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Characterizing the Successful Student in Virtual Gross Anatomy

(Running Title: Success in Virtual Gross Anatomy)

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Abstract

The coronavirus disease 2019 (COVID-19) pandemic abruptly shifted the Lake Erie College of Osteopathic Medicine's (LECOM) pre-clinical curriculum to a virtual format, including that of the anatomical sciences. As anatomy is so fundamental to clinical medicine, we sought to identify characteristics and behaviours influencing success in the 2020 virtual cohort of human gross anatomy. This data will inform student support in gross anatomy as the pandemic progresses and eventually resolves. First-year medical students at the Erie, Seton Hill, and Elmira campuses of LECOM were surveyed about personal wellbeing, academic habits, and examination preparation. Survey responses were compared to students' final cumulative gross anatomy grade, identifying contributors to success in the course. Final course grade increased with life satisfaction, support system strength, self-perceived merit, comfort admitting academic difficulties, and seeking appropriate academic assistance. Concentrating fully while studying, taking ten-minute study breaks, and self-generating test questions were also associated with increased final grade. Additionally, students completing undergraduate studies 0-2 years prior to matriculation performed significantly better than their peers. Cramming, fear of failure, test-tasking anxiety, study routine changes prior to examinations, poor adherence to study schedules, and studying in groups were associated with decreased course grade. Final grade also decreased when students reported difficulty identifying main ideas and understanding test questions. Interestingly, reporting an awareness of mental health resources at our institution was associated with decreased final course grade. Identification of these correlates to success will allow for proper support of our students in a virtual environment complicated by pandemic stressors.

Keywords: Anatomy; medical education; student success

Introduction

Human gross anatomy is one of the first challenges posed to incoming medical students at the Lake Erie College of Osteopathic Medicine (LECOM). While traditionally a face-to-face lecture with complementary cadaveric dissection, the coronavirus disease 2019 (COVID-19) diverted students to a virtual educational format. This diversion posed unique challenges to learning human gross anatomy, which relies heavily upon visuospatial reasoning [1-4]. Though felt acutely at our institution, this radical shift was by no means unique. Anatomists across the globe responded readily and creatively to this abrupt shift, the details of which can be found in numerous publications [1,4-7]. Preliminary data from these adaptations demonstrates a mostly positive response from students, at least in the short term [4]. However, these studies fail to identify how students have maintained successful learning within these virtual adaptations.

Virtual education has been a lifeline during times when face-to-face encounters pose infection risks, however, it is not without its challenges [8]. Online learning, especially asynchronous courses, increases student feelings of isolation and disrupts senses of community [9-10]. Anatomy-specific virtual learning is often complicated by a limited two-dimensional display of three-dimensional structures [11-12]. Additionally, the cognitive load of navigating unfamiliar material in an unfamiliar virtual terrain exacerbates the challenges described above [7,13-14]. Combined with the negative effects of the pandemic on student wellbeing and motivation, successful anatomy education was particularly susceptible to compromise [15].

This threat to anatomical education prompted our investigation of student success during the 2020 cohort of human gross anatomy at LECOM's three northern campuses. Particularly, we aimed to characterize the behaviours and attitudes that contributed to student success in gross anatomy, despite the stressors associated with virtual learning in a pandemic. Pre-pandemic medical education literature has provided a rich source of best practices for effective student learning and study techniques. For example, numerous studies suggest that active recall, spaced repetition, and self-testing are all essential to academic success [16-19]. In contrast, passive learning methods such as re-reading lecture handouts and notes are generally associated with poor academic performance, compared to more active techniques [12,20]. Prior investigations also indicate that delivery format of gross anatomy courses is not as important as prior academic performance in predicting student success [21]. Additionally, wellness literature emphasizes the often-overlooked role that mental health plays in ensuring student success [22-24]. As the aforementioned reports were generated before the COVID-19 pandemic, recent educational shifts grant an opportunity to determine if these factors remain predictive of learning success in a virtual format complicated by the stressors of the pandemic.

This study investigates how student demographics, education and professional background, wellbeing, and study methods differ between high and low performers during the virtual 2020 cohort of human gross anatomy at our institution. We hypothesize that students with an undergraduate degree in the biological sciences will have a higher gross anatomy grade than those who do not. We also expect gross anatomy grades to increase as the time between completion of undergraduate studies and matriculation to medical school decreases. Past work or volunteer experience in healthcare is predicted to be more frequently present in students with higher final course grade. Students who report behaviors and characteristics consistent with high levels of wellbeing and academic confidence are hypothesized to perform better than those without such qualities. Finally, students who report higher frequency of using evidence-based study methods, such as self-testing and proper scheduling, are hypothesized to perform better than students who do not exhibit such behaviors. Several of the identified factors are readily modifiable and therefore provide opportunity for intervention of at-risk students.

Methods

Gross Anatomy in the LECOM Curriculum

LECOM Erie is composed of three, geographically separated campuses: Erie, Seton Hill, and Elmira. First year medical students at all three locations synchronously take the human gross anatomy course during the first 12 weeks of the fall semester. Human gross anatomy is a comprehensive course, containing both lecture and lab components, and is worth 9 credits. During this twelve-week period, embryology and histology lectures complement the gross anatomy curriculum. Due to the COVID-19 pandemic, the traditional in-person format was shifted to a virtual environment.

The gross anatomy course consisted of approximately 93 hours of lecture, which were live streamed to students at the Erie, Seton Hill, and Elmira campuses via Zoom. Fortunately, lectures and other academic materials were frequently exchanged between campuses through virtual meetings and the online portal even prior to the COVID-19 pandemic. Therefore, LECOM benefited from a pre-existing distance learning infrastructure. Students could view lectures at their homes or in designated, socially distanced areas on campus. In addition to traditional lectures, these hours included interactive forums and question-and-answer sessions to enhance comprehension. All lectures were recorded and uploaded to a digital repository, allowing students to re-watch them if desired. Virtual attendance to all lectures was mandatory. Despite the virtual format, lecture content and structure remained largely unchanged from pre-pandemic cohorts.

Approximately 36 hours of virtual lab instruction complemented the didactic components of gross anatomy. Lab instruction was distance-based, and students could log into Zoom meetings from a location of their choice. Students were placed into Zoom breakout rooms as small groups of approximately ten members and staffed with a professor or graduate teaching assistant to facilitate discussion. The lab sessions began with a pair of students providing a short presentation on the topic of that lab, followed by group discussion of associated anatomical atlas images. The lab sessions concluded with a short, five-question quiz pertaining to the material covered in lab. Again, virtual attendance to all lab sessions was mandatory. Graduate teaching assistants provided short, pre-recorded, instructional videos of prosected cadaveric specimens to reinforce topics learned in each laboratory session. Each LECOM student also received access to Acland dissection videos via the school's online portal system. Due to the provided resources and individualized nature of laboratory sessions, small group sessions were not recorded for later viewing.

Resources Provided to LECOM Students

All lecture materials were distributed prior to lecture and students could view recorded lectures after attendance, as previously specified. Anatomy faculty also compiled practice exams for both lecture and laboratory material for student exam preparation. These practice exams are complemented by short review podcasts developed by the course director. The anatomy faculty also compiled a compendium of clinical correlates to anatomical concepts learned in lecture, along with summary sheets of specific concepts (e.g. myotomes and cranial nerve pathways). LECOM also provides students with access to Acland dissection videos. To help students prepare for laboratory sessions, graduate teaching assistants prepared short videos for the topics to be covered in lab, including prosecutions of the particular body region.

Assessment

Anatomical knowledge was assessed through multiple exams and quizzes. Quizzes were periodically administered to assist students in measuring progress with exam material. The largest weight in the course was given to three regional exams (back and extremities, cavities, head and neck). All students completed the National Board of Medical Examiners anatomy shelf exam at the conclusion of the course. Practical exams were conducted virtually, utilizing images from anatomical atlases as the virtual equivalents of prosecutions. All exams were taken at the students' homes on their personal computer through a secure browser. Practical examinations ended with a short oral examination, worth only a small portion of the student's overall exam grade. These oral examinations consisted of ten questions and were conducted via Zoom. Finally, a small portion of the student's grade was derived from their performance as peer teachers, assessed during their presentations at the beginning of lab sessions.

Data Collection

The data presented in this study is derived from an investigation of medical students participating in the human gross anatomy course at LECOM in the 2020 fall semester. Initial survey development included two medical students and two professors at LECOM, both with extensive experience in educational research. Survey items were primarily based on student success factors reported in a review of primary medical education literature. The combination of perspectives and expertise promoted validity of the survey. Survey questions then underwent several rounds of review and revision. Finally, survey items were reviewed by three administrators at our institution with extensive experience in medical education.

Demographic information collected by the survey included: student ID number, learning pathway, age, gender identity, undergraduate major and year of graduation, and experiences prior to matriculation. Students were then asked how much time they spent studying on weekdays, as well as weekends, in addition to the characteristics of their breaks during those study periods. Students were requested to identify a primary study method, as well as reporting any secondary methods they used. Some survey items were targeted to how students dealt with difficulties or stress. For example, students were asked whether they have sought academic help at LECOM. Additionally, they were asked to provide examples of how they coped with the stress of medical school. Lastly, students were asked if they were aware of mental health resources at our institution and whether they agreed that LECOM provides adequate mental health resources to students.

The remainder of the survey consisted of questions, detailed in Tables 1 and 2, that evaluated the student's wellbeing, academic confidence, and study techniques. Responses were provided on a Likert scale ranging from "not at all typical of me" to "very typical of me," with "not very typical," "somewhat typical," and "fairly typical" as intermediates. The 57-item survey was distributed to the students after completion of the human gross anatomy course via Survey Monkey. Participation in the study was entirely voluntary and was not incentivized. Not all participating students responded to all survey questions, leading to variability in sample size depending on the survey item.

The principal investigator linked survey responses to final gross anatomy course grades, then immediately deidentified the data. Prior to survey administration, institutional review board approval was given to conduct this study (Lake Erie College of Osteopathic Medicine IRB Protocol 27-067). A copy of our survey is included in the supplemental material of this report.

Statistical Analysis

Statistical analysis was performed using Prism 9 software. Descriptive statistics were first generated to summarize survey response data based on response groups. The D'Agostino-Pearson normality test indicated that our data was non-parametric. Therefore, the Mann Whitney U and Kruskal-Wallis tests were used as appropriate. Kruskal-Wallis tests were followed by Tukey's B post hoc analysis for multiple comparisons. Finally, the correlation between student age and final anatomy course grade was evaluated with a Spearman rank test. We used an alpha of 0.05 to determine statistical significance.

Results

Educational Background and Demographics

Of the 493 medical students invited to participate, 141 students submitted survey responses for a response rate of 28.6%. The medical students in this study had a mean age of 24.7 years and 57% of respondents were female. The age of respondents was consistent with the national average for matriculating medical students in 2019, whereas more respondents were female compared to 51.9% for osteopathic medical schools on average [25-26]. Overall, the mean final course grade for the 2020 gross anatomy cohort was 87% with a standard deviation of 9.1%. No significant correlation was found between age and final grade in gross anatomy (r (140) = 0.08386, p = 0.3240). Additionally, no significant difference in final course grade was found between male and female students (U (140) =2042, p =0.1220).

Students were asked to report their undergraduate majors, which were then categorized as biological science (n =98); science, non-biological (n =32); non-science (n =5); and allied health (n =6). Allied health majors included emergency medicine, nursing, and physician assistant studies. Cumulative final grade did not differ amongst these groups (H (3) =5.042, p =0.1688). Prior job or volunteering experience was stratified into healthcare (n =81); non-healthcare, non-science (n =22); science (n =21); and none (n =16). No difference in final course grade was found between these groups (H (3) =1.422, p =0.7003). Students were also stratified into three groups based on the amount of time elapsed since completion of undergraduate studies: 0-2 years (n =91), 3-4 years (n =20), and 5+ years (n =24). Students who graduated 0-2 years prior to matriculation earned a higher final grade (89%) than students graduating 3-4 years prior to matriculation (84%) (H (2) =7.569, p =0.0227). Students 5+ years beyond undergraduate completion earned the highest median grade (90.5%) compared to the 0-2 years and the 3-4 years post-undergraduate groups, though this difference did not achieve statistical significance.

Student Wellness and Academic Confidence

The initial portion of the survey evaluated wellbeing and academic confidence. Students were first asked whether they agreed with the statement, "LECOM values and provides adequate mental health support for students," using a five-point Likert scale. No difference was found when responses were compared to final grade (H (4) =1.373, p =0.7120). In contrast, when asked whether they were aware of the mental health resources our institution provides, students who responded "no" had a significantly higher median course grade (90%) compared to those who answered "yes" (84%) (U (138) =1089, p <0.0001).

See Table 1 for statistical analysis of the remaining student wellness and academic confidence items. Increased overall life satisfaction and reporting a strong support system were both associated with higher final course grade. Additionally, self-perceived merit was evaluated when students were asked whether they deserved to be in medical school. Those who responded that it was "very typical" of them to feel they deserved a spot in medical school achieved significantly higher final grades than all other groups. Similarly, students who reported that they rarely worried about failing out of medical school had significantly higher final grades compared to those who frequently had such fears. Those who had fears of failing while taking exams also had significantly lower final grades compared to those who rarely had such fears. In contrast to the negative effects of fearing failure, students who reported that test anxiety was a "somewhat typical" experience achieved the highest final grade, though this difference did not reach statistical significance. Comfort admitting academic difficulties and seeking appropriate assistance were both associated with increased final grade. However, Tukey's B post hoc analysis did not reveal significant differences between individual groups.

Table 1: Statistical analysis of student wellness, academic confidence, and final cumulative gross anatomy grade.

	Not at all typical of me	Not very typical of me	Somewhat typical of me	Fairly typical of me	Very typical of me	Kruskal-Wallis *H* (df); *p*	Tukey's B post hoc analysis
	Median (CI) N	Median (CI) N	Median (CI) N	Median (CI) N	Median (CI) N		
Even when I am well prepared for a test, I feel very anxious.	89 (74.3-95.4) 7	86.5 (86.1-91.4) 20	93 (87.1-92.4) 32	89.5 (84.2-89.8) 38	86.5 (84.1-88.8) 40	4.492 (4); 0.3435	n/a
I am much more stressed than I was before medical school.	81 (63.17-100.8) 4	92 (88.04-95.13) 12	91 (85.82-91.41) 26	91 (86.09-91.85) 32	87 (84.14-88.08) 63	8.281 (4); 0.0818	n/a
I am not comfortable asking for help from my instructors in my courses.	91 (85.66-93.44) 20	90 (87.34-91.38) 50	88.5 (84.2-89.2) 40	87 (78.79-88.15) 17	85 (82.48-88.92) 10	10.7 (4); 0.0301	n/a
I am performing at the same level as my peers.	81 (63.17-100.8) 4	92 (88.04-95.13) 12	91 (85.82-91.41) 26	91 (86.09-91.85) 32	87 (84.14-88.08) 63	8.281 (4); 0.0818	n/a
I am satisfied with my current state of life.	85 (69.71-94.29) 6	85.5 (80.52-89.59) 18	86 (82.09-88.03) 35	90 (87.68-90.87) 51	93 (88.47-93.85) 25	12.85 (4); 0.012	"Very typical" differs from "Somewhat typical"
I deserve to be in medical school.	80 (68.38-89.62) 6	79 (74.4-89.8) 10	85 (82.12-88.88) 30	88 (85.86-89.25) 54	93 (91.11-93.92) 35	24.57 (4); <0.0001	"Very typical" differs from all other groups
I have a positive attitude about attending my classes.	93 (73.85-104.2) 4	87 (78.45-92.22) 12	87 (85.79-90.44) 27	87 (84.04-88.58) 55	90 (87.67-92.02) 38	4.678 (4); 0.3219	n/a
I have a strong support system.	84 (n/a) 1	86.5 (73.56-95.11) 6	80 (73.95-88.49) 9	86 (83.34-88.88) 35	90 (87.67-90.65) 86	10.03 (4); 0.0399	n/a
I worry that I will fail out of school.	93 (89.79-93.23) 43	87.5 (85.65-90.41) 34	87 (84.07-90.11) 23	81.5 (77.8-86.8) 20	86 (79.54-88.22) 17	21.78 (4); 0.0002	"Not at all typical" differs from "Somewhat typical" and "Very typical"
It is normal for me to be stressed in medical school.	73 (n/a) 1	96 (n/a) 1	91 (86.14-93.11) 16	90 (86.5-90.53) 58	87 (84.29-88.37) 61	7.457 (4); 0.1136	n/a
My family and friends are expecting me to succeed in medical school.	n/a	n/a	91 (80.36-95.07) 7	88 (85.63-90.43) 30	89 (85.85-89.11) 100	0.007965 (4); 0.996	n/a
My personal relationships interfere with my academic responsibilities.	89 (86.35-90.65) 48	87.5 (84.68-89.36) 58	91.5 (85.94-92.39) 18	84 (76.74-89.93) 6	85 (83.3-88.99) 7	5.11 (4); 0.2762	n/a
Other students fuel my stress.	89.5 (84.78-91.72) 24	90 (86.75-91.49) 41	86 (83.51-88.95) 30	85.5 (79.19-88.61) 20	89.5 (87.19-91.54) 22	6.13 (4); 0.1897	n/a
The cost of my education is a major concern.	89 (84.42-90.36) 31	89 (85.61-89.89) 36	90 (86.12-91.45) 28	86 (82.45-89.47) 27	94 (82.87-94.2) 15	2.857 (4); 0.5821	n/a
When I am struggling in one or more courses, I am too embarrassed to admit it to anyone.	90.5 (82.19-92.31) 16	91 (87.9-91.25) 70	87 (81.59-89.05) 25	86 (81.13-88.17) 17	85 (81.21-88.79) 9	11.47 (4); 0.0218	n/a

When I am taking a test, worrying about doing poorly interferes with my concentration.	93 (88.12-93.65) 27	89.5 (87.38-91.52) 38	90 (84.88-90.56) 32	85 (80.69-88.07) 21	84 (78.12-85.99) 18	19.61 (4); 0.0006	"Not at all typical" differs from "Somewhat typical" and "Very typical"; "Not very typical" differs from "Very typical"
Abbreviations: CI = 95% confidence interval							

Study Technique

The final portion of the survey inquired about students' study techniques and attitudes. No significant difference was found in final course grade when students were stratified into groups according to hours spent studying during a weekday (H (4) =1.211, p =0.7503). Student responses were as follows: 0-1 hours (n =1), 2-4 hours (n =20), 5-6 hours (n =54), 7-8 hours (n =20). Similarly, no significant difference was found in final grade when students were stratified into groups according to how many hours they studied during a Saturday or Sunday (H (4) =2.514, p =0.4727). Student responses were as follows: 0-1 hours (n =1), 2-4 hours (n =3), 5-6 hours (n =27), 7-8 hours (n =44). The frequency with which students reported taking breaks while studying was not associated with a difference in final grade, however, the length of those breaks did breach significance. Students who took 10 minute-breaks achieved a higher course grade (92%) compared to students who took 40 minute-breaks (85%) (H (3) =10.66, p =0.0137).

Students were also stratified according to their primary study method. Differences in median final course grade did not breach statistical significance when compared via Kruskal-Wallis test. Primary study methods were as follows: review lecture slides (n =25), read the textbook (n =6), rewatch lectures (n =4), rewrite lecture slides (n =4), make study guides (n =20), use pre-made flashcards (n =24), creating their own flashcards (n =9), using practice questions (n =11), quizzing with a partner (n =10), self-teaching (n =24), other (n =1).

See Table 2 for statistical analysis of the remaining study technique items. Cramming for exams, last-minute changes to study routines, and poor adherence to study schedules were all associated with lower median final grades. Additionally, studying in groups was associated with a significantly lower final course grade. Despite this association, studying alone was not associated with an increased final grade. Students who reported concentrating fully while studying achieved higher final grades, though Tukey's B post hoc analysis was not significant. The practice of generating possible test questions was associated with a significantly higher median final grade. This effect was not replicated when students were asked about self-testing in general. Difficulty identifying main ideas was associated with a decreased final course grade, as was difficulty deciphering examination questions.

Table 2: Statistical analysis of study technique and final cumulative gross anatomy grade.

	Not at all typical of me	**Not very typical of me**	**Somewhat typical of me**	**Fairly typical of me**	**Very typical of me**	**Kruskal-Wallis *H* (df); *p***	**Tukey's B post hoc analysis**
	Median (CI) *N*	**Median (CI) *N***	**Median (CI) *N***	**Median (CI) *N***	**Median (CI) *N***		
I can grasp the material during lecture.	89 (77.28-93.58) 7	88 (83.56-90.44) 25	87 (85-89.47) 43	89 (85.58-90.24) 44	93 (85.18-93.82) 18	2.895 (4); 0.5755	n/a
I concentrate fully when studying.	83 (n/a) 1	77.5 (60.09-93.41) 4	89 (84.34-91.11) 22	88 (85.6-88.95) 77	91 (87.03-92.54) 33	10.02 (4); 0.04	n/a
I end up "cramming" for every test.	93 (87.05-93.33) 21	90 (86.87-91.06) 55	89 (84.08-89.92) 32	89 (85.36-90.03) 39	85 (82.13-86.94) 28	12.88 (4); 0.0119	"Very typical" differs from "Not very typical" and "Not at all typical"
I find it hard to stick to a study schedule.	92.5 (88.95-93.95) 20	87.5 (84.63-89.71) 46	89.5 (86.31-90.63) 36	84 (79.89-87.05) 17	90 (81.83-91.5) 18	10.94 (4); 0.0273	"Not at all typical" differs from "Fairly typical"
I have difficulty identifying the important points in my reading.	94 (85.72-94.59) 13	91 (87.71-91.95) 47	87.5 (85.28-89.14) 48	85 (79.91-88.28) 21	84 (74.14-90.11) 8	12.44 (4); 0.0144	n/a

I have trouble understanding exactly what test questions is asking.	91 (87.04-93.33) 27	90 (86.66-90.21) 65	86 (83.01-88.44) 29	82.5 (76.36-88.47) 12	86.5 (71.25-101.3) 4	10.95 (4); 0.0271	n/a
I often study alone.	75 (50.78-113.9) 3	87 (62.34-115) 3	86 (83.27-89.95) 23	89 (83.63-89.34) 33	90 (86.87-90.31) 75	3.108 (4); 0.54	n/a
I often study in groups.	91 (87.37-92.45) 33	87 (85.21-90.53) 39	89 (85.39-89.58) 37	84 (77.52-87.11) 16	89 (83.37-94.45) 11	10.11 (4); 0.0387	"Not at all typical" differs from "Fairly typical"
I pay attention in lecture.	89 (77.93-96.74) 3	82.5 (74.02-91.98) 6	92.5 (86.22-93.58) 20	87 (84.32-88.79) 54	89 (86.22-90.54) 50	5.362 (4); 0.2521	n/a
I review my notes before the next class.	88.5 (84.15-91.29) 18	89 (86.09-90.94) 33	87 (84.92-88.98) 56	91.5 (84.17-92.73) 20	93 (78-95.77) 9	2.239 (4); 0.6918	n/a
I stop periodically while reading and mentally go over or review what was said.	75.5 (56.53-99.47) 4	87.5 (81.64-91.16) 10	86 (85.49-90.38) 31	89 (85.42-89.64) 57	91 (86.27-91.55) 35	4.417 (4); 0.3525	n/a
I test myself to see if I understand what I am studying.	91 (n/a) 1	84 (61.02-98.31) 3	86 (85.34-89.13) 47	90 (84.96-89.86) 56	89 (86.78-92.05) 29	5.616 (4); 0.2297	n/a
I translate what I am studying into my own words.	92 (63.06-109.9) 4	84 (80.53-88.04) 14	90 (83.23-89.97) 25	87 (85.15-89.33) 46	91 (87.29-91.84) 48	9.139 (4); 0.0577	n/a
I try to find relationships between what I am learning and what I already know.	n/a	91 (69.38-105.6) 4	87 (80.14-91.14) 14	86 (84.47-88.25) 59	90 (87.28-91.23) 59	5.804 (4); 0.1216	n/a
In the last hour, I decided to change an aspect of my study routine.	90.5 (87.17-91.27) 50	89 (85.76-89.94) 53	88.5 (84.71-90.71) 24	77.5 (72.22-86.28) 8	73.5 (67.15-79.85) 2	14.37 (4); 0.0062	"Not at all typical" differs from "Fairly typical"
To check my understanding of the material in a course, I make up possible test questions and try to answer them.	84 (81.75-89.11) 21	85.5 (83.66-88.34) 44	91 (87.08-92.22) 34	87.5 (84.47-90.33) 30	94.5 (90.66-98.09) 8	14.1 (4); 0.007	"Very typical" differs from "Not very typical" and "Not at all typical"
To help me remember new principles we are learning in class, I practice applying them.	81 (-46.06-208.1) 2	90 (81.21-95.36) 7	85.5 (84.04-88.36) 40	89 (85.96-89.98) 61	91 (85.74-92.7) 27	5.774 (4); 0.2167	n/a
When I do not understand how to use a method or procedure presented in one of my courses, I ask another student to teach me so that I can do it on my own.	90 (82.1-94.07) 12	92 (85.52-92.58) 21	89 (86.29-90.71) 38	90 (85.01-89.87) 43	85.5 (81.12-88.79) 22	3.729 (4); 0.4439	n/a
When it comes to studying, procrastination is a problem for me.	89.5 (82.54-90.96) 16	90 (85.85-90.33) 57	87 (85.32-89.59) 33	90 (81.95-93.91) 14	85 (83.33-90.43) 17	2.232 (4); 0.6931	n/a

When studying, I seem to get lost in the details and miss the important information.	87 (82.9-93.1) 13	90 (87.24-90.73) 69	89 (84.78-89.76) 37	84.5 (78.59-88.27) 14	85 (63.79-97.21) 4	8.724 (4); 0.0684	n/a
Abbreviations: CI = 95% confidence interval							

Discussion

In this study of LECOM medical students, we identified several behaviours and attitudes contributing to success in gross anatomy during the COVID-19 pandemic. Many of these factors are observable in successful medical students prior to the COVID-19 pandemic while attending in-person programs. Therefore, this study provides insight into supporting gross anatomy students in both face-to-face and virtual environments. These results also provide a springboard for deeper and more specific investigation of factors contributing to success in virtual gross anatomy cohorts.

Education Background and Demographics

Medical schools in the United States attract students from a variety of backgrounds. Numerous studies have confirmed that undergraduate major does not influence success in medical school [27-29]. These findings were consistent with our virtual cohort of gross anatomy. Additionally, prior work and volunteer experience did not affect student success in the course. A similar investigation of histology students at the University of Michigan also found that past work experience did not affect students' final grades [30]. While length of time between undergraduate completion and matriculation did not affect student success in histology at the University of Michigan, a significant increase in gross anatomy grade was associated with attending medical school 0-2 years after undergraduate completion in our study [30]. We hypothesize that this effect is explained by the proximity to pre-medical courses taken during college, as well as familiarity with current educational technology. Though not statistically significant, those who finished undergraduate degrees 5+ years ago achieved the highest median final grade in gross anatomy compared to the 0-2 years and the 3-4 years post-undergraduate groups. This effect may be due to increases in emotional intelligence and maturity that ameliorate the stress of virtual learning during the pandemic [31-33].

Student Wellness and Academic Confidence

Negative consequences of mental distress on academic performance in medical students have been well documented [22-24]. The effects of mental distress demonstrated in our report mainly center on impaired academic confidence. As general indicators, students reporting greater life satisfaction and strong support systems exhibited superior academic performance in gross anatomy than those who did not, consistent with our current understanding of medical student wellness [22]. Interestingly, students with increased awareness of mental health resources at our institution had significantly lower final grades compared to those without such awareness. It may be that students with mental health issues have greater interaction with mental health resources. Poor academic performance is thus pursuant of their mental health issues rather than mental health resource knowledge. Increased fears of "failing out" and doing poorly on exams were associated with lower final anatomy grades. A cursory review of the literature demonstrates this fear is not unique to medical students during the pandemic [34-35]. However, the unique demands placed on those in medical fields may exacerbate any pre-existing internal expectations of performance [34,36]. Fear of failing may also reflect a student's correct interpretation of poor academic performance, thus resulting in an association with lower final grade. Deeply intertwined with fear of failure is a student's sense of deserving a place in medical school. Our data suggest that students who feel they deserve to be in medical school perform significantly better in gross anatomy than those who do not. Again, this effect of self-merit is not unique to medical students during a pandemic [37-39]. Like fear of failure, however, such feelings of inadequacy may have been exacerbated by the psychological burden of the pandemic [36].

Though fears of failure and feelings of inadequacy negatively impact academic performance, such feelings may also preclude students from seeking help. A report of student pharmacists found that help-seeking was most prevalent in students who had greater self-perceived academic confidence [40]. Thus, students who perceive themselves as academically struggling with gross anatomy content may be less likely to seek academic support [34,41-42]. This hypothesis is supported by the significant decrease in final course grade associated with low comfort seeking help and frequent feelings of embarrassment when struggling academically in our student population. The feelings of isolation associated with a virtual education may have also limited students' comfort with seeking help from professors or instructors [10].

Study Practices and Technique

Several study techniques were demonstrated to modify student success during virtual gross anatomy. Cramming immediately prior to examinations was associated with a significant decrease in final course grade, consistent with most educational literature [43-45]. This increase in cramming is likely associated with last-minute study routine changes and is an extension of difficulties adhering to pre-developed study schedules, echoing the results of cramming on the students' final grades [43].

Even students who can maintain focus and adhere to study schedules do not have inexhaustible study potential [46]. Despite this limitation, there was not a significant difference in final grade when students were compared based on break frequency during study periods. This is at odds with literature on the effects of rest on vigilance tasks, however, this may be explained by the very small proportion of students (3%) who reported that they did not take breaks [47]. Most of our students (40%) reported taking a break every sixty minutes. Examining length of break revealed that students taking ten-minute breaks scored significantly higher than those students taking forty-minute breaks. This is consistent with reports that taking breaks improves performance, though the decrement in performance when returning to a task increases with the length of break [48]. As expected, full concentration during non-break study periods is essential for optimal performance [49].

Studying in groups was associated with a significantly decreased final gross anatomy grade. While this finding is informative, it may reflect the difficulties of small group interactions in a virtual environment rather than ineffectiveness of group study [50]. Crouch and Mazur's work demonstrating a significant improvement in comprehension when implementing peer instruction lends support to this interpretation [51]. Though studying alone was not associated with higher gross anatomy grade, reports on histology study techniques indicate that most medical students actually prefer to study alone [30]. Further research is thus required to determine whether solo or group study sessions are most beneficial in the virtual setting. Overall, these findings are of limited applicability due to restrictions on social interaction that were in place during the COVID-19 pandemic.

The testing effect has demonstrated continual efficacy in knowledge acquisition and retention [16,52]. Karpicke and Roediger's data confirm these principles by demonstrating a lack of recall improvement after repeated encoding in contrast to the remarkable improvement when students practiced serial retrieval [16]. An interesting development in our study was that testing was only associated with an increase in final grade when the students generated questions themselves. This indicates that the testing effect requires a deep interaction with the material for optimal benefit [17-19].

Students who reported difficulty identifying main ideas earned significantly lower grades than those who did not have such difficulties. These students may be suffering from cognitive overload, in which the bandwidth of working memory is outstripped by the information that must be engaged [53]. Though lectures were largely unchanged during the pandemic, the decreased interaction with professors may have limited the students' ability to identify salient features of gross anatomy content. Cognitive overload may also account for the lower grades among students who had difficulty understanding what a question was asking of them, leading to disorganized mental schema and impaired information utilization.

Overall, it appears that educational behaviours contributing to success during a typical school year continue to provide benefits for students during the pandemic. Accepted, evidence-based study behaviours should continue to be supported as gross anatomy embraces online learning. Special attention should be given to group learning, however, as this appears to be particularly susceptible to compromise during the pandemic, leading to impaired academic performance.

Limitations

While providing useful information and insights into the success of a virtual gross anatomy cohort during the COVID-19 pandemic, this study does have several limitations. First, the data we obtained was not normally distributed. This necessitated the use of non-parametric statistical tests which have decreased statistical power compared to their parametric counterparts. Additionally, the data collected pertains to an individual medical school. Therefore, the behaviours that contributed to student success at our institution may not apply to others. This may be slightly ameliorated by the fact that students attended three different campuses.

Conclusions

We have identified several factors contributing to success in a virtual gross anatomy course. Matriculating to medical school within 0-2 years of undergraduate completion may enhance student success in gross anatomy, while the maturity associated with matriculating 5+ years after undergraduate completion may ameliorate the distress of high academic loads during the pandemic. Student wellness incontrovertibly contributes to academic success in medical school and is even more crucial during the COVID-19 pandemic. Low life satisfaction and awareness of mental health resources at our institution were associated with lower final gross anatomy grades. The paradoxical decrease in final grade associated with awareness of mental health resources may be explained by the increased interaction with these resources that students in crisis may exhibit. A culture of positive self-evaluation and social support should be cultivated at each institution, ameliorating fears of failure and reducing anxiety during examinations. Additionally, feelings of embarrassment or virtual isolation may contribute to reluctance in seeking academic help. As a result, those exhibiting frequent hesitation to seeking academic assistance earned significantly lower final course grades. Students who were able to stick to a study schedule, avoiding last minute routine changes and cramming, were able to perform well during virtual gross anatomy in the pandemic. Taking breaks during study periods is encouraged, though breaks should be limited to 10 minutes or less to prevent decremental performance and maintain full concentration afterward. Generating test questions appears to be an especially effective use of the testing effect. Students suffering from cognitive overload should be given special instruction in identifying the salient features of lecture content and exam questions. Further research is required to determine the specific effects of group and individual studying in virtual gross anatomy.

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Supplemental Material

Survey Questions

1. Student ID number

2. Learning pathway

a. Lecture-discussion pathway (LDP)
b. Problem-based learning (PBL)
c. Directed study pathway (DSP)
d. Primary care scholar's pathway (PCSP)

3. Age

4. Sex

a. M
b. F
c. Other

5. Undergraduate major

6. Year of graduation from undergrad

7. Job/Volunteering experience that you did immediately prior to entering medical school

a. Lab technician
b. Scribe
c. EMT
d. Full Time Job

i.If so- what?

b. Other

i.If so- what?

8. Current GPA

9. Grade in Anatomy

a. A
b. B
c. C
d. F

10. How much time do you spend studying per weekday on average in hours?

a. 0-1
b. 2-4
c. 5-6
d. 7-8
e. 9+

11. How much time do you spend studying per day over the weekend on average in hours?

a. 0-1
b. 2-4
c. 5-6
d. 7-8
e. 9+

12. How often do you take breaks while studying?

a. I don't take breaks until I finish
b. Every 30 minutes
c. Every 60 minutes
d. Every 90 minutes
e. Every 120 minutes
f. Other: Write In

13. How long are the breaks that you take while studying (minutes)?

a. 5
b. 10
c. 20
d. 40
e. 60

14. What do you do on breaks?

a. Eat
b. Watch TV
c. Browse the internet
d. Read the news
e. Check Facebook/Instagram
f. Check email
g. Tweet
h. Exercise
i. Text
j. Use my phone
k. Other

15. What is your primary study method?

a. Review PowerPoint slides
b. Read textbook
c. Re-watch lectures
d. Re-write PowerPoints
e. Make study guides
f. Anki decks
g. Flash cards
h. Practice questions
i. Board review material (Boards & Beyond, Pathoma, etc)
j. Quizzing with a study partner
k. Teach yourself concepts
l. Other

16. How many secondary study methods do you use?

a. Review PowerPoint slides
b. Read textbooks
c. Re-watch lectures
d. Re-write PowerPoints
e. Make study guides
f. Anki decks
g. Flash cards
h. Practice questions
i. Board review material (Boards & Beyond, Pathoma, etc)
j. Quizzing with a study partner
k. Teach yourself concepts
l. Other

17. Have you ever sought out academic help while at LECOM?

a. Yes/No
b. If yes, with whom?
i. Tutor
ii. Advisor
iii. Lecturer
iv. Peer
v. Upper classman

18. What are some ways you cope with the stress of medical school?

a. Call family/friends
b. Do a recreational activity (video games, sports, social events, etc)
c. Drink alcohol
d. Use recreational drugs
e. Exercise
f. See a therapist
g. Read a self-help book
h. Seek assistance from advisor
i. Spend time alone
j. Increase time studying

19. LECOM values and provides adequate mental health support for the students.

a. Yes/No

20. I am aware of the mental health support services LECOM provides.

a. Yes/No

	Not at all typical of me	Not very typical of me	Somewhat typical of me	Fairly typical of me	Very much typical of me
My family and friends are expecting me to succeed in medical school					
I deserve to be in medical school					
I am performing at the same level as my peers					
I am much more stressed than I was before medical school					
It is normal for me to be stressed in medical school					
I am satisfied with my current state of life					
Other students fuel my stress					
I have a strong support system					
I often study alone					
I pay attention in lecture					
I am able to grasp the material during lecture					
I often study in groups					
I try to find relationships between what I am learning and what I already know.					
I find it hard to stick to a study schedule.					
I concentrate fully when studying					
When I am struggling in one or more courses, I am too embarrassed to admit it to anyone.					
To help me remember new principles we are learning in class, I practice applying them.					
When it comes to studying, procrastination is a problem for me.					
I have difficulty identifying the important points in my reading.					
I review my notes before the next class.					
I translate what I am studying into my own words.					
I stop periodically while reading and mentally go over or review what was said.					
I am not comfortable asking for help from my instructors in my courses.					
I have a positive attitude about attending my classes.					
When I am taking a test, worrying about doing poorly interferes with my concentration.					
I have trouble understanding exactly what a test questions is asking.					
I worry that I will fail out of school.					

	Not at all typical of me	Not very typical of me	Somewhat typical of me	Fairly typical of me	Very much typical of me
To help make sure I understand the material, I review my notes before the next class.					
When studying, I seem to get lost in the details and miss the important information.					
To check my understanding of the material in a course, I make up possible test questions and try to answer them.					
Even when I am well prepared for a test, I feel very anxious.					
I test myself to see if I understand what I am studying.					
When I do not understand how to use a method or procedure presented in one of my courses, I ask another student to teach me so that I can do it on my own.					
I end up "cramming" for every test.					
My personal relationships interfere with my academic responsibilities.					
The cost of my education is a major concern.					
In the last hour, I decided to change an aspect of my study routine.					