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Research Paper

Virtual Dissection Table: A Supplemental Learning Aid for a Physical Therapy Anatomy Course

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ABSTRACT
While cadaver dissection and prosection are deemed quintessential methods for studying anatomy, these methods are attenuated by the flat, 2-D structures incorporated into didactic segments of the anatomy courses that minimize students' ability to comprehend anatomy, leading to constraints in the teaching and learning experience. Several tools, such as 3-D virtual anatomy apps and anatomical models, enhance teaching and students' understanding of gross human anatomy. The Anatomage, a virtual anatomy dissection table (VDT), is a compelling technological development with dissection capabilities and a prosection of the human body and its segments. This study intends to explore incorporating a VDT into a physical therapy anatomy course as an enhanced anatomical learning technique. The methods encompass the inclusion of the VDT as an extra dissection table within the cadaver lab setting. Each group of scholars was required to locate the anatomical configurations and dissections assigned to the topic on the VDT. The anatomy course included four examinations covering the entire human body. The results suggest advancements in knowledge retention following the incorporation of VDT in the cadaver dissection portion of the course. Therefore, we ascertained that the VDT is an exemplary tool to adopt in anatomy courses to aid in the comprehension of complex anatomical structures. Integrating VDT is paramount to the assimilation and application of human anatomy in students' future health careers.

INTRODUCTION

Gross anatomy is one of the core courses in numerous health-related programs, such as physical and occupational therapy (www.twu.edu). The conventional methods for instructing gross anatomy are lectures with adjunct textbooks (Hammond, Taylor, & McMenamin, 2003) and cadaver dissections and prosections (Houser & Kondrashov, 2018). Two-dimensional (2-D) screen projections are among the styles most resorted to during the didactic segment of anatomy courses. However, although 2D screen projections are the most applied strategy in nearly every anatomy course, they have limitations associated with the teaching and learning experience (TLE). These screen projections, such as PowerPoint presentations, inflict numerous constraints on scholar comprehension, including difficulties in learning depth perception, understanding anatomical orientations among nearby structures, and clinical applications (Berkowitz et al., 2014).

The limitations generated by 2-D instructional methods in the lecture portion of anatomy courses often produce gaps or discrepancies between scholars' knowledge and comprehension, and the areas covered during lectures and cadaver laboratories (Chakraborty & Cooperstein, 2018). As previously noted, gross anatomy is a paramount course in nearly all health-related programs, which often pair the course with successive clinical experiences as another significant component of such curricula. As scholars advance to more analytic-oriented courses requiring a strong understanding of anatomy, such as kinesiology and clinical environments, the critical issue of students' disconnection between anatomy comprehension and application resulting from 2-D learning becomes critical, as the repercussions materialize in these settings and can become problematic.

To help close the divide between the didactic and cadaver laboratory sections of anatomy courses, many educators have adopted adjunct teaching-learning tools in both sections, such as software applications (apps) with three-dimensional (3-D) aspects (Chakraborty & Cooperstein, 2018), which are utilized in efforts to alleviate issues of discrepancies in student's comprehension by building more tailored and holistic views and perspectives during both segments of gross anatomy courses. The active interaction with some of these supplemental technologies is valuable in strengthening students' understanding of human anatomy and overall scores in anatomy-based courses (Sugand, Abrahms, & Khurana, 2010).

Virtual reality, models, and 3-D anatomy apps are among the adjunct devices designed to promote the interpretation of depth perception and the association of deeper and more complex arrangements within the human body (Iwanaga et al., 2020; Rosario, 2021; Rosario et al., 2019). While augmented virtual reality (AR) has been reported as a valuable supplement for human anatomy guidance, 3-D virtual anatomy applications are just as thorough and beneficial as other approaches used to strengthen the understanding of anatomy (Iwanaga et al., 2020), and their successes and advantages in anatomy courses have been reported by many researchers (Chakraborty & Cooperstein, 2018; Houser & Kondrashov, 2018; Rosario, 2021). Both the 3-D app and AR techniques have been established as successful in targeting the perceived benefits of student participants in more specialized and advanced programs, along with reinforcing their comprehension of anatomy (Bairamian, Liu, & Eftekhar, 2019; Bork, 2019; Duncan-Vaidya & Stevenson, 2020; Ha & Choi, 2019). Therefore, incorporating augmented reality (AR), 3-D apps (Uruthiralingam & Rea, 2020), and virtual dissection tables (VDT) (Bork, 2019) as adjunct tools to cadaver dissection are favorable and have proven to furnish numerous advantages and enhancements to the TLE of those in anatomy courses.

Scholars often prefer to step outside of the traditional lecture scenario to strengthen their understanding of the course material by using some of the accessories mentioned above (Chakraborty & Cooperstein, 2018), which increases excitement among learners, which successively helps and enhances the TLE of anatomy courses (Berkowitz et al., 2014). The impact of 3-D anatomy apps and VDT as adjuncts to undergraduate human cadaver anatomy outreach activities has been previously explained, along with the usefulness of these technologies for the comprehension of anatomy, which further encourages pupils to pursue graduate studies (Mathis M., González-Solá, & Rosario, 2020). The effectiveness of incorporating 3-D anatomy apps into lectures was also established to improve course grades and boost the perceived benefits of such tools on the TLE (Rosario, 2021).

In addition to the clear disadvantages of learning anatomy from flat 2-D resources, scholars often exhibit a passive learning posture as a result of using these resources, such as simply listening and waiting for the professor to show them the material rather than seeking a more hands-on approach (Minhas, Ghosh, & Swanzy, 2012). The VDT is a valuable instrument that allows the user to manipulate various anatomical structures and navigate across different architectural arrangements (Ward, 2018; Brucoli, et al., 2020 & Brucoli, et al.,2018) while illustrating real human anatomy details and heightening TLE, even in earlier stages, such as among undergraduate scholars (Rosario et al., 2019). We recognize that the VDT can provide students with a smooth transition from the didactic portion of anatomy courses to the cadaver laboratory portion by enhancing 3-D perspectives, as it has been previously successful in similar scenarios (Afsharpour et al., 2018).

The addition of adjunct tools through a multimodal approach to the lecture and laboratory portion of courses had several immediate benefits that promote the TLE (Houser & Kondrashov 2018). Subsequently, prospective healthcare professionals need to be provided with anatomy education of the utmost quality to enact proficiency in various clinical scenarios (Schofeild, 2017). The human cadaver laboratory is the best opportunity to implement such education. Therefore, upon taking all that has been mentioned above into consideration, this study delves into exploring and reporting the effectiveness of supplementing the Anatomage VDT into a graduate anatomy course for physical therapy students on the TLE.

METHOD

Participants

A total of 216 first-year physical therapy graduate students enrolled at Texas Woman's University (TWU) during the fall semester from 2016 to 2019. The first cohort of 108 pupils (54 scholars per year) was enrolled in the anatomy course during the fall of 2016 and 2017, before the addition of the anatomage VDT. During Spring 2018, the VDT was obtained and subsequently incorporated into the anatomy course for the Fall of 2018 and 2019 laboratories. Therefore, the second cohort of 108 students (an additional 54 per year) was enrolled in the anatomy course using the VDT.

Human cadaver Laboratory

The School of Physical Therapy at Texas Woman's University has a human cadaver laboratory coordinated by a trained anatomist. The human cadaver laboratory has ten tanks, each of which contains one cadaver for a total of ten human specimens, which were obtained from the University of Texas Southwestern Medical Center's Willed Body Program.

Equipment

Virtual Dissection Table Anatomage, a life-size table that allows for the virtual dissection of fully segmented cadavers, features a full-length interactive touch screen that depicts "real-life virtual human cadavers" (Anatomage, 2019). The Anatomage includes options to dissect either the entire body, specific regional anatomy, or targeted organs while performing interactive segmentation and isolation of all body components, including those deemed most complex, all of which can be fully annotated. The anatomage VDT was added to the cadaver lab layout, as shown in Figure 1, during the Fall 2018 semester. During cadaver dissection, scholars were requested to reserve 15 minutes of their allocated laboratory time for using the VDT to study the structures and dissect the areas associated with that day's topic. After all tank members rotated, examined, and participated in the dissection, students then went to the VDT to locate and study the structures from that day and any other areas they needed to inspect further.

Anatomy Unit Tests

Per course requirements, all students underwent four unit tests, each of which was worth 100 points. The information in the first unit was composed of the back and upper extremities, the second unit covered the lower extremity regions, the content of the third unit consisted of the body cavities (thoracic, abdominal, and pelvic), and the fourth unit comprised the head and neck regions.

Data Analysis

The information used in this inquiry was collected from the four-unit test scores of all student participants and was then organized into an Excel spreadsheet where descriptive statistics and averages were analyzed using SPSS version 25. The benefits of using the VDT as a supplement for the lab's dissection portion were evaluated by comparing scholars' test scores before (Fall 2016-2017) and after (Fall 2018-2019) the addition of VDT to the anatomy course. A one-way ANOVA was conducted to compare both groups, and a p-value of 0.05, was considered significant for this inquiry.

RESULTS

Table 1 illustrates the student and gender distributions before and after the VDT was introduced to cadaver dissection.

Table 1. Participants

Characteristics	**Pre VDT n=108**	**VDT n=108**
Gender	Male= 29; Female = 79	Male= 23; Female = 85

Table 2 shows the grade comparisons between the two groups. After incorporating the VDT, there was a slight increase in grades; however, this increase was not statistically significant.

Table 2. Grades comparisons

Characteristics	**Pre VDT n=107**	**VDT n=107**	**P value**
Course Grade	169.1+/-15.0	170.9+/- 12.7	0.35*

*Anova analysis was performed with a P value of 0.05 as significant.

DISCUSSION

Anatomy professors often encounter difficulties in helping scholars comprehend the complexity of human anatomy. Coincidingly, a few challenges students face are ascribed to discerning the relationships between the various arrangements presented, along with distorted depth perception, resulting from the use of TLE-hindering 2-D study accessories, such as presentation projections and textbooks. The primary concern with these strains in health-related programs is that scholars will ultimately work with people in clinical environments rather than with an image on a computer screen or in a book, making it crucial to address the alleviation of these issues (Smith et al., 2013). In an attempt to help students promptly discern problematic anatomical concepts, relationships, and depths, this report focused on the impact of adding a VDT to the TLE in an anatomy course, which revealed several conclusions worth sharing.

As previously stated, cadaver dissection is a unique and unparalleled experience that is paramount to many health-related programs (Ghosh, 2015). However, anatomy supplements, such as the VDT used in this study, are vital in aiding students' comprehension, reducing the gap created by didactic lectures, and minimizing the time needed to connect concepts learned in lectures with the structures dissected and observed in the anatomy lab (Krause et al. 2015; Custer, & Michael, 2015).

Among the scholars who utilized the VDT, the slight increase in their test scores compared to the scholars who were not exposed to the table illustrates the benefits of the VDT as a supplemental tool. We deduce that, while they are not statistically significant, higher test scores are essential to consider. The VDT allowed the pupils to experience gross anatomy in a more in-depth way, including aspects that are not always visible in physical cadavers. We conclude that this is what led to the higher test scores, delineating that the VDT provides students with greater knowledge and a more thorough understanding of the human body (Ward, Wertz, & Mickelsen, 2018). Similar to other reports, we can infer that by incorporating a 3-D perspective in combination with the instructor requiring pupils to interact with the VDT during the cadaver dissection period, enhancements in understanding complex regions in the anatomy course are present (Peterson & Mlynarczyk, 2016). We recommend integrating VDT into other clinical classes that require a strong background in anatomy, such as kinesiology and musculoskeletal courses. However, we suggest providing this opportunity to scholars when they have the advantage of physically manipulating the virtual structure, thereby allowing them to be active learners during the activity, as proposed by Chakraborty & Cooperstein (2018).

One of the main concepts worth highlighting in the current study is the methodology and logistics in integrating the VDT into the anatomy course without hindering the TLE in cadaver dissection. As depicted in Figure 1, the VDT was incorporated as an additional cadaver tank in the laboratory layout, allowing students to rotate when needed without any restrictions. Nevertheless, to ensure that each student had experience working with and manipulating structures on the VDT, they were required to reserve time to work with the VDT during each cadaver lab interaction.

The cadaver dissection experience logistics were designed so that each group of students was assigned to one cadaver tank; this lab portion of the anatomy course consisted of 3 h of dissection followed by an hour of prosection, twice weekly. After the first hour of dissection, rotations for each tank group with the VDT began, as students were required to use the table for 15 minutes each lab session to interact with the dissection region and structures covered that day. The tanks were rotated every 15 min to allow each student to utilize the VDT in every lab session, which potentially allowed for the full and comprehensive view of anatomical structures that are not always explicitly observable in cadavers (Figures 1 and 2). Finally, after each group of students completed their allotted time with the VDT, they were encouraged to return to the VDT for further clarification, as needed.

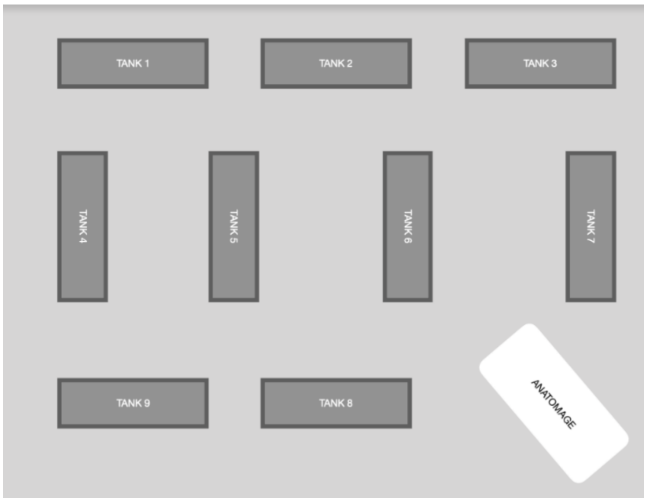

Figure 1. Cadaver Lab Setup with the addition of the anatomage

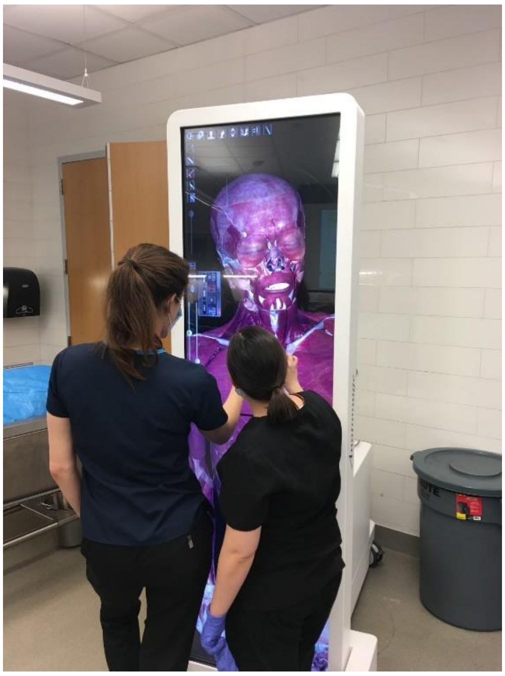

Figure 2. TWU DPT Students Using the Anatomage in Gross Anatomy PT6015

While the successful integration of this particular VDT model has been previously reported, they involved programs that differ from those in this study (Afsharpour et al., 2018; Ward, Wertz, & Mickelsen, 2018). As we knew the potential of the VDT and the quality of its specimens and images, we were confident that this cadaver lab setting and protocol would provide additional opportunities for students to review gross anatomy related to the regions being explored in the lab while boosting their anatomy comprehension and grades. Additionally, requiring students to be more actively involved in their learning by manipulating the virtual cadaver and analyzing different structures enabled them to discern the structural and functional anatomical relationships and how these configurations and areas fit together while influencing movement (Brucoli et al., 2020 & Darras et al., 2020).

Following the incorporation of this 3-D technology into the lecture and lab, there has been a noticeable increase in excitement and motivation concerning learning human anatomy, which can be attributed to the VDT providing students with the "full picture" in a concise manner, as previously reported in similar settings (Berkowitz et al., 2014). As a result, deliberations on adding the VDT to other courses and outreach activities are underway. Further, this report was composed of only physical therapy students and the respective gross anatomy course; considerations will be made for interdisciplinary collaborations by focusing on the necessity of students' needs.

CONCLUSION

Since its incorporation into the cadaver laboratory at Texas Woman's University in the Fall of 2018 semester, the Anatomage virtual dissection table has proven to be a substantial adjunct to the gross anatomy course for physical therapy students. As cadavers often have inconsistencies, integrating the VDT into the TWU gross anatomy course allowed future doctors of physical therapy to thoroughly examine, study, and comprehend each anatomical structure and relationship unambiguously.

Regardless of the many advantages presented by supplemental tools in anatomy courses, such as that reported in this study, it is essential to point out that they are not a substitute for human cadaver dissection and should be used as adjuncts to enhance the TLE. Nevertheless, the VDT has made remarkable impacts as a teaching tool for both institutional and non-institutional students (Mathis, Gonzalez, & Rosario, 2020) at Texas Woman's University's School of Physical Therapy in Dallas.

Given that this investigation used VDT solely in an anatomy course, along with observing only a modest increase in grades, our findings and data cannot be generalized or transposed to differential courses. However, as the results of this study demonstrate students' grades to be steadily higher than in decline, it can be concluded that the VDT should be included in human anatomy courses within graduate programs in order to support the TLE.

Additional examinations should focus on employing the VDT among students who do not typically reap the benefits of experiencing education from observing, dissecting, prosecting, or studying cadavers, such as those pursuing undergraduate degrees, occupational therapy scholars, and students from other universities, which would further allow for a broader network of collaborators.

As per the discoveries of this inquiry, we propose incorporating a VDT into every anatomy-related course, regardless of the program's specifications or degree pupils are enrolled in. Likewise, since graduates tend to adopt a more passive learning approach, we encourage reserving time within the curriculum during which students would be required to maneuver the VDT, such as through small group assignments to complete appointed tasks. We further recognize that to learn anatomy successfully and all of the components it embodies over a shorter period of time, scholars must not simply watch and heed to their instructor within teaching and lab scenarios in a passive manner, but must also be proactive in engaging with the VDT. Since the VDT is expensive, we advocate including a supplemental 3-D application to anatomy courses, comparable to that of Rosario (2021) investigated; having a 3-D anatomy-based application available both inside and outside of class for scholars to examine and manipulate anatomical structures will only further expand upon their understanding and minimize the inevitable gap between lectures and laboratories.

As a final remark, we expect and aim to enhance the understanding of surface anatomy and underlying tissues among our physical therapy students in an effort to improve their palpation skills and ability to tailor future interventions per patients' needs effectively. Therefore, we recommend combining the use of a VDT with traditional instruction methods as an adjunct tool within other physical therapy graduate courses, such as kinesiology and musculoskeletal courses, to improve pupils' detailed human anatomy comprehension and clinical skills of prospective doctors of physical therapy.

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Ethics and Consent: The author utilized the ARECCI tool to stipulate and justify that this examination is categorized under the Program Quality Improvement, for which the ARECCI tool is instructed as a replacement for an institutional review board. This report can be retrieved at this URL:

http://www.aihealthsolutions.ca/arecci/screening/453976/8b87ac3c83723ce66cad073476cfc24d

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