Utilizing 3-D Digital Models in Synchronous Blended Anatomy & Physiology Courses During the COVID-19 Pandemic

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Abstract

The use of electronic media in the classroom was prevalent during the height of the COVID-19 global pandemic because it afforded the health and safety of students in blended course modalities. This project aimed to quantify the effectiveness of a three-dimensional computer-based human anatomical online platform in a blended synchronous course design. We asked our students to self-report the learning efficacy and overall student engagement of the online learning platform. We found that with intentional course design utilizing in-person anchored Zoom Buddy blended classes and a 3-D anatomy software, students reported high levels of learning efficacy and engagement in anatomy & physiology courses. The course design presented in this paper provides a viable option should we be faced with similar emergency learning situations or when course enrollments are high and class spaces are limited. https://doi.org/10.21692/haps.2023.019

Key words: course design, 3-D computer models, student-to-student interactions, anchor-student

Introduction

The COVID-19 pandemic and the resultant social distance precautions implemented in the classroom largely reduced important student-to-student interactions in higher education. Student-to-student interactions have been shown to positively enhance learning, a feeling of community, and student engagement within online classrooms (Bickle & Rucker, 2018; Majewska & Vereen, 2020). While strictly face-to-face courses typically provide the most ideal student-to-student interactions, the pandemic limited in-person interactions due to largely remote online and blended course modalities. Now more popular than ever, blended courses involve at least some portion of in-person instruction in combination with either asynchronous or synchronous online instruction. Learning about human anatomical structures can be particularly difficult under blended learning conditions and the constraints of the pandemic afforded us lessons on how to adapt the anatomy & physiology (A&P) learning environment for a blended course delivery.

Even under normal circumstances, learning human anatomy can be difficult for students because it requires good spatial awareness and three-dimensional (3-D) visualization of both surface level and deep body structures. Over the past two decades an increasing number of 3-D computer-based models of ever-improving quality have been incorporated into the human anatomy learning classroom to enhance student engagement with varying levels of success (Azer & Azer, 2016; Triepels et al., 2020). Others have shown the moderate effectiveness of earlier, more basic 3-D computer models for enhancing engagement and anatomical knowledge for students (Agbetoba et al., 2017; Hassinger et al., 2010). Yet student engagement and learning efficacy using highly sophisticated, modern, and web-based 3-D computer models of human anatomy remain largely unexplored.

While primarily positive student self-reporting of an online learning platform's effectiveness can itself be representative of student engagement, directly determining engagement in an online learning modality is difficult to assess (Henrie et al., 2015; Sinatra et al., 2015). Even finding agreement in the literature regarding definitions of "engagement" can be challenging. Yet, anecdotally, the distinction between an "engaging" and "unengaging" class is clear to most students.

When pressed, students find it difficult to say what makes an engaging class feel engaging or even how they would define engagement at all. However, they will definitively say that they know when they are engaged, and they distinctly know when they are not. Currently, the literature broadly defines student engagement as either behavioral (Boucheix et al., 2013; Thompson et al., 2012), cognitive (Bangert-Drowns & Pyke, 2002; Guertin et al., 2007; Zhu, 2006), or emotional (Kay 2011; Missett et al., 2010; Sun & Rueda, 2012).

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For the purposes of this research project, student engagement should not be conflated with total usage of the technology. Students were required to take the course as designed due to the teaching constraints imposed by the COVID-19 pandemic and were not provided with an alternative resource to use. Consequently, this project did not measure the time students spent using the anatomy software. Therefore, for this project, student engagement in the course and with the online learning platform is defined primarily as behavioral and cognitive, but also to some extent as emotional. As such, behavioral engagement is classified as the level of student involvement with the software, while cognitive engagement is categorized as student perceived long-term value of the software and if students would recommend it to future students. Lastly, emotional engagement is categorized as the preference for the software used in this study over other available learning modalities and their intent to continue to use the software beyond the classroom.

The purpose of this project was to evaluate learning effectiveness and student engagement through enhanced student-to-student interactions in multiple synchronously blended lab sections utilizing an online human anatomy learning platform during the COVID-19 global health pandemic. Our working hypothesis was that a strong blended course design that enhanced student-to-student interactions and the high learning efficacy of the learning platform would link to correspondingly high levels of student engagement.

Methods

Course Design and the Visible Body® Learning Platform

Our blended course design included synchronous online lectures with 2.75-hour lab sections split into a weekly alternating in-person group (Group A) and a synchronous, remote, online group (Group B). The class utilized the video conferencing platform Zoom (Zoom Video Communications, Inc.) for all lab sections. One way in which the split-group was utilized in the lab was to generate breakout rooms that included a student from the in-person Group A with one or more students attending remotely from Group B in real-time. I categorized these blended breakout rooms as physically anchored Zoom Buddy groups.

An advantage of having these physically tethered groups was that social distance within the room was maintained while also fostering student-to-student connection with students attending remotely. Even though socially distanced, the in-person group established a sense of community for students physically present and those attending remotely. The largely positive response to the course design and the online software indicates that a greater sense of community was developed. While not directly measured in this project, the correlation between student-to-student interactions and increased sense of community has been shown using similar classroom technology in group-work-based course design (Bickle & Rucker, 2018). Additionally, the anchor-student from the physically present group linked real-time communication from the instructor to the tethered remote students in each collaborative Zoom Buddy group.

The Visible Body® learning platform (www.visiblebody.com) provides a suite of web-based and smart-device applications that include high definition 3-D graphical models of human anatomy and 3-D interactive learning modules (Figure 1). Along with in-class activities such as specimen dissections, Visible Body® was utilized by students within the Zoom Buddy breakout rooms to work on weekly collaborative lab assignments.

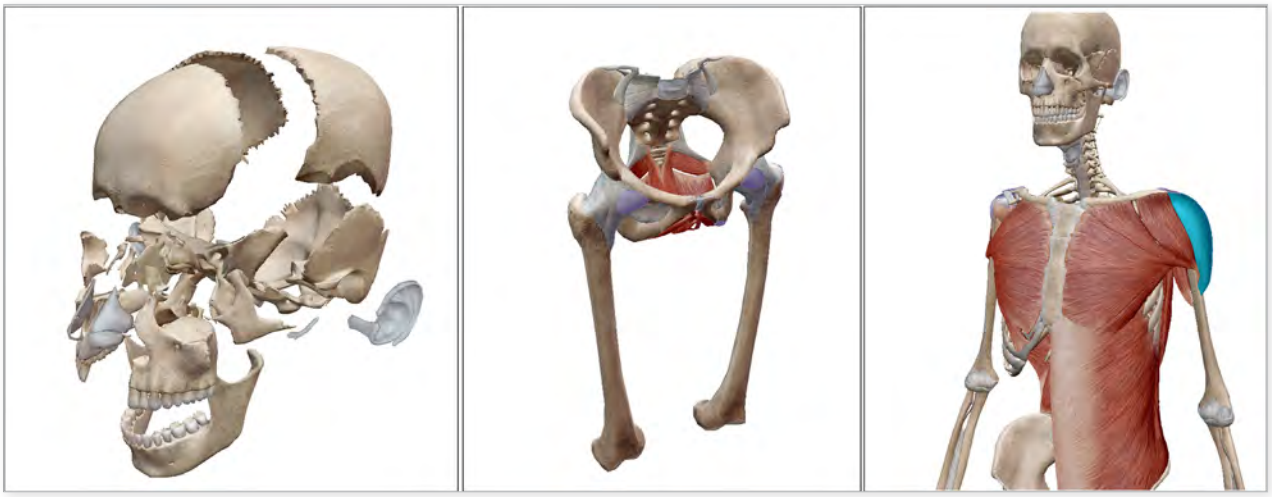

Figure 1. *Visible Body® 3-D models of the skull (left), pelvis (middle), and shoulder joint (right). Images courtesy of Visible Body®.*

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Self-reported Learning Efficacy and Engagement Questionnaire

Most of the classes surveyed were the standard two semester sequence of A&P but combined single semester human biology courses were also surveyed. However, the survey did not collect information regarding which type of course was taken by each participant. It's likely that responses came mostly from the A&P courses based on the number of students that typically take the two types of courses. When the courses were completed in the Spring of 2021, I surveyed all students with an anonymous online questionnaire (Appendix) utilizing primarily Likert scale responses from: strongly agree, agree, neutral, to disagree, and strongly disagree. The questionnaire explored course design and student self-reported learning efficacy of Visible Body® along two dimensions of inquiry: "Using Visible Body® during the COVID-19 global health pandemic" and "Overall information and learning effectiveness" respectively. Student engagement was also measured in the first two dimensions of inquiry in addition to a third which was, "Visible Body® overall assessment". The Institutional Review Board of Worcester State University approved this project as exempt, and informed consent was obtained from all participants.

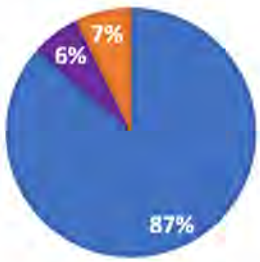
Results

Of the approximately 90 students that utilized Visible Body® at our institution during the 2020-2021 academic year, 39 students (43%) responded to the online questionnaire. However, one participant submitted a blank questionnaire effectively reducing the response rate to 42%. No demographic or identifiable information was collected from our participants in order to keep their responses completely anonymous. The participant responses are categorized as overall agreement (agree and strongly agree responses), overall disagreement (disagree and strongly disagree responses), and neutral (neither agree nor disagree) with the survey questions. The survey did not address satisfaction or dissatisfaction with the course design, the online technology, or the participant's motivation for filling out the survey. However, it is likely the participants who volunteered for this research project were sufficiently motivated by either their satisfaction or dissatisfaction with the overall course design to provide a response.

Student responses to course design questions in the "Using Visible Body® during the COVID-19 global health pandemic" dimension of inquiry were largely in overall agreement resulting in: 1. an 86.5% overall agreement with "The online functionality of Visible Body® was useful in a blended classroom modality", 2. an 80.6% overall agreement with "The computer 3-D models were effective at group learning while maintaining safe social distancing", and, 3. an 81.6% overall agreement with, "I preferred using the online 3-D models during the COVID-19 global health pandemic" (Figure 2). However, these values express *overall* agreement only and it is unclear if this represents the more moderate response of agree to a greater extent or if it trends more toward strongly agree.

Student responses to the learning effectiveness questions in the "Overall information and learning effectiveness" dimension of inquiry were also largely in overall agreement resulting in: 1. an 83.8% overall agreement with "The Visible Body® content was useful", 2. an 89.2% overall agreement with "The Visible Body® content effectively supported my

Dimension of Inquiry	Agree or Strongly Agree	Disagree or Strongly Disagree
Using Visible Body during the COVID-19 global health pandemic.		
Please rate how useful Visible Body has been during the COVID-19 global health pandemic.		
1. The online functionality of Visible Body was useful in a blended classroom modality.	86.49%	6.25%
2. The computer 3-D models were effective at group learning while maintaining safe social distancing.	80.56%	6.90%
3. I preferred using the online 3-D models during the COVID-19 global health pandemic.	81.58%	16.13%



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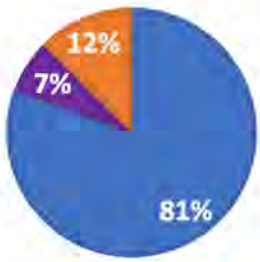

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Figure 2. *Response percentages for the three questions in the Course Design dimension of inquiry, "Using Visible Body® during the COVID-19 global health pandemic". Overall agreement in blue, overall disagreement in purple, and neutral responses in orange.*

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studying of human anatomy", and, 3. An 83.8% overall agreement with "The Visible Body® content improved my knowledge of human anatomy" (Figure 3). It is also important to note the small overall disagreement. It was decided that it would be less useful to further evaluate the overall disagreement responses since, in many cases, they were few in number and nearly equivalent to the neutral responses.

Student responses to the student engagement questions in the "Visible Body® overall assessment" dimension of inquiry were also largely in overall agreement resulting in: 1. an 89.2% overall agreement with "I would recommend this software as an educational tool to others.", 2. an 89.2% overall agreement with "I primarily used this software instead of traditional physical anatomy models in this class.", and, 3. a 73.0% overall agreement with "I plan to utilize this software in my future classes or clinical practice." (Figure 4). Given that these values showed some decline in the overall agreement response category for the, "I plan to utilize this software in my future classes or clinical practice" question, it was decided to further explore the relationship between the strongly agree and agree responses with regard to all three study arms: course design, learning efficacy and student engagement. In other words, were the somewhat mediocre agree responses dominating the overall category and artificially inflating the overall agreement to appear as if there was an overall strong agreement?

Dimension of Inquiry	Agree or Strongly Agree	Disagree or Strongly Disagree
Overall information and learning effectiveness		
Please rate the V.B. information content and learning effectiveness.		
1. The Visible Body content was useful	83.78%	9.68%
2. The Visible Body content effectively supported my studying of human anatomy.	89.19%	6.06%
3. The Visible Body content improved my knowledge of human anatomy.	83.78%	9.68%

Figure 3. *Response percentages for the three questions in the Learning Efficacy dimension of inquiry, "Overall information and learning effectiveness". Overall agreement in blue, overall disagreement in purple, and neutral responses in orange.*

Dimension of Inquiry	Agree or Strongly Agree	Disagree or Strongly Disagree
Visible Body overall assessment.		
Please provide your overall assessment of the Visible Body online platform.		
1. I would recommend this software as an educational tool to others.	89.19%	9.09%
2. I primarily used this software instead of traditional physical anatomy models in this class.	89.19%	9.09%
3. I plan to utilize this software in my future classes or clinical practice.	72.97%	14.81%

Figure 4. *Response percentages for the three questions in the Student Engagement dimension of inquiry, "Visible Body® overall assessment". Overall agreement in blue, overall disagreement in purple, and neutral responses in orange.*

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To address our working hypothesis and to compare the strongly agree with the agree responses I scaled the three dimensions of inquiry to the 5-point Likert range for both of the overall agreement responses. To account for any missing responses to individual questions I corrected the scaled values to the total number of responses for each question of the survey. I then took an average of the three questions to express both strongly agree and agree as a single value under each dimension of inquiry making them comparable on a 5-point scale.

All mean comparisons between the three dimensions of inquiry for both the strongly agree and agree responses were not significantly different ($p > 0.05$). The means and standard deviations for strongly agree in the three dimensions of inquiry were 3.06 ± 0.17, 2.84 ± 0.27, and 2.97 ± 0.49 for course design, learning efficacy and student engagement, respectively. The corresponding results for agree in the three dimensions of inquiry were 1.08 ± 0.11, 1.44 ± 0.41, and 1.22 ± 0.14 (Figure 5). This shows that the trend towards strongly agree was almost double that of just agree on all three dimensions of inquiry. Indeed, these comparisons were all significantly greater in favor of strongly agree (course design, $p = 0.0002$, learning efficacy, $p = 0.03$, and, student engagement, $p = 0.01$).

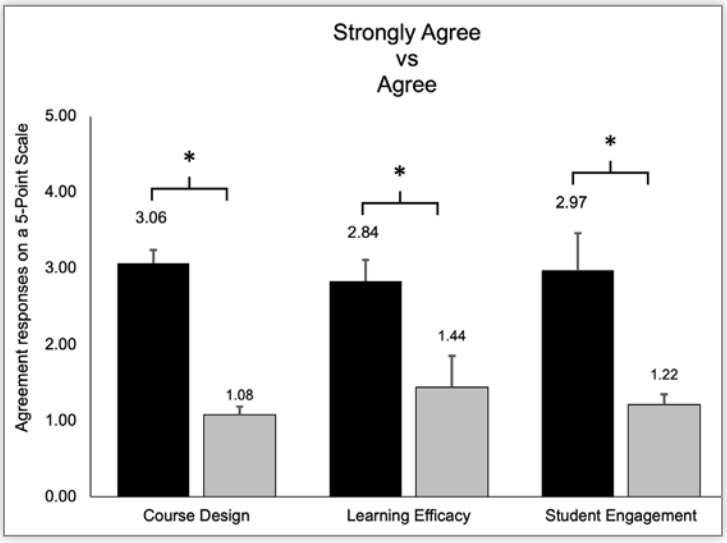

Figure 5. *The three dimensions of inquiry on a 5-point scale comparing "Strongly Agree" (black bars) and "Agree" (light gray bars). Error whiskers represent standard deviation from the mean value listed above the bars. Refer to the text for all values.*

Discussion

The COVID-19 global health pandemic constrained student-to-student interaction opportunities by largely isolating students within various virtual video telecommunication platforms. This project aimed to show that carefully planned blended course design and the learning efficacy of the Visible Body® online platform enhanced student engagement under these unusual constraints. The results show strong student agreement with the blended course design utilizing this platform, high self-reported learning efficacy of Visible Body®®, and subsequent high levels of self-reported student engagement.

The largely positive self-reported response to this approach indicates the importance of student-to-student interactions even if only tethered through a Zoom breakout group. As such, these results indicate that anchoring-students with Visible Body® in Zoom breakout rooms may have enhanced a feeling of student-to-student interaction for our students. During the same period of the COVID-19 pandemic, the Visible Body® company surveyed over 800 students actively using their products and found the same largely positive response to their online learning platform (Visible Body®, 2021). Their results strengthen and help to corroborate the findings of this study. Since the positive impacts of collaborative learning such as social and psychological benefits are well known (Laal & Ghodsi, 2012), the take home message of this project is that using an online anatomy learning platform allowed for a collaborative, while remotely anchored, learning environment that engaged students who strongly agreed that it improved their learning of human anatomy and physiology.

While face-to-face courses will continue to provide the highest level of collaborative student-to-student interactions (Rokusek et al., 2022), utilizing anchor students for synchronous blended course modalities could be an effective strategy to increase these crucial interactions and positively influence student learning of human anatomy. However, there are technological limitations to this course design that if not addressed, could impact equitable and accessible learning for underserved students. The primary limitation is that all students are required to have a laptop computer that meets the technical specifications to run an online platform like Visible Body®. Worcester State University, like many institutions striving for equity and equal access, has a laptop purchasing program to ensure all students enrolled begin their education with the necessary technology for success. Therefore, the split-group and anchor-student course design utilizing an online learning platform does provide a viable option for any future emergency situations that might limit our student's ability to be in a physical classroom or indeed when class enrollment sizes are too large for the available physical lab classrooms.

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About the Author

Luis Rosado, Ph.D., is an Assistant Professor and the Anatomy & Physiology course coordinator in the Department of Biology at Worcester State University. He teaches human biology, A&P, basic kinesiology, endocrinology, and human movement & perception. His research goals aim to improve the integration of technology in all human A&P-related courses. His broader research interests include human visual perception from Gibson's Ecological Approach. He is also very involved in the HAPS DEI committee and actively promotes diversity, equity, and access in the A&P two-course sequence at Worcester State University.

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Appendix: Visible Body® Research Questionnaire

PROJECT TITLE: How effective is the Visible Body® 3-Dimensional online platform for learning human anatomy?

INVESTIGATOR: Luis D. Rosado, PhD, Department of Biology, Worcester State University, Worcester, MA

PURPOSE: The purpose of this study is to determine the learning effectiveness of three-dimensional (3-D) computer based anatomical models in a blended classroom environment during the COVID-19 global health pandemic.

PROCEDURES: If you decide to participate in this study, you will complete an anonymous online survey about the effectiveness of the Visible Body® online learning software. The survey should take approximately 15 minutes.

RISK/DISCOMFORT: The risks or discomforts involved in the project are the same or less than what you would encounter sitting during your normal daily life. There may also be risks that are unknown at this time.

BENEFITS: While you will not experience any direct benefits as a result of your participation, the information that you provide will be adding to our understanding of how effective 3-D anatomical models are for learning human anatomy which could help future students of human anatomy.

PAYMENT TO YOU: There is no compensation for participating in this study aside from the knowledge that you could be helping future students of human anatomy.

CONFIDENTIALITY: Information produced by this study will be confidential and private. The survey is anonymous and no identifying information will be collected. All collected data would be reported numerically and as statistical results in research presentations or publications. However, confidentiality cannot be guaranteed; your personal information may be disclosed if subpoenaed or otherwise required by law.

To ensure that this research activity is being conducted properly, Worcester State University's Human Subjects Review Board has the right to review your data but confidentiality will be maintained as allowed by law.

COST TO YOU: There is no personal cost involved in participating in this study.

PARTICIPANT RIGHTS: Your participation in this study is voluntary. You do not have to be in this study if you don't want to be. You have the right to change your mind and leave the study at any time without giving any reason, and without penalty. Any new information that may make you change your mind about being in this study will be given to you. You will get a copy of this consent form to keep. You do not waive any of your legal rights by signing this consent form.

QUESTIONS ABOUT THE STUDY OR YOUR RIGHTS AS A RESEARCH PARTICIPANT: If you have any questions about the study, you may contact Luis Rosado at... If you have any questions about your rights as a research subject, you may contact Dr. Henry Theriault, Institutional officer at...

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DO YOU CONSENT TO VOLUNTARILY PARTICIPATE IN THIS STUDY? *Mark only one oval.*

◯ YES, I GIVE MY CONSENT TO PARTICIPATE IN THIS STUDY

◯ NO, I DO NOT GIVE MY CONSENT TO PARTICIPATE IN THIS STUDY

Overall information and learning effectiveness. *Mark only one choice per row.*

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The Visible Body® content was useful.					
The Visible Body® content is easy to read and understand.					
The Visible Body® content is well formatted and well designed.					
The Visible Body® content effectively supported my studying of human anatomy.					
The Visible Body® content improved my knowledge of human anatomy.					

Visible Body® 3-D graphics and interphase. *Mark only one choice per row.*

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The interface for interacting with Visible Body® content is easily accessible.					
The 3-D models were information rich (easy access to supplemental information).					
The 3-D models were information starved (no access to supplemental information).					
I am satisfied with the 360^0 rotation of the 3-D computer models.					
I am satisfied with the selection menu of the 3-D models.					
I am satisfied with the hide function.					
I am satisfied with the fade function.					
I am satisfied with the zoom function.					
The Visible Body® 3-D models are of high quality.					

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Comparing 3-D computer models & traditional physical models. *Mark only one choice per row.*

	Computer models	Traditional physical models	No difference between the two learning modalities
Which learning modality helped most in improving your knowledge of the human skeletal system?			
Which learning modality helped most in improving your understanding of the human muscular system?			
Which learning modality helped most in improving your understanding of macroanatomy?			
Which learning modality helped most in improving your understanding of microanatomy?			
Which learning modality did you use the most?			

Visible Body® overall assessment. *Mark only one choice per row.*

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I would recommend this software as an educational tool to others.					
The software was easy to understand and use.					
The software has accelerated my education and understanding of human anatomy.					
I primarily used this software instead of traditional physical anatomy models in this class.					
I plan to utilize this software in my future classes or clinical practice.					

Using Visible Body® during the COVID-19 global pandemic. *Mark only one choice per row.*

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The online functionality of Visible Body® was useful in a blended classroom modality.					
The computer 3-D models were effective at group learning while maintaining safe social distancing.					
The computer 3-D models were effective at group learning while wearing face masks.					
I preferred using the online 3-D models during the COVID-19 global pandemic.					
I would have been OK using physical anatomical models during the COVID-19 global pandemic.					

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