

EDUCATION

COVID-19 modifications to a first year medical human anatomy course: Effects on student performance on summative examinations

John Patrick McNamara  | Michael F. Nolan 

Department of Basic Science Education,
Virginia Tech Carilion School of Medicine,
Roanoke, Virginia, USA

Correspondence

John Patrick McNamara, Department of Basic
Science Education, Virginia Tech Carilion
School of Medicine, 1 Riverside Circle, Suite
202, (540) 526-2248, Roanoke, VA 24016,
USA.

Email: jpmcnamara@vt.edu

Abstract

The COVID-19 (COVID) pandemic forced changes in how medical curricula are organized and delivered. In addition to disease mitigation strategies, other curricular modifications were required to maintain educational effectiveness and student and faculty safety. While these changes appear to be successful in their primary goal, their effect on learning and other important educational outcomes is less well understood. We describe changes to our anatomy course and describe their effects on summative examination scores. We compared anatomy examination scores from 4 years prior to COVID with scores from the 2 years following COVID mandated changes in an effort to determine the effectiveness of our course modifications. Examination scores for the first of four successive Blocks of instruction following the implementation of curricular changes demonstrated a lower mean score and greater range of scores than for the four pre-COVID years. Pre-COVID and post-COVID scores for Blocks II, III, and IV were comparable. Our results indicate that our changes to the anatomy curriculum did not prevent a performance decline during the first Block of instruction only. However, students were able to successfully adapt to these changes during the remainder of the course. We discuss factors that may have accounted for the Block I performance decline and call attention to changes within the larger curriculum that may have affected student performance.

KEYWORDS

anatomy, academic performance, COVID-19, curricula

1 | INTRODUCTION

Medical school curricula, since the time of Flexner, have progressively evolved by adding, reducing or in some instances eliminating topics and subject matter. The rate at which these changes occur is not steady, but tends to mirror advances in numerous fields of knowledge. Changes to curricula are most evident following the development and introduction of new or better treatments for specific disorders,

advances in diagnostic methods and techniques, or more recently, an increased recognition of and sensitivity to personal and cultural issues.

Other influences on medical education have arisen from the domain of pedagogy. Changes related not to what is taught, but how it is taught have also had an effect on medical curricula. Approaches such as problem-based learning, flipped classroom techniques and other methodologies shifts from faculty directed instruction to more

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student-centered learning environments. These are now part of the curricular landscape.

Historically, curricular changes based on scientific advances related to disease origin, mechanism or therapeutic approaches have been supported by evidence developed in support of those advances. Changes in teaching approaches likewise are typically accepted and implemented based on reports of successful usage in educational settings, some medical and some with other groups of learners.

In the past, curricular changes related to teaching approaches have been comparatively gradual, allowing time for review of the evidence presented in support of the change. In some institutions, new approaches are readily and enthusiastically adopted. In others, for a variety of reasons, certain approaches may not be feasible or desirable. The speed with which the recent COVID pandemic spread across the country forced medical school administrators and faculty to implement curricular changes on short notice with comparatively little time to address recommendations and mandates for protecting individuals and limiting the spread of disease. Among the mandates were requirements for adequate face coverings and social distancing. The need for social distancing has been particularly challenging for some schools, particularly those with large class sizes in which lectures are delivered in rooms and lecture halls with seating arrangements in which students are in relatively close proximity.

An additional challenge has been the need to provide educational materials and content to students who became infected and were required to enter a period of quarantine. To address this need, additional print and electronically resources were identified with links to our educational platform. Several ZOOM sessions were developed to provide additional direct access to the faculty.

Since the appearance of COVID in 2020, virtually all schools have implemented strategies designed to protect their students and faculty and maintain effective educational offerings. Descriptions of curricular modifications can be found in both the general medical and discipline-specific scholarly literature. Most of these reports (Baptiste, 2021; Cheng et al., 2021; Das & Mushaiqri, 2021; Flynn et al., 2021; Harmon et al., 2020; Longhurst, 2021; Moszkowicz et al., 2020; Patra et al., 2021; Pather et al., 2020; Singal et al., 2020; Srinivasan, 2020; Tucker & Anderson, 2021; Zarcone & Saverino, 2022) are descriptive in nature, outlining specific changes and modifications specific to their particular program. Only a few describe the effectiveness of their changes in terms of performance data and other measurable outcomes. Of these, Syed et al. (2021) found no significant differences between men and women in either stress levels or examination grades in their brain and behavior module. Brakora et al. (2021) compared test scores for one histology and one gross anatomy examination before and after a change to online lectures and found essentially no significant differences among groups. Grand et al. (2021) found no significant differences in scores in a renal course after switching from a traditional to a remote format. Finally, Smith (2022) reported no significant differences in examination scores in a pharmacology course following a shift to a virtual/online curriculum.

In contrast, Andersen et al. (2022) reported that while 77% of first year students scored above the national average on their first five

examinations prior to COVID, only 55% of first year students did so following COVID. These authors noted also that students rated their mental health and relationships lower after COVID than before.

These conflicting observations prompted us to examine whether, and to what extent, changes made to our anatomy course at the Virginia Tech Carilion School of Medicine (VTCOSOM) might have affected performance on our anatomy examinations. We briefly describe our pre-COVID anatomy curriculum and our post-COVID course modifications and then compare student examination scores for 4 years before COVID to those of students during 2 years after the implementation of these changes. We discuss our findings in relation to factors that we believe affected student behavior and examination performance.

2 | MATERIALS AND METHODS

2.1 | Pre-COVID anatomy curriculum

Prior to academic year 2020–2021 when changes were implemented to address personal safety and social distancing requirements associated with the COVID pandemic, our anatomy curriculum was delivered during each of four “Blocks” of instruction during the first year. Each Block was 10 weeks in length with the first 8 weeks composed of instruction in the form of lectures and laboratory sessions. Summative examinations were scheduled during Week 9 with Week 10 reserved for remediation of deficiencies (failures) based on performance on the End of Block anatomy examination. Each Block included a total of 32 scheduled contact hours for instructional purposes during the first 8 weeks and 2 h during Week 9 for the administration of the End of Block summative anatomy examination. A total of 120 h was scheduled for instruction in anatomy over the course of the year.

Anatomy sessions were scheduled on Thursdays between 8:00 am and 12:00 noon during academic years 2016–2017 thru 2019–2020 and were shifted to Tuesday mornings beginning in academic year 2020–2021. Instructional activities included time allocated for cadaver dissection, traditional live lectures and dry laboratory sessions described below.

Students were provided with a VTCOSOM Anatomy Guide & Workbook which included dissection instructions, clinical correlation material, imaging challenges and daily self-study review questions. A practice examination identical in format to the summative examination was administered during the last week of each Block.

The anatomy session content and the non-anatomy basic science session content of each Block was organized to provide topic reinforcement between the two components of the basic science curriculum. For example, when cardiac and pulmonary physiology and pharmacology were being considered during the non-anatomy sessions of Block II, the anatomy sessions during that time were focused on the heart and lungs.

The teaching faculty included four core individuals, all of whom are clinicians from different areas of practice (chiropractic, emergency medicine—trauma surgery, physical therapy, and radiology) who have

participated in the course for the previous 6 years with assistance provided in both the lecture and laboratory components by members of our clinical faculty from Carilion Clinic with expertise in particular areas during the course.

2.2 | Pre-COVID cadaver dissection laboratory sessions

During the pre-COVID years, our 42 students were grouped into teams of three or four students, each team being assigned to one of 12 cadaver dissection tables. Each student in the group had an assigned responsibility. One or two performed the dissection, one read the instructions in the VTCsOM Anatomy Guide & Workbook and another was responsible for finding appropriate images in the atlas and looking up material in reference material including the recommended textbook. Group membership was changed for each of the four Blocks of the course.

The VTCsOM Anatomy Guide & Workbook (the Guide) for each of the four Blocks, was written by the faculty to meet the specific requirements and time constraints of our curriculum. It was provided in hard copy to each student and posted on our educational platform at the beginning of each Block. More than 80% of the individual tasks described in the Guide included an associated short answer question printed in *italics* and referred to as the italic's questions. These questions focused on different, but relevant information designed to facilitate a more complete understanding of the body regions under study. The questions required the student to actively seek out information related to the dissection task beyond simple identification of a particular structure. The purpose of the italics questions was to prompt interactive discussion and learning among the group members. One student in the group would be responsible for finding the answers to these questions using print or electronic resources available in the laboratory and for explaining and sharing this information with the others in the group. Frequently, students would call upon a faculty member to help answer the question at the dissection table, thereby turning dissection sessions into brief teaching opportunities. All four core faculty members were present during each laboratory session.

2.3 | Pre-COVID lecture and dry laboratory sessions

Fifty-minute live faculty lectures were delivered to the entire class at 8:00 am each class day. Lectures typically focused on structural and functional topics related to the dissection activities scheduled for later that morning. Emphasis was placed on more conceptually difficult aspects of the structures and regions being studied during a particular Block. Other lectures focused on anatomy as encountered using various imaging approaches. Lecture materials (e.g., MS Power Point slides and Supplementary Material) were posted prior to the beginning of each Block to allow for preparation before each session. Lectures

were recorded and posted to our educational platform by the end of the day.

Dry laboratory sessions included small group, hands on activities with skeletal material and models, and other sessions designed as applied anatomy workshops. These later sessions consisted of small group exercises with students using their peers as subjects. In these sessions students would become familiar with anatomical structures, relationships and functions as they might be encountered in living individuals. The applied anatomy activities involve learning human anatomy (e.g., the texture and position of the thyroid gland, or the position and relationships of the radial artery at the wrist) by visual inspection, palpation and auscultation. Many of the applied anatomy exercises were modeled after techniques and procedures used in the typical physical examination with the focus being placed on anatomical structures and relationships rather than on diagnostic or therapeutic implications of elicited findings (McNamara & Nolan, 2022).

2.4 | Pre-COVID student assessment in anatomy

2.4.1 | Formative assessments

Formative assessment during the pre-COVID years include the italics questions described above and approximately 10–15 short answer questions included in the Guide for each Block. Performance on these questions was not factored into the final Block score.

A 1-h practice examination comprised of 25 questions similar in format to the summative examination was administered during Week 8 of each Block. All students were invited to attend the practice examination session. Questions were projected in the classroom with time provided to think about each question and arrive at an answer. Correct answers were then revealed and students were encouraged to ask questions if they answered incorrectly or if they felt unsure about the concept being tested.

2.4.2 | Summative assessment

The End of Block summative anatomy examination was comprised of approximately 50 questions written by the faculty to include a balanced number of questions addressing the stated learning objectives for the Block. The questions included an equal mixture of multiple-choice questions (MCQ's) and single answer fill-in-the-blank (FIB) questions. Approximately half of the questions of each type included an anatomical image with a single arrow to direct the student's attention to the focus of the question. Questions with images were of a variety of types ranging from lower-level questions such as "Name the structure marked by the tip of the arrow." (FIB) or "Which of the arteries listed below perfuses the structure marked by the tip of the arrow?" (MCQ), to higher order questions such as "Which of the following clinical finding would most likely be observed in a patient with injury involving the structure marked by the tip of the arrow?" (MCQ) or "On which side and in which intercostal space is the pulmonary

valve best auscultated?" (FIB). Questions without images were likewise formatted as either MCQ or FIB type questions. The majority of both types of questions were constructed as clinical vignettes using NBME guidelines. End of Block anatomy examinations were administered using Exam-Soft® and scored using Exam-Score® technology.

Success in the basic sciences component of the curriculum was based on performance on an End of Block examination for which students receive a grade of pass or fail. The examination is composed of two parts: a 50-question anatomy examination and an approximately 150 question examination comprised of questions obtained through the Customized Examination Program of the NBME focusing on the non-anatomy basic science content of the Block. The two parts of the examination are administered separately. Overall performance on the End of Block basic science examination was calculated with 20% contributed by the anatomy examination and 80% from the non-anatomy basic science examination. This course structure and examination approach was used for 4 years prior to our COVID modifications from academic year 2016–2017 to 2019–2020.

3 | CURRICULAR CHANGES IN RESPONSE TO COVID-19

With the COVID pandemic taking full effect in the spring of 2020, the anatomy faculty undertook a review of the anatomy curriculum during the summer of 2020 to determine how best to implement new federal and institutional mandates for academic year 2020–2021. Our review addressed the lecture and dry laboratory components, our dissection laboratory sessions and our assessment approaches and materials. We also addressed modifications needed to accommodate an increase in class size from 42 students to 49 students.

3.1 | Post-COVID modifications to the cadaver dissection laboratory sessions

Institutionally approved laboratory safety and utilization policies, which had been in place since the laboratory was initially opened in 2014, were updated to mandate both face masks and face shields for all users at all times while in the dissection laboratory. Spacing between cadaver tables was increased from approximately 6 feet in prior years to 12 feet for academic years 2020–2021 and 2021–2022. In addition, further distancing measures included usage of every other dissection table in the laboratory.

Maximum capacity for the dissecting laboratory which prior to COVID was 65 individuals which was now reduced to 32 persons. To address these space limitations, the class was divided into two groups of 24 students (group A) and 25 students (group B). Scheduling of dissection and dry laboratory sessions were arranged to ensure that students in both groups had identical amounts of time for these activities. Because of the hands-on nature of the applied anatomy workshops, these sessions were eliminated from the schedule.

Time allocated for laboratory activities which previously had been 3 h per week for all students over an 8-week Block (24 total hours per Block) was reduced to 90 min per group per week (12 total hours per student per Block). Group A dissected from 8:00 to 9:30 am and group B dissected from 10:00 to 11:30 am. The 30 min between 9:30 and 10:00 am was used to clean areas in the laboratory used by students and to perform routine maintenance of the cadavers.

The number of cadavers used was reduced from 12 in prior years to 7 in academic year 2020–2021, and to 14 in 2021–2022 with either 3 or 4 students assigned to each cadaver during each of the two dissection sessions. We continued to use prosected specimens prepared by 4th year students as part of our anatomy elective course requirements.

Because of the reduction in weekly overall dissection time for each student, it was necessary to review the Guide to ensure that assigned dissection tasks could be accomplished within the time available. Based on this review, some less critical and more time-consuming dissection activities were eliminated, retaining those judged by faculty consensus to be important for first year medical students. The elimination of some dissection tasks was accompanied by the elimination of the *italics* questions associated with those tasks, a result we were concerned about in light of the favorable responses we received previously regarding those questions. Among those dissection tasks deleted were those involving the hand, foot and face. These topics were, however, retained in the lecture series and recommended readings for the course.

3.2 | Post-COVID modifications to the lecture and dry laboratory sessions

Chief among the challenges were restrictions related to social distancing. Splitting the class into two groups for dissection left us with the challenge of what to do with those students who were not dissecting during the scheduled class time. Since the faculty would be in the dissection laboratory for two consecutive 90 min periods, they would not be available to deliver lectures or oversee dry laboratory activities. Our solution to this problem was to pre-record lectures. In previous years, lectures had been delivered live and posted to the educational platform in voiced-over MS Power Point and MP4 formats. Three new pre-recorded lectures were added, one on the hand, the foot and the face to address those topics previously covered but now deleted from the laboratory schedule. Students were encouraged to view these lecture materials during the part of the morning while not in the dissection laboratory.

The dry laboratory session activities were posted and students were asked to complete the exercises during the time on Tuesday's when not in the dissection laboratory, in small group settings, adhering to appropriate social distancing and masking directives. Answers to questions in the Guide were included in an Appendix. The exercises were accomplished without the physical presence of an instructor although all participating faculty were available by e-mail to answer inquiries outside of scheduled laboratory time. Not infrequently,

questions regarding these activities were raised with the faculty during the dissection laboratory sessions. We were careful to ensure that these activities could be accomplished within the time allocated for these activities.

3.3 | Post-COVID student assessment in anatomy

3.3.1 | Formative assessments

The practice examination administered during Week 8 and the italics questions used prior to COVID were continued for each Block during the two COVID years. In addition, we developed weekly quizzes composed of questions focusing on the material covered during the preceding week. These questions were developed to compensate in part for the loss of a number of italics questions, and to provide additional formative opportunities. The weekly quizzes were posted to the learning platform on Tuesday of each week following the laboratory session. The number of questions per week ranged from 8 to 15 resulting in over 330 questions for the entire course. In addition to providing answers to each question, we included explanatory comments indicating why the correct answer was correct and why an incorrect response was incorrect.

Students were encouraged to utilize these questions both as preparation for the weekly dissection laboratory session and/or as a review after completion of the session. Performance on these questions was not factored into the final Block grade.

3.3.2 | Summative assessment

We continued to administer the same End of Block anatomy examinations that we used during the pre-COVID years. The method for administering End of Block anatomy examinations was not altered as a result of COVID. Students continued to take the examination using their laptop in a room assigned for testing on the assigned day during examination week.

4 | RESULTS

Anatomy summative examination mean scores and ranges for all four Blocks for the 4 years prior to COVID and for the 2 years following implementation of COVID related changes to the anatomy curriculum are presented in Table 1. For Block I, the mean examination score for the 2 years following the implementation of COVID related changes was 70% with a range of 71% points (Table 2). For the 4 years immediately preceding COVID, the mean Block I examination score was 78% with a mean range of 44.75% points (Table 2). These results reflect an 8% decline in mean performance in Block I following COVID coupled with a 26% point larger range of scores for these years.

TABLE 1 Anatomy examination mean and range scores for pre- and post-COVID years

	Mean	Range
Block I		
AY 2016-17	80%	56%-95%
AY 2017-18	78%	48%-98%
AY 2018-19	77%	54%-96%
AY 2019-20	77%	48%-96%
AY 2020-21	70%	23%-94%
AY 2021-22	70%	40%-94%
Block II		
AY 2016-17	90%	79%-98%
AY 2017-18	85%	58%-98%
AY 2018-19	88%	69%-98%
AY 2019-20	86%	61%-98%
AY 2020-21	86%	59%-98%
AY 2021-22	88%	67%-100%
Block III		
AY 2016-17	90%	77%-98%
AY 2017-18	88%	79%-96%
AY 2018-19	92%	77%-100%
AY 2019-20	86%	71%-98%
AY 2020-21	87%	63%-100%
AY 2021-22	85%	62%-98%
Block IV		
AY 2016-17	80%	64%-94%
AY 2017-18	81%	50%-98%
AY 2018-19	81%	55%-95%
AY 2019-20	82%	56%-100%
AY 2020-21	85%	55%-100%
AY 2021-22	82%	59%-98%

TABLE 2 Pre- and post-COVID anatomy examination mean and range scores

	Mean	Range
Block I		
Pre-COVID	78%	44.75% points
COVID	70%	71.0% points
Block II		
Pre-COVID	87%	31.25% points
COVID	87%	39.0% points
Block III		
Pre-COVID	89%	24.5% points
COVID	87%	37.0% points
Block IV		
Pre-COVID	81%	40.5% points
COVID	84%	45.0% points

For Blocks II, III, and IV, the mean examination scores for the four Blocks prior to COVID ranged from 81% for Block IV to 89% for Block III, with the ranges varying from 24.5% for Block III to 40.5% for Block IV (Table 2). Following COVID, the average examination score ranged from 84% for Block IV to 87% for Blocks II and III, with ranges varying from 37% points for Block III to 45% points for Block IV.

5 | DISCUSSION

5.1 | Factors related to dissection laboratory sessions that might have affected examination scores

During the two COVID years, face-to-face interactions during scheduled dissection time was significantly reduced from 24 h per student per Block prior to COVID to 12 h for each student per Block for both years following COVID related changes. This reduction not only limited opportunities available for learning from dissection and interactions with their peers in this setting, but also eliminated time for live interactions with the faculty. This reduction may have affected the ability of some students to learn the material, particularly for topics that are conceptually difficult. Our data suggests, however, that if these reductions had an effect on examination performance in Block I, this influence of reduced dissection time was effectively overcome for Blocks II, III, and IV.

Some dissection tasks, specifically those involving unpaired organs such as opening the chest and extracting the heart or opening the cranium and removing the brain, could only be done one time. In these cases, only one group had the opportunity to perform the dissection. For several of these dissections, including brain removal and exposure of the spinal cord, we recorded and posted a video of the dissection which the students who did not do the dissection could view during the same time frame in which the dissection was occurring. The likelihood that the poorer examination scores for Block I were the result of a situation wherein half of the class was unable to participate in the actual dissections was greatly reduced by the fact that the dissection sessions in Block I involved paired structures. One-half of the students dissected the right upper and lower limbs while the other half of the class dissected the upper and lower limbs on the left side.

Several dissections were eliminated (e.g., the hand, foot and face) in an effort to maintain a reasonable work load for the allocated time. It is possible that despite this reduction in work load, the new work load was greater than could be effectively managed during the assigned time. It is possible also that had we not reduced the number of dissection tasks, the average examination score might have been somewhat lower.

5.2 | Factors related to lecture and dry laboratory sessions that might have affected examination scores

Anatomy lectures, previously delivered live, were now presented in a pre-recorded format. The use tracking feature of our educational

platform allowed us to determine how many times a particular lecture file was accessed, but does not permit us to identify students who accessed those lecture files or if lectures were watched completely from beginning to end. We therefore are not able to directly link use of the pre-recorded lectures with individual student performance on the examinations. We do know that access to these recordings was much lower than we expected; however, we were not particularly surprised by this observation in light of a reduction in lecture attendance that we have seen over the past several years, including several years prior to the COVID related changes. We are unable therefore to attribute the decline in Block I examination performance to a shift from live to pre-recorded lectures.

Among the adaptations commonly employed in response to COVID was the shift from live lectures and class sessions to remote learning approaches. Live interaction with the faculty were limited to scheduled class time in the dissection laboratory. Some students appreciate the ability to “attend lectures” without leaving their home or apartment, while others find this non-traditional learning setting less than ideal, presenting distractions that may have affected their ability to concentrate and focus their efforts. Contemporary student preferences regarding class attendance are well known and range from those who describe themselves as “home schoolers” to those who identify themselves as “class attenders.” We believe that some students may have adapted less well than others to limitations in time spent with the faculty and this factor must be considered when searching for explanations for changes in student performance on examinations.

Most students were able to perform the dry laboratory exercises independently, answer the brief associated questions and confirm their answers using a variety of available print and electronic resources. However, a few students who admitted to be less familiar with the material found that the activity would have been more effective had there been faculty present who could help with certain tasks and questions. Since these sessions involve activities similar to those used in the general physical examination, it is likely that students without some familiarity with these skills might have benefitted less from these activities than those with greater familiarity. Our previous experience with these sessions with faculty present is in full agreement with this belief. Whether the change from live sessions with faculty guidance affected examination performance is difficult to determine. However, our data from Blocks II, III, and IV again suggests that this change did not affect examination performance.

5.3 | Factors related to self-assessment materials that might have affected examination scores

The incorporation of weekly self-assessment questions was a new addition to our COVID curriculum. Tracking features of our learning platform (Canvas) allowed us to monitor some features of utilization of these questions over the course of the 8-week Block.

Our data reveal that these questions were accessed only infrequently during the first 6 weeks of a Block, but increasingly during

Weeks 7 and 8, suggesting that they were being used not as a means of immediate self-assessment, but rather as a method for assessing their cumulative understanding of the material as they approached the summative examination. This level of usage was seen in all four Blocks, suggesting that other approaches to examination preparation were more highly favored. Our data do not provide information on which students accessed the questions or how many times a particular student may have done so.

The influence of the use of these questions on student performance is difficult to determine. Our data from Blocks II, III, and IV suggests that students were successful in adapting to the various challenges associated with the COVID modifications; however, we cannot directly attribute this success to the use of these additional formative assessment questions. Considerable time and effort were expended in the writing of the questions and their explanations. In light of the overall reduced time available for face-to-face interactions, the explanations provided with these questions may have served as an indirect, though valuable means of providing instructional guidance for the students. Despite the absence of a measurable effect on student examination performance, we believe our work in developing these questions to have been worthwhile and beneficial.

5.4 | Factors related to the summative assessments that might have affected examination scores

For Block I, during both years following COVID mean examination scores were characterized by a drop in the mean score and a marked increase in the range of scores (Table 2). For Blocks II, III, and IV, summative examination scores and ranges varied little between the four pre-COVID years and the 2 years following COVID related curricular changes, suggesting that factors and challenges that influenced performance during Block I were for most students identified and effectively overcome for later Blocks. Our data suggests that despite offering a practice examination during the final week of the Block, and the availability of weekly self-assessment questions, students nonetheless performed less well on the Block I End of Block anatomy examination during the two post-COVID years than during pre-COVID years.

Examination data from Blocks II, III, and IV suggest that factors that contributed to the decline in Block I performance were identified and successfully overcome. We did not make any additional changes to the anatomy curriculum for the second post-COVID year beyond those made for the first post-COVID year that might have brought examination scores back to pre-COVID levels. Our observation that a similar decline in Block I performance during the second post-COVID year, but not for Blocks II, III, and IV, suggests that factors unique to Block I continued to influence examination performance.

Of these factors, we are able to identify several within the anatomy curriculum that may have contributed to this result. Those include reduced time to interact with faculty during the dissection laboratory, reduced scheduled dissection time per student, the

substitution of pre-recorded lectures for live lectures, and dry laboratory sessions without direct faculty participation.

5.5 | Factors not related to anatomy that might have affected examination scores

In addition to changes within the anatomy curriculum, other factors may have affected student performance on the Block I End of Block anatomy examination. The first set of examinations in medical school, the Block I examinations, typically represent a novel experience for most students. Students bring a variety of learning styles and study habits to medical school. Some of these approaches, while effective in prior educational settings, may be less effective in rigorous medical curricula where content may be heavy and available time may be relatively limited. Some students may rely more heavily on faculty-centered instruction or need more time with a particular learning approach (e.g., cadaver dissection). Others may be hesitant to seek help and guidance from a faculty new to them or may not take advantage of the various materials identified and/or developed by the faculty for their use. Some may have been guided by advice from peers or upperclassmen that may have been incorrect or not helpful for a particular student. Time management is not uncommonly a challenge for many medical students early in their careers. We believe it likely that a combination of these factors could have affected student performance in Block I to a greater extent than for Blocks II, III, and IV. While we recognize that the ability to quantitatively determine the influence of some of these factors is difficult, we are well aware from student comments on End of Block student surveys that these factors do influence student performance on examinations.

At VTCSOM, End of Block summative examinations are administered during Week 9 (examination week) of each Block of instruction during the 2 years of the preclinical curriculum. During this week, students take four separate summative examinations plus a single integrated case-based examination comprised of information from the basic science and clinical science (i.e., physical examination) content of the Block. The anatomy examination is one of two parts of the basic science examination and represents 20% of the calculated score with the non-anatomy content valued at 80%. Given this grading differential, some students prioritize their study time for the basic science examination based on this formula. Their argument being that it is better to spend more time preparing for the higher valued component of the examination. During Block I, in particular, this strategy for an unfamiliar examination can be risky and may result in scores that are unexpectedly lower than what the student had hoped. Students who have taken this approach and failed the basic science examination not uncommonly report that they used this approach and are not likely to carry it forward to subsequent Blocks.

An additional factor which we find to be frequently overlooked in discussions regarding examination performance relates to the first-year medical curriculum overall. That is, what other courses do the students participate in concurrently, what are the time and effort commitments of those courses, what other summative examinations might students be taking, and at what intervals? When considering factors that can affect examination performance it is necessary to recognize that these

factors, particularly when they change suddenly and may be new or unfamiliar to the student as most certainly occurred in response to COVID, may increase or reshape the workload in such a way that performance is affected. The effects of change can be cumulative and may create new and challenging problems regarding time management and the allocation of effort. It is incumbent on the faculty of all courses running concurrently during a particular Block, term or semester to be aware of the expectations each may be placing on the students and create learning objectives and activities that are achievable by the students. Failure to do so may place a level of stress on students that can interfere with effective learning.

Our results over consecutive academic years based of summative examination scores demonstrate that despite course changes developed to accommodate COVID related safety mandates, students nonetheless scored well below their predecessors on their first anatomy examination. We found that scores on the three subsequent anatomy examinations during the remainder of the course were comparable to those for several years prior to implementation of COVID related changes. We attribute the decline in performance on the first examination only to an interaction of multiple factors, both within the anatomy curriculum and within the overall first year curriculum that were novel and challenging for first-year medical students. That the scores on subsequent examinations were comparable to scores obtained for pre-COVID years indicates that students were able to successfully adapt to a modified learning environment.

Importantly, our results call attention to the multifactorial influences that can affect student performance on examinations in a novel and challenging curriculum, and the ability of the students to identify specific challenges and adapt to them successfully. We emphasize the importance of addressing the full spectrum of curricular changes and their interactive effects when attempting to link particular outcomes, in this case anatomy examination scores, with those changes.

6 | LIMITATIONS

This paper describes the changes made in one anatomy curriculum to incorporate safety mandates associated with the COVID pandemic. These changes were designed for a particular course within particular medical curriculum. We recognize that medical curricula vary greatly in structure and organization as do specific courses within the curriculum, and that our modifications might not be appropriate for other schools. We believe, however, that student responses to curricula that may be unfamiliar or novel are likely to differ based on a variety of factors and that it is important for faculty to identify, understand and effectively address these issues in order to maintain the high expectations and level of success both our students and the public expects of our medical education programs.

7 | CONCLUSION

The drop in the average student performance on the Block I End of Block anatomy examination following COVID related instructional

modifications suggests that some students were less successful than others in adapting to the changes in the curriculum, including those made to the anatomy curriculum. Changes and modifications across the curriculum, likely in combination, contributed to the performance declines observed in Block I. Our data indicate that despite the challenges faced during the first Block of instruction, students were able to adjust their behavior and approaches for Blocks II, III, and IV, such that performance during these Blocks was comparable to that observed during the 4 years prior to implementation of COVID mandated changes. Our experience suggests that adaptations made in a single course may not fully explain changes in examination performance for that course. A return to pre-COVID levels of performance, despite continuance of COVID related curricular changes, highlights the ability of students to adapt to challenges associated with a changing learning environment.

ORCID

John Patrick McNamara  <https://orcid.org/0000-0002-5178-7750>

Michael F. Nolan  <https://orcid.org/0000-0002-9177-4276>

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