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Abstract

Understanding anatomy is vital to occupational therapy (OT) for clinical success. Anatomy requires comprehending three-dimensional (3D) human structure relationships and student age and learning style differences may affect this understanding. This study examined how 3D anatomy software influenced online OT students' grades among different ages and learning styles. The intervention group had 17 students (mean age 33 ± 8 years) and the control group had 18 students (mean age 32 ± 6 years). Students were categorized above or below the age of 30 and completed a learning style questionnaire at the beginning of the course. To determine the usefulness of the software, the intervention group completed a custom-survey. Independent sample t-tests were used to compare grades between the intervention and control groups. Non-parametric tests were used to compare grades of different ages and learning style groups. The intervention group had higher overall final course grades when compared to the control group, although not statistically significant ($p>0.05$). Additionally, lecture and laboratory grades were not higher ($p>0.05$). Most students (82%) reported the use of the anatomy software to be helpful in understanding course concepts. No statistically significant course grade differences were found among the different learning styles or two age groups ($p>0.05$). In conclusion, intervention group final course grades were higher and the software benefitted all learning styles and both age groups. Thus, OT programs should consider using 3D anatomy software programs to aid in foundational anatomy education.

Keywords

Human anatomy, 3D software, online education

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ABSTRACT

Understanding anatomy is vital to occupational therapy (OT) for clinical success. Anatomy requires comprehending three-dimensional (3D) human structure relationships and student age and learning style differences may affect this understanding. This study examined how 3D anatomy software influenced online OT students' grades among different ages and learning styles. The intervention group had 17 students (mean age 33 ± 8 years) and the control group had 18 students (mean age 32 ± 6 years). Students were categorized above or below the age of 30 and completed a learning style questionnaire at the beginning of the course. To determine the usefulness of the software, the intervention group completed a custom-survey. Independent sample t-tests were used to compare grades between the intervention and control groups. Non-parametric tests were used to compare grades of different ages and learning style groups. The intervention group had higher overall final course grades when compared to the control group, although not statistically significant ($p>0.05$). Additionally, lecture and laboratory grades were not higher ($p>0.05$). Most students (82%) reported the use of the anatomy software to be helpful in understanding course concepts. No statistically significant course grade differences were found among the different learning styles or two age groups ($p>0.05$). In conclusion, intervention group final course grades were higher and the software benefitted all learning styles and both age groups. Thus, OT programs should consider using 3D anatomy software programs to aid in foundational anatomy education.

INTRODUCTION

Human anatomy is an essential foundational course for many graduate level health professions that involve medicine, diagnosis, and therapy (Estai & Bunt, 2016; Yammine & Violato, 2015). Mastering an anatomy course requires students to understand three-dimensional (3D) human structures relationships as well as retaining this information to demonstrate clinical success (Bareither et al., 2013). Recently, universities have reported many medical graduates are deficient in anatomy knowledge and perhaps below the standards for safe medical practice (Yammine & Violato, 2015). However, technology advancements may be a promising tool to enhance anatomy knowledge (Yammine & Violato, 2015) and in particular for online occupational therapy (OT) students. Online students have less face to face interactions with cadavers to learn anatomical structures and the use of 3D anatomy software may result in significantly higher grades in graduate anatomy courses (Yammine & Violato, 2015). Additionally, anatomy software may be more time efficient and allow students access to course materials outside of the classroom (Trelease, 2008). However, limited OT education research is available to determine whether a 3D anatomy software program is a superior learning tool for specific learning styles for online OT students. Additionally, there are no OT education studies on the academic performances of various age groups while using a 3D anatomy software program in an online OT program. Therefore, this study investigated how 3D anatomy software affected online OT student grades in a graduate level anatomy course in comparison to students who did not use the software. In addition, course grade differences among various ages and learning styles were investigated when using the 3D anatomy software.

There are many 3D anatomy tools to assist students in learning spatial relationships between anatomical structures (Chen et al., 2017). Students can view anatomical images at their own pace and rotate the images to view objects at different angles (Peterson & Mlynarczyk, 2016; Yammine & Violato, 2015). Furthermore, some healthcare professionals reported increased motivation to learn and many students reported reduced study time with use of this technology (Battulga, Konishi, Tamura, & Moriguchi, 2012). The 3D tools may improve some students' learning of anatomical concepts (Bareither et al., 2013; Chen et al., 2017; Yammine & Violato, 2015). Knowing how 3D technology could impact anatomy knowledge may motivate more OT professors to use the technology. Thus, the use of the technology could enhance OT students' anatomy education.

Anatomy education with both technology (anatomical 3D and 2D software programs) and traditional methods (lectures and face to face cadaveric laboratory use) have been shown to be effective (Elizondo-Omaña et al., 2004). However, researchers demonstrate inconsistently that 3D technology improved academic performance more than traditional teaching (Azer & Azer, 2016; Yammine & Violato, 2015). More evidence is needed to support the usage of 3D anatomy technology with a traditional curriculum (Elizondo-Omaña et al., 2004). When students are educated using a combination of teaching methods, they appear to answer more questions correctly in class (Peterson & Mlynarczyk, 2016). Computer-assisted learning models with traditional lectures have been suggested to increase students' grades (Elizondo-Omaña et al., 2004; Yammine & Violato, 2015). Therefore, understanding this information may help professors develop the most effective anatomy curriculums to assist students' academic success (Davis, Bates, Ellis, & Roberts, 2014).

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Furthermore, academic success may be dependent on student learning style. Creating anatomy curriculums to accommodate student learning styles may be needed (Bareither et al., 2013; Meyer, Stomski, Innes, & Armson, 2015; Yammine & Violato, 2015) since students appear to have greater academic success when a course assignment uses one's learning style (Bareither et al., 2013; Farkas, Mazurek, & Marone, 2016). To determine learning style, many health profession students complete learning style questionnaires (Bareither et al., 2013; Mathiowetz, Yu, & Quake-Rapp, 2016; Meyer et al., 2015), but limited OT anatomy studies investigate learning style. Therefore, it is important to determine which learning styles benefit most from the usage of 3D anatomy software (Meyer et al., 2015) for OT educators to create an effective anatomy course.

An effective anatomy course may depend on a student's age as well. Many traditional aged students (younger than 30 years old) typically have more experience using technology (Olson, O'Brien, Rogers, & Charness, 2011). Therefore, it may be assumed that younger students will benefit academically from the use of additional technology resources in an anatomy course as compared to older students. However, there is limited research available comparing students' anatomy academic performance among different age groups (Yammine & Violato, 2015) for OT students. Only one study indicated students' age and familiarity with computers did not influence students' overall performance in post-secondary anatomy courses (Yammine & Violato, 2015), but this was not specific to OT education. Thus, with limited OT anatomy literature about age differences, further research is needed to determine if 3D anatomy software is an effective learning tool.

As a learning tool, 3D technology has given instructors new opportunities for creating an innovative classroom environment (Chen et al., 2017). Students can have access to 3D technology resources while on a phone or laptop which gives professors a new way to incorporate technology usage into a curriculum (Trelease, 2008). This technology may be useful when traditional resources for anatomy education may be unavailable at all times (Estai & Bunt, 2016). For instance, some cadaver laboratories have limited hours, which restrict student access (Estai & Bunt, 2016). As anatomy education continues to develop, 3D technology resources will continue to be valuable (Chen et al., 2017). Thus, integrating technology and traditional teaching methods in curriculums could be beneficial (Biasutto, Caussa, & Criado del Río, 2006) for OT programs.

Therefore, the purpose of the study was to determine whether the use of 3D human anatomy software affected online OT student grades in a graduate level anatomy course. In addition, the researcher investigated academic grade differences of various ages and learning styles when using the 3D anatomy software. It was hypothesized that the 3D anatomy software would be an effective learning tool as compared to not using the 3D anatomy software and all studied age and learning style groups would benefit from its use.

METHODS

Research Design

Occupational therapy students in an online Master's of Occupational Therapy program participated in this level II (two groups, nonrandomized) study that investigated grade differences between students when using a 3D anatomy software, BioDigital Human (BioDigital Inc., 2018). The online students completed the graduate level anatomy course during a 16-week period in their first semester. The majority of the course was administered online; however, students were required to come to a weekend on-campus class for eight hours once a month (four times a semester). The on-campus class consisted of four hours of lecture and four hours of laboratory time. The researcher's university Institutional Review Board approved this study. The Occupational Therapy Department's program chair gave written consent to use student data for this study.

The participants included 35 OT students who were accepted into a Master's of Occupational Therapy program. The intervention group consisted of 17 students (mean age 33 ± 8 years) and utilized the anatomy software. The control group contained 18 students (mean age 32 ± 6 years) who did not use the anatomy software. The inclusion criteria for the participants were acceptance and enrollment into the online Masters of Occupational Therapy program. Participant pool characteristics are in Table 1. Data from the intervention group was compared to the control group who had previously taken the course to analyze the software effects.

Final course grades, lecture and laboratory exam grades were analyzed for each cohort. The final course grade included quiz/assignment grades, lecture exams and laboratory exams grades. The lecture exam grade was the mean grade for all written exams completed in the semester. The laboratory exam grade was the mean grade for all laboratory exams completed in the semester.

Course grades were compared among the different student learning styles to investigate who benefitted from the software use. On day one of the anatomy course, students in both groups completed the VARK (Visual Aural Read/write Kinesthetic) Questionnaire version 7.1; Fleming, 2017; Fleming & Mills, 1992) online to determine each student's preferred learning style. This information was recorded by the professor and used to investigate the grade differences among the various learning style groups.

To understand grade differences for each age group, students were divided into the following groups: above 30 or below 30 years old. The researcher chose these age groups because most traditional students complete a Master's in OT by the age of 24. However, more time was added because the participants needed to complete the following prior to graduate school enrollment: an occupational therapist assistant (OTA) certificate, a Bachelor's degree, and worked for 1 year as an OTA. Also, the Council of Graduate Schools (2009) used the same age group for non-traditional students. Ages were gathered at the beginning of each course.

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Toward the end of the course, students anonymously completed a custom survey to provide a qualitative understanding of the software effectiveness. The students completed the survey one month before completion of the course as not to burden students with two surveys at the end of the semester. Typically, students are requested to complete a general course evaluation at the end of every course. The students were able to focus their responses on the software by completing the survey earlier in the semester. The survey had four questions that included the following: the number of hours/week spent using the software, the recommendation of the software to others, the belief that their grade improved because of the software use and a narrative explaining their overall impression of the software.

Table 1

Subject Pool Characteristics

Group	Number of Students (Age)	VARK Scores	Number of Students Below 30 Years Old (Age)	Number of Students Above 30 Years Old (Age)
Intervention	17 (age range 25-49 years old, 33 ± 8 years old)	Visual = 2 Aural = 5, Read/Write = 2 Kinesthetic = 6 Multimodal=2	8 students (age range 24-29 years old)	9 students (age range 30-46 years old)
Control	18 (age range 24-46 years old, 32 ± 6 years old)	Visual = 3 Aural = 2 Read/Write = 3 Kinesthetic = 9 Multimodal=1	7 students (age range 24-29 years old)	11 students (age range 30-46 years old)
All Students	35 (age range 24-49, 32 ± 7 years old)	Visual = 5 Aural = 7 Read/Write = 5 Kinesthetic = 15 Multimodal=3	15 students (age range 24-29 years old)	20 students (age range 30-49 years old)

Data Analysis

A statistical software program, IBM SPSS Statistic 25, was used to analyze the data. An independent samples t-test was used to compare the mean final course, final lecture exam, and laboratory exam grades between the intervention and control groups. The researcher reviewed histograms for normality and used the Levine’s test for variance. Independent samples Mann-Whitney U tests were used to compare mean final course, lecture exam, and laboratory exam grades between the two age groups. Independent samples Kruskal-Wallis tests were used to compare mean final course, lecture exam, and laboratory exam grades between different learning styles. The data for age and learning style was not normal and it was a small sample size. Therefore, the researcher used non-parametric tests. Similar results were found with parametric tests.

RESULTS

The final course grades of students who used the anatomy software (intervention group) were higher but not statistically significant (p = 0.364) when compared to the final course grades of the students who did not use anatomy software (control group); see Figure 1. No statistically significant differences were seen between the intervention and control groups when comparing lecture and laboratory exam grades (p=0.891) and (p=0.507), respectively (see Table 2).

A Kruskal-Wallis test showed that there was no statistically significant difference in final course grade percentages for all students between the different learning styles at p = 0.727 (see Figure 2). Additionally, the final lecture exam and laboratory exam grades showed no statistically significant differences at p = 0.995 and p = 0.171, respectively (see Table 2).

A Mann-Whitney U test showed that there was no statistically significant difference between the final course grades of all students who were above the age of 30 and the grades of all students who were below the age of 30 at p = 0.705 (see Figure 3). Additionally, the final lecture exam and laboratory exam grades showed no statistically significant differences at p = 0.934 and p = 0.521, respectively (see Table 2).

Additionally, learning styles and ages were separated into intervention and control and there were no statistically significant grade differences within groups. For learning style differences of the intervention group, the following were the results: final course grade, p = 0.643; final lecture exams, p = 0.776; and laboratory exams, p = 0.618. For learning style differences of the control group, the following were the results: final course grade, p = 0.609; final lecture exams, p = 0.625; and laboratory exams, p = 0.189. For age differences of the intervention group, the following were the results: final course grade, p = 0.673; final lecture exams, p = 0.888; and laboratory exams, p = 0.423. For age differences of the control group, the following were the results: final course grade, p = 0.425; final lecture exams, p = 0.930; and laboratory exams, p = 0.659. Results are presented in Table 2.

Lastly, 82% of students reported the anatomy software was a helpful learning tool.

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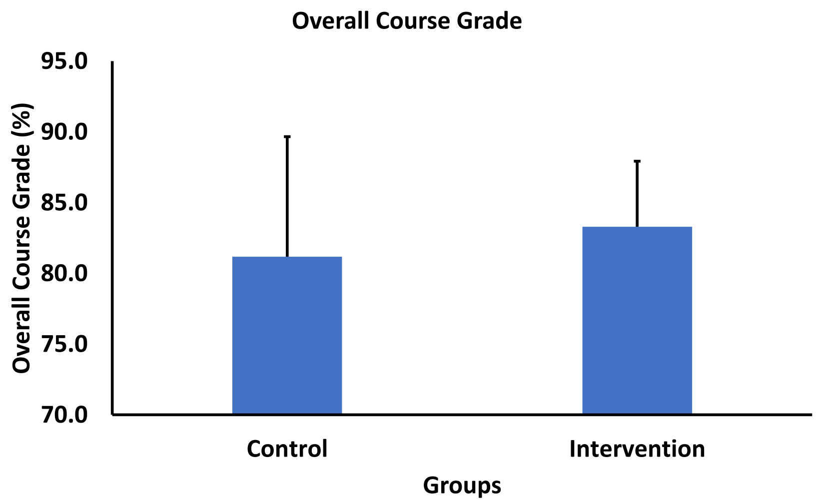

Figure 1. Demonstrates that the overall course grade of students who used anatomy software (intervention group) were higher than the overall course grade of the students who did not use anatomy software (control group) (p = 0.364).

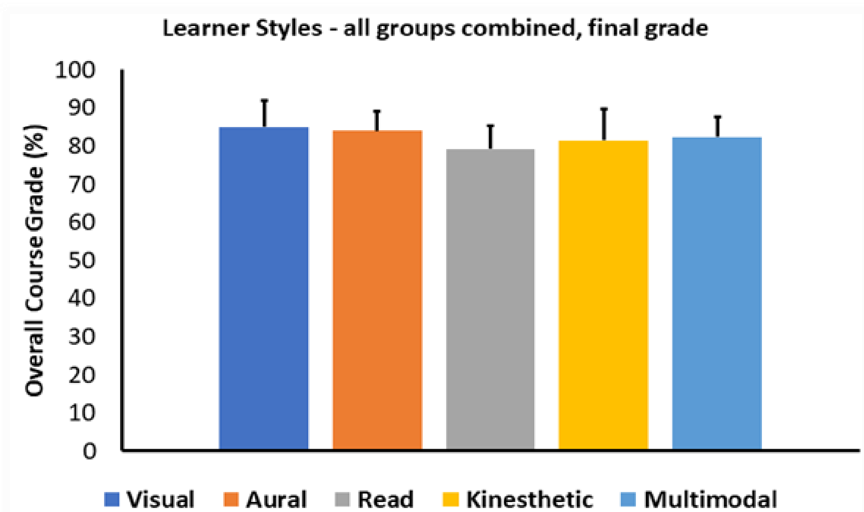

Figure 2. Demonstrates there were no significant overall (final) grade percentages differences for learning styles (all students combined) (p > 0.05). There were no significant grade differences for learning style within each intervention and control group (p > 0.05; not in figure).

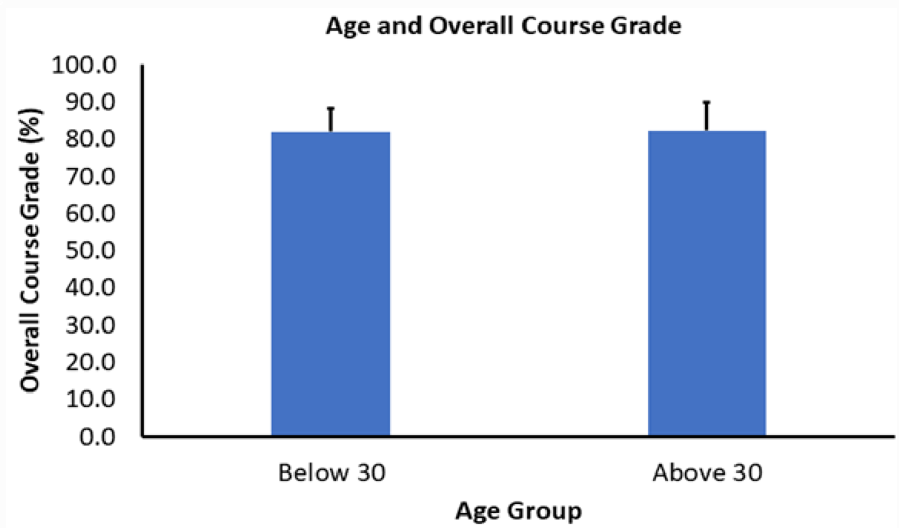

Figure 3. Demonstrates that there was no significant overall (final) grade difference of students who were below age thirty and the grades of students who were above age 30 (all students combined) ($p > 0.05$). There were no significant grade differences for age within each intervention and control group ($p > 0.05$; not in figure).

Table 2

Results

Variable ($p < 0.05$)	Intervention vs control group	All students - Learning style	All students - Age above 30 vs below 30	Intervention Group - Learning style	Control Group - Learning style	Intervention Group - Age above 30 vs below 30	Control Group - Age above 30 vs below 30
Final anatomy course grade	p=0.364 (Fig. 1)	p=0.727 (Fig. 2)	p=0.705 (Fig. 3)	p=0.643	p=0.609	p=0.673	p=0.425
Anatomy lecture exam grade	p=0.891	p=0.820	p=0.856	p=0.780	p=0.775	p=0.673	p=0.375
Anatomy laboratory exam grade	p=0.507	p=0.171	p=0.521	p=0.618	p=0.189	p=0.423	p=0.659

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DISCUSSION

The intervention group had higher overall course grades as compared to controls but not statistically significant ($p = 0.364$). The researcher showed that using anatomy software can be effective in improving anatomy overall course grades (Yammine & Violato, 2015), but not effective for lecture or laboratory exam grades. Therefore, quiz and assignment grades contributed to the higher final course grade.

In addition, the researcher showed there were no statistically significant grade differences when considering learning style or age. The results indicated the anatomy software was beneficial for all learning styles and both age groups (Bareither et al., 2013; Yammine & Violato, 2015). A wide range of ages and learning styles in graduate school anatomy courses may be able to use the software. Additionally, age and learning style did not appear to affect the grades of intervention or control group. Therefore, variations in preferred learning style and age may not influence an online student’s ability to use the anatomy software.

Furthermore, the researcher showed a majority of students believed the use of the anatomy software improved their understanding of the course content (Battulga et al., 2012). This finding aligns with the results about the impact of the anatomy software on final course grade (Elizondo-Omaña et al., 2004; Yammine & Violato, 2015). Overall, one can conclude the anatomy software was beneficial to the student users and it may be used across a variety of ages and learning styles.

Limitations

Study limitations included a small sample size of two groups to determine the effects of the anatomy software (Francis et al., 2010). The intervention group had 17 students. This small sample size could affect the applicability of the results to a larger sample size. Future study will investigate software use over 3 years to increase applicability.

Prior knowledge of anatomy and other environmental factors may have influenced the results (Peterson & Mlynarczyk, 2016). Some students used 3D software programming prior to enrolling in this graduate anatomy course. Also, the participants were required to complete an undergraduate anatomy course prior to enrollment. However, the rigor of each student’s undergraduate anatomy course differed depending on the course instructor and university.

Additional limitations included difficulty in attributing only the software impacted the increased final course grade, as students used a combination of traditional methods and the software (Mathiowetz et al., 2016). Lastly, final course grades may have been affected by the teaching style of the course professor since there was a different professor for the intervention and control groups. It cannot be ruled out if the academic performances were affected by use of the software (Mitrousias et al., 2018), professor teaching style or prior student knowledge.

Implications for Occupational Therapy

Occupational therapy students could enhance their ability to link anatomical structures to function when using a 3D anatomy software. Using the anatomy software could assist students in comprehending anatomical relationships and how those structures work with a particular functional task. The 3D software could assist in creating structure location connections to function beyond a 2D book format, which are traditionally used in most OT curriculums.

Occupational therapy programs could continue threading the structure to function link by using the 3D program beyond anatomy courses. The software is more portable then using cadavers, therefore, students could use it when working with clients in pro-bono clinics, wellness seminars or fieldwork sites. In these settings, students could use the software to educate clients on anatomical injuries' effect on function and continue using it as practicing OTs to educate patients and colleagues. Additionally, the software could be utilized in kinesiology, neuroscience and orthopedic courses to continue assisting students in comprehending 3D anatomical relationships to function. Similar software programs may be a worthwhile purchase for many OT programs since it could be useful in many curriculums and into OT careers to enhance structure to function connections.

CONCLUSION

Overall, the 3D anatomy software program was likely beneficial for online OT students as most students reported the program as a useful learning tool. Additionally, final course grades were better for the intervention group as compared to the control group, regardless of age and learning style. Future study will include a larger subject pool and investigate long-term effects. This study investigated short-term anatomy course performances. Long-term academic performances that include grades in neuroscience, kinesiology, and orthopedic courses could demonstrate how students continue to benefit from the 3D software anatomy tool throughout their occupational therapy studies.

As technology continues to advance, 3D human anatomy software may become a beneficial and accessible learning tool for many OT programs. Thus, OT education programs should consider using 3D anatomy software programs to aid in learning and retaining anatomy concepts, which are vital to OT practice.

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