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The Utilization of the Anatomage Virtual Dissection Table in the Education of Imaging Science Students

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Abstract

Study Background: The purpose of this research was to investigate the use of the Anatomage Virtual Dissection Table in the education of imaging science students and to assess the beliefs and perceptions of the students in regard to using the Table for teaching imaging-based anatomy and pathology.

Subjects and Methods: Seventeen medical imaging students participated in the study including nine Diagnostic Medical Sonography students, two Magnetic Resonance Imaging students, two Nuclear Medicine Technology students, two Radiation Therapy students and two Cardiovascular Interventional Technology students. Data was collected through focus groups and course/instructor evaluations. The researchers followed Creswell's procedure for data analysis and representation.

Results: Assessment of students' perceptions showed that 96% of students felt that the Table was a positive/beneficial tool in terms of their learning. Students also noted several advantages to using the Table in the education of imaging science students.

Conclusion: The use of virtual dissection technology seems to have a promising role in future educational training although more research is needed to better understand the efficacy of using this technology in the classroom. The results of this study show that students appreciate learning with this technology and believe that it is a beneficial and effective tool in preparing them to enter a health care profession.

Keywords: Virtual dissection table; Anatomage table; Medical simulation technology; Anatomy education; Medical imaging education

Introduction

A solid understanding of normal anatomy and function enhances students' abilities to recognize how normal function may be affected when the anatomy has been altered as the result of a developmental defect, disease, or trauma [1]. For imaging science students, learning anatomy provides a basis for critical thinking, reasoning and problem solving skills that are essential in the clinical environment. Understanding of anatomy may be enhanced using technology such as anatomy visualization systems.

Currently, no research exits in regard to the use of anatomy visualization in the education of imaging science students. Fredieu et al. note the use of digital 3D anatomic models, such as anatomical visualization systems, have been reported as an effective tool in enhancing learning and retention in medical and dental students although further examination is still needed [2]. Research notes that the form or type of model along with the presentation of anatomical models has a large impact on learning efficacy in medical curricula. The use of models has been shown to promote a more active learning environment and students tend to prefer the use of 3D models vs. 2D images [3]. Other advantages of 3D models include the ability to manipulate the model, the ability to create unlimited depictions of anatomical structures using technology, enhanced spatial knowledge for learners, increased opportunity for collaborative and experiential learning, and increased motivation and engagement for learners [4].

Over the past year, faculty at the University of Nebraska Medical Center have implemented the Anatomage Virtual Dissention Table and Invivo5 software into the curriculum to improve educational practices and outcomes for imaging science students. The Anatomage Table (Figure 1) is a life-size virtual dissection table that displays gross anatomy models reconstructed from cadavers [5]. The accompanying Invivo5 software allows for the creation of case studies from computed tomography (CT) and magnetic resonance (MR) images imported via DICOM files. Anatomy can be presented in 3D format and in coronal, axial, sagittal or user-defined planes. As this technology was incorporated into the curriculum, data were collected to evaluate students' perceptions and beliefs related to the implementation of these tools into the courses. This paper will highlight best practices and student perceptions related to the use of interactive technology in the education of imaging science students.

Material and Methods

This study was approved by the Institutional Review Board (IRB) at the University of Nebraska Medical Center (IRB #450-14-EX). Participants were recruited based on their enrollment in various post-primary imaging science programs.

Students enrolled in the study were post-primary program students enrolled in either 9 or 12 month programs. Purposeful, nonprobability sampling was used for the study. The group of participants was composed of 17 students, all of whom consented to participate in

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the study. The only essential attribute used in the sampling was that the students were in good standing with the program. Of the 17 participants, two were male (12%) and 15 were female (88%). There were three minority students represented in the study. Prior to data collection, all subjects were informed of the purpose of the research and signed informed consent forms approved by the IRB.

The Anatomage Table was used in three fall semester courses, Gastrointestinal Ultrasound, Sectional Anatomy and Pathology and Oncology Sectional Anatomy & Pathology. The faculty teaching these courses had extensive training on the Anatomage Table and were both committed to incorporating the interactive educational tool into their classroom. The Gastrointestinal course met twice a week for two-hour periods. The Table was used for instruction or review every week. The Sectional Anatomy & Pathology courses each met four times over the course of the semester. The Table was used for review of imaging based patient case studies, student led patient case studies and for exam review.

Examples of classroom activities included:

- Viewing anatomy and pathology in 3D and different anatomical planes
- Dissecting the anatomy based on various body systems
- Viewing and presenting pathology case studies
- Using the Table quiz and drill and practice functions for in and out of class activities
- Viewing an entire patient scan using the Invivo5 software

The study was completed using a qualitative, single-site case study method. Data was collected by conducting three focus groups held over the course of two semesters. The investigators developed the focus group and interview questions based on previous experience and knowledge. All focus group sessions were audiotaped, transcribed and reviewed by the researchers for data analysis. The researchers followed Creswell's procedure for data analysis and representation. This involved the organization of the data, a preliminary read through, coding and organizing of themes, data representation and finally interpretation [6]. Feedback from course evaluations from both fall and spring semesters was analyzed, also.

Results

The identified themes were labeled and further separated into subthemes. The themes were broken down into the following categories: (a) advantages of utilizing the Anatomage Table, (b) disadvantages of utilizing the Anatomage Table and (c) student beliefs in regard to utilizing the Anatomage Table. The student beliefs category was further divided into perceptions based on the time frame (i.e. perceptions at the beginning of the course, perceptions mid-semester, perceptions at the end of the course and perceptions four months after the course had been completed).

Advantages of utilizing the Anatomage Table

The Anatomage table can be utilized in a variety of ways to better demonstrate and learn anatomy and pathology. First, the Anatomage table enables students to view and manipulate full-body male and female models through the use of three virtual cadavers. One of the main advantages noted by students when using the cadavers was the ability to better visualize the anatomy and pathology using a 3D format along with different anatomical planes including axial, coronal, sagittal and user defined planes. The ability to scroll through the entire body vs. simply seeing subsequent images from a textbook was noted to be very beneficial.

The Anatomage Table is equipped with numerous pre-installed pathological examples which can be used to evaluate and compare normal and abnormal anatomical structures. Faculty at our institution did not utilize these examples extensively due to the fact that the table also provides the ability to load real patient data for manipulation and viewing. Students listed the ability to load and view real patient data into the table as a huge advantage. This feature allowed both the faculty and the students to present specific pathological case studies to the class after the imaging exams were performed in the clinical environment. The accompanying *In vivo* 5 software also provides the ability for students to access these specific pathological case studies on their own computers without the use of the Anatomage Table.

The Anatomage Table provides the students and instructors with the ability to perform drill/practice activities along with quizzing and testing. Faculty have the ability to create entire lab practical exams or simple discussion section quizzes using the data within the table. Faculty found that by creating Table based homework assignments; students were able to get hands on time with the table outside of class. Students noted these in and out of class activities to be very beneficial.

Disadvantages of utilizing the anatomage table

The students who participated in this study were enrolled in a variety of different post-primary imaging programs and the Table was used for a variety of different courses. The main disadvantage students noted was the inability to view Sonography and Positron Emission Tomography (PET) imaging scans on the Table. At this time, the Table best displays computed tomography and magnetic resonance imaging scans.

One other disadvantage noted by the students was the amount of time the Table was used in the different courses. Several courses began with slow incorporation of the Table by utilizing it for only four times over the course of the semester in one-hour increments. Other courses utilized the Table for several hours each week during the first semester. Overall, the students felt that exposure to the Table from one to three hours per week was optimal.

Other minor disadvantages involved specific function errors of the Table which were easily resolved with technical support and also improved as faculty and students became more comfortable with the daily operation of the Table. A summary of the advantages and disadvantages can be found in Table 1.

Student beliefs in regard to the use of the anatomage table

As the research began, on day one of class, faculty asked students for specific information in regard to their background in anatomy. Of the 17 students who participated in the research, three reported they had worked with a cadaver in an anatomy based pre-requisite course. The participants were also asked if they had ever worked with the Anatomage Virtual Dissection Table as part of any prior coursework. None of the seventeen students had ever worked with the Table as part of a prior course.

Once the students began using the Anatomage Table, focus groups were held at different time intervals over the course of eight months. One of the goals of the research was to learn how student beliefs and perceptions in regard to the Anatomage Table changed over time and as the students became more comfortable with using the Table. The

Aspect	Perception
Advantages	• Ability to view the anatomy in reconstructed and cross-sectional planes vs. viewing still images in a text book • Ability to rotate and dissect the anatomy to better visualize the different body systems • Ability to visualize the anatomy/pathology in relation to the surrounding tissues/organs • Ability to view pathology exams both on the table and within the on-line course (egg)
Disadvantages	• Ability to view the anatomy in reconstructed and cross-sectional planes vs. viewing still images in a text book • Ability to rotate and dissect the anatomy to better visualize the different body systems • Ability to visualize the anatomy/pathology in relation to the surrounding tissues/organs • Ability to view pathology exams both on the table and within the on-line course (egg) • Jumping Table image when scrolling through a patient scan • Inability to view Positron Emission Tomography images • Inability to view Ultrasound images • Inability to view an egg on a MAC computer

Table 1: Multiple focus groups were used to collect themes and subthemes based on Students' Perceptions of the Anatomage Table and its use in the classroom.

Students Perceptions of the Anatomage Virtual Dissection Table				
Focus Group Survey Items	**Total Items, n**	**Mid Semester, Agree, n (%)**	**End of the Semester, Agree, n (%)**	**Final months of Spring Semester, Agree, n (%)**
The use of the Anatomage Table in class has been a benefit to my learning.	17	14 (82.35%)	15 (88.24%)	16 (94.1%) – 1 undecided
The use of the Anatomage Table has had a positive influence on my learning/classroom experience.	17	11 (64.71%)	15 (88.24%)	15 (88.24%)
Using the Anatomage Table in the educational setting has better prepared me to enter a health care profession.	17	16 (94.1%) – 1 undecided	14 (82.35%)	16 (94.1%) – 1 undecided

Table 2: Multiple focus groups were used to collect data to learn how Students' Perceptions of the Anatomage Table changed over time.

focus groups were held at the middle of the first semester, at the end of the first semester and four months after the initial course had been completed. Table 2 provides an overview of the finding from the focus groups.

Focus Group Item #1: Did the use of the Anatomage Table in class benefit your learning? Results for this question showed a majority of the students felt the Table did benefit their learning and the results improved over time. Fourteen of the seventeen (82%) students agreed with the statement mid-semester and sixteen of the seventeen (94%) agreed with the statement in the final focus group.

Focus Group Item #2: The use of the Anatomage Table had a positive influence on my learning/classroom experience. This item showed a more marked change in student's perceptions with an improvement in result by over 20%. During the first focus group, only 65% (11/17) of the students agreed with this statement. By the last focus group, 88% (15/17) of the students were in agreement with the statement.

Focus Group Item #3: The use of the Anatomage Table in the educational setting better prepared me to enter a health care profession. For this statement, the results stayed consistent over time. Sixteen of the seventeen (94%) students agreed with this statement both mid semester and in the final focus group.

Discussion

The use of interactive technology in medical education is constantly evolving and increasing. There is very limited data in the literature in regard to how the use of this technology is impacting students' learning. This study focused specifically on medical imaging students' perceptions related to the use of the Anatomage Virtual Dissection Table in three courses. The results of the study showed the advantages of adding the Table to the courses outweighed the disadvantages. Students liked the ability to manipulate the virtual cadaver to better understand relational anatomy and cross-sectional imaging. The students found value in being able to dissect and rotate the anatomy to view from different planes. Although not reported by the students, during class time the faculty noted the students' use of the "reset" button which allowed the students to go back to the original cadaver. This allowed the students to either review what they had just done to gain a better understanding of the anatomy or to try to find a better "view or cut" that would help them to better understand the topic. This advantage is exclusive to this type of technology; it cannot be performed with a textbook or a cadaver. How the technology allowed for a more interactive classroom environment was also unreported by the students.

Class time required students to interact with the table, their classmates and the instructor versus sitting and listening to a lecture. Class sessions generally involved students gathered around the Table locating various anatomical or pathological structures as requested by the instructor. The instructor served as a facilitator guiding the students through the learning. The students relied heavily on each other as they worked together in the problem based learning environment, similar to how they will work as a team in the clinical environment. The authors found it interesting that this was not reported as an advantage by the students in the focus groups. One explanation may be that this generation of learners now expects this type of technology and learning approach to be part of the classroom experience. Another possible explanation could be that, the students were so immersed in the activity they did not realize how they were impacting their own learning process and that of their fellow classmates.

The disadvantages cited by the students were more reflective of where they would like to see improvements in the Table. At this time, the Anatomage Table can only display CT and MRI images. The courses in which the students were enrolled included sonography and nuclear medicine students who would benefit from viewing additional types of images (ultrasound and PET scans) on the Table as well. This has been communicated to the company.

Another noted disadvantage was the inability to view an "egg" on Apple based technology (MacBook, iPad, etc.). The faculty frequently used the "egg" option during the courses which allowed them to share specific pathological case studies from the clinical environment with the students. These scans could be posted to the learning management

Figure 1: A student-centered learning environment. Diagnostic Medical Sonography students using the Anatomage Table Virtual Dissection table under the guidance of faculty to review relational anatomy. Virtual cadaver is displayed on the screen behind students.

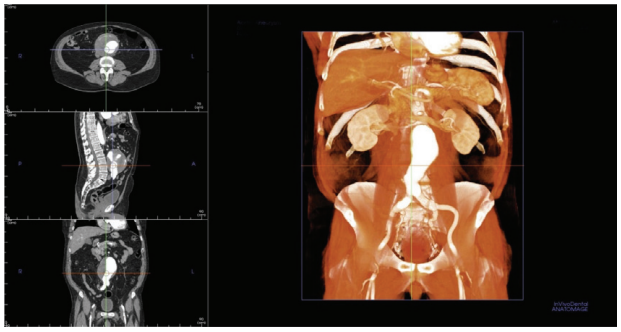

Figure 2: Example of an "egg" created using the Invivo5 Software. The egg was reconstructed from computed tomography DICOM data. It could be displayed on the Anatomage Table or added to the Learning Management System.

system (LMS) for the students to view and manipulate on their own devices. This also allowed for students to use this information to create their own pathology-based case studies to then later be presented in class using the Anatomage Table. Figure 2 shows an example of an egg that was created using an anonymized patient case study.

Data gathered over time from the focus groups was positive. By mid-semester, 82% of the students felt the Anatomage Table was beneficial to their learning. This number rose to 88% by the end of the semester, and almost achieved 100% by the end of the study with one student remaining undecided. The students believed the addition of the Anatomage Table to the curriculum was advantageous to their learning. This advantage may have been defined differently by the participating students. For some it may have been a higher-than-expected score on an exam. For others, it may have been the added confidence of understanding a concept, not just memorizing information for the exam. Others may have appreciated taking a class that offered state-of-the-art technology to enhance their learning. As with all curriculum changes, there is a delicate balance between the addition of new technology and its related activities and the burden of added work to an imaging science student's already heavy course load.

Some students' fear of added work may have been demonstrated when the focus group addressed if the Anatomage Table had a positive influence on their learning/classroom experience. At the first focus group only 11 of the 17 students (64.7%) felt the experience was positive. This number increased and then remained at 88% for the other two focus groups. The Table was incorporated into three different courses by two faculties. This did allow for some variation in when the Table was first introduced in the semester, how often it was used in each course, and what types of activities were completed. The most positive learning experience was related to early introduction of the Table and frequency of use. The results note the students who spent one to two hours per week working on the Table had a more positive perception. There was also a significant change in the perceptions over time. This change may be related to the faculty becoming more experienced and creative with the Table. As with any new technology there is a learning curve for the faculty also. To prepare for the addition of the Table into the fall semester curriculum, the two faculties dedicated five hours each week in the preceding spring and summer semesters to become familiar with the Table functions and design case studies for use on the Table. While this provided a strong foundation for the fall semester, it quickly became apparent that lessons plans and activities were modified and developed to meet the students' needs. Throughout the semester, faculty shared what worked well, what did not, and what new ideas came from classroom experimentation. This resulted in an increase in use from the beginning of the semester to the end and would also correlate with the increase in percentile scores from the mid to end of semester.

As with any professional program, the goal of the program is to prepare students to enter their chosen health care profession. In this study, at mid-semester and at the end of study, 16 out of 17 students felt the use of the Anatomage Table in the educational setting better prepared them to enter the health care profession. One student was undecided. These high numbers may come from the student feeling more confident in the mastery of the classroom material. That confidence may have then carried over into the clinical education environment. One future area of research will be to look at quantifiable data, comparing exam scores from the previous years' class who did not have the Anatomage Table in their courses. The students who did participate in this study had a 100% first time certification rate in their chosen field of study.

Conclusion

This study documented and described the perceptions and beliefs of imaging science students in regard to the Anatomage Virtual Dissection Table. The use of virtual dissection technology seems to have a promising role in future educational training although more research is needed to better understand the efficacy of using this technology in the classroom. The results of this study show that students appreciate learning with the Anatomage Table and believe that the Table is a beneficial and effective tool in preparing them to enter a health care profession.

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