SHORT COMMUNICATION

The Effectiveness of a Virtual Anatomy Curriculum Versus Traditional Cadaveric Dissection in UNC SOM’s First-Year Class

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Abstract

Even prior to the COVID pandemic, the push for medical schools to adopt virtual anatomy curricula in lieu of human cadaveric dissection was growing. In this study, musculoskeletal and gastrointestinal anatomy examination scores of first-year medical students at the UNC School of Medicine were compared across three consecutive years. These classes experienced in-person, virtual, and hybridized anatomy curriculum, respectively. There was not a single instance noted where in-person curriculum produced higher examination scores than virtual or hybridized models. By incorporating virtual or hybridized models of anatomy, medical education programs can effectively reach and educate students far beyond the traditional cadaver laboratory.

Keywords Virtual curriculum · Medical education · Educational technology · Distance education · Pedagogy

Background

The disruption in medical education brought about by the COVID pandemic was swift. Medical schools pivoted rapidly to deliver content virtually and, due to social distancing rules, could not have in-person coursework of any kind. The need for innovation in teaching material associated with tactile experiences, such as in a cadaver laboratory, was managed creatively. However, there remains a debate about how well students could learn this content in a strictly virtual environment.

Prior to the COVID pandemic, the push for medical schools to adopt virtual anatomy curricula in lieu of human cadaveric dissection was growing on both ethical and economic fronts [1]. Since 2012, the International Federation of Associations of Anatomists (IFAA) has recommended that cadavers be sourced strictly from voluntary donation, yet 53% of countries surveyed use unclaimed bodies as their primary source of cadavers [2]. The hiatus on in-person medical education during the COVID pandemic highlighted the necessity of having virtual components as an integral part of medical schools’ curricula [3]. While the pros and cons of shifting away from cadaveric dissection have been debated theoretically [1], there is a substantial lack of quantitative data to show how a virtual anatomy curriculum compares to traditional cadaveric dissection.

There has been speculation that the field of anatomy will suffer from moving to a virtual composition since students are not physically dissecting [4]. It has previously been shown at the University of North Carolina School of Medicine that medical student examination performance has been unhindered by integration of a dissection/prosection hybrid model [5]. Additionally, the University of South Carolina School of Medicine’s shift to virtual histology in 2003 has shown to be effective and well-received by students and professors alike [6].

The purpose of this study is to compare student examination performance on anatomy practical examinations and anatomy-dominant multiple-choice examinations across three consecutive years of first-year medical students. These students were instructed through a fully in-person curriculum, a fully virtual curriculum, and an in-person lab/virtual lecture curriculum, respectively. By assessing the trends in student examination performance, we can better assess how a virtual anatomy curriculum compares to traditional cadaveric dissection in the real world.

Activity

Our study sample included first-year medical students attending a large public institution in the southeastern United States. To better understand medical student performance
on examinations related to gross anatomy, an analysis of examination results from two curriculum blocks offered in April and May of 2019, 2020, and 2021 was conducted to determine if there was a statistically significant difference across years. Over the three years, there were a total of 521 examinations from different students included in this study (2019: 160; 2020: 165; 2021: 196).

During 2019, students were in-person and were able to attend an equal mix of dissections and prosections in the anatomy lab, 7 of each. During 2020, the experience consisted entirely of virtual instruction due to the COVID-19 pandemic. During 2021, students experienced in-person instruction, but due to social distancing precautions, students performed only 3 dissection sessions, instead attending 11 prosections and receiving supplemental virtual instruction. The virtual instruction consisted of in-house video recordings of dissections performed by an anatomy professor. The total number of hours of anatomy content for the three classes was roughly equal.

For the purposes of this study, the overall average percentage from the gastrointestinal (GI) block (5 weeks) and musculoskeletal (MSK) block (5 weeks) were explored. The GI block grade was calculated as follows: quizzes (20%), gross anatomy practical (3%), problem sets (4.5%), midterm exam (35%), and final exam (37.5%). The MSK Block grade was calculated as follows: small-group participation (6%), dermatology midterm 1 (14%), upper limb exam (20%), lower limb exam (15%), quizzes (7%), and final exam (38%). Additionally, the GI practical exam and second MSK midterm exam were used. Midterm exams were multiple-choice and held either in-person (2019) or remotely with virtual proctoring (2020, 2021). Practical examinations involved students identifying anatomical structures that were either pinned (in-person) or photographed (virtual). MSK did not offer practical examinations in 2020 and 2021, thus limiting our analysis of those practical examinations. All midterms and practical examination questions were either identical or highly similar across all three years.

The Shapiro–Wilk test for normality was used to determine if the examination scores were normally distributed. For all variables, $p < 0.05$, indicating that the distribution of scores was not normally distributed. Therefore, the Kruskal–Wallis test of independent samples was used to compare results across years, reported as the $H$ test statistic (chi-square test). Post hoc comparisons were made using the Mann–Whitney $U$ test. Analyses were conducted using IBM SPSS v 28 (Armonk, NY).

### Results and Discussion (Tables 1 and 2)

To determine if there were differences in course performance across the years, we compared overall final percentage in GI and MSK. For the GI block, there was a statistically significant difference ($H(2) = 8.14, p = 0.017$), where the overall average was highest in 2020, followed by 2021 then 2019. Post hoc comparisons were significant between 2019 (Mean = 84.77) and 2020 (Mean = 86.18; $p = .012$) and 2019 and 2021 (Mean = 85.96; $p = 0.014$), but not between 2020 and 2021 ($p = 0.860$).

The overall MSK comparison was not statistically significant ($H(2) = 2.04, p = 0.361$). No further analyses were conducted for the MSK examination.

The practical examination results for the GI block identified statistically significant differences across years ($H(2) = 42.88, p = 0.001$). Examination performance was highest in 2021 (Mean = 97.86) followed closely by 2020 (Mean = 97.36) then 2019 (Mean = 93.94). Post hoc comparisons were significant between 2019 and 2020 ($p = 0.001$) and 2019 and 2021 ($p = 0.001$), but not between 2020 and 2021 ($p = 0.514$).

The second examination for the MSK block was analyzed, as the examination focuses the most on anatomy. There was a statistically significant difference ($H(2) = 11.48, p = 0.003$), where examination performance

### Table 1 Examination averages by academic year

| Exam   | 2019      | 2020      | 2021      |
|--------|-----------|-----------|-----------|
| GI average | 84.77 ± 4.88 | 86.18 ± 6.17 | 85.96 ± 6.40 |
| MSK average | 88.14 ± 4.57 | 87.41 ± 5.14 | 87.90 ± 5.47 |
| GI practical | 93.94 ± 7.34 | 97.36 ± 4.33 | 97.86 ± 3.47 |
| MSK 2 | 91.08 ± 6.02 | 92.60 ± 5.91 | 91.09 ± 6.70 |

| Post hoc comparisons | $p$-value |
|----------------------|-----------|
| 2019 vs 2020         | .012*     |
| 2019 vs 2021         | .014*     |
| 2020 vs 2021         | .860      |

| 2019 vs 2019         | NR        |
| 2019 vs 2021         | NR        |
| 2020 vs 2021         | NR        |

*Level of significance, $p < .05$
was highest in 2020 (Mean = 92.60) and essentially equal for 2019 (Mean = 91.08) and 2021 (Mean = 91.09). Post hoc comparisons were significant between 2019 and 2020 ($p = 0.001$) and 2020 and 2021 ($p = 0.037$), but not between 2019 and 2021 ($p = 0.116$).

There are several notable findings illustrated by the data set. For the GI block overall grade, there was a significant increase in scores when using an all-virtual or hybridized virtual model over a traditional, in-person curriculum. The same held true for the GI practical examination, where fully virtual and hybridized scores were significantly higher than traditional. While there was no significant difference for the MSK block overall grade, for the second MSK exam, the fully virtual grades were significantly higher than both hybridized and traditional grades. In fact, there was not a single instance noted where in-person curriculum produced higher mean examination scores than virtual or hybridized models.

The traditional belief has been that one of the main benefits of cadaveric dissection is that it produces a vivid, three-dimensional knowledge of anatomy that cannot be matched by virtual instruction. However, our results showed that virtual instruction fared non-inferiorly to that of in-person instruction.

There are a few limitations worth noting in this study. While this study spanned 521 examinations across three subsequent classes, all data were collected from a single medical school. Although students were virtually proctored during examinations and bound by a university honor code, there is increased risk of unethical behavior/cheating with remote examination. Even though 2020 and 2021 GI practical scores were both higher than 2019 scores, the 2020 GI practical was administered in a virtual format due to COVID restrictions, which could have impacted grades in either direction. In addition, the COVID pandemic was a period of rapid change and adaptation, so there are potential unidentified confounds/modifiers that could have influenced examination scores, either positively or negatively.

As the world progresses ever onward into a virtual format, it is inevitable that this transition plants its feet in medical education. Our study shows that the staunch aversion to virtual anatomy curricula is perhaps exaggerated, as virtual anatomy has shown itself to be non-inferior to traditional cadaveric dissection. Further research in this topic that encompasses more examinations, students, medical programs, and teaching styles is needed, but the preliminary data appear promising. There are further implications of the impact of virtual medical education on future physician clinical skills that should be explored in future studies. By incorporating fully virtual or hybridized virtual models of anatomy, medical education programs can continue to reach and educate students far beyond the traditional cadaver laboratory.

Author Contribution Aaron Fox provided drafting and revision of the manuscript. Dr. Gary Beck Dallaghan provided IRB approval application, data retrieval, and statistical analyses. Dr. Kurt Gilliland provided information on the structure of the educational curriculum at UNC School of Medicine.

Availability of Data and Material The data used was anonymized and accessed through the UNC School of Medicine.

Declarations

Ethical Approval This study received approval through UNC’s Institutional Review Board, IRB Number 20–3335.

Informed Consent N/A

Consent for Publication All authors consent for publication of this original work.

Conflict of Interest The authors declare no competing interests.

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