy, improved their approach to the subject, and were a worthwhile use of their time. Participants also expressed a high likelihood of recommending the modules to others (Figure 1). Open-ended comments reinforced these findings, highlighting the clarity and interactivity of the modules. For example, one student noted, “These modules have been very helpful during my learning for FNA, as they simplified complex topics” while another appreciated the self-paced design and interactive features, stating, “I appreciated the flexibility to review the material at my own pace and found the interactive elements engaging and useful for reinforcing my learning.”

While feedback was overwhelmingly positive, one student suggested reducing the background music volume to improve audio clarity, an actionable point that will guide future module refinements.

Table 1 Comparison Between the Pre-Module Quiz and Post- Module Quiz Scores

	Pre-Score Mean (SD)	Post-Score Mean (SD)	Difference (Post-Pre) Mean Difference (CI)	P-Value
Module 1	47.57 (21.30)	73.26 (30.49)	25.69 (16.71–34.67)	<0.001
Module 2	62.03 (29.02)	79.63 (27.63)	17.59 (8.92–26.26)	<0.001
Module 3	43.05 (21.59)	79.63 (27.63)	36.57 (28.07–45.08)	<0.001
Module 4	58.33 (31.49)	88.46 (27.83)	30.09 (21.07–39.12)	<0.001

Table 2 Neuroanatomy Weekly Quiz Performance Between Students Who Participated in the Study and Those Who Did Not

	Module 1	Module 2	Module 3	Module 4
Average scores for students who participated in the study	85.3	85.3	82	79.1
Average scores for the whole class	84.6	85.9	82.9	79.5
Average scores for students who did not participated in the study	80.3	86.8	82.8	79.1
P-value	0.229	0.709	0.842	>0.999

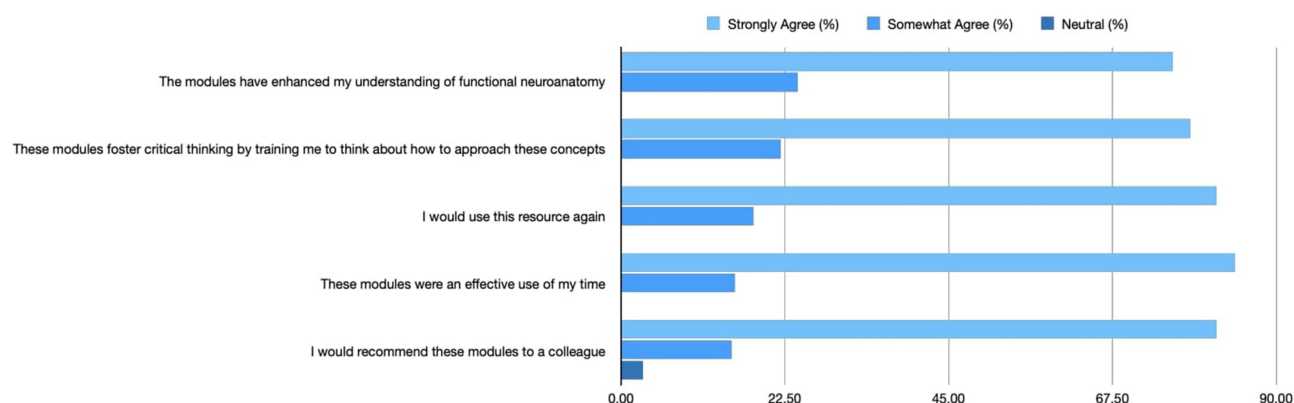


Figure 1 Students' responses regarding the usefulness of the FNA modules.

Discussion

The integration of diverse online platforms into medical curricula has transformed traditional pedagogy, offering flexible and self-directed learning opportunities tailored to modern students' needs. This study contributes to that growing body of work by evaluating the impact of a uniquely structured, expert-reviewed, and clinically oriented set of Functional Neuroanatomy modules on student learning and satisfaction. Unlike many previous digital interventions, our modules were embedded within a core course and aligned with clinical content, utilizing a scaffolded, interactive format. This study not only assessed knowledge acquisition through pre- and post-module quizzes but also explored user engagement and satisfaction.

This study's strength stems from its carefully constructed pre- and post-module assessments that were equivalent in content but used different questions, thereby reducing recall bias while preserving measurement validity. Canvas metadata revealed that students who delayed completing the post-module quiz performed similarly to those who completed it immediately after module use, suggesting retention of learning. These findings support the effectiveness of the modules as a supplement to core instruction, especially given their emphasis on visualization, structured narration, and clinical application. Importantly, the study design accounted for the broader learning environment. Students were simultaneously engaged in lectures and small group tutorials, highlighting that the observed performance gains cannot be attributed solely to the modules. Instead, the results likely reflect a synergistic effect in which the FNA modules functioned as a reinforcement tool rather than a standalone instructional method. This aligns with studies emphasizing the value of blended learning in reducing variability in learner outcomes and optimizing comprehension of spatially complex subjects such as neuroanatomy.^{21–24} Previous studies have suggested that blending digital and traditional learning methods may minimize variations in neuroanatomy education outcomes.^{25,26}

In comparison to existing literature, our findings are consistent with studies demonstrating the educational value of interactive video content, simulations, and case-based learning in neuroanatomy education.^{3,20,27,28} However, while many prior interventions focused on stand-alone tools or optional supplementary resources, our modules were fully integrated into the course structure and addressed real clinical scenarios, thereby enhancing contextual relevance. De Castro et al similarly emphasized the need for digital resources that connect anatomical knowledge to clinical practice, a central aim of our intervention.²⁹

Despite the improvements observed in pre- to post-module performance, no significant differences were found in the regular weekly neuroanatomy quiz scores between module users and non-users. The weekly quizzes are part of the regular curriculum and were administered according to a fixed schedule for all students, regardless of their study participation status. Our findings aligns with prior research showing that optional digital resources may not produce measurable differences in exam performance among high-achieving student populations.³⁰ One interpretation is that students who did not engage with the modules may have compensated through other means, such as textbooks or peer learning,³ thereby reducing the observed effect size. Moreover, this finding reinforces the idea that online tools should be viewed as complementary rather than replacement strategies for traditional teaching.³¹

The current study also captured student perceptions through an anonymous Qualtrics survey, which revealed high levels of satisfaction. Students praised the modules' clarity, clinical relevance, and effectiveness in simplifying complex material. The ability to revisit content at their own pace was particularly valued, echoing prior studies that underscore the importance of self-paced, modular learning.^{21,32} Some students did suggest minor audio adjustments, which offers actionable feedback for future iterations.

While these results are encouraging, several methodological limitations must be acknowledged. The study was conducted at a single institution with a small sample size, which constrains the statistical power and generalizability of our findings. The synchronous nature of module delivery allowed students to access external resources during assessments. While this is a common limitation in non-proctored online learning environments, the pre- and post-quizzes were designed primarily to measure knowledge gain and learning impact rather than serve as formal summative assessments. Nevertheless, we acknowledge that this format may introduce performance inflation and limit our ability to maintain full control over academic integrity. Additionally, we were unable to control for external study behaviors, which may have influenced performance. Student engagement with the modules may have varied, as we did not track detailed usage patterns or time spent on each module. The study should be interpreted as preliminary and exploratory, providing valuable pilot data to inform future research. Future studies should incorporate larger, more diverse student populations, more rigorously controlled evaluation conditions, delayed post-tests to evaluate the durability of learning gains, and assessment methods that better capture clinical application of concepts, which is critical for clinical practice.

Conclusion

This study provides preliminary evidence supporting the use of online Functional Neuroanatomy (FNA) modules as a targeted intervention to reinforce key neuroanatomical concepts in a clinical context. The observed gains in post-module quiz scores suggest that the modules contributed to short-term learning of structure-function relationships. Unlike prior research that broadly promotes online tools, our study specifically demonstrates how brief, scripted, clinically integrated video modules, developed using a low-cost platform and validated by expert review, can effectively supplement neuroanatomy instruction within a real-world medical curriculum.

However, the small sample size, synchronous assessment format, and lack of long-term retention evaluation limit the generalizability of these findings and highlight the need for more robust, controlled studies. Despite these constraints, the study offers a practical and scalable approach to enhancing neuroanatomy education and provides valuable pilot data for future research into the effectiveness of targeted digital interventions in medical curricula.

Ethics Approval and Informed Consent

This study received approval from the Weill Cornell Medicine–Qatar Institutional Review Board (IRB approval number: 24-00024). Informed consent was obtained from all participants prior to their inclusion in the study. Participants provided informed consent, which included permission for the publication of anonymized responses and direct quotes.

Consent for Publication

This study did not include any identifiable images, videos, or recordings requiring consent for publication.

Acknowledgments

We would like to extend our sincere gratitude to Ms. Gurveer Kaur Guron and Dr. Hiam Chemaitelly for their invaluable assistance during the development of the research proposal. We are also deeply thankful to the students of the class of 2027 for their participation and contributions to this study. Their involvement was essential to the success of this research.

Author Contributions

All authors contributed meaningfully to the work reported—whether through the conception, design, execution, data acquisition, analysis, or interpretation. Each author was involved in drafting, revising, or critically reviewing the

manuscript; approved the final version for publication; agreed on the journal of submission; and accepts responsibility for all aspects of the work.

Disclosure

The authors declare no financial or non-financial competing interests related to this study. No affiliations exist that could influence the content of this manuscript.

References

- Verhoeven BH, Verwijnen GM, Scherpier AJJA, Van Der Vleuten CPM. Growth of medical knowledge. *Med Educ.* 2002;36(8):711–717. doi:10.1046/j.1365-2923.2002.01268.x
- Feigin VL, Vos T, Nichols E, et al. The global burden of neurological disorders: translating evidence into policy. *Lancet Neurol.* 2020;19(3):255–265. doi:10.1016/S1474-4422(19)30411-9
- Welch MC, Yu J, Larkin MB, et al. A Multimedia Educational Module for Teaching Early Medical Neuroanatomy. *MedEdPORTAL.* 2020;16:10885. doi:10.15766/mep_2374-8265.10885
- Zinchuk AV, Flanagan EP, Tubridy NJ, et al. Attitudes of US medical trainees towards neurology education: “Neurophobia” - a global issue. *BMC Med Educ.* 2010;10(1):49. doi:10.1186/1472-6920-10-49
- Flanagan E, Walsh C, Tubridy N. ‘Neurophobia’—attitudes of medical students and doctors in Ireland to neurological teaching. *Eur J Neurol.* 2007;14(10):1109–1112. doi:10.1111/j.1468-1331.2007.01911.x
- Narayanan SN, Merghani TH. Real-life scenario blended teaching approach for nurturing inquisitive learning of central nervous system in medical students. *Adv Physiol Educ.* 2023;47(1):124–138. doi:10.1152/advan.00054.2022
- Hlavac RJ, Klaus R, Betts K, Smith SM, Stabio ME. Novel dissection of the central nervous system to bridge gross anatomy and neuroscience for an integrated medical curriculum. *Anat. Sci Educ.* 2018;11(2):185–195.
- Javaid MA, Chakraborty S, Cryan JF, et al. Understanding neurophobia: reasons behind impaired understanding and learning of neuroanatomy in cross-disciplinary healthcare students. *Anat Sci Educ.* 2018;11(1):81–93. doi:10.1002/ase.1711
- Moreno-Zambrano D, Sandrone S, Meza-Venegas J, et al. Exploring the key factors behind neurophobia: a systematic review of the English, Spanish and Portuguese literature. *Brain Disord.* 2021;2:100011. doi:10.1016/j.dscb.2021.100011
- Jozefowicz RF. Neurophobia: the fear of neurology among medical students. *Arch Neurol.* 1994;51(4):328–329. doi:10.1001/archneur.1994.00540160018003
- Evins AI, Rothbaum M, Kim N, et al. A novel 3D surgical neuroanatomy course for medical students: outcomes from a pilot 6-week elective. *J Clin Neurosci.* 2023;107:91–97. doi:10.1016/j.jocn.2022.12.009
- Jeyakumar A, Dissanayake B, Dissabandara L. Dissection in the Modern Medical Curriculum: an Exploration into Student Perception and Adaptions for the Future. *Anat Sci Educ.* 2020;13(3):366–380. doi:10.1002/ase.1905
- Sweeney K, Hayes JA, Chiavaroli N. Does spatial ability help the learning of anatomy in a biomedical science course? *Anat. Sci Educ.* 2014;7(4):289–294.
- Fernandez R, Dror IE, Smith C. Spatial abilities of expert clinical anatomists: comparison of abilities between novices, intermediates, and experts in anatomy. *Anat Sci Educ.* 2011;4(1):1–8.
- Pettersson AF, Karlgren K, Al-Saadi J, et al. How students discern anatomical structures using digital three-dimensional visualizations in anatomy education. *Anat. Sci Educ.* 2023;16(3):452–464.
- Abushouk AI, Duc NM. Curing neurophobia in medical schools: evidence-based strategies. *Med Educ Online.* 2016;21(1):32476. doi:10.3402/meo.v21.32476
- Shelley BP, Chacko TV, Nair BR. Preventing neurophobia: remodeling neurology education for 21 st-century medical students through effective pedagogical strategies for “neurophilia”. *Ann Indian Acad Neurol.* 2018;21(1):9–18. doi:10.4103/aian.AIAN_371_17
- Han F, Zhang Y, Wang P, et al. Neurophobia among medical students and resident trainees in a tertiary comprehensive hospital in China. *BMC Med Educ.* 2023;23(1):824. doi:10.1186/s12909-023-04812-1
- Chytas D, Noussios G, Salmas M, Demesticha T, Vasiliadis AV, Troupis T. The effectiveness of three-dimensional printing in undergraduate and postgraduate anatomy education: a review of reviews. *Morphologie.* 2024;108(361):100759. doi:10.1016/j.morpho.2023.100759
- Dekesel LMR, Perletti LGJB, Madeleyn AS, et al. Structured Online Modules and Near-Peer Teaching in Neuroanatomy Stimulate Active Learning and Can Have Beneficial Effects on Medical Students’ Scores. *Med Sci Educ.* 2022;32(5):1077–1085. doi:10.1007/s40670-022-01617-7
- Nathaniel TI, Black AC. An Adaptive Blended Learning Approach in the Implementation of a Medical Neuroscience Laboratory Activities. *Med Sci Educ.* 2021;31(2):733–743. doi:10.1007/s40670-021-01263-5
- Tong DH, Uyen BP, Ngan LK. The effectiveness of blended learning on students’ academic achievement, self-study skills and learning attitudes: a quasi-experiment study in teaching the conventions for coordinates in the plane. *Heliyon.* 2022;8(12):e12657. doi:10.1016/j.heliyon.2022.e12657
- Nathaniel TI, Goodwin RL, Fowler L, McPhail B, Black Jr AC. An Adaptive Blended Learning Model for the Implementation of an Integrated Medical Neuroscience Course During the Covid-19 Pandemic. *Anat Sci Educ.* 2021;14(6):699–710. doi:10.1002/ase.2097
- Morton CE, Saleh SN, Smith SF, et al. Blended learning: how can we optimise undergraduate student engagement? *BMC Med Educ.* 2016;16(1):195. doi:10.1186/s12909-016-0716-z
- Adnan S, Xiao J. A scoping review on the trends of digital anatomy education. *Clin Anat.* 2023;36(3):471–491. doi:10.1002/ca.23995
- Naidich TP, Yousry TA. Functional Neuroanatomy. In: Stippich C, editor. *Clinical Functional MRI. Medical Radiology.* Berlin, Heidelberg: Springer; 2007.
- Schloss KB, Schoenlein MA, Tredinnick R, et al. The UW Virtual Brain Project: an immersive approach to teaching functional neuroanatomy. *Transl Iss Psychol Sci.* 2021;7(3):297–314. doi:10.1037/tps0000281
- Bindelli DM, Kafura SAM, Laci A, et al. Effective Use of Student-Created Case Studies as Assessment in an Undergraduate Neuroscience Course. *J Undergrad Neurosci Educ.* 2021;19(2):A141–A162. doi:10.1145/3170358.3170410

29. de Castro SKA, Nishijo H, Aversi-Ferreira TA. Neuroanatomy teaching: an example of active teaching applied to medical formation. *Am J Educ Res Rev.* 2018;3:37.
30. Krishnamoorthy K, Reid L. A Review of the Effectiveness and Utility of Digital Resources in Anatomical Education. In: *Enhancing Biomedical Education. Biomedical Visualization*. Gröning F, editor. 2024. Vol. 7.
31. Totlis T, Tishukov M, Piagkou M, Kostares M, Natsis K. Online educational methods vs. traditional teaching of anatomy during the COVID-19 pandemic. *Anat Cell Biol.* 2021;54(3):332–339. doi:10.5115/acb.21.006
32. Alim E, Coşkun Ö, Peker TV. Comparison and Evaluation of the Effectiveness of Traditional Neuroanatomy Teaching in Medical Education with Virtual-Reality Application Based On 3D Virtual. *Gazi Med J.* 2024;3:1.

Advances in Medical Education and Practice

Publish your work in this journal

Advances in Medical Education and Practice is an international, peer-reviewed, open access journal that aims to present and publish research on Medical Education covering medical, dental, nursing and allied health care professional education. The journal covers undergraduate education, postgraduate training and continuing medical education including emerging trends and innovative models linking education, research, and health care services. The manuscript management system is completely online and includes a very quick and fair peer-review system. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <http://www.dovepress.com/advances-in-medical-education-and-practice-journal>

Dovepress
Taylor & Francis Group