**Evolution of a Practical Anatomy Course in the Covid-19 Quarantine Era**

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Practice points:

* Due to pandemic restrictions, the anatomy staff reviewed and restructured the fourth module of a four module anatomy course. This allowed us to evaluate and compare our practical and theoretical anatomy online teaching framework to traditional in person instruction.
* The comparison was performed in a two-tiered fashion. In tier one, we compared the performance of a student group taught the fourth module online to the performance of the same cohort on the three previous modules within the same course taught by a traditional in person structure. In tier two, we compared the performance of the online student group to the performance of groups from two previous academic years taught the material contained in the online module using the traditional structure.
* Whereas most students preferred conventional teaching, advantages of the online method were reported that can be applied be used for future course improvement.
* Given our results and student feedback, future combinations of online and conventional anatomy teaching appear preferable.

ABSTRACT:

The Covid-19 pandemic necessitated an educational revolution - transitioning to online teaching. While most courses replaced the usual classroom activities with online instruction, a core element of medical education, cadaveric dissections, was jeopardized. Here, we document our institutional approach to overcome the challenges of distance practical anatomy teaching. The effectiveness of the resultant module and its objective and subjective impact on the learning experience are evaluated.

Methods: During March and April of 2020, our second year medical students participated in Zoom only based anatomy instruction for the “limbs” portion of their course. Theoretical frontal in person lectures, cadaveric dissection groups with identically sized groups compared to previous modules, and virtual laboratories were delivered via Zoom. After the course, all students completed an anonymous questionnaire to evaluate the online module compared with previous conventionally taught modules. Within the same student group, grades for the online module were compared to those from previous traditionally taught modules completed during the same pre-COVID-19 academic year. Additionally, the grades of the online student group were compared to those of distinct student groups from two prior academic years that were taught this specific module traditionally.

Results: Whereas most students preferred the conventional method, some identified benefits to the online method. Our two-step analysis indicated there was no significant difference between the mean grades of students in the theoretical exam based on book, video and online presentations and the mean grade in previous theoretical exams taught traditionally.

Conclusion: While under optimal conditions cadaveric dissection is key in anatomy teaching, our online method was sufficient during this time, and with adjustments it should be considered a valuable resource in the future.

**Keywords:** Gross anatomy education, medical education; Covid-19; cadaver dissections; remote learning.

**INTRODUCTION:**

In March 2020, the World Health Organization (WHO) announced Covid-19 a global pandemic (WHO Covid-19: situation report 51, 2020). To limit its spread, countries enforced varying levels of quarantine restrictions, the strictest of which were “stay at home” mandates (Waldrop, 2020; Wolf, 2020). Educational institutions, medical schools included, converted to online education. Indeed, medical schools rapidly changed their pre-clinical instruction methods, including anatomy instruction, to online-only options (Brassett et al, 2020; Evans et al., 2020; Franchi et al., 2020; Hanad et al., 2020; Pather et al., 2020; Yuen et al., 2020).

The Medical School for International Health (MSIH) at Ben-Gurion University of the Negev (BGU) immediately halted lectures and converted all pre-clinical courses to online learning via Zoom (Zoom Video Communications Inc. San Jose, CA) and Modular Object-Oriented Dynamic Learning Environment (Moodle) (Moodle HQ, Perth, Australia). These modalities were well established teaching, learning and distance communication tools (Cole and Foster, 2007; Archibald et al., 2019; Srinivasan, 2020). Online teaching was appropriate for most pre-clinical courses, enabling an easy transition for most traditional lectures, group discussions and problem-based learning, including theoretical anatomy lectures. However, the anatomy staff at BGU were skeptical that online lectures could adequately replace cadaveric dissections.

Ideally during practical dissection laboratories, students would have a tangible, three-dimensional experience enabling them to develop accurate perception of spatial relationships between body parts and anatomical areas (Arora and Sharma, 2011). Due to the restrictions, the dissection laboratory was closed, so delivering a core experience in anatomy learning (Bergman, 2015) was impossible. The timing of the shelter-in-place pandemic restrictions challenged our school and others to reinvent ourselves including teaching cadaveric anatomy online (Evans et al., 2020; Franchi, 2020; Longhurst et al., 2020; Ravi, 2020; Srinivasan, 2020; Theoret and Ming, 2020).

Many changes have been examined and reported, including studies examining the implications on educational staff (Cheng et al., 2021; Jones, 2020; Pather et al., 2020). Jones et al. have examined ethical issues that may arise should online teaching continue post-pandemic (Jones, 2020). A lesser number of studies examined the reactions of students to such changes (Cuschieri et al., 2020). however, to our knowledge previous studies have not compared online teaching to conventional methods of instruction in terms of student performance.

To best replicate the dissection experience while maintaining the safety of students and faculty, the staff surveyed relevant literature regarding supplemental anatomy teaching methods. A commonly described method to enhance anatomy teaching is using videos and animated programs. Although widely researched (Attardi et al., 2015; Attardi et al., 2016; Attardy et al., 2018; Grosser et al., 2019), the impact of these approaches on student accomplishment, knowledge acquisition and preferences is still debated. Some authors claim these strategies have a positive impact on student satisfaction and grades, (Dev et al, 2006; Topping, 2014; Choi-Lundberg et al., 2016; Ozer et al., 2017), whereas others found them equivalent to traditional strategies (Saxena et al., 2008; Mahmud et al., 2011). Furthermore, some studies were conducted on non-dissection based courses ( ), whereas others supplemented traditional courses with videos or animated programs ( ).

To our knowledge no study was reported comparing online only teaching, including dissections, to traditional classroom teaching, especially within the same student cohort.

To address this question, provide practical results for future online teaching, and provide clarity to the literature, we hypothesized that online anatomy teaching would be equal to or not inferior to the traditional dissection based method.

This article reports the outcomes of exclusively remote practical anatomy teaching, including student learning experiences, by comparing inter and intra group performance quantitatively and student feedback qualitatively.

**MATERIALS AND METHODS**

**Context:**

The MSIH program at BGU is a four year international program recognized by the ECFMG. Its curriculum is modeled after an American four year medical school curriculum. Each class is comprised of 24-30 students, many of whom graduated from US undergraduate institutions with 50% completing a B.Sc. The minimum MCAT score for admission is 504. While class characteristics vary the student body is 50% female on average.

The gross anatomy course is taught during the secondyear, in four modules (thorax, abdomen and pelvis, head and neck, limbs). All modules traditionally include frontal conceptual/theoretical lectures and practical cadaveric dissections. Lectures are delivered by anatomy instructors from the faculty of Ben Gurion university. Practical laboratory groups (up to 8 students) are instructed by teaching assistants (TAs). Students are requested to review structures before cadaveric lab using the assigned course book (Netter, 2011) then participate in relevant dissections. Dissections are performed according to Grant's dissector book (Tank, 2012). For the 2019-2020 academic year, the first three modules (thorax, abdomen and pelvis, head and neck) were taught traditionally.

**Online Anatomy experience**

Once restrictions were issued, the staff had to convert the remaining module (limbs) to remote learning. As a basic principle, their goal was to minimize changes to the module while maintaining course style, depth of instruction and attention to detail. Accordingly, the number of practical and theoretical hours, the composition of dissection groups and instructors from the other modules remained. As with other pre-clinical courses, theoretical lectures previously delivered as frontal were taught online with existing presentations using Zoom. Most students attended the Zoom lectures and virtual dissections from Israel whereas several returned abroad (mostly to the US).

Regarding the module’s dissection component, the class was divided into two groups that participated in Zoom lessons, each assigned to a teacher assistant (TA). This allowed personal attention and a convenient platform for participation, especially due to time-zone gaps (Israel is GMT+2, 7 hours ahead of US Eastern).

Recommended learning goals for medical students and milestones in anatomy are described by the Anatomical Society of Great Britain (Smith et al., 2016) and were considered in adapting our limbs module to distance learning. Furthermore, adaptation was done according to the needs assessment and instructional objectives steps in Kern’s six step curriculum development model (Sweet et al., 2015).

Dissection discussions were conducted using the course book “Atlas of Human Anatomy” (Netter, 2011) and photographic dissections contained within the book “Color Atlas of Anatomy: A Photographic Study of the Human Body” (Rohen et al, 1993). Instead of dissecting according to Gray’s Anatomy, the class reviewed pictures of professional dissections from the course books (Figure 1). Additionally, the TAs reviewed open-access online dissection videos by the University of Wisconsin (UW, 2015) in real-time Zoom sessions. The videos were previously confirmed to satisfy the requirements of the Anatomical Society of Great Britain. Table 1 compares the properties of the practical module before and after Covid-19.

**Module Assessment**

Due to the adoption of online teaching between modules, students who already experienced traditional anatomy learning in three previous modules had to adapt to the new method for the final module (limbs). A model evaluating online and traditional teaching was required because the modified module may have altered student reactions and satisfaction which could affect learning.. Kirkpatrick’s model (Panchenko, 2013) was used for the evaluation. It allowed the assessment of student reactions to the new format (Kirkpatrick’s first level) as well as an evaluation of the learning process (Kirkpatrick’s second level).

**Performance Outcomes of Online Module**

Knowledge acquisition was evaluated by theoretical and practical spotter exams for the first three traditionally taught modules of the 2019-2020 academic year and from all four traditionally taught modules from previous academic years. The theoretical exam included 60 multiple-choice questions (two per academic hour) and graded between 0 to 100, 65 being the passing grade. The spotter exam was typically held in the dissection room using cadavers dissected during the course as stations. There were 25 stations, each containing three pins on anatomical structures for the students to identify by full name as in the course book, yielding a total of 75 structures. Correct answers were calculated out of 100, 55 being the passing grade.

For the online module, the theoretical exam was identical to previous years. However, the practical exam differed. The online exam contained 25 stations, each with one to three pictures (from the photographic dissection book) with arrows pointing to structures to be identified (Figure 2). The total number of structures and grading method were similar to the traditional exam.

Students participated in both exams using Moodle ( ) while being proctored via Zoom.

**Self-Report Assessment of Online Versus Traditional Module**

To assess student reactions and satisfaction (first level of Kirkpatrick’s model) for the new fourth module compared to previous three traditional modules for year 2019-2020, students completed an anonymous questionnaire approved by our Institutional Review Board (16-2020) (Appendix 1). To diminish comparison bias, the questionnaire first asked students to evaluate the online module before answering the same questions about the three previous modules.

The questionnaire was divided into three sections:

1) *General Module Assessment*: Module quality was assessed by measures developed by researchers and used to assess online and conventional modules separately. It included seven self-reportable questions on a five point Likert Scale that focused on the following: teaching quality, understanding level, contribution to theoretical knowledge, value in test preparation and memorization, and overall satisfaction (Figure 3).

2) *Preferred Module Method*: Participants were asked to indicate their preferred teaching method for five learning aspects (e.g., ability to concentrate). For each, students chose the method they felt was superior (Figure 4). In an open-ended section, students were encouraged to explain their choices.

3) *Qualitative Assessment of the Module*: Text boxes allowed students to express their views about the online method and comment on issues not otherwise addressed. Students were asked about advantages and disadvantages of the online method, and how they anticipate it should be integrated into future modules.

The anonymous questionnaire was sent after the final exam but before grades were published to reflect student opinions more accurately without their own numeric grades potentially affecting survey responses (Appendix 2).

As mentioned, all students previously completed three traditionally taught modules of the anatomy course. This allowed students to serve as an internal control group to evaluate satisfaction and opinion on the quality of the modified module’s remote instruction and learning.

**Data Analysis**

Data was analyzed using SPSS V.26.

*Analyzing performance:* To analyze student performance in the online module, we first examined their group performance in the three previously taught traditional modules (thorax, abdomen and pelvis, head and neck) in the 2019-2020 academic year. We then compared online class performance on the online module (limbs) to the class performances on that module taught traditionally the two previous academic years 2017-2018 and 2018-2019. Specifically, performances in the online module exams were compared respectively to the same 2019-2020 year theoretical and practical performances in the traditional modules, by two repeated measures ANOVA models: one for theoretical and one for practical exams.

In addition, comparisons between student outcomes in the online limbs module and those from two previous classes traditionally taught the limbs module (academic years 2017-2018 and 2018-2019) were tested by linear regression models. Each model tested the predictive effect of academic year (calculated as two dummy variables comparing 2020 to the previous years) on student performance in each exam.

Differences in age, gender and admission test scores from all three academic years were controlled for each of the regression and ANOVA models.

*Analyzing the self-report questionnaire:* To test differences in the General Module Assessment of the online and conventional modules, we conducted paired-sample t-tests using Cohen’s d for measuring effect size. To test the Preferred module method, the preference rates for the online versus traditional module were compared for each learning aspect. Finally, answers to the Qualitative Assessmentportion were analyzed and themes identified using Braun and Clarke’s framework (Braun and Clarke, 2006). Frequencies of answers relating to themes were compiled to formulate a general description.

**RESULTS:**

All students (n=24) completed the questionnaire in full. Fifty-five percent were male, and the mean age was 25.6 years.

The results of a repeated measurements ANOVA comparing mean student grades in the theoretical online limbs exam to their mean grades in in theoretical exams from the three prior traditional modules revealed no significant difference (F(1,17)=1.67, p>.1). A second repeated measurements ANOVA done on respective practical exam grades from the two previous academic years showed similar results. No significant difference were found between student grades from the online practical exam and mean grades from the traditional practical exams (F(1,17)=2.10, p>.1). These results suggest no detectable differences between student performances (practical and theoretical) in the online module compared with prior traditional modules within the same academic year.

Finally, we compared student performances in the online limbs module to those of previous classes taught the traditional limbs module the prior two academic years 2017-2018 and 2018-2019. Figure 5 shows mean grades from the practical and theoretical limbs module exams and mean grades from practical and theoretical exams for the three other anatomical modules for the three academic years 2017-2018, 2018-2019 and 2019-2020. The results of a regression model on the grades of the limbs module theoretical exam by academic year show the grades from 2019-2020 were not significantly different from those of 2017-2018 and 2018-2019. Additionally, a similar regression model on the practicalexam showed that grades in 2019-2020 (online) were significantly lower than those from 2018-2019 but not significantly different from 2017-2018 grades for this module (traditional) (Table 2).

**Self-Report Assessment of Online Versus Conventional Modules**

General Module Assessment showed high internal consistency for both online and conventional module assessment scales (Cronbach’s α=.89, Cronbach’s α=.95, respectively). Paired-sample t-tests showed significant differences between online and conventional module evaluations demonstrating lower scores for the online module, across all seven questions (Figure 3). To measure the overall difference between the methods, seven items reflecting aspects of the modules were averaged and compared with the means. The mean evaluations of the online module (M*=*3.39) were lower than those of the conventional module (*M=*4.25), significantly so (T(23)=-.40, p<.01, Cohen's d = 1.050).

Students reported superior clarity of larger anatomical structures (Q3) and 3D perception (Q4) during in-person dissections (83% and ~91% respectively) (Figure 4). Under the comment section, students reported that seeing and touching cadavers was deemed irreplaceable for visualization. However, in evaluating the online method, students did comment on enhanced ability to see smaller structures which are often difficult to visualize. This point is also applicable to the dissection course books which can be displayed by the anatomy instructor in a more organized fashion online, compared to a crowded dissection laboratory. Finally, students were asked to select a preferred method for hypothetical additional modules. Most, 87%, chose the conventional method, whereas 13% chose the online method. Additional student comments are discussed in the Discussion.

*Preferred module method*: Five preference questions were presented with space for explanation for each. Student preferences for each question are described in Figure 4. According to students, the laboratory learning environment enhanced student abilities to concentrate. Most students (Q1, ~87%) claimed they were able to better concentrate during in-person dissections. Students also claimed that laboratory attendance promoted active participation and that tactile learning engaged them for longer. A minority of students (13%) claimed that online-learning better enabled concentration because they could review the virtual dissection, easing their anxiety and apprehension about “missing” something. They felt this improved their learning experience. Regarding time-utilization (Q2), ~66% thought conventional dissections were more efficient in use of allocated time and resulted in improved recall of material meaning. Specifically, they needed less time to review the material. Thirty-three percent claimed to have better time-utilization in the online dissections, by not having to prepare and find structures. Structures were “cut and ready”, and less time was spent on activities deemed external to learning.

*Qualitative Assessment of the Module:*A majority of students (79%) provided extensive answers to this section. Analysis of this section yielded five major themes (listed from most cited to least): spatial 3D competence; review opportunities of virtual dissections; available virtual dissections; time-utilization and efficiency; cadaver preservation and learning environment. The most valuable responses are quoted verbatim in Table 3. Spatial 3D competence, opportunity to re-watch virtual dissections and available virtual dissections were the most common (about 20% of answers). Other themes were less common and mentioned in less than 10% of answers.

**DISCUSSION:**

In this study, we showed that student performance did not differ significantly between online and traditional modules and between years except for the practical exam grades in academic year 2018-2019. Student responses delineated benefits and disadvantages of the online method. Based on responses, most students preferred conventional modules over the online module. Note that students had already completed the previous three modules of the course conventionally and had to adapt to a different learning experience under stressful circumstances induced by the ongoing Covid-19 pandemic. We logically posit that upon facing new experiences students might naturally prefer the familiar “safe” mode. This may partially explain dissatisfaction and differences between the methods.

The advantage of the online method is on-demand viewing anytime and from anyplace. Whereas some students remained in university residences, others were scattered globally across various time-zones. However, all could access and complete the course. Students referred positively to this availability in the questionnaire open-ended sections, especially compared to the in person cadaveric lab which is locked and requires permission for access. This may be utilized for future improvements, including guest lectures and more.

Another advantage of online learning we found is the option to revisit recordings and enhance repetitive learning. Although most institutions allow self-study for dissections, it is often not guided by a tutor, is performed on an already dissected cadaver and does not necessarily focus on key issues. Recordings and replay of dissections are perfect remedies for these shortcomings.

Also, online learning utilizes higher quality dissection books and videos that are difficult to replicate in real-life, as previously addressed (McLachlan et al., 2004). As noted, delicate anatomy, which dissections struggle to preserve, is better demonstrated using online material. Structures appeared clearer with enhanced detail resulting from better vantage points and resolution. Moreover, using such resources save preparation time, promoting more efficient time management.

Frontal in person dissection advantages were also addressed by many students. Even the highest-definition 3D is inferior to reality. Tactile learning facilitates concentration and understanding relationships between structures, tissues and movement-induced anatomical changes. Student ability to dissect and find structures is important for retention of anatomical landmarks and verbiage. Also, traditional dissections have convey a “hidden” curriculum. Students report a transformative experience where donated cadavers are referred to as their first patient. This is often formative and credited with learning how to relate to future patients respectfully (Hafferty and Finn, 2015).

As mentioned in Results, there was no statistically significant difference between the theoretical grades of online or traditional methods. Ostensibly, deficiencies in practical knowledge would have negatively affected students performance on the theoretical exam. We believe the lack of significant difference suggests virtual dissections prepared students equally compared to traditional teaching for theoretical portions of the course. The difference in the practical exam grades may be attributed to challenges acclimating to a new method. Specifically, for the practical exam we switched from the traditional spotter exam on a 3D cadaver to a computerized two-dimensional picture based exam. This alone could have resulted in worse performance. While our distance learning course adhered to the Anatomical Society’s guidelines (Smith et al., 2016), the level of understanding, internalization and long-term recall of material requires further study.

Limitations: The study has several limitations. First, our evaluation was based only on the first two levels of Kirkpatrick’s model. Though a common approach to analysis (Yardley and Dornan, 2012), further research considering behavioral and methodological changes in a larger context is needed for higher level analysis. Second, the students had to rapidly adjust to a different learning experience concurrent with the additional stress and anxiety of the unprecedented Covid-19 crisis. This surely affected their attention, resources and ability to accommodate to the change to online learning. Future research evaluating online anatomy laboratories should allow students time to acclimate to the reported deficiencies. This may minimize subjectively reported deficiencies. Given the lack of statistical difference in theoretical knowledge acquisition, our online model may be more educationally acceptable.

**CONCLUSIONS:**

While there are challenges when we must adapt, online practical anatomy teaching can effectively substitute for traditional methods when needed, as during the Covid-19 crisis. However, traditional in-person dissections are still preferred, especially for students who have already experienced them. Based on our results an evolution of practical anatomy learning will benefit from the incorporation of both online and traditional teaching methods resulting in enhanced retention and improved experience. This may include enhanced preparation with online resources before dissections and recording dissections which can be revisited. We propose that this combination may optimize learning and time utilization while maintaining benefits of the traditional experience.

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