The Use of Anatomical Dissection Videos in Medical Education

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Abstract

Dissection videos are commonly utilized in gross anatomy courses; however, the actual usage of such videos, as well as the academic impact of student use of these videos, is largely unknown. Understanding how dissection videos impact learning is important in making curricular decisions. In this study, 22 dissection videos were created to review structures identified in laboratory sessions throughout the Organ Systems 1 (OS1), 2 (OS2), and 3 (OS3) courses. Dissection videos were provided to 201 first-year medical students, and viewing data were recorded. Demographic data for age and gender identity were also collected from students. Overall, there was a significant decrease in total views ($P = 0.001$), the number of students who pressed play ($P < 0.001$), and the number of students who viewed 90% of the total length of videos ($P < 0.001$) from OS1 to OS3. The total adjusted time spent viewing videos was not significantly different between individual OS courses. There were some instances where significant differences existed in examination performance between those who did and did not view videos, and by time spent viewing videos. There were no significant differences in time spent viewing videos by gender. Together these data suggest that students may utilize dissection videos more at the beginning of a dissection course, although they remain an important resource throughout the year for a subset of students.

Keywords

Gross anatomy education; medical education; dissection videos; gross anatomy laboratory; dissection

INTRODUCTION

Anatomical dissection has a long history in medical education (Dyer and Thorndike, 2000; Aziz et al., 2002; Elizondo-Omaña et al., 2005; McLachlan and Patten, 2006). With advances in technology, the debate around anatomical dissection and the use of technology in the laboratory has come to the forefront of curricular decisions. There has been a general trend of reducing curricular time devoted to teaching gross anatomy in medical schools over the years (Collins et al., 1994; Dyer and Thorndike, 2000; Drake et al., 2009). In extreme

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instances, dissection has been completely eliminated (McLachlan et al., 2004; Ramsey-Stewart et al., 2010), only to be later reinstated due to deficiencies in anatomical knowledge (Rizzolo and Stewart, 2006; Ramsey-Stewart et al., 2010). When surveyed, students themselves have disagreed with dissection being removed from the curriculum, as well as its replacement by prosection or other methods of instruction (Azer and Eizenberg, 2007), thereby recognizing its importance to their education (Lempp, 2005; Ramsey-Stewart et al., 2010; Hajj et al., 2015; Flack and Nicholson, 2017). Accordingly, to date, although hours may have been reduced, dissection has largely remained a mainstay in medical education (Fitzharris, 1998; Drake et al., 2002; Drake et al., 2009).

There is much evidence to support the inclusion of dissection in medical education. It lends itself to a three-dimensional understanding of the human body through tactile and sensory perception (Aziz et al., 2002; Granger, 2004; Lempp, 2005; Azer and Eizenberg, 2007; Ramsey-Stewart et al., 2010; Flack and Nicholson, 2017), and the ability to reconstruct the body after dissection (Korf et al., 2008). Working with multiple donors in a laboratory, and observing deviation from textbooks fosters an appreciation of human variability (Amadio, 1996; Aziz et al., 2002; Granger, 2004; Korf et al., 2008; Flack and Nicholson, 2017). Additionally, this experience promotes an understanding of trauma and the opportunity for exposure to medical procedures (Fitzpatrick et al., 2001; Reidenberg and Laitman, 2002; Glasgow et al., 2006; Azer and Eizenberg, 2007; Gogalniceanu et al., 2008; Flack and Nicholson, 2017), without the danger of harming the patient. Further, working in the anatomy laboratory provides an opportunity for fostering self-growth and professionalism through self-reflection (Lachman and Pawlina, 2006; Flack and Nicholson, 2017), learning to work with peers (Aziz et al., 2002; Lempp, 2005; Swartz, 2006; Flack and Nicholson, 2017), and engaging with death and dying (Marks and Bertman, 1980; Marks et al., 1997; Aziz et al., 2002; Granger, 2004; Kotze and Mole, 2013; Flack and Nicholson, 2017). Finally, anatomical donors have been described in terms of both the students' first teacher and patient (Granger, 2004; Winkelmann and Guldner, 2004; Swartz, 2006; Swick, 2006; Lin et al., 2009; Bohl et al., 2011). This approach may further support the development of professionalism and empathy in future healthcare professionals as the humanism and identity of donors continue to evolve and be embraced by academic institutions (Vannatta and Crow, 2007; Lin et al., 2009; Crow et al., 2012; Bohl et al., 2013; Jones et al., 2014; Jones and King, 2016; Greene et al., 2017).

Anatomical dissection can bring forth multiple challenges that students may not have yet encountered. Students must learn, conceptualize, and retain a large amount of new information and simultaneously learn new medical terminology (Aziz et al., 2002; Netterstrøm and Kayser, 2008), improve their spatial abilities (Lufler et al., 2012; Vorstenbosch et al., 2013), and experience and cope with a range of emotional responses related to working with anatomical body donors (Nnodim, 1996; Dinsmore et al., 2001; Lempp, 2005; Arráez-Aybar et al., 2008; Cahill and Ettarh, 2009; Boeckers et al., 2010; Quince et al., 2011; Flack and Nicholson, 2017). Additionally, students must often learn the technique of dissection (Flack and Nicholson, 2017), and therefore might not initially complete dissections of sufficient quality to obtain an ideal view of the structures they are attempting to find. Therefore, it is not surprising that students desire more guidance surrounding dissection (Azer and Eizenberg, 2007). As technology has evolved, dissection

videos, sometimes categorized as computer-assisted instruction (CAI) or learning (CAL), have been incorporated into many classrooms. Such media serve as aids for demonstrating how to complete a dissection, reviews of the structures that should be identified in a particular dissection, and even replacements for at least a portion of dissection (Bacro et al., 2000; Inwood and Ahmad, 2005; DiLullo et al., 2006; Granger et al., 2006; Saxena et al., 2008; Mahmud et al., 2011; Topping, 2014; Choi-Lundberg et al., 2016a). Further, dissection videos are now incorporated into electronic dissection manuals (Gould et al., 2015; Detton, 2016). Finally, as class sizes have increased, one method for maintaining small groups within the laboratory has been to alternate dissection time amongst the class (Collins et al., 1994; Brueckner and MacPherson, 2004; Granger and Calleson, 2007; Manyama et al., 2016), meaning that not all students are exposed to the exploration and discovery of particular structures. In such cases, dissection videos may benefit the non-dissecting students (Granger and Calleson, 2007).

While the impact of dissection videos on academic performance has been studied, the actual patterns of usage across the anatomy curriculum have received less attention. The effect of gender on the usage of dissection videos also remains largely unexplored, despite reports of course media being utilized differently by males and females in medical education (Romanov and Nevgi, 2007; Adamczyk et al., 2009; McNulty et al., 2009). Additionally, much of the literature that has evaluated course performance has done so by comparing the performance of entire cohorts of students before and after dissection videos have been introduced, or evaluation of survey responses. Results of these studies have not been consistent, with some studies reporting an improvement in performance (Saxena et al., 2008; Topping, 2014), and others reporting no significant differences in examination performance (Pereira et al., 2004; Josephson and Moore, 2006) when evaluating the effectiveness of such media. One study evaluated actual student usage of videos as measured by individual student access and length of viewing, and demonstrated these to have a positive impact on academic performance (Choi-Lundberg et al., 2016a). However, these were created using successive static photographs of dissections, as opposed to actual video footage, and patterns across the year were not evaluated. Therefore, actual video usage data has been limited in informing the utilization and impact of dissection videos in the anatomy curriculum.

The purpose of this study was to evaluate the usage and impact of dissection videos across the entire first year in two cohorts of students. The goals of this study were to (1) Determine how students utilized the dissection videos throughout the year, (2) Determine if there were differences in video usage by gender, (3) Determine if there were relationships between viewing the dissection videos and performance on practical examinations, and (4) To review the current literature on cognitive load theory, and explore how dissection videos might fall within current learning theories in medical education.

MATERIALS AND METHODS

This study was classified and approved as exempt by the Institutional Review Board (IRB) at Morehouse School of Medicine (MSM; protocols 1191852–1 and 871717–1).

Gross Anatomy Curriculum at Morehouse School of Medicine

The gross anatomy curriculum at MSM has been described in detail previously (Klement et al., 2017; Greene, 2018). Briefly, gross anatomy was a component of the Organ Systems (OS) OS1, OS2, and OS3 courses within the integrated curriculum for first-year medical students at MSM. Students participated in every laboratory session across all courses, and 3 to 5 faculty members were typically available to answer questions during each three-hour session. Students utilized the online dissector available through Thieme MyCourse (Gould et al., 2015), which was an editable manual that could be customized to the MSM course. The OS1 course ran from September through December, and the anatomy component of this course covered back, upper limb (UL), thorax, and abdomen across approximately 63 hours of laboratory dissection time. Four laboratory group quizzes and two practical examinations were given within this course. The first practical examination covered back and upper limb (UL), and the second covered thorax and abdomen. The OS2 course ran from January to March, and the anatomy component of this course covered pelvis, perineum, and lower limb (LL) across approximately 30 hours of laboratory dissection. Two laboratory group quizzes and one practical examination were given on this material. The OS3 course ran from March to May, and the anatomy component of this course covered head and neck across approximately 60 hours of laboratory dissection. Three laboratory group quizzes and one practical examination were given in this course. All laboratory quizzes were taken within each table group (4 to 5 students), and consisted of 12 questions, where students were asked to identify structures on their own dissection on a rotating basis. Therefore, each individual student was asked to identify 2 to 3 structures on each quiz, and all members of each group received the same overall quiz score. Practical examinations ranged from 35 to 50 questions on student dissections, faculty prosections, models, and bones. Most questions were primary identification, however some were structured as second or third order questions. Each individual student was asked to fill in answers on a blank answer sheet, and therefore received an individual score.

Creation of Dissection Videos at Morehouse School of Medicine

The dissection videos evolved to provide students an overview of material covered in multiple laboratories throughout the year. Each year, a faculty member, utilizing similar methods to those provided to the students in the dissection manual, performed all dissections for each video. Deviations from the student dissections were generally for one of two purposes: (1) To demonstrate structures that students were not required to dissect, but were responsible for identifying on the prosection, such as structures related to the spinal cord, or (2) to provide students an alternate or unique view apart from what they would see on their own dissections, such as removing the clavicle to view the brachial plexus during OS1, which was a procedure that students would not perform until OS3. Additionally, the prosection donor was utilized to provide short, 5 to 10 minute laboratory introductions that reviewed the structures to be identified that day, including some instructional dissection tips. Although the online dissector included some instructional and review videos, they were not specific to the MSM course, and did not, as individual videos, comprehensively cover the full dissection for the day, nor did they present the unique views in the prosection or direct students about which structures to identify on their donors versus the prosection donor. Therefore, formal dissection videos were created internally with the support of the Office of

Digital Technology at MSM. The purposes of these videos were the same as the purposes for having the prosection donor, however the videos provided students the opportunity to view the dissections at any time, and as many times as they desired.

Dissection videos were either recorded live in the laboratory using the laboratory camera, or by the Office of Digital Technology. In both cases, they were downloaded and imported into Camtasia[®], version 2.10.3 for Mac computers (TechSmith Corp., Okemos, MI) for editing. Editing included removing unwanted or unnecessary components of the videos, occasional voice-overs, adding orientation markers and text as needed, as well as adding one slide to introduce the video and a second slide to acknowledge the anatomical donors. The final product was not an instructional dissection video on how to perform a dissection, but rather a summary of structures to be identified in the corresponding laboratory. The average length of the videos was six minutes and 18 seconds, with the shortest video at one minute and 53 seconds and the longest at 13 minutes and 57 seconds. Once editing was complete, all videos were loaded into TechSmith Relay[®] (TSR), version 5.0.6, (TechSmith Corp., Okemos, MI). Videos were linked to TSR through Blackboard curriculum management system (Blackboard Inc., Washington, DC), which was the course management system for the OS courses. References to the videos were also incorporated into the Thieme dissector (Gould et al., 2015) under each relevant dissection, which indicated the location where the videos could be located within Blackboard. Students were not advised as to how best to utilize the videos, and could use them in whatever manner they found most helpful.

For the 2016–2017 course (Year 1 of this study [Y1]), 21 dissection videos were available to students. These included 18 videos that were formally recorded through the Office of Digital Learning, and three that were recorded live during a laboratory session. Some of these videos were created during the year, and therefore not available prior to the corresponding laboratory. For the 2017–2018 course (Year 2 [Y2]), 22 videos were available, as a new video covering the face was created. All videos for Y2 were available at the beginning of and throughout each OS course. Videos that were available to each class can be found in Supplemental Tables 1, 2, and 3.

Tracking of Views

Viewing data were recorded through TSR in real time. Viewing data were recorded in at the time of each practical examination for Y1, and weekly for Y2. Viewing data for both Y1 and Y2 included the total number of views for each video, the individual students that viewed each video, and the total percent length of each video that each student viewed. Data for multiple views across each course were available for Y2, which included the total percent length of each video that was viewed each time a student pressed play. Given that students viewed varying lengths of each video with each view, rather than using the number of times a student pressed play, the percent length of each individual view was converted to time (in minutes), and time for all views was added together to provide the total time that each student spent viewing each video.

Surveys

One survey was sent out to the Y2 students at the end of each OS course regarding overall use of course media. These surveys included questions about age and gender identity. The final survey also included an open-ended question that invited students to describe why their patterns of viewing dissection videos changed or remained constant throughout the year.

Course Performance

Laboratory quiz scores were not evaluated, given that these were administered and scored for each table group as a whole. Performance on practical examinations was recorded for each individual student. As a majority of students passed each examination, grades were converted into quartiles, and the 50th percentile was used to place students into fairly even lower and higher scoring groups. Therefore, for each examination, students were categorized into one of two groups for comparisons: Lower performing (defined as scoring below the 50th percentile), and higher performing (defined as scoring at or above the 50th percentile). Quartiles were utilized when performing correlation analyses.

Statistical Analyses

Overall Dissection Video Views.—Viewing data were recorded in Microsoft® Excel, version 14.5.9 for Mac (Microsoft Corp., Redmond WA). Statistical analyses were completed using SPSS Statistics, version 24.0 for Mac (IBM Corp., Armonk, NY). Data were collected within Y1 (n = 96 for OS1; n = 97 for OS2 and OS3) and Y2 (n = 101 for OS1; n = 102 for OS2 and OS3) for usage of dissection videos, and individual students were categorized as clicking to play a video, not viewing a video (viewed <10% of the total length), and viewing a full video (viewed ≥ 90% of the total length). Those who viewed between 10 to 89% of videos were excluded from analyses where comparisons were made between students who did and did not view videos. Additionally, individual students for Y2 were classified as viewing less than one minute, one to five minutes, five to ten minutes, ten to fifteen minutes, and greater than 15 minutes of each video, which accounted for multiple views. Videos were categorized based on if they were relevant to OS1, OS2, or OS3.

To evaluate differences by year, z-tests with Bonferroni correction were completed to determine if there were significant differences in proportions of students who pressed play for each video, and the proportion of students who had viewed each full video.

Comparisons by Gender.—For comparisons by gender, the time category for each individual video, as well as overall video viewing time category during OS1, OS2, OS3 were made using Pearson Chi-Square analyses with follow-up z-tests with Bonferroni correction. Time categories for time spent viewing all relevant videos for each OS course were defined as viewing less than one minute, one to five minutes, five to ten minutes, ten to fifteen minutes, fifteen to twenty minutes, and greater than twenty minutes. Mean time for viewing videos within each course was also calculated.

Changes Across the Year.—Within and across Y1 and Y2, mean total views, mean number of students who pressed play, and mean number of students who viewed the full videos were compared between OS1, OS2, and OS3 videos using a one-way analysis of

variance and follow-up Tukey tests. For Y2, mean length of time viewing videos was compared between OS1, OS2, and OS3 videos using a one-way analysis of covariance with follow-up pairwise comparisons using Bonferroni confidence interval adjustment. The covariate used was the length of each video, which was entered to account for the varying lengths of videos by OS course.

Dissection Video Views and Course Performance.—Independent sample t-tests were completed to determine if practical examination scores were significantly different by year. The total number of fully viewed dissection videos relevant to each practical examination was calculated for each individual student. Based on these totals, students were categorized as dissection video viewers (those who viewed all dissection videos for each examination) or non-viewers (those who did not view any dissection videos for each practical examination). Those who did not fall in either category were excluded from analyses. For each relevant practical examination, Pearson Chi-Square analyses with follow-up z-tests with Bonferroni correction were completed to determine if the proportions of those who fully viewed and did not view each individual dissection video were significantly different between lower and higher performing groups, as well as if the proportions of viewers and non-viewers were significantly different between lower and higher performing groups, within each year. To evaluate total time spent viewing videos in Y2, Pearson Chi-Square analyses with follow-up z-tests with Bonferroni correction were completed to determine if there was a significant difference in proportions of lower and higher performing students for the relevant practical examination between time categories. Time categories were defined as previously described for overall dissection video views and gender comparisons. Finally, Spearman correlations were completed to determine if relationships existed between time category for viewing the videos and examination performance quartile.

RESULTS

Overall Dissection Video Views

Overall dissection video views, as well as significant differences by year, are summarized in Supplemental Tables 1, 2, and 3. Total minutes viewed for each video, as well as the mean minutes viewed per student for each video, were only available for Y2. The patterns of viewing across the year are presented Figure 1.

Changes Across the Year

Within Y1, there was an overall significant difference in the mean total number of views ($P < 0.01$), and the mean number of students who pressed play to view any length of the videos ($P = 0.01$) by OS course. Follow-up comparisons revealed that the mean total views of dissection videos were significantly higher for OS1 (mean of 76.8) than OS2 (mean of 35.2; $P < 0.01$) or OS3 (mean of 37.3; $P < 0.01$). Additionally, the mean number of students that pressed play to view any length of the videos was significantly higher for OS1 (mean of 32.3) than OS2 (mean of 18.3; $P < 0.05$) or OS3 (mean of 17.4; $P < 0.05$).

Within Y2, there was an overall significant difference in the mean total number of views ($P < 0.001$), the mean number of students who pressed play to view any length of the videos (P

< 0.001), and the mean number of students who viewed 90% of the total length of the videos ($P < 0.001$) by OS course. Follow-up comparisons revealed that the mean total views were significantly higher for dissection videos in OS1 (mean of 139.4) than OS2 (mean of 48.2; $P < 0.001$) or OS3 (mean of 72.6; $P = 0.001$). Additionally, the mean number of students who pressed play to view any length of the videos was significantly higher for OS1 (mean of 52.8; than OS2 (mean of 22.2; $P < 0.001$) or OS3 (mean of 28.3; $P < 0.001$). Similarly, the mean number of students who viewed 90% of the total length of the videos was significantly higher for OS1 (mean of 41.6) than OS2 (mean of 19.3; $P < 0.001$) or OS3 (mean of 27.1; $P < 0.01$). Although there was an overall significant difference in the adjusted total time that dissection videos were viewed across all students and videos by course (when video length was entered as a covariate; $P < 0.05$), there were no significant differences in follow-up comparisons (Figure 2).

Surveys – Comparisons by Gender

Across the three surveys, 60 students responded to at least one survey, (57.7% response rate). Demographics are presented in Table 2, and means are reported in Figure 3. There were no significant differences by gender identity for viewing time categories within each course. Due to the low number of qualitative responses on the final survey, qualitative analyses were not performed.

Dissection Video Views and Course Performance

Comparisons of the proportions of students who fully viewed and did not view each individual dissection video between lower and higher performing groups on the relevant practical examinations are presented in Supplemental Table 4. There were no overall significant differences in proportions of viewers and non-viewers between lower and higher performing groups on the relevant practical examination for Y1 or Y2 in any of the OS courses.

Organ Systems 1: Back and Upper Limb.—For the OS1 course, mean scores for the practical that covered back and UL for Y1 and Y2 were 85.1% and 82.7%, respectively, and these scores were not significantly different. The mean scores for the practical examination that covered thorax and abdomen for Y1 and Y2 were 86.0% and 88.9%, respectively, and these scores were significantly different ($P < 0.01$).

For Y2, there were numerous significant differences based on time spent viewing the videos. A z-test revealed that for the examination that covered back and UL, a significantly larger proportion of lower (55.3%; $n = 26$) than higher performing students (33.3%; $n = 18$) had spent less than one minute viewing the anterior arm and forearm video ($n = 101$; $P < 0.05$). Conversely, for the same examination, a significantly larger proportion of lower (19.1%; $n = 9$) than higher performing students (5.6%; $n = 3$) had spent greater than 15 minutes viewing the video covering the hand ($n = 101$; $P < 0.05$). There were significant positive correlations between time category and quartile performance on the back and UL practical examination for several videos, which included superficial back ($r_s = 0.201$, $n = 101$, $P < 0.05$), intermediate and deep back ($r_s = 0.230$, $n = 101$, $P < 0.05$), and axilla – part one ($r_s = 0.208$, $n = 101$, $P < 0.05$). There was also a significant correlation between categories for time spent

viewing relevant videos covering back and UL and quartile performance on practical examination covering this content ($r_s = 0.204$, $n = 101$, $P < 0.05$).

Organ Systems 2: Pelvis, Perineum, and Lower Limb.—For the OS2 course, mean scores for the practical examination that covered pelvis, perineum, and LL for Y1 and Y2 were 78.0% and 82.7%, respectively, and these scores were significantly different ($P = 0.001$).

When evaluating time spent viewing videos for Y2, a z-test revealed that for the examination that covered pelvis and LL, a significantly larger proportion of higher (16.7%; $n = 9$) than lower performing students (4.2%; $n = 2$) had spent 5 to 10 minutes viewing the video covering the gluteal region ($n = 102$; $P < 0.05$). For the same examination, there was an overall significant difference in the proportions of students falling into the higher and lower performing groups based on categories for time spent viewing the dissection video that covered posterior thigh ($X^2 [2 \text{ } n = 102] = 7.06$, $P < 0.05$). A z-test revealed that a significantly larger proportion of lower (89.6%; $n = 43$) than higher performing students (68.5%; $n = 37$) had spent less than one minute viewing this video ($P < 0.05$). Similarly, a significantly larger proportion of higher (24.1%; $n = 13$) than lower performing students (6.3%; $n = 3$) had spent 1 to 5 minutes viewing this video ($P < 0.05$). Finally, a z-test revealed that a significantly larger proportion of higher (20.4%; $n = 11$) than lower performing students (6.3%; $n = 3$) had spent greater than 20 minutes viewing dissection videos across the OS2 course ($n = 102$; $P < 0.05$). There was also a significant correlation between categories for time spent viewing relevant videos across the course and quartile performance on the examination that covered pelvis and LL ($r_s = 0.198$, $n = 102$, $P < 0.05$).

Organ Systems 3: Head and Neck.—For the OS3 course, mean scores for the practical examination that covered Head and Neck for Y1 and Y2 were 80.9% and 86.0%, respectively, and these scores were significantly different ($P = 0.001$). For the Y2 practical examination, there were no significant differences in proportions of lower and higher performing students between time categories for viewing videos. There were no significant correlations between time category for viewing videos and quartile performance on this practical examination.

DISCUSSION

Use of Dissection Videos Across the Year

The first goal of this study was to determine if students would utilize the dissection videos similarly throughout the year, and indeed this was not the case. Instead, there was a general decrease in the percent of the class that both accessed and viewed the full length of the videos after the OS1 course (Figure 1), which is consistent with a report by Saxena and colleagues (Saxena et al., 2008). This drop in viewership was more profound in Y2, although there were striking differences in viewership between Y1 and Y2 in OS1, particularly for the videos relevant to the first two laboratory sessions of the year (Back 1 and Back 2). The differences by year may have been due to the fact that not all videos were available at the onset of each course for Y1, as they were still being created and edited, while all videos were available to students throughout each course for Y2. It should be noted

that first two videos of the year were recorded live during the first laboratory session for Y1 and made available shortly after the these sessions, but were available prior to the corresponding laboratory for Y2. Therefore Y2 students had the opportunity to utilize the videos in preparation for these laboratory sessions, while the Y1 students could not do this. Within both years, there were significant decreases in total views and the number of students accessing the videos, and in Y2, there was also a significant decrease in the number of students viewing the full length of the videos from OS1 to OS2 and OS3. Interestingly, there was a corresponding trend of spending less time viewing videos beyond the OS1 course. One theory that has been posed as a reason for a decrease in dissection video views over time is student burnout (Saxena et al., 2008). However, some survey respondents in the current study reported less viewing toward the end of the year due to feeling that there wasn't enough time to utilize them, which is consistent with other studies (McNulty et al., 2009; Topping, 2014).

One additional reason for the salient difference between Y1 and Y2 could be explained by the videos serving to prepare the Y2 students for entering and adjusting to the anatomy laboratory. It has been documented that students utilize dissection videos both as a resource to prepare for dissection, as well as to study for examinations (Inwood and Ahmad, 2005; Granger et al., 2006; Saxena et al., 2008; Topping, 2014; Choi-Lundberg et al., 2016a). Students may have utilized the dissection videos not only in preparation for finding anatomical structures, but also as a resource for emotional preparation for entering the laboratory. There have been numerous reports of students experiencing anxiety related to anatomical dissection (Nnodim, 1996; Dinsmore et al., 2001; Houwink et al., 2004; Boeckers et al., 2010; Quince et al., 2011; Lamdin et al., 2012). As students adjusted to working with anatomical body donors, the videos may have no longer been needed for this purpose. This is supported in one study regarding student attitudes toward dissection, where approximately half of respondents reported that viewing a dissection video prior to a formal dissection experience would have been of benefit to them (Cahill and Ettarh, 2009), and also by another study that suggests that such audiovisual exposure does, in fact, reduce anxiety experienced in anticipation of dissection (Casado et al., 2012). Secondly, dissection videos may help students feel more confident and prepared for dissection (Choi-Lundberg et al., 2016a), and make their laboratory experience less intimidating (Inwood and Ahmad, 2005). As students learned and became more confident in the technique of dissection, they may have relied more heavily on demonstrations provided at the beginning of the laboratory as sufficient preparation for their own dissection. This theory was supported by one survey respondent: *"The demonstration in lab that day and reading the dissector became adequate enough to [not] necessarily watch the dissection videos since our bodies never really were that easy to dissect."*

Interestingly, as visualized in Figure 1, the proportion of students who both accessed the videos and viewed the full length of the videos increased from OS1 to OS3, suggesting that students refined their studying strategies over time and were more intentional in accessing the videos by the end of the year. Students may have been exploring available resources without the intent of utilizing every resource during the OS1 course, and abruptly ending the videos upon deciding that they did not find them helpful. Once they became familiar with the resources available to them, and decided which of these resources were most helpful to

their own study strategy, they may have explored less and pressed play with the intent of watching the full video more often. This was supported by one survey respondent: “*I watched the videos more in the beginning of the year because I still was not sure where all the structures were and how to learn them and what resources to use.*” Additionally, student reports have varied with regard to the usefulness of videos as compared to other course resources, with reports of preference toward the use of textbooks over multimedia (Adamczyk et al., 2009), including videos (Choi-Lundberg et al., 2016b), and in other cases have ranked them more similarly (Choi-Lundberg et al., 2016a). These inconsistent findings may be influenced by different preferences among students as they develop their individual study strategies. The drop in viewership over time, as well as comments quoted previously, provide insight into this theory, suggesting that students were indeed adjusting their study strategies early on, and their need for the videos decreased as they found the resources that were most useful to them. This theory has also been posed by Saxena and colleagues (Saxena et al., 2008). However, despite this overall drop in viewership, a subset of students continued to utilize the dissection videos consistently throughout the year, suggesting that these videos can be of benefit throughout dissection for some students. This was outlined well by one of the survey respondents, “*The dissection videos [and other tutorials] were extremely helpful and were my primary method of studying anatomy.*”

Comparisons by Gender

The second goal of this study was to explore dissection video usage by gender. Results demonstrated no significant differences for time categories for individual videos or across any course by gender. Although there is limited research on this topic, these results are in contrast to previous studies where a higher frequency of log-ins for accessing interactive course tutorials (McNulty et al., 2009) as well as a larger proportion of viewing more than one video (Romanov et al., 2007) by female students was reported. In some cases, there have been no significant differences between male and female students’ evaluations of course media (Adamczyk et al., 2009; Choi-Lundberg et al., 2016b). However this does not necessarily translate to similar utilization, as a larger proportion of males utilized media in one of these studies (Adamczyk et al., 2009). While this portion of the current study was based on a small sample size, the measure of actual viewing time may have provided more specific information about video usage by gender. Regardless, this remains a topic for continued investigation.

Dissection Video Views and Course Performance

The third goal of this study was to determine if students who viewed the dissection videos would perform significantly better on relevant practical examinations than those who did not view these videos. Students have reported that the use of dissection videos positively impacted their learning and performance (DiLullo et al., 2006; Granger et al., 2006). However there was no clear evidence to support an improvement in performance based on viewing the dissection videos. In fact, the opposite was true for the video that covered the hand, where in Y1, for the corresponding OS1 practical examination, a larger proportion of lower performing students had viewed this video. Additionally, in Y2, lower performing students demonstrated more viewing time for this video. There was only one instance (for the video covering posterior thigh in Y2) where a larger proportion of higher performing

students had viewed a video. However, there were instances where lower performing students demonstrated less viewing time (for videos covering anterior arm and forearm and posterior thigh), and where higher performing students demonstrated more viewing time in at least one time category (for the videos covering the gluteal region and posterior thigh, and for time spent viewing all videos across the OS2 course). There were also significant positive correlations between time spent viewing videos and quartile performance on examinations within both OS1 and OS2 courses. These results are consistent with reports of dissection videos demonstrating a positive impact on course performance (Saxena et al., 2008; Topping, 2014; Choi-Lundberg et al., 2016a). A majority of these results were unique to OS2, which could be due to these videos receiving some of the lowest views across the year. The OS2 course differed from OS1 and OS3 not only in content, but also with regard to the schedule, as it had more laboratory sessions per week than the other courses. This could have contributed to the low number of views, as students experienced less time to prepare and review for the laboratory each day. Together, it is reasonable to conclude that perhaps only the highest achieving students were prioritizing the videos at that time. The lack of significant differences across the remainder of the videos is consistent with other reports (Pereira et al., 2004; Josephson and Moore, 2006; Mahmud et al., 2011). Overall, these data suggest that, with some exceptions, both high and low achieving students utilized the videos across the year.

Dissection Videos and Medical Education: Future Directions

The final goal of this study was to explore how dissection videos fit into current learning theories in medical education. As many of the theories explored could not be directly observed through the results of the current study, this goal led to the development of future directions beyond the current study. However, the relevancy of dissection videos to cognitive load theory was evident. One topic that is often discussed in relation to designing course media, though less so for dissection videos to this point, is cognitive load theory. Cognitive load refers to the amount of new information that can be processed within the limits of working memory, and the effects on learning when these limits are exceeded (Sweller, 1988). Three major components of cognitive load have been described, and include intrinsic load, which is related to the complexity and interactivity of material; extraneous load, which is related to instructional design, and includes both audio and visual presentation; and germane load, which relates to how a learner utilizes working memory, including bringing new information together to create schema (Paas et al., 2003; van Merriënboer and Sweller, 2010). With respect to these three components of cognitive load, the success of learning gross anatomy is likely dependent on the complexity of anatomical relationships, how they are presented to the student, and how the student brings together structural relationships, as well as relationships between structure, function, and injury and/or disease processes.

The overall use of the videos throughout the year suggests that even after the initial adjustment to dissection, the videos continued to be of use to students. This could have been due to some of the features of the videos that potentially reduced cognitive load. For example, the videos were kept brief and restricted to specific regions, allowing for students to group material, likely assisting with intrinsic load (Khalil et al., 2005; Brame, 2016), while also increasing the likelihood that students would view the full video (Cann, 2007;

Fishman, 2016). As previously stated, in the current study, it appeared that students became more focused and more likely to both access and view the entire length of the video towards the end of the year. However, it is possible that the longer length of some videos contributed to fewer students viewing the full length. Further data would need to be collected to determine if these aspects of the videos did indeed have an effect on intrinsic load.

The design of the videos likely reduced extraneous load by avoiding the split attention effect (Chandler and Sweller, 1992; Sweller and Chandler, 1994; Khalil et al., 2005; Leppink and van den Heuvel, 2015), as viewers only needed to focus on one portion of the screen where a structure or structures were being pointed out and verbally discussed, and where included, text was spatially close to the structures being pointed out. Additionally, a previous study found that the use of a single educational source (a paper manual) was more effective for learning a new computer program than when this manual was used in combination with the computer program, due to a reduction in splitting attention between multiple sources (Chandler and Sweller, 1996). From this, one could reason that the use of dissection videos might have the same positive effect by similarly alleviating split attention for novice learners prior to studying actual dissections. This could be accomplished through providing students with all of the instruction in one source, rather than splitting their attention between the dissection manual, structure lists, and the body donor. In this study, actual viewing data were not available for exactly when and how the dissection videos were utilized within each course; such as before, during, or after the corresponding laboratory; and therefore this is most certainly a topic for future study.

Finally, the online format of these videos allowed for individual students to view each video multiple times. When the mean time viewed per student who played each video was calculated (Supplemental Tables 1, 2, and 3), it was observed that in all but one video (abdomen), the mean minutes viewed per student was greater than the length of the video itself. And in several instances, the total minutes viewed by an individual student was equivalent to the total length of the video many times over. Together these data indicate that students were indeed viewing a portion of or the full length of these videos multiple times. As previously mentioned, one method for reducing cognitive load and the number of items being processed in working memory is to group information to create schema that can eventually become automated with repetition (van Merriënboer and Sweller, 2010). Such schemas can then be stored in long-term memory, rather than being tethered to the limitations of working memory (Sweller, 1998). It is possible, using this theory, that repeatedly viewing dissection videos might have facilitated students in constructing schemas of structures based on regional relationships, thereby removing the limitations of working memory. Over time, by utilizing the routines presented in the videos for identifying structures, the videos could have potentially fostered these schemas into becoming automated. As data were not collected on why students chose to view videos multiple times or the interpretation of how multiple views were of benefit to them, this is a theory that merits future investigation.

Taking together all of the methods utilized for reducing cognitive load, one could surmise that these videos may have functioned as a learning tool that, when used for preparing for either a laboratory session or an examination, allowed for a reduction in cognitive load when

students later studied actual dissections in the anatomy laboratory. This hypothesis is beyond the scope of this study, but is most certainly a topic for future study in anatomical education.

Limitations of the Study

One limitation in this study was that multiple views and time spent viewing videos by individual students were only available for Y2 students. Additionally, some students may have viewed the videos as a group, and therefore all views may not have been captured in TSR. There is also the possibility that students may not have actively been watching the videos as they played if there were distractions during their viewing time. The survey responses were lower than expected, and due to the low response rate in the final survey, qualitative responses were not analyzed. Lastly, the use of the dissection videos within the online dissector could not be evaluated, and therefore it is possible that use of these videos may have influenced the results of this study. However, no students reported using the videos within the dissector as a reason for not viewing the MSM videos.

CONCLUSIONS

This study contributes important information regarding the use of dissection videos within a gross anatomy course. Unexpectedly, there was a decrease in nearly all measures of viewing across the year, suggesting that many students found them most helpful toward the beginning of the year, but at the same time accessed the videos more intentionally toward the end of the year. With regard to student use of dissection videos, overall, data suggest that at least a subset of students found the dissection videos to be helpful throughout the year. Evidence regarding the impact of dissection videos on academic performance remains uncertain, although students appear to appreciate them being available as a resource. Finally, based on the literature, there may be advantages of dissection videos in relation to reducing cognitive load for learners, which is a topic for future study. Overall, this study suggests that, when made available to students, dissection videos are likely to be utilized by at least a portion of the class, and that making students aware of such a resource may be especially beneficial at the beginning of a dissection course.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1:

Video Viewing Patterns. Percent of students who viewed the full video (defined as viewing 90% of the total length). A, Year 1 and B, Year 2. Videos are listed in order from beginning to end of the year, based on the calendar date that the corresponding laboratory occurred. Corresponding videos are as follows: (1) Superficial Back, (2) Intermediate and Deep Back, (3) Posterior Shoulder, (4) Axilla-Part 1, (5) Axilla – Part 2, (6) Anterior Arm and Forearm, (7) Hand, (8) Abdomen, (9) Posterior Abdominal Wall, (10) Gluteal Region, (11) Posterior Thigh, (12) Anterior and Lateral Leg, (13) Posterior Leg, (14) Foot, (15) Face (for Year 2 only), (16) Orbit, (17) Anterior Triangle of Neck, (18) Posterior Triangle of Neck, (19) Root of Neck, (20) Infratemporal Fossa, (21) Pterygopalatine Fossa, (22) Posterior Pharynx.

Figure 2:

Mean Total Viewing Time by Organ Systems Course. Mean total time viewed per video (in minutes $\pm$ SE) by organ systems course in Year 2. Total viewing time by all students was calculated for each video, and the mean total viewing time was calculated by course. When the length of each video was entered as a covariate to account for differing lengths of videos by course, the means and $\pm$ SE were as follows: OS1: 484.6 $\pm$ 58.3 min; OS2: 255.1 $\pm$ 62.2 min; OS3: 289.6 $\pm$ 60.5 min. While there was an overall significant difference in adjusted means ($P < 0.05$), there were no significant differences in follow-up comparisons.

Figure 3: Mean Viewing Time by Gender. Mean viewing time (in minutes $\pm$ SE) by gender for Year 2. Total viewing time per student was calculated across each course, and mean total viewing times were calculated by gender. There were no significant differences by gender.

TABLE 1:

Viewing Status Within and Across Years

Practical Examinations	Total by Viewing Status N (% of class)	
	Year 1	Year 2
Viewers^a		
OS1 P1	0 (0.0) ^c	15 (14.9) ^c
OS1 P2	19 (19.8)	18 (17.8)
OS2 P1	9 (9.3)	9 (8.8)
OS3 P1	9 (9.3) ^c	21 (20.6) ^c
Non-Viewers^b		
OS1 P1	31 (32.3) ^c	25 (24.8) ^c
OS1 P2	11 (11.5)	14 (13.9)
OS2 P1	70 (72.2)	69 (67.7)
OS3 P1	73 (75.3) ^c	63 (61.8) ^c

^aViewers were those who viewed ≥90% of the total length of all videos relevant to each practical examination;

^bNon-viewers were those who viewed <10% of the total length of all dissection videos relevant to each practical examination.

^c $P < 0.05$ when proportions were compared by year; Two practical examinations were given during the Organ System 1 (OS1) course, and therefore are listed as OS1 P1 and OS1 P2. Only one practical examination was given for OS2 and OS3, and each is listed as P1; OS, Organ System course; P, practical examination.

TABLE 2:

Demographic Data from Year 2 Surveys

Organ System Course	N (% of class)	Age Mean ($\pm$ SD)	Gender N (% of respondents)	
			Female	Male
OS1	42 (39.6)	25.5 ($\pm$ 3.4)	23 (54.8)	19 (45.2)
OS2	30 (29.4)	24.9 ($\pm$ 2.8)	17 (56.7)	13 (43.4)
OS3	34 (33.3)	25.4 ($\pm$ 2.9)	19 (55.9)	14 (41.2)
Total	60 (57.7)	25.1 ($\pm$ 3.1)	33 (55.0)	26 (43.3)

For the last row reflecting the total, age and gender identity were collapsed across all surveys, so that no student was counted more than once; OS, Organ System course.