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# A Dive into Immersive Learning: 360-Degree Deer Dissection Videos

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# ABSTRACT

Immersive learning technologies are new tools that are starting to be used in education. Virtual reality is one of the newest forms of immersive learning being used in classrooms and labs. These changes in technology are becoming slowly accepted in education. The objective of this study was to assess undergraduate students' perceptions regarding the use of this new technology for teaching anatomy concepts. Each video was outlined prior to filming. The videos were then filmed at Penn State using multiple cameras and microphones. These cameras allowed for the videos to be developed for virtual reality viewing. Adobe Premiere was used to edit the videos over the span of a few months. Each participant filled out the first half of the survey which focused on their experience with VR prior to watching the videos. They were then asked to view the 360 deer dissection videos developed by the team using the VR headsets. Following the viewing they then filled out the other half of the survey that was broken into two main sections. The first section was broken into four subsections, technology usefulness, ability to learn from videos, overall viewing experience, and how it compares to traditional teaching methods. The second section was open-ended questions about how this tool could be improved and what should stay the same. The data from the surveys showed that in general people liked the idea of utilizing this technology in the classroom, but as a secondary tool, not a main teaching resource.  About 78 percent agreed or strongly agreed that this would be a good tool to use along with lectures and to use along with dissections. The open-ended questions showed that students liked the idea of using VR if that meant they could be exposed to different anatomy dissections that would otherwise not be possible. Based on these results it is possible that VR can be implemented into anatomy labs and other classrooms as secondary tools.

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# Chapter 1

# Background

## 1.1 Immersive Learning

### *1.1.1 Immersive Learning Technologies*

Research done by J. Herrington, et al. (2007) *focused* on the history of immersive learning, what teachers and students have found most effective, and whether immersive learning is a better option than experiential learning (Herrington et al., 2007). Immersive learning can be seen as the Hellenistic Greeks, who used art to represent realistic landscapes (Herrington et al., 2007). They would paint entire rooms with realistic landscapes to give people the opportunity to immerse themselves in that environment without traveling to different places (Herrington et al., 2007).It's one of the first records of people being able to experience alternative realities. Since then, schools and companies have found new and innovative ways to teach people through immersive learning. The most popular type of immersive learning that was being used in the early 2000s was simulations. Internships, externships, military programs, space programs, medical training, and other educational outlets were implementing simulations in place of "real-world" experience. In most cases, the simulations were used to make training safer or more viable for larger groups of people. Simulations came in the form of either computer programs, augmented reality, or virtual reality (VR). The US space program often uses augmented reality and VR to train its astronauts. It allows them to create an environment that is identical to what they will experience while in space. Allowing the trainees to be prepared when they arrive. It also allows the trainees to practice emergency protocols without being put in harm's way (Herrington et al., 2007). It is also common for medical students to use simulations to practice procedures, without operating on real people. This allows the students to get a real feel for what it's like to operate on someone. Leading them to be more prepared when they enter the real world.

Herrington, et al. (2007) determined that for a simulation to be effective there are six key characteristics to focus on: 1) immersiveness, 2) networking and databases, 3) the story being told, 4) characters, 5) setup, and 6) direction (Herrington et al., 2007). Immersiveness needs to focus on creating a realistic experience. Networking and databases need to focus on content distribution and how it is organized and stored. The story being told needs to be compelling and have an interactive narrative. The characters need to be humans that are replaced by automated ones. The setup should focus on creating a solid environment, model, and experience. While the direction should help the person participating understand what a true experience would be like (Herrington et al., 2007).

Herrington, et al. (2007) looked at how effective and realistic immersive learning was and if it was comparable to experiential learning. In terms of how realistic the program could be it depended on the program running the experience and what was the focus of the immersion. This is because realistic and effective experiences cost a lot of money and are resource-intensive (Herrington et al., 2007). After interviewing multiple instructors, authors determined it was more important that those using the technology felt like they were engaged and being prepared than how well the overall technical quality of the program was (Herrington et al., 2007). It was determined that in certain circumstances immersive learning is more practical than experiential learning, but the two were comparable. In certain instances, it was more practical to use immersive technology to learn than to experience it. For example, it is logistically complex and costly to send a large group of people to a town to experience the different places of the town, but a realistic simulation can give them the same experience and cost less. Overall, it was determined that if the simulation felt realistic, it was very comparable to the experiential version (Herrington et al., 2007).

### *1.1.2 Effectiveness of Immersive Learning*

Immersive learning is currently focused on computer programs and virtual reality. Bian Wu, et al. (2020) researched the effects of using immersive virtual reality (IVR) compared to desktop virtual reality (DVR). In this study, there was two VR groups: 1) immersive VR (IVR) and 2) non-immersive VR (Wu et al., 2020). The most important result of this study was the effects of VR (specifically head-mounted-display (HMD)) on those in K-12 is larger than those in post-secondary education. In general, they found that IVR with HMD was more effective than non-immersive VR. But the size of the effect of IVR with HMD was relatively small (Wu et al., 2020). It is hard to say that HMD IVR is better since 34 percent of the participants said either no effect on learning or a negative effect on learning was achieved when using this kind of technology (Wu et al., 2020). Even though a majority said it improved their learning, 34 percent is a very large portion of the population that had no effect or a negative effect. For HMD based VR to be more effective for those who are older, the HMD needs to have a more customizable interface and better design (Wu et al., 2020). This would allow it to be more effective for older people. As expected, IVR was overall a more effective teaching method than DVR and in-classroom lectures. This may be due to its more interactive nature. Immersive virtual reality allows the person to immerse themselves in what they are learning, compared to a lecture where there is minimal interaction with the material being learned (Wu et al., 2020). Even though HMD and IVR are effective, they can become less effective as time goes on, due to fatigue or sickness that can come with using the technology for long periods of time (Wu et al., 2020). In the end, Bian Wu, et al. (2020) determined that HMD based IVR was more effective at teaching than non-immersive techniques.

### *1.1.3 Emerging Technologies for Collaboration*

Technology is a key piece when it comes to immersive learning. Jody Clarke, et al. (2008) assessed the different types of collaborative immersive technologies that are being used and their effectiveness. There are three styles of technology that are helping students learn, especially in K-12. There's a world-to-the-desktop, multi-user virtual environment (MUVE), and Augmented Reality (AR) (Clarke et al., 2008). World-to-the-desktop is a form of learning where the student works on a desktop or laptop to do different activities such as research, communicate with peers, and work in mentoring programs. This is the most common style of learning utilized in K-12 nowadays. Multi-user virtual environment is when the student interacts with other students through avatars or is able to interact with an artifact on the screen, for example being able to click on a photograph to learn more about its history. Augmented reality allows the students to carry a phone or tablet with them that shows the context of a topic in the real world. It focuses on having virtual information superimposed on physical landscapes (Clarke et al., 2008). AR is an emerging field of study given how new the technology is, and it is not understood how effective it is in keeping students engaged and learning.

Having this kind of technology in classrooms is very important according to Clarke et al. (2008). The main reason is because AR and MUVE help kids to develop skills that they will need in the real world (Clarke et al., 2008). Incorporating these collaborative immersive technologies into classrooms have the potential to improve important skills in young students such as working collaboratively and communicating better with people, recognizing and solving problems, critically thinking, and expressing their creativity (Clarke et al., 2008). Learning how to use this technology will also help students to become more competitive in the global work market. But determining which immersive technology is the best will be dependent on the student and how they learn (Clarke et al., 2008).

*1.1.4 Observing 360-Degree Classroom*

Three hundred sixty-degree technology is still relatively new in the tech field, and it is even newer in education. Bernadette Gold and Julian Windscheid (2020) researched how 360-degree videos affected the presence of student teachers, their emotions, and their mental workload. Gold and Windscheid (2020) describe 360-degree videos as a new form of linear moving images. Depending on the device that is being used to view the 360-degree video it can be highly immersive or less immersive. Desktops require the user to use a mouse and drag the screen to change the angle and view in the video. Whereas a phone or tablet allows the user to move the device around to change the view (Gold and Windscheid, 2020). A phone can also be placed in a VR headset to create a more immersive experience. This allows the person to move in a circle to change the view. It’s not as immersive as a full VR experience but it’s more immersive than the other options. Three hundred sixty-degree videos are becoming more popular because it allows an entire area to be captured on film. This means the camera operator doesn't have to determine what scene is more important since 360-degree videos capture every angle (Gold and Windscheid, 2020). The one downfall is that it is easy to overlook certain things since there is so much going on. The user must remember to move the device or screen around to capture the full picture. It is thought that this can lead to a heavier mental workload. The more immersive the device, the more present a person feels (Gold and Windscheid, 2020). Gold and Windscheid (2020) looked at how 360-degree videos affected different aspects by putting students and teachers into two random groups and showing each group the same video. One group viewed the video in 16:9 (widescreen aspect ratio of 16 units wide and 9 units high), while the other viewed it in 360-degrees (Gold and Windscheid, 2020). In the end, they found that the 360-degree video allowed people to feel significantly more present in the moment. However, the 360-degree video had no significant effect on a person's emotions or mental workload (Gold and Windscheid, 2020).

### *1.1.5 Effects of Different Types of Virtual Reality*

Research on immersive learning is often focused on how well the technology works but fails to mention the downfalls and positives that people experience using the technology. Sara de Freitas, et al. (2009) chose to focus on how people responded to the technology rather than the technology itself. The main attribute they focused on was usability, interactivity, and accessibility (De Freitas et al., 2009). To study these characteristics, they used the game Second Life (SL), a desktop-based virtual, interactive world. Freitas et al. (2009) admit that the technical issues they had on the day of the experiment caused a lot of negative feedback from people. This led to the conclusion that immersive technology like SL needs to have a strong internet connection. Otherwise, the technology can glitch, causing the user to feel less present in the world (De Freitas et al., 2009). Another issue users complained about was how realistic the graphics looked. For some participants this caused them to be unable to feel immersed in the experience, while others said it didn't bother them. The group decided this was a personal issue that would vary from user to user and would be difficult to avoid, without increasing the finances need to improve the program's graphics (De Freitas et al., 2009). The final issue that participants reported with immersive technology is its usability. For some users, the adjustment was made rather quickly since people are at different levels when it comes to technology. Those that reported the highest immersion were the users that either had extensive background knowledge on internet gaming or were on the younger side (De Freitas et al., 2009). On the other hand, the participants that reported a lower understanding of technology said it was hard for them to adjust, making them feel less present in the virtual world (De Freitas et al., 2009).

Freitas, et al. (2009) did discover some major benefits and future uses of this style of immersive technology. The major discovery was that it would be very useful for communicating with people who either have a hard time communicating in the real world or those who are located in other countries around the world. The virtual environment would allow for more international collaborations. Second Life and other virtual world immersive experiences would also be useful for remote educational settings. It would help to engage learners from all over the world as well as those who have trouble communicating in normal settings (De Freitas et al., 2009). Virtual worlds can also be used to support traditional learning environments, or help students adjust to video-conferencing and other virtual learning environments (De Freitas et al., 2009). Overall Freitas, et al. (2009) reported that this kind of technology will come with technical issues due to its innovative nature and mentioned that new users should be willing to adjust when technical problems arise, otherwise the use of this immersive technology will never improve (De Freitas et al., 2009).

## 1.2 Viewpoints of Dissection in the Classroom

### *1.2.1 History of Dissection*

Animal dissections have always been a part of science classrooms. The history of dissections goes back centuries starting with cadavers and eventually transitioning to animals. Vesalius was deemed the greatest anatomist of the sixteenth century. To gain this status, he utilized the cadavers of “sinners” to perfect his craft. In the early 19th century, Burke and Hare of Edinburgh were the number one suppliers of bodies to the local medical schools. In order to keep up with the demand, they turned to murder (De Villiers and Monk, 2005).

Eventually, people switched to using animals for dissections since many of the systems and organs are similar across species, including humans. The basis of dissections is the building on prior knowledge to guide one to new discoveries. Performing dissection in cadavers allows people to understand the structure of body organs, while a live animal provides people with a better understanding of the function of these organs (De Villiers and Monk, 2005). Together they help to form a bigger, clearer picture of how living organisms function.

In the years since animal dissections have become more common in the classroom, animal-rights movements have also become more common in fighting against using animals for research. Animal-rights groups have raised concerns over the ethical and established practices of using animals for dissection and research. As a result, these groups have taken to the streets to protest and in some cases become violent (De Villiers and Monk, 2005). But with this pushback, came new alternatives, including cell cultures, isolated organs, and computer models. But there is a major debate over whether these alternatives could ever replace the real specimens (De Villiers and Monk, 2005).

Animal dissections for use in regular classrooms instead of just medical training began in the twentieth century (De Villiers and Monk, 2005). As a result, there have always been questions over whether it is necessary to use real specimens. This has led to teachers along with students questioning the ethics behind the practice and if it really provides any life skills for those who are not interested in going into the medical field. In the 1980s, animal dissections were formally challenged in the classroom. As a result of this challenge, dissections have not been required in the biology curriculum in the UK since 1990 (De Villiers and Monk, 2005).

After people started to question the necessity for animal dissections, alternatives began to be formed. The first alternatives included preserved specimens, books, charts, photographs, models, computer simulations, and films (Oakley, 2012). The education world decided that alternatives were acceptable if the students were still achieving the same level of proficiency that a normal dissection would provide (De Villiers and Monk, 2005).

Over the years, alternatives have improved and been perceived differently throughout the decades. In the 1960s it was determined that watching a film was just as effective as performing an actual dissection. In order to determine if the film taught the students anything they had them cut out figures to test their detail-oriented dexterity (De Villiers and Monk, 2005). In the 1970s, stereoscopic slides were used. The problem with this method is that students struggled to establish the proper anatomical orientation. This was later combined with films and dissected human cadavers. This combination was deemed equivalent to the traditional lecture and dissect model that was being used at the time (De Villiers and Monk, 2005). In the 1980s, microcomputer simulations were used. The interactive nature of this method allowed students to feel more in tune with the material, without having to do the actual dissections (De Villiers and Monk, 2005). In the 1990s, interactive video disc-based frog dissection programs were introduced. This alternative was used as a precursor for dissecting, allowing those who did not want to participate in the actual dissection a chance to at least see all the systems and parts. While those who wanted to do the real dissection were more prepared and had a better base understanding of what they were looking at and doing (De Villiers and Monk, 2005).

Advantages of using alternative methods include saving time, saving money, lessening confusion and frustration, and easier disposal (De Villiers and Monk, 2005). Since the students and the teachers do not have to take the time to do the actual dissection, they are saving time in the classroom for more questions and studying the material (Oakley, 2012). Not using real specimens saves the annual cost of purchasing the specimens, plus, the alternatives can often be used multiple times over multiple years, allowing their overall cost to be lower (Oakley, 2012). Dissecting an animal can become confusing and frustrating, especially the first time a person does it. Using an alternative can limit the amount of confusion and frustration that is caused by this. Finally, not having real specimens means disposal is a lot easier and is less specific (De Villiers and Monk, 2005); especially if it is an alternative that can be used multiple times.

Disadvantages of alternatives include a lack of sensory experience, visual-spacial thinking, realism, and dissection skills (De Villiers and Monk, 2005). Without actually dissecting, a person loses out on the sensory learning experience as well as the development of dissection skills (Oakley, 2012). The latter is only important if someone would like to enter the medical field.

Alternatives also lack a sense of realism. They are often too perfect and do not provide an accurate representation of the different types of specimens that would be seen in an actual dissection (De Villiers and Monk, 2005). Finally, there is often a lack of interest from students to participate in alternatives when they could be experiencing the same material hands-on (Oakley, 2012).

The ethics behind animal dissections have always been a part of debate (Oakley, 2012). Certain arguments are always brought up when discussing the ethics behind the practice. Are people killing just to use animals for dissections? Can certain religious groups be exempt from participating if it goes against their religion? How does one's upbringing affect their outlook on this practice? Should those who do not believe in dissections for various reasons be forced to dissect? All these questions and more should not only be discussed by those making curriculum decisions but should also be discussed in class during the dissection units. An ethical discussion should be included whether alternative methods are used or not.

With the shift to alternatives, there is also a debate on whether any of it is necessary for primary school. Most agree that in primary school it is not necessary (Oakley, 2012), but for secondary education, dissections need to be viewed on a case-by-case basis. This is because it would only benefit a few students who know what they want to do career-wise. In terms of university-level education, most believe it is necessary for those interested in any medical or science field to gain hands-on dissection experience that could be useful in their future careers (Oakley, 2012). This can include future biology teachers, doctors, or veterinarians (De Villiers and Monk, 2005).

*1.2.2 Teachers Opinions on Dissections in the Classroom*

Teachers have always been a part of the debate over whether dissections are necessary for the classroom. This debate has also brought about the conversation surrounding alternatives and their effectiveness. As of now, teachers have implemented virtual dissections, 3D models, plastinated specimens, slides, and videos, among others, for students to use either as complimentary materials for dissections or as replacements for real animal dissections (De Villiers and Monk, 2005). There is an ongoing ethical debate within the teacher community about how far is too far and how young is too young. High school biology teachers agree for the most part that dissections are beneficial to a high schooler's education (Oakley, 2012). As a result, in North America, most biology classes have dissections built into the curriculum. When looking at this from a global perspective, North America uses animal dissections at a larger rate than any other nation. The Netherlands, Switzerland, Argentina, Slovak Republic, Israel, Sweden, Germany, and England rarely practice dissections at a primary and secondary school level (Oakley, 2012).

When discussing if dissections should be used in the curriculum, teachers often worry about the availability of resources. It is expensive to constantly obtain animals for dissecting while using virtual dissections and alternatives can save costs. Other variables that are considered include, willingness to investigate new methods of learning, attitudes towards technology in the classroom, budgets, and how much time can be spent on the dissection unit (Oakley, 2012).

A study was done to gain a wider perspective and hear more teachers’ opinions on the matter. A total of 153 teachers who taught grades 9 through 12 were interviewed and were asked to complete a Likert scale survey. The results showed that most teachers believed there was unparalleled value in traditional dissections. The number one benefit that teachers agreed about was the pedagogical value that hands-on dissections provide (Oakley, 2012). Being able to dissect an animal allows the student to see the interconnections and complexities within, that otherwise would be impossible to replicate (De Villiers and Monk, 2005). Another benefit that was commonly mentioned was the fact that hands-on dissections provided students with "surprises" that alternatives would hide to make the model perfect (Oakley, 2012). The "surprises" provide the students with a realistic view of what happens in nature. A simulation may leave out a disease that causes internal lesions to show a perfect specimen, while a real dissection would show students what this looks like. Another benefit that teachers cited for hands-on dissections was the increase in student engagement and teamwork (Oakley, 2012). Many dissections are done in groups, and as a result, require students to work together and be more engaged than they are during a regular lecture (De Villiers and Monk, 2005).

The study also looked at the concerns or negatives that came with dissecting. The main concern teachers had was the health and safety of themselves and their students. The biggest health concern was the high level of exposure to formalin solutions (Oakley, 2012). This solution is commonly used to preserve the specimens (De Villiers and Monk, 2005). Some teachers have moved away from formaldehyde preservation, but most still use formaldehyde-containing specimens (Oakley, 2012). The next biggest concern was classroom management, including student behavior. Some students' behaviors resulted in them deliberately abusing or disrespecting the animal. This is something that is hard to combat without alternatives. Another concern had to do with cost and budgeting (Oakley, 2012). As a result of trying to cut costs, people are often forced to work in larger groups than before and as a result, do not get as much hands-on experience (De Villiers and Monk, 2005).

After compiling all the data, it was determined that alternatives had more benefits than dissections, but real-time dissections are still used more frequently. Although the benefits of alternatives outweighed the negatives on paper, most teachers agreed that the benefits that come from an actual dissection outweigh all the positives found in alternatives. Alternatives were often deemed inadequate replacements (Oakley, 2012). The engagement that they get from students when performing dissections is way higher than the engagement they get when using alternatives.

## 1.3 Overview of Gross Deer Anatomy

### *1.3.1 Antlers*

Antlers on a deer play a major role in terms of survival as well as classification. Deer will use their antlers as a defense mechanism as well as a way to attract a mate. In order to classify deer based on their antlers, there are a few factors that must be considered. The main characteristic that is looked at is the grooves and streaks in the antlers. Within the grooves, there is a focus on the branching directions of the tines, positions of the forks, any overlapping that is occurring between tines, and the overall position in relation to the skull (Samejima and Matsuoka, 2020).

The streaks found in antlers are thought to be from the extension force that an antler goes through when it is growing (Samejima and Matsuoka, 2020). The grooves are most seen in the proximal region of the antler and run parallel to the streaks. The direction of the streaks combined with the direction of the grooves helps to determine the overall branching structure of a deer (Samejima and Matsuoka, 2020).

When looking at the branching direction of tines, there is a specific order that is implemented. First, the point on the fork where the target tine branches off another tine is found. Then the cross-section of the target tine that is facing the opposite point on the fork is located. This provides the overall branching direction. Once this is done, the branching direction is drawn along the antler groove to the burr (Samejima and Matsuoka, 2020). Once the branching direction of the tines is determined, the position of the forks is looked at. The best practice to determine the position of the forks where the tines split apart is to look at the antler grooves. First, the point of the fork that is located near the maximum curvature point is found. From there, this point is traced along the maximum curvature of the antler grooves and is parallel to the ridge of the fork (Samejima and Matsuoka, 2020). Once the burr is reached, a fork can divert into two directions when viewing a cross-section.

Some branching directions allow tines to reach all the way down to the burr, but it is more common for tines to overlap with other proximal tines, blocking them from ever reaching the burr (Samejima and Matsuoka, 2020). When this occurs the focus should be switched to the antler grooves present on the proximal tine that are overlapping. This leads to following two flows of antler grooves, one towards the burr and one towards the other tine (Samejima and Matsuoka, 2020). Focusing on both helps to center the antler and make sure that the proper branching and fork positions are determined.

The last thing viewed when classifying an antler is the position of the antler in relation to the skull. All antlers form from pedicles, protrusions of the frontal bone, that are part of the skull (Samejima and Matsuoka, 2020), but the location can vary. As a result, many indicators are used to determine where exactly the antler is located on the skull and how this can impact the branching directions. The ridge extending from the suborbital region to the burr on the pedicle is used as a reference point, along with the branching of the superficial temporal artery. When looking at the temporal area of the skull, the ridge extending from the retro-orbital region to the burr on the pedicle is used (Samejima and Matsuoka, 2020). The last thing that is used as a reference point is the location of the nerves that innervate the pedicle. They are derived from the trigeminal nerve and appear on both the medial and lateral sides (Samejima and Matsuoka, 2020).

*1.3.2 Nasal Fossa*

The rostral region of the nasal fossa in deer is very complex. The maxilloturbinals have a double scroll, one that expands ventrally and one that expands caudally. In addition to this, the maxilloturbinals are entirely lined in non-sensory epithelium and regress into the lateral wall and rostral tip (Yee et al., 2016). This helps to form the ethmoturbinal. The rostral nasoturbinals are single scrolled, starting from the nasals and eventually attaching to the caudal end of the lateral wall. The ethmoturbinals have complex folds that help to fill the nasal chamber. This is due to the thick epithelium that covers the outside of the ethmoturbinal folds (Yee et al., 2016). In deer, the ethmoturbinals make up about forty percent of the surface area and are about the same size as the maxilloturbinals. The larger surface area is a result of the complex folds the ethmoturbinals form. The olfactory bulb, which helps deer with their superior sense of smell, is located above the meatus and below the nasal bone (Yee et al., 2016). This location helps the nerves present in the olfactory bulb to be more sensitive, improving a deer's sense of smell.

### *1.3.3 Vertebrae*

Deer vertebrae have to be extremely strong to withstand deer’s movements and the strong muscles that attach to it. For a deer to be able to support its head when in a resting position the posterior cervical neck muscles are extremely strong (Goel et al., 2011). In order to support the muscles necessary to support the head, the occipital crest is very thick. This thickness provides enough support for the various muscle attachments that need to occur. Deer also have a platybasia, which is a flattening at the base of the skull. The clivus and the anterior skull base are both present in the same horizontal plane. This is most likely due to the smaller size of a deer's brain. The fact that the maxilla and upper jaw protrude anteriorly from the cranial base, most likely also plays a role in this flattening (Goel et al., 2011).

The superior articular surface of the atlas and the occipital condyles are large, thick, and strong. The occipital condyles sit deeply in the anterior articular facets of the atlas. This forms a hinge joint that provides extra stability and mobility (Goel et al., 2011). The occipitoatlantal articulation has mobility mainly focused on extension and flexion but also has minor lateral oblique movements (Goel et al., 2011). The atlas bone has arches in the anterior and posterior positions that are ring-shaped and have wide, flat lateral projections (transverse processes). The transverse processes are relatively large and deep compared to those found in other species. In addition to this, the ventral arch is much thicker, narrower, and less curved than the dorsal arch is (Goel et al., 2011).

Moving on to the axis, which is the longest vertebrae in deer. It is roughly 4.9 centimeters long (Goel et al., 2011). The transverse processes located on the axis are generally small and project out caudally, while the spinous processes are large, strong, and divided. The first cervical nerve comes through the lateral vertebral foramen of the atlas and supplies sensations to most muscles in the nape of the neck. While the second cervical nerve is the larger of the two and comes through the spinal canal and then through the lateral vertebral foramen of the axis. This nerve supplies sensation to the skin and neck muscles (Goel et al., 2011).

The lumbar spine has uniform ventral vertebral bodies, while the dorsal vertebral body height of the upper and mid thoracic spine also show uniformity (Kumar et al., 2000). When transitioning to the sacral region there are extra lumbar vertebra. The end plate of the vertebral body is basically the surface that articulates with the intervertebral discs. The rostral end plate was largest at thoracic vertebra one and then remains a constant going caudally until the midthoracic spine is reached (Kumar et al., 2000). The depths of the endplates were largest at thoracic vertebra one when compared to the rest of the thoracic and lumbar spine. When viewing the spinal canal width, the upper cervical region is larger than the lower cervical region (Kumar et al., 2000). The spinous processes increase from thoracic vertebra one to four and then begin to decrease until a minimum is reached at thoracic vertebra thirteen. This decrease in size reflects the transition from thoracic to lumbar. The transverse processes however are more uniform in the thoracic and lumbar region compared to the spinous processes (Kumar et al., 2000). When looking at the angle of the projections, the cervical region has caudally projecting transverse processes, while the thoracic and lumbar regions have cranially projecting transverse processes. Anterior disc height is largest in the cervical spine and then decreases in the midthoracic spine and then begins to increase in the lower thoracic spine going into the lumbar spine (Kumar et al., 2000). In terms of spinal curvature, a deer's spine has slight lordosis in the thoracic spinal region and kyphosis in the lumbar spinal region (Kumar et al., 2000).

*1.3.4 Gastrointestinal Tract*

Deer are often characterized as intermediate feeders, meaning they forage for food based on what is available each season and feed on grasses (Pérez et al., 2014). There are no sex-related differences in a deer's gastrointestinal tract. Since deer are classified as ruminants, this means their stomach is composed of four compartments, the rumen, reticulum, omasum, and abomasum.

The dorsal sac of the rumen communicates with the ventral sac via the ostrium intraruminale. The ostrium intraruminale has borders that are formed by the ruminal pillars (Pérez et al., 2014). The thickest ruminal pillars present in the ruminal mucosa are the cranial and caudal pillars. The left and right longitudinal pillars differ in that the left pillar does not reach the caudal pillar while the right one does. The left end of the caudal pillar does not reach the left longitudinal pillar resulting in no left accessory pillar (Pérez et al., 2014). Within the rumen, the ruminal papillae are distributed unevenly. The papillae are most abundant in the atrium and dorsal sac of the rumen. The pillars within the rumen show no signs of ruminal papillae.

The reticulum contains the cellulae reticuli, which have a honeycomb appearance that is lacking any divisions or secondary crests (Pérez et al., 2014). Cellulae reticuli are deeper near the greater curvature of the reticulum and less deep near the lesser curvature of the reticulum. Following the reticulum, the omasum is the smallest gastric compartment seen in deer. Within the omasum, the sides of the laminae omasi contain paillae omasi (Pérez et al., 2014). The abomasum is the second-largest compartment in the deer and is known as the "true stomach". It contains plicae spirales abomasi and torus pyloricus. After the abomasum is the small intestine which is broken into three distinct sections, the duodenum, jejunum, and ileum. The duodenum and the jejunum are separated by the duodenojejunal flexure (Pérez et al., 2014).

The large intestine contains the caecum, ascending colon, transverse colon, descending colon, rectum, and canal anal. The transition from the small intestine to the large intestine is between the ileum and caecum. The ileum is connected to the caecum via the ileocecal fold (Pérez et al., 2014). The ascending colon is then attached to the caecum via a short cecocolic fold. The ascending colon is the most developed portion of the intestine and is the most complex, being made up of three ansae: proxima, spinal, and distal. An S-shaped proximal ansa is directed cranially and turned over on itself caudally and then turned medially to attach to the left mesentery. Following the ascending colon is the transverse colon then the descending colon which turns into the rectum once it reaches the pelvic cavity. The overall intestinal tract is situated on the right side, with the greater omentum covering almost the entire intestine except for the descending duodenum (Pérez et al., 2014).

### *1.3.5 Female Reproductive System*

All female deer have the same reproductive system. Their reproductive system contains ovaries, an oviduct, uterine horn, and a uterine body that contains a cervix, vagina, and vulva. The left and right uterine horns and oviducts did not have any significant size differences. Female genital organs are located within the pelvic cavity, which is located ventral to the rectum and dorsal to the urinary bladder. Both ovaries are located cranial to the external iliac artery and towards the middle of the lateral half of the pelvic inlet. Ovaries are oval and lie flat, with connections at the caudal ends of the uterine horns. There are follicles present on the left ovary but not the right ovary (Mahre et al., 2016). Oviducts are in the mesosalpinx and adjacent to the ovaries. Within the oviducts are the infundibulum, ampulla, and isthmus, which are relatively long in length. The infundibulum covers the ovaries forming an ovarian bursa with a large opening (Mahre et al., 2016).

The uterus has a small uterine body along with two short uterine horns that connect directly to the oviducts (Mahre et al., 2016). There are three locations that the board ligament attaches to the reproductive system to adhere it to the abdominal wall: ovaries, oviducts, and the uterus. Towards the caudal end of the uterine body, the cervix can be found. The cervix is a firm and muscular tube that has a constricted lumen (Mahre et al., 2016). Within the cervical canal are six circular folds or cervical rings. The vagina in deer is long and wide and has vaginal mucosa that forms folds within. The vaginal cavity goes from the cervix to the vestibule. While the vestibule goes from the external urethral orifice to the vulva (Mahre et al., 2016). Between deer species, there can be varying degrees of size for each component of the reproductive system, but in general, the sizes are similar regardless of species.

### *1.3.6 Male Reproductive Tract*

All male deer have the same reproductive system. Their reproductive system is composed of testicles, epididymides, deferent ducts, accessory genital glands, a prepuce, and a penis (Pérez et al., 2013). The testicles work with the scrotum, external spermatic fascia, cremasteric fascia, cremaster muscle, internal spermatic fascia, and tunica vaginalis, all of which help to form the ovoid shape of the testicles. Testicles also varied in size, with the right testicle being heavier (Pérez et al., 2013). The scrotum is composed of skin and dartos muscle, while the external spermatic fascia is formed by a loose layer of connective tissue. This connective tissue helps with mobility. The cremaster muscle is located dorsocaudal to the testicle. The internal spermatic fascia is thicker than the external spermatic fascia and is bound to the vaginal tunic (Pérez et al., 2013).

Both epididymides are roughly the same size and do not vary from left to right. The epididymis head is attached to the testicles cranially while the epididymal body is located lateral and caudal (Pérez et al., 2013). The deferent ducts are located caudomedially to the testicles and enter the abdominal region as the spermatic cord through the inguinal canal. Accessory glands include the ampullary glands, vesicular glands, and the prostate. The ampullary glands of the vas deferens and the vesicular glands form an ejaculatory duct that opens into a hole cranial to the prostate. The prostate is located dorsal to the pelvic urethra which has a well-developed urethral muscle (Pérez et al., 2013).

Deer prepuces are single folds of skin formed by an external and internal layer that join on the preputial ostium (Pérez et al., 2013). Between these two layers are nerves and blood vessels that supply the penis. The penis is fibroelastic with a thick albuginea and lacks a sigmoid flexure. At the root of the penis, it inserts into the ischiatic arc via two small pillars surrounded by ischiocavernosus muscles (Pérez et al., 2013). The penile urethra is surrounded by thin erectile tissue that swells at the bulb of the penis. Multiple arteries supply blood to the various portions of the male reproductive tract.

**1.4 Dissection Techniques for Ruminants**

Dissection techniques are similar across species, but certain considerations must be taken when dissecting a ruminant. Some basic dissection techniques include identifying the subject, using the proper tools for each system, and sample collecting if necessary. Identifying the subject can include looking at ear tags, collar tags, earmarks, tattoos, microchips, etc. (Henrik Elvang Jensen, 2011). The next step should be to determine the age of the subject, especially if further testing is going to be performed.

Using the proper tools during dissection is very important in terms of personal safety and preservation of tissues and organs for evaluation. Having a sharp knife is the most important tool when it comes to dissections. This means throughout the dissection the knife may need to be sharpened. So, it is key to have either multiple sharp knives available or to keep a knife sharpener nearby (Henrik Elvang Jensen, 2011). Using different knives is also key when going from soft tissue to joints to more delicate areas. For example, a tripe knife should be used for opening the abdominal cavity since its rounded tip will minimize the chance of accidentally cutting any internal organs (Henrik Elvang Jensen, 2011). A curved knife or spoon can be used for Bovine Spongiform Encephalopathy (BSE)-testing samples and a scalpel can be used for more delicate dissections involving arteries, veins, and nerves (Henrik Elvang Jensen, 2011). A saw can be used to open pelvic cavities of large animals, while a chisel and hammer are used to aid in brain dissections. Multiple scissors and forceps will also be useful for holding certain materials while cutting through muscle or fat (Henrik Elvang Jensen, 2011).

Once the proper dissection tools are obtained, the actual dissection can begin. First, the fur and/or skin will need to be removed, by placing the deer in left lateral recumbency and strapping down the legs. The first cut will be placed just below the midline of the chin and go down just ventral to the anus in males and around the udder up until ventral to the vulva. The extremities are then cut on the medial side to the pastern joints. Now the skin can be retracted, but it is often not necessary to skin the genitals. In females, the udder should be removed with its lymph nodes before completely removing the skin (Henrik Elvang Jensen, 2011). After removing the skin, the external genital organs will be removed, and the abdominal cavity will be opened carefully using a knife facing up. This will prevent any puncturing of internal structures. Once the abdominal cavity is opened it is important to figure out the normal position of the intestines and other organs. Most often the dissection will first focus on the proventriculi and the abomasum, followed by the gastrointestinal tract, then the duodenum, pancreas, and liver. After that, the kidneys and adrenal glands will be removed, then the genital and pelvic cavity organs will be explored (Henrik Elvang Jensen, 2011). Once the internal dissection is complete, the external dissection will be next. This will include evisceration from the head, neck, and thoracic cavity, in that order (Henrik Elvang Jensen, 2011). Next, the organs and tissues will be prepared for further examination. The order of preparation will often be the trunk, pelvic limbs, thoracic limbs, head, "plucks" (tongue, cervical and thoracic vicera), tongue, oesophagus, larynx, and trachea. Then the lungs, heart, genital organs, urinary bladder and urethra, kidneys and adrenal glands, the oral part of the duodenum, pancreas, and liver, udder, spleen, proventriculi, and abomasum, and finally the intestinal tract will be prepared (Henrik Elvang Jensen, 2011). It is important that throughout the dissection care is taken to not accidentally cut or remove things before they have been viewed and examined.

# Chapter 2

## Introduction

Immersive learning is an emerging field in education, with options including virtual reality (VR), augmented reality, 360-degree videos, etc. With VR headsets being mass produced for gaming purposes it was important to start asking questions about how this technology could be implemented in the classroom. Classrooms are always trying to find new ways to engage students as well as prepare them for the world. Being up to date on what technology is being used and how to properly use it, is an important part of being prepared for a world that is always trying to advance their technology in order to better society. The objective of this study was to assess undergraduate students' perceptions regarding the use of this new technology for teaching anatomy concepts. The rationale behind this study is to be able to develop cost-effective and user-friendly educational materials regarding animal dissections and increase the accessibility of these educational resources.

In order to gain a better understanding on this topic, multiple VR videos were created revolving around a deer dissection. Our hypothesis was that students would perceive immersive learning to be beneficial and useful for their education.

# Chapter 3

# Methods and Materials

## 3.1 Dissection

A female deer was used for these videos collected from the Pennsylvania University deer farm. This deer was humanely euthanized for the sole purpose of creating this video. Institutional Animal Care and Use Committee (IACUC) protocol PROTO201900696 approval was received. The techniques used to dissect this deer followed those outlined in Henrik Elvang Jensen's *Necropsy A Handbook and Atlas*. All techniques utilized were described in the literature review provided above. The tools used included different knives for skinning and dissecting. Multiple pairs of scissors as well as hedge trimmers were also used. After the filming component was finalized, the deer remains were properly disposed of following biosecurity protocols.

## 3.2 Filming and Editing

Filming these videos required multiple pieces of filming equipment. The first camera that was utilized was an Insta360 Pro 2 (Insta360). This specific camera can shoot 8K footage and can capture 3D or flat footage. 3D footage is called stereoscopic footage and flat footage is called monoscopic footage. Monoscopic footage was used in order to shoot at a higher frame rate, which creates higher quality footage. For better audio, two Tascam DR-10L lavalier microphones (Tascam) were used. This allowed the audio to be clearer and easier to export and input into the final videos. The audio from the portable microphones is also louder than the audio the camera captures.

Editing the videos was done in Adobe Premiere. This software is equipped to make editing 360-degree videos easier, as it includes multiple plugins for picture, text, and standard video insertion into the already filmed 360-degree content. Since 360-degree videos create massive files a 5 TB hard drive (Western Digital (WD)) was used in order to store the RAW and edited footage. The final videos were posted on YouTube as “unlisted”.

### 3.3 Viewing and Surveying

Participants signed up for a 45-minute time slot to view a 30-minute video sample created from a longer series of videos. This gave participants an idea of what this technology could do. They then completed a survey before and after watching the video. Oculus Quest 2 headsets were used for viewing. This headset allows for higher resolution videos to be viewed with a smoother viewing experience. Each video covered a different section of the dissection process from skinning to organ differentiation.

The survey that was handed out was broken into three separate sections. The first section was questions that pertained to pre-viewing ideologies. These questions were either “yes/no” or “none/some/extensive”. The next section was to be completed after viewing the videos and focused on the viewing and learning experience. Within this section there were five subsections, all of which used the Likert scale. The Likert scale is a system of using “strongly disagree, disagree, neither, agree, and strongly agree” to answer specific questions or statements. The final section was also a post-viewing section but was focused on open-ended questions. Mainly to determine what could be improved and what did not need to be fixed in anyway.

### 3.4 Statistical Analyses

Results in this study are purely observational and no statistical analyses were performed in this data set. Therefore, no associations or correlations can be inferred from these results, and results should be cautiously interpreted.

# Chapter 4

# Results

## 4.1 Pre-Viewing Question Results

Nine Participants participated in this study. Figure 5 shows the results of the first pre-viewing question, “Have you used virtual reality (VR) technology before?”. About half the participants had no experience with VR (55.6%) while the other half had some form of experience (44.4%). The types of usage varied from using it to play video games, on a roller coaster, and in the classroom for lab activities. Figure 6 shows the results of the second pre-viewing question which can be found in table 1. For this question, 100% of participants had never used VR as a sole teaching resource. This was interesting, given the fact that a few people had mentioned in the previous question using VR technology in labs. This most likely means the labs were using the technology as a supplemental or optional component and was therefore supporting what the students had already learned. Figure 7 displays the results of the third pre-viewing question that can be found in table 1. All the participants had some level of exposure to ruminant anatomy. With 88.9% having some experience and 11.1% having extensive experience. The most common exposure came from the classroom, either in VBSC 421 or ANSC 201. One participant gained experience by working on a dairy farm. Figure 8 shows the results for pre-viewing question 4 which was focused on experience with ruminant dissections. The results varied for this question, with 33.3% having no experience, 55.6% having some experience, and 11.1% having extensive experience. Those that had experience attributed this experience to classes like VBSC 421 and ANSC 431. Figure 9 shows the results for question 5 of the survey, which focused on experience with deer anatomy. Just like question 4, the results varied. 66.7%

had no experience, 11.1% had some experience, and 22.2% had extensive experience. All participants that had some to extensive experience attributed this to being avid hunters and being exposed by butchering their own deer. Figure 10 shows the results for pre-viewing question 6. 66.7% had no experience, 22.2% had some experience, and 11.1% had extensive experience. In this instance, ANSC 431 and hunting were the main ways the participants had gained experience in deer dissections. Figure 11 shows the results for question 7. 33.3% of participants had no experience in deer biology, while 66.7% had some experience with deer biology. The experience ranged from classroom and campus exposure to hunting. ANSC 201 and ENT 496 were the two classes' participants listed.

### 4.2 Technology Benefits Results

Figure 1 displays the results of the portion of the post-viewing survey that is focused on the benefits of the technology overall. Table 2 has listed the exact questions that participants were asked after viewing the VR videos. For all four questions, nobody strongly disagreed with any of the statements. For the first statement most people either agreed or strongly agreed with the statement, this accounted for 88.9% of responses, while 11.1% were indifferent towards the statement. Statement two had a majority (66.7%) of participants agree with the statement. The remaining participants either strongly agreed (22.2%) or disagreed (11.1%) with the statement. Statement three had a majority strongly agree (55.6%) with the statement while the remaining participants either agreed (33.3%) or were indifferent (11.1%). Statement four once again had a majority of participants strongly agree, with a percentage of 55.6%. 22.2% of participants either agreed or were once again indifferent towards the statement. Statement five had the largest variety of answers. The majority (55.6%) were indifferent towards the statement, while 11.1% strongly agreed or agreed and 22.2% disagreed with the statement.

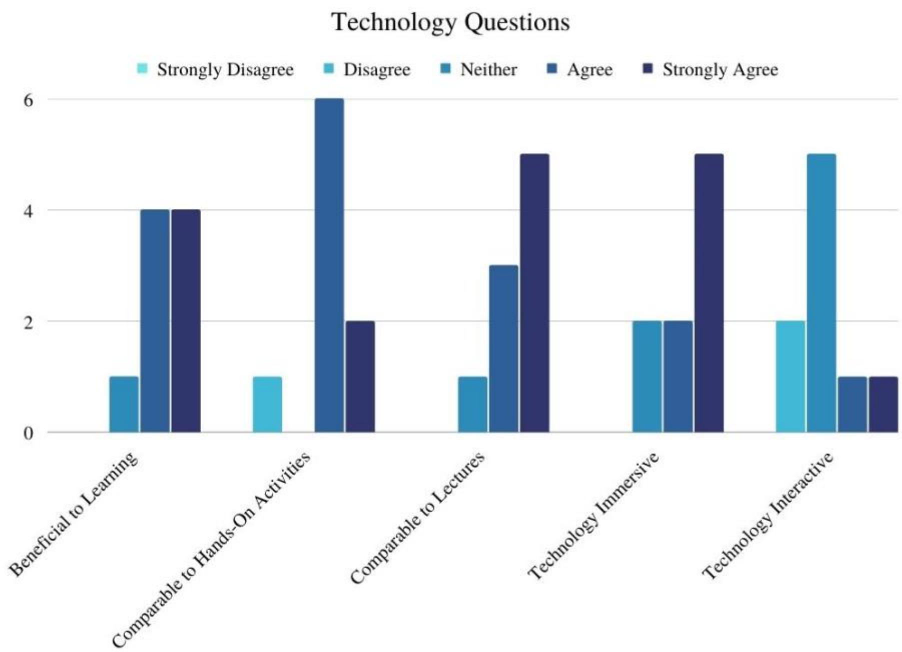


**Figure 1: Technology Questions**

### 4.3 Video Quality Results

Figure 2 shows the results for the post-viewing survey questions focused on the overall video quality and information given. Table 3 has the exact questions listed that participants were asked. Out of the five questions asked, none of them had participants strongly disagree or disagree with them. Most participants (55.6%) strongly agreed with the first statement while the remaining 44.4% agreed with the statement.  The second statement had a majority of participants (55.6%) agree, while 33.3% strongly agreed and 11.1% were indifferent. For the third statement 44.4% strongly agreed, 33.3% were indifferent, and 22.2% agreed that their understanding of anatomic adaptations was improved. The fourth statement was focused on improved understanding of deer organ anatomy. 44.4% of participants strongly agreed, 33.3% agreed, and 22.2% were indifferent about the statement. The fifth question asked if these videos would be useful in VBSC 421 and 77.8% of participants strongly agreed that they would be. While 11.1% agreed and 11.1% were indifferent.

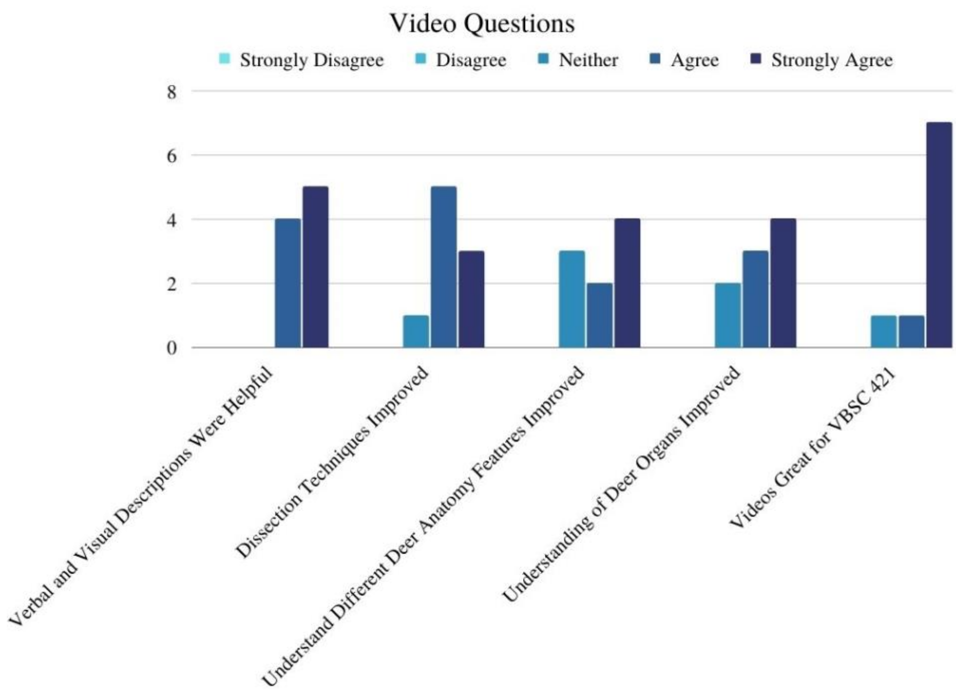


**Figure 2: Video Questions**

### 4.4 Overall Viewing Experience Results

Figure 3 shows the results for the third section of post-viewing questions and table 4 displays the exact questions. These questions were focused on the overall viewing experience that the participants had. The first question asked if the VR gear was comfortable. 33.3% of participants strongly disagreed, while 55.6% agreed and 11.1% strongly agreed. 44.4% of participants strongly agreed that the video audio and quality were good. 44.4% agreed and 11.1%

were indifferent. The third question had 55.6% of participants agree that the details were easy to see while 44.4% strongly agreed. The fourth question had a majority (77.8%) strongly agree while 22.2% agreed the extra pictures were useful. The fifth question is the only one that had participants strongly disagree. 22.2% of participants strongly disagreed while 44.4% agreed and 33.3% strongly agreed that the VR videos did not make them nauseous.

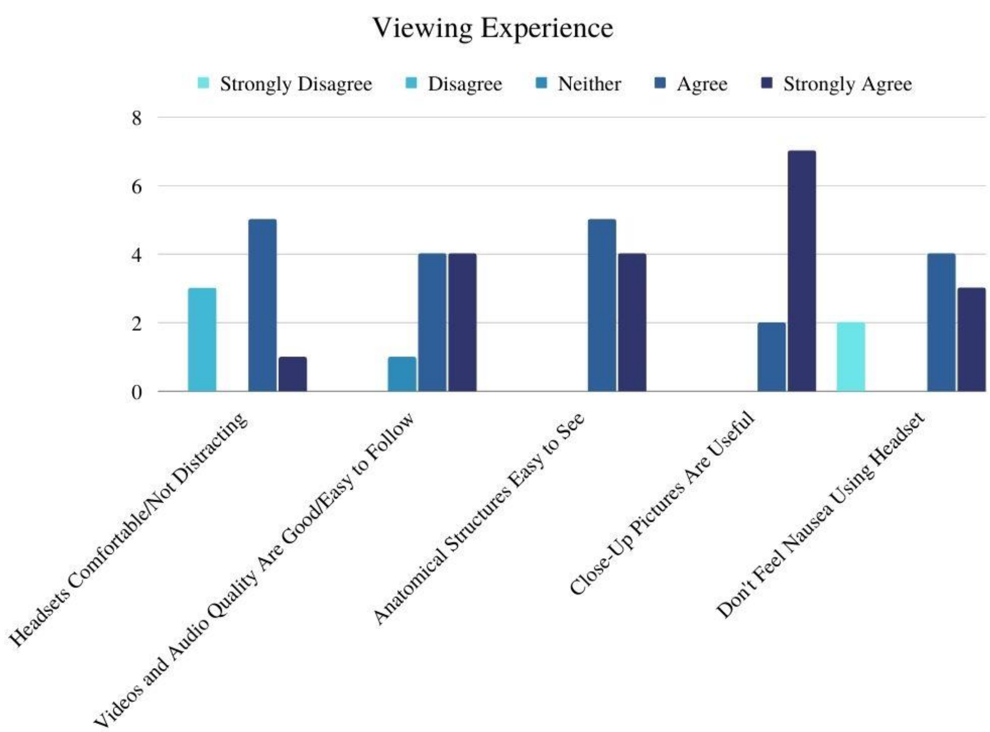


**Figure 3: Viewing Experience Questions**

### 4.5 Technology Learning Preference Results

Figure 4 shows the results for the technology learning preference part of the survey. The specific questions can be found in table 5. This section of questions had the largest spread of answers and had the highest amount of strongly disagree and disagree. The first question asked participants if they would rather use VR over hands-on activities. 55.6% disagreed with this, while 22.2% strongly disagreed. 11.1% of participants were indifferent and 11.1% agreed that they would rather use VR instead of hands-on activities. The second question had a majority of participants (44.4%) agree and 11.1% strongly agree. 22.2% were indifferent and 22.2%disagreed that they would rather use VR over lectures. 44.4% of participants agreed that using VR with hands-on activities was preferred, while 33.3% strongly agreed and 22.2% were indifferent. The last question asked if participants would prefer to use VR with lectures. 55.6% agreed, 22.2% strongly agreed, 11.1% were indifferent, and 11.1% strongly disagreed.

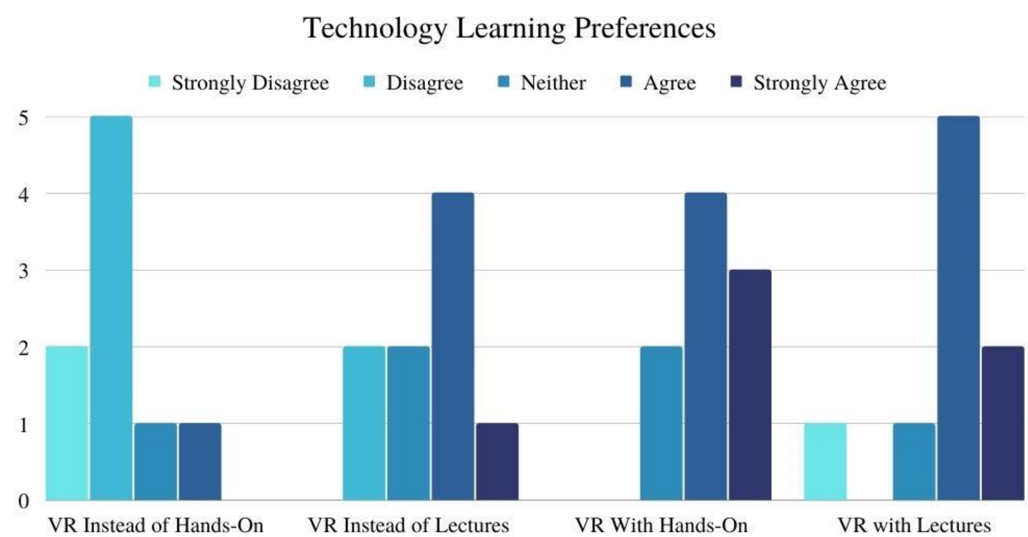


**Figure 4: Technology Learning Preference Questions**

### 4.6 Open-ended Question Results

Table 6 displays the specific open-ended questions that participants were asked. The first question focused on the expectations of this technology. The general consensus from participants was that they hoped it would help people learn about more species and help to support anatomy courses. One participant stated, “I expect that it would give students clear information on anatomy, differences in species, and important landmarks”. They also expect it to make learning easier and more accessible. The second question focused on the concerns of VR technology in this setting. Most were concerned with the weight of the headset and the fact that it could cause neck pain and nausea. Another concern was that the video quality would not be comparable to hands-on labs. One participant stated, “the picture quality wouldn’t be good, and I wouldn’t be able to distinguish certain organs due to picture quality”. Participants were then asked what changes they would recommend. The two biggest recommendations were to find a way to make the headset lighter and to find a way to zoom into smaller structures by either raising the table or changing the camera angle. One participant recommended having a mini quiz at the end of each video to act as a review of key points. The next two questions focused on what each participant liked the most and least. The most common thing participants liked was that they felt like they were there during the dissection since they could move around and change the viewing angle. Another positive was the pop-up pictures that relayed extra information. As one participant stated, “I liked the pop-ups of diagrams that further described the information presented. I also liked how the presenters went through the connections of the body”. They claimed that this helped them to better understand what they were viewing. The headset weight was the most common thing participants liked least. The motion of the video and the constantly having to look down was another complaint. The last complaint was that it is still hard to learn without physically touching anything. There were only a few additional comments mentioned. Most were stating how cool this technology was and that using VR was a great idea. The other comments mentioned that VR anatomy could never replace hands-on anatomy but could be a great secondary resource for students since a lot of people prefer hands-on dissection experiences.

# Chapter 5

## Discussion

The results of this study might suggest some trends on students' perceptions about implementing VR technology in the classroom, especially as it pertains to anatomy. Based on the results of the pre-viewing survey, the participants came in with an open mind and little to no experience with VR technology. This is most likely a result of the lack of availability of VR technology in everyday life. Access to VR technology is not common and often are costly. These costs come from either buying the equipment for personal use or paying an establishment to use their VR technology. Although it is becoming more common for VR to be used in the gaming world, it is not common in everyday life yet. This can be seen by the fact that most participants who stated having previous VR experience did so from gaming. Ultimately allowing this study to have very raw opinions since most participants came in with an open mind and lack of experience with the technology but at least a little experience with anatomy. The lack of exposure in classrooms also allows us to better understand the type of technology being used in classrooms today. Since most participants had not utilized this technology in the classroom this can show that classrooms are not advancing in terms of the technology, they are providing students with. This could once again be a cost and availability issue.

After viewing the videos, there were four different sets of questions to answer. The first set was focused on the benefits of using VR technology compared to other methods used in the classroom. Based on the results utilizing VR technology in the classroom is comparable to traditional methods of teaching, in terms of lessons pertaining to anatomy. Also, VR technology allowed participants to feel immersed in the videos, almost as if they were in the lab during the dissection. Which can be very beneficial when it comes to using this technology down the line to do dissections on animals that are not as readily available as deer are. Based on the rest of the results there were not many strong feelings one way or the other to the remaining questions. This could be due to the lack of experience with the technology and the fact that the viewing time only allowed a small amount of exposure to VR. Nowhere near the amount of exposure that would be had if this was implemented in the classroom.

The second set of questions was focused on how well the videos conveyed information. These results were overall positive across the board. There was not a single negative response in this section of questions. The positive responses allow us to better understand how this technology could be useful in a lab setting such as VBSC 421 or other anatomy-based classes. In general, the participants believed this would be a good supplemental source to use and not the sole learning tool used in the classroom. Which makes sense given the different learning styles of students. Plus, this level of technology is not ready to be the main source of learning in the classroom yet. There is not a large enough catalog of videos or animal species that have been looked at yet. Regardless, the participants did feel that this increased their understanding of the material. The positive response shows that students would be willing to implement this into their classrooms.

The third section was focused on the overall viewing experience. The biggest finding was that the headset was too heavy. The biggest complaint was that the headset was so heavy it was starting to cause neck pain, and this in combination with the motion of the videos was leading to some nausea. The weight of the headset will be hard to fix without spending more money to get lighter headsets. Which is not plausible for most classrooms or labs. Regardless of headset weight these videos still had a general consensus that the quality was high. This is most likely due to the high-quality cameras and audio equipment used to film the videos. The use of images within the videos was also highly received. It was said that they provided extra material to help the participants better understand what they were watching. These images appeared in proper locations due to the editing software used. The overall positive response to the viewing experience shows that this technology could be feasible down the line if the minor things are fixed.

The fourth section asked the participants about their learning preferences regarding using VR in the classroom. This section had mixed results and had the most negative responses. In general, participants felt if VR was to be used in the classroom it should be secondary to more traditional methods like lectures and hands-on activities. Citing the fact that nothing can really compare to a hands-on experience, regardless of how immersive the alternative is. These results show that students are interested in the idea of implementing new technology into their education but want to start out as having it be a supplementary material, not the main tool yet. Overall, the survey questions display that there is a high level of interest in implementing VR technology in anatomy classes to improve student learning and to provide them with access to dissections that otherwise would be impossible.

# Chapter 6

## Conclusion

This study focused on answering questions regarding new technology use in teaching settings. Should VR be the next step in immersive learning and is VR the next technology to be used for animal dissections? The consensus was that new technology would be great for the classroom, but at this point should be used as a secondary tool, not the main tool for teaching. In terms of VR being the next step in immersive learning, the jury was out on this. Some said that this was a great learning tool and would be helpful for immersive learning, while others said that it would be great but only if the equipment could be lighter and there was more flexibility. Like the outlook on new technology in general, it was clear that at this point VR should be used as a secondary source to accommodate those who learn better with hands-on experiences and lecture style teaching. Finally, using VR as the next technology for animal dissections received mixed reviews. Most would rather participate in the dissection themselves, regardless of the immersive nature VR provides. The lack of hands-on skills gained using VR is a challenge that will take years to figure out and is outside the scope of technology that is readily available. This method of learning will be very beneficial for animals that are not readily available for dissections, providing students with a broader look at animal dissections and thus broader views of anatomy. Overall, this study showed that technology is advancing in the classroom and students are ready to start having it implemented into their curriculums, especially in complex courses like anatomy where any outside tool is welcomed.

# Appendix A

## Tables

| Pre-Viewing Questions |
|---|
| Have you used Virtual Reality (VR) technology before? |
| Have you used Virtual Reality (VR) technology as a teaching resource? |
| Do you have experience in ruminant anatomy? |
| Do you have experience in ruminant dissection? |
| Do you have experience in deer anatomy? |
| Do you have experience in deer dissection? |
| Do you have any experience in deer biology? |

**Table 1: Pre-Viewing Questions**

| Specific Questions: Technology Questions |
|---|
| This technology is greatly beneficial to my learning. |
| This technology is highly comparable to learning through hands-on activities. |
| This technology is highly comparable to learning through lectures. |
| This technology is immersive (provides deep absorption or immersion in activities related to deer anatomy knowledge). |
| This technology is interactive (involve participants on knowledge activities that require participant actions). |

**Table 2: Technology Likert Scale Questions**

| Specific Questions: Video Questions |
|---|
| The verbal descriptions and visual aids utilized in these videos helped me to better understand the material. |
| My understanding of animal dissection techniques improved as a result of using this technology. |
| My understanding of different deer anatomical adaptations improved as a result of using this technology. |
| My understanding of deer organ anatomy improved as a result of using this technology. |
| These videos would be a great compliment for the Comparative Anatomy of Vertebrates VBSC 421 course. |

**Table 3: Video Likert Questions**

| Specific Questions: Viewing Experience |
|---|
| The VR headsets are comfortable and not distracting during the videos. |
| The videos and audio quality are good and are easy to follow. |
| The details of anatomical structures and organs are clear and easy to see. |
| The close-up pictures added in the videos are very useful. |
| I don’t feel nausea using the headsets. |

**Table 4: Viewing Experience Likert Questions**

| Specific Questions: Technology Learning Preference |
|---|
| I prefer using this technology instead of hands-on activities to learn anatomy concepts. |
| I prefer using this technology instead of lectures to learn anatomy concepts. |
| I prefer using this technology in combination with hands-on activities to learn anatomy concepts. |
| I prefer using this technology in combination with lectures to learn anatomy concepts. |

**Table 5: Technology Learning Preference Likert Questions**

| Open-Ended Questions |
|---|
| What are your expectations from this technology? |
| What are your concerns going into this? |
| What changes would you recommend? |
| What did you like the most? |
| What did you like the least? |
| Additional comments? |

**Table 6: Open-Ended Questions**

# Appendix B

## Pre-Viewing Question Figures

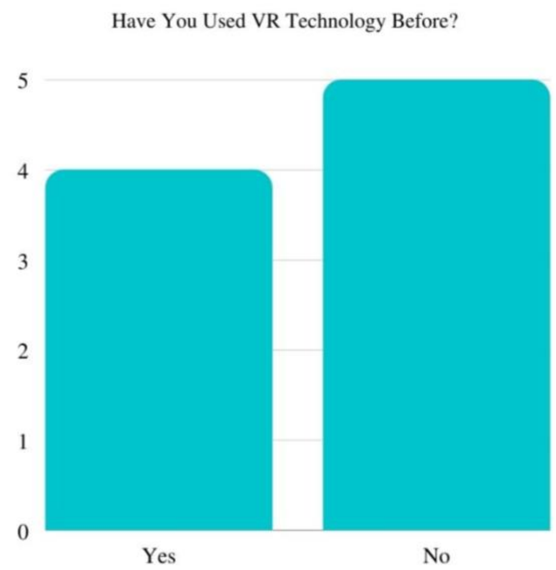


Figure 5: Used VR Before

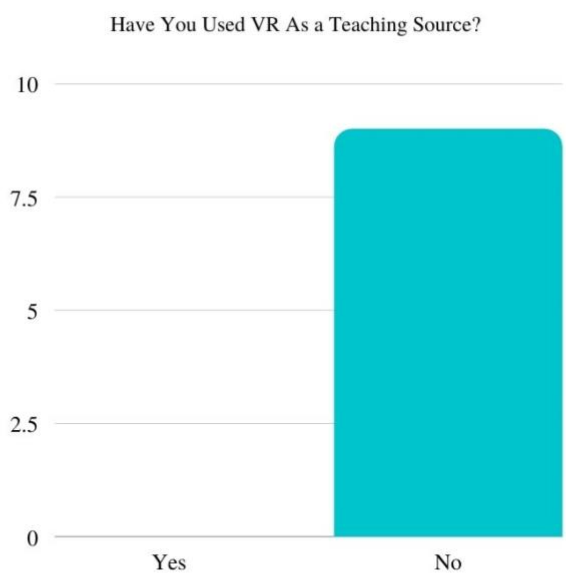


Figure 6: VR as a Teaching Resource

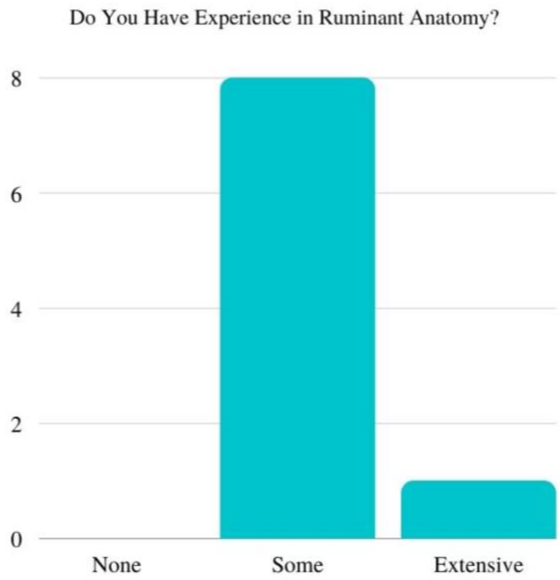


**Figure 7: Ruminant Anatomy**

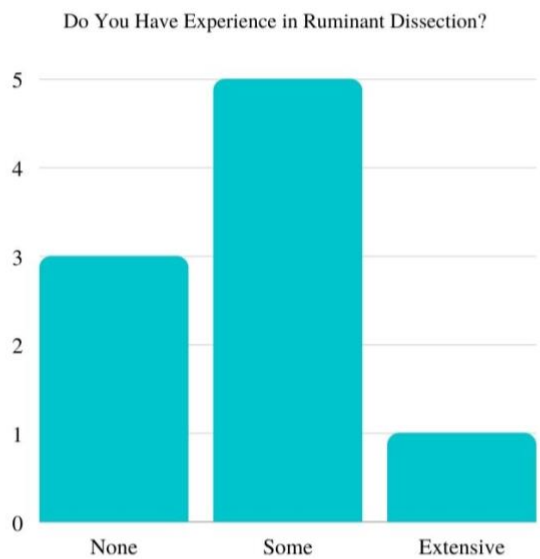


**Figure 8: Ruminant Dissection**

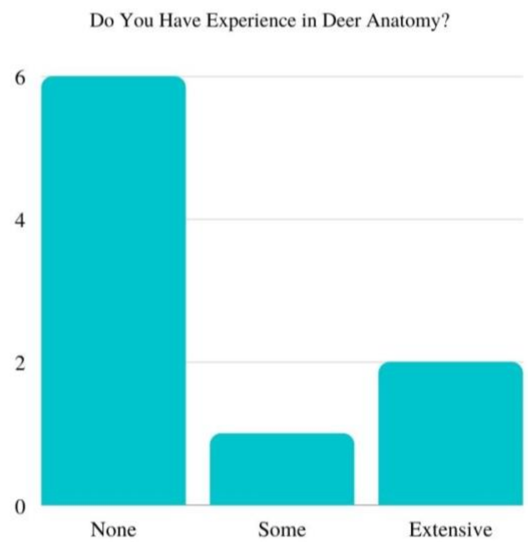


**Figure 9: Deer Anatomy**

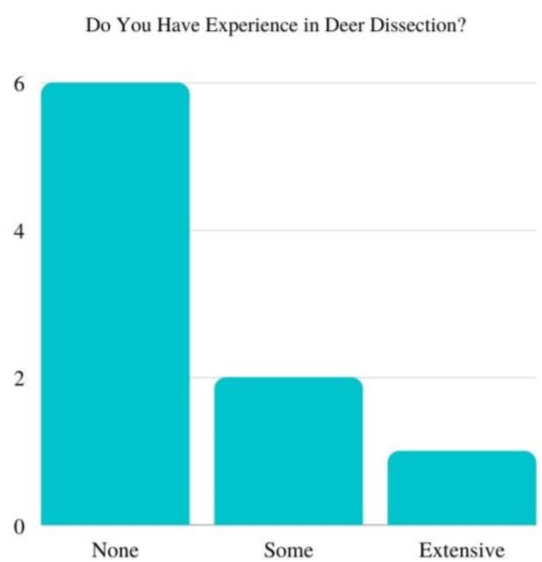


**Figure 10: Deer Dissection**

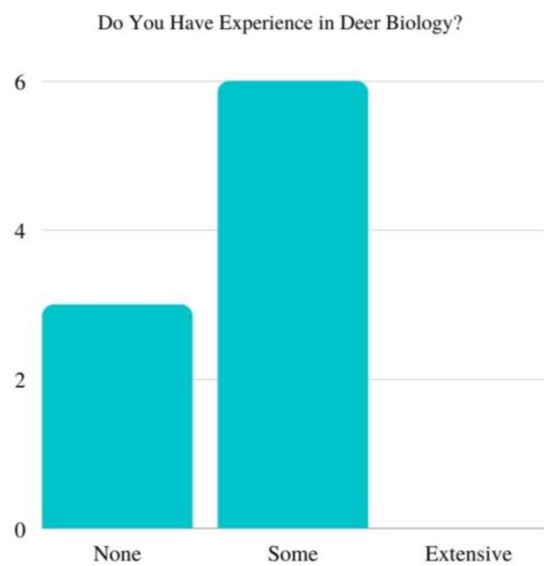


**Figure 11: Deer Biology**

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# ACADEMIC VITA
# Deana Johnson
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**EDUCATION**

**The Pennsylvania State University,** University Park, PA |**College of Agricultural Sciences** | **Schreyer Honors College**
Bachelor of Science in Veterinary and Biomedical Science — Expected Graduation May 2022
Minor: Chinese Language and Culture

- *Relevant Courses:* Companion Animal Biology, Animal Science, Mechanisms of Disease

**Leadership Positions**

- *Secretary*: Schreyer Honors College Student Council
- *Scholar Ambassador*: Ambassador for Schreyer Honors College

**EXPERIENCE**

**Pre-Vet Club** — August 2018 - Present
Penn State University | State College, PA

- Learn about the veterinary career field, interact with industry professionals, gain exposure from special outings and labs
- Attend the yearly APVMA symposium

**Penn State Dairy Barns** — May 2021 - Present
State College, PA

- Milk, treat, and move hundreds of cows and heifers while also caring for and monitoring calves
- Clean barns, pens, and other facilities

**Thailand Virtual Internship** — March 22, 2021 – April 9, 2021
Loop Abroad

- Followed a practicing vet to clinics and sanctuaries to view spay and neuter surgeries and general medical aid
- Learned about the Thailand veterinary system and animal care standards

**Thesis Research** — July 2020 - Present
Penn State University | State College, PA

- Literature review completed on immersive learning, dissection techniques, and anatomical structures and systems in deer
- Work with faculty to film 360-degree dissection videos to be shared with anatomy classes and industry professionals
- Produce surveys to gain feedback from student participants

**Study Abroad** — February 2020 - June 2020
University of Melbourne | Melbourne, Australia

- Semester abroad studying animal science, animal behavior, and Australian culture

**McLanahan's Salesclerk** — August 2019 - December 2019
State College, PA

- Worked as a cashier while being a full-time student
- Worked the register, stocked new products, organized store, take inventory
- Worked 3-5 days a week (20-30 hrs)

**Study Abroad** — May 7, 2019 - May 27, 2019
Kenya and Tanzania

- Learned about African wildlife and volunteered on a food production farm
- Volunteered at multiple girls' schools
- Experienced African Culture and interacted with locals

**SKILLS**

Animal Behavior Analysis | Embryology and Genetics | Microsoft Office Software | Interpersonal Skills |