Learning Anatomy in the Metaverse: Evaluating Medical Students' User Experiences with a 3D Virtual Anatomy Tool

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Research Topic & Why Important

Topic

Study conducted in 2021 on investigating the user experience of medical students and their use of a 3D virtual application to learn anatomy. Their experience was measured by usability and flow state.

To examine the use of the 3D virtual platform in performing dissection learning tasks, to understand aspects of user experience as assessed by ease of use and flow.

Why?

- Interested in understanding adoption of emerging technology for learning.
- What aspects of user experience contributed to or impeded adoption.
- Limited research research that evaluates the use of interactive 3D anatomy systems.

Who benefits?

Educators (Anatomists), educational technologists, qualitative researchers, Human-Computer Interaction (HCI) and User Experience (UX) researchers and practitioners.

Metaverse

What is it?

- Evolution of the internet.
- Persistent network of 3D spaces.
- Combines physical reality and digital virtual worlds in a continual and persistent multiuser environment.

Convergence of various technologies:

- Virtual and Augmented reality
- 3D visualizations
- AI
- IoT
- Spatial and edge computing

LITERATURE REVIEW

CHANGES IN ANATOMY INSTRUCTION

- Changes in anatomy courses: reduction of hours and removal or limited cadaver-based learning (Memon, 2018; Rizzolo et al., 2010)
- Need for interactive virtual anatomy solution in the anatomy courses to supplement traditional pedagogies (Azer & Eizenberg, 2007; Battulga et al., 2012; Memon, 2018).
- Innovations with interactive 3D virtual anatomy platforms gets attention (Alharbi et. Al, 2020; Iwanaga et al., 2021; Stirling & Moro, 2020; Zhao et al., 2020), especially in times of the COVID-19 pandemic (Inawaga et al., 2020; Onigbinde et al., 2020).

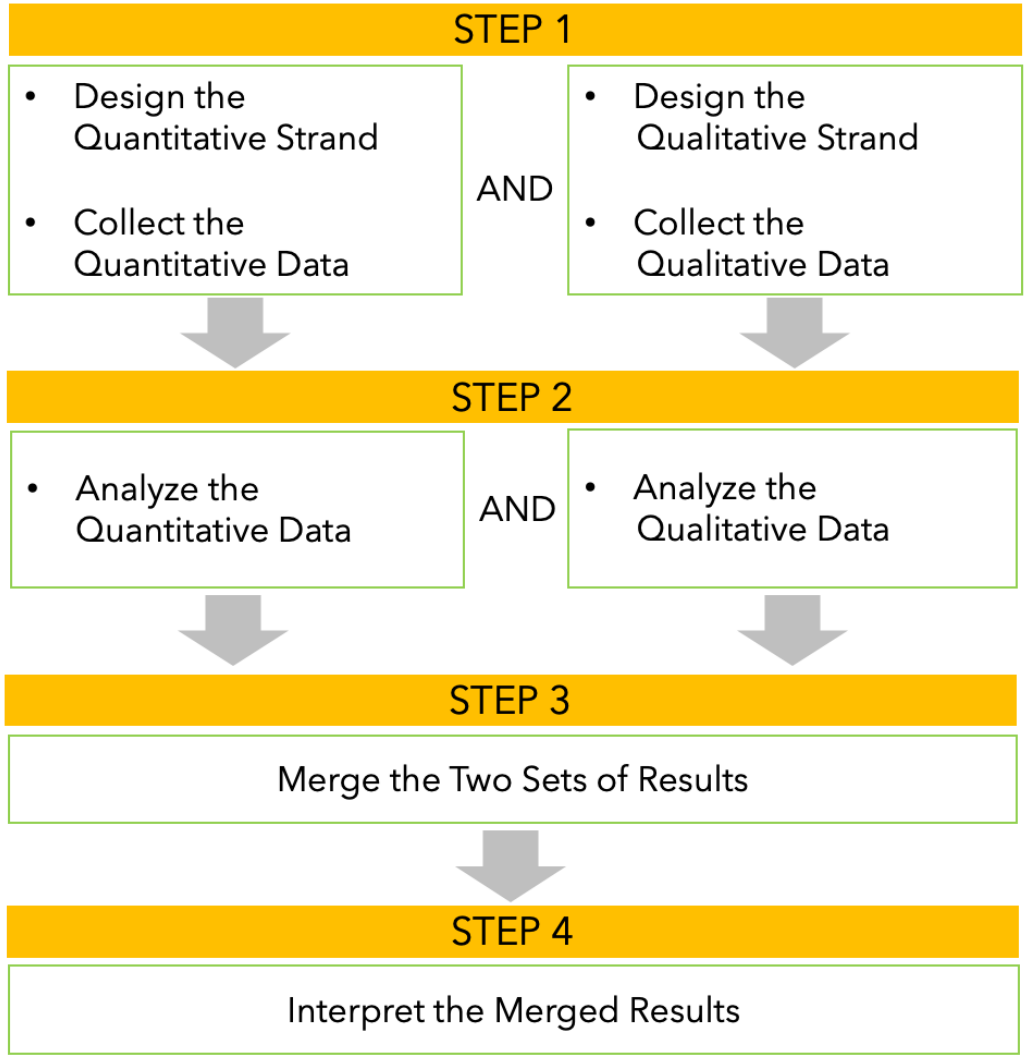
HCI & UX RESEARCH

- Usability factors may impede the successful adoption of 3D anatomy tools (Nuland et al., 2017; Peterson & Mlynarczyk, 2016; Preim & Saalfield, 2018).
- Limited research on evaluating usability in the use of elearning tools, interactive anatomy systems (Nuland et al., 2018 ; Rodrigues et al., 2019)
- Need for deeper understanding of user experience (UX)—flow as a measure of engagement (Buil et al., 2018; Hart et al., 2012; Heflin et al., 2017;Lallemand et al., 2015).
- Limitations of the task-oriented aspects of usability assessments and promote focus on non-utilitarian qualities of the user experience that captures the users' internal state in their interaction with the product (Bargas-Avila & Hornbaek, 2011).
- HCI researchers recognize the minimum level of usability needed for engagement with the system to be possible (O'Brien & Toms, 2008).

FLOW AS A MEASURE OF ENGAGEMENT

- The state of flow and engagement have often been viewed as synonymous. Like flow, engagement has been evaluated for measuring optimal experience (Doherty & Doherty, 2018).
- Flow is conducive to learners feeling immersed in their learning engagement and influences subsequent usage behaviour (Goh & Yang 2021; Ghani, 1995).
- Csikzentmihaly (1975, 1997) identified nine specific dimensions necessary for flow experience to be achieved.

Methodology



CONVERGENT MIXED-METHOD

Flowchart of the Basic Procedures in Implementing a Convergent Mixed-Methods Design adapted from Creswell and Clark (2017).

Independent Session (Learning Task: Heart Virtual Dissection)

Quantitative data:

- System Usability Scale (SUS) (Brooke, 1996)
- Short Flow State Scale-2 (S FSS-2) (Jackson et al., 2008)

Subsequent Session (Learning Task: Abdomen Virtual Dissection)

Qualitative data:

- Cognitive Walkthrough (CW) with Think-Aloud Protocol (TAP)
- Semi-structured Interview

STUDY DESIGN

PARTICIPANTS

Eligibility: All currently enrolled FIU medical students

Activities	Target	Actual
Independent Session -SUS & S FSS-2 Surveys	50	17
Subsequent Session -Cognitive Walkthrough with Think-Aloud Protocol -Semi Structured Interviews	12	10

PROCEDURES

Study Orientation: *Articulate Rise 360 Modules*

Training

- Study Overview
- Getting Started w/ the Independent Session
- Complete Anatomy Online Training- Tutorial Videos

Independent Session: *Heart Dissection*

- Self-paced & Independent
- Qualtrics Surveys:
  - Demographics
  - Attestation
  - SUS
  - S FSS-2

Subsequent Session: *Abdomen Dissection*

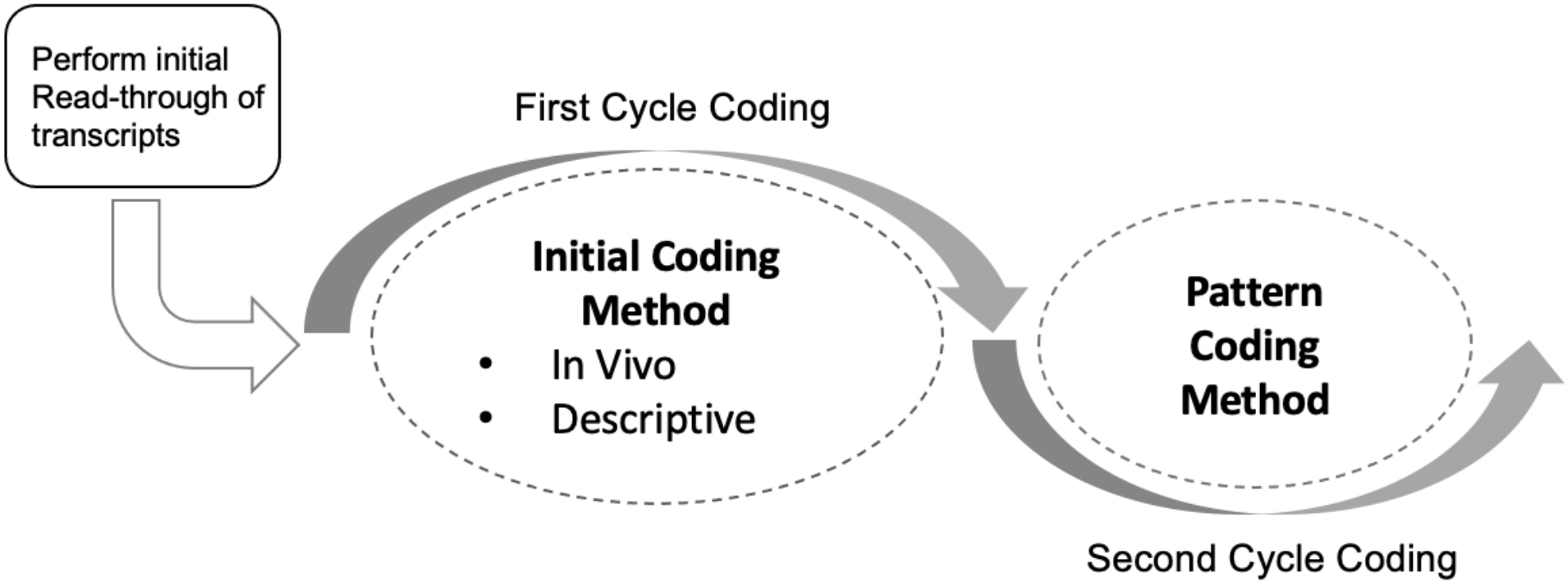
Interview Session

- Zoom
- 1 on 1 w/ researcher
- Cognitive Walkthrough w/ TAP
- Semi-structured interview

Coding & **Analysis**

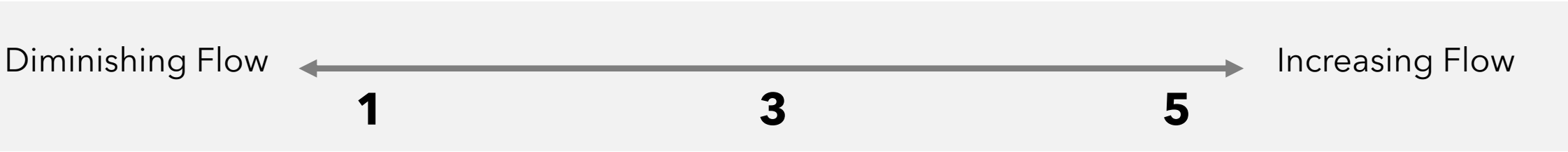
- Quant Data Descriptive Statistics
- Qual Data Coding and Thematic Analysis
- SPSS – recording and computing quant data
- NVIVO – organize, manage, analyze, qual data

CODING CYCLES



FLOW SCORES

Low (< 3)	Moderate (3)	High (> 3)
1 participant	12 participants	4 participants

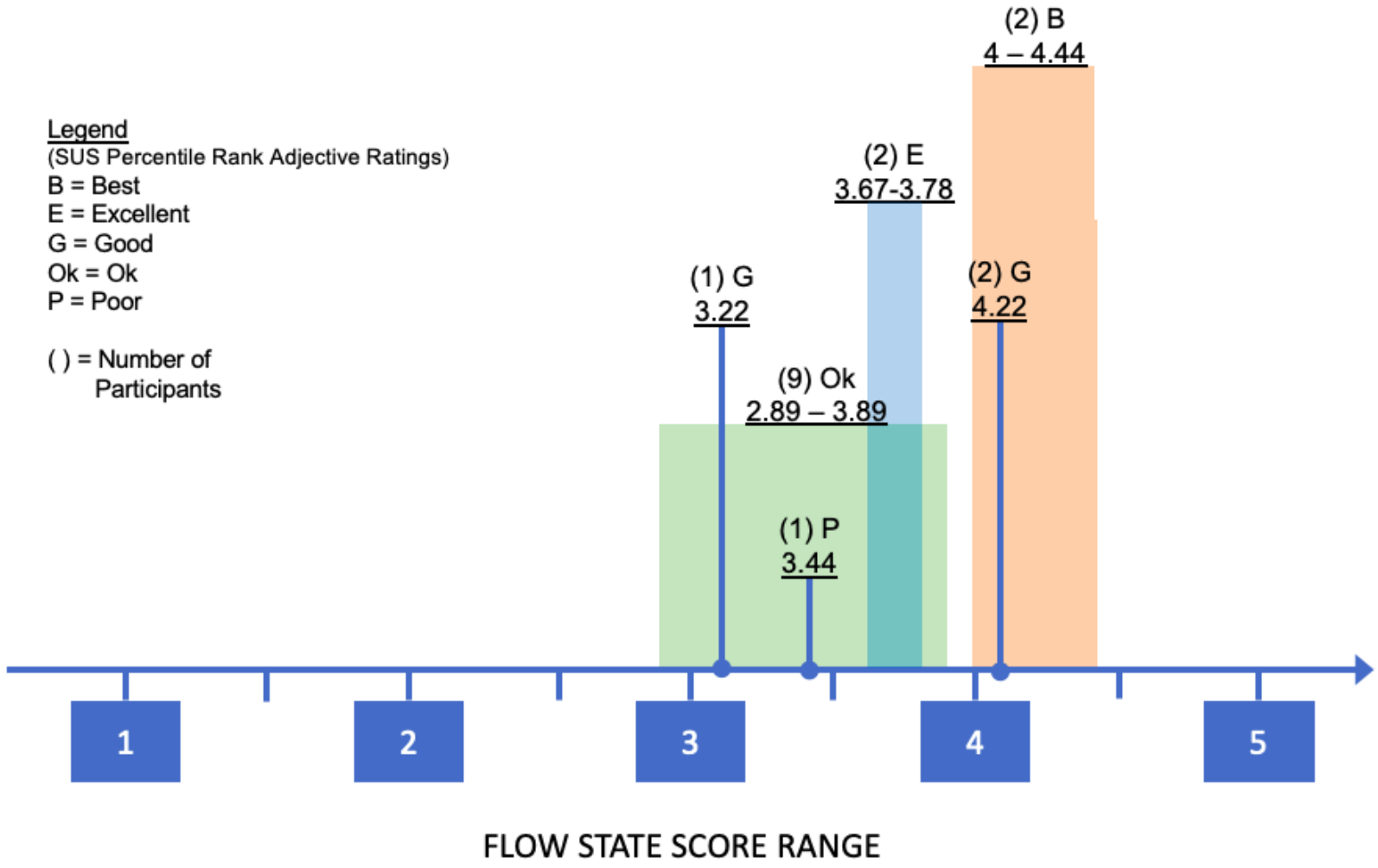


FLOW STATE SCALE

QUANTITATIVE RESULTS COMPARISON

Flow State Score Range with SUS Descriptive Ratings

	N	Mean
SUS	17	67.64
S FSS-2	17	3.58



Findings

Super-ordinate Themes	Descriptions
Ease of Use	How easy Complete Anatomy is to use to accomplish the task goal. Reactions to using Complete Anatomy include perceptions of intuitiveness and user-friendliness; emotional reactions such as frustrations, struggles, and annoyances.
Learnability	How easy Complete Anatomy is to learn and figure out to accomplish a task goal from initial and repeated use.
Interface-Technical	Technical issues encountered, including connection latency, lag time with loading the app and images.
User Satisfaction	Quality of the user's experience expressed as feelings and emotional response. Encompasses sub-categories: Preferences, User Control, Motivation
Visuospatial	Capability to imagine and visualize spatial relationships among items (anatomical parts and inter-relatedness). Encompasses sub-category: 3D Visualization.
Focus/In the Zone	Describes state and level of concentration while interacting with Complete Anatomy to perform the learning tasks. Encompasses sub-category: Engagement
CA vs Cadaver	Compares the similarities and differences between Complete Anatomy and Cadaver-based learning.

- **Ease of use had some impact on the flow experience**
  (Super-ordinate Theme: Ease of use and Focus/In the Zone)

"Complete Anatomy is pretty intuitive. If you're good with computers, if you have been using this kind of apps for a while…things are already pre-selected, so if you want to switch whatever you select, you have to go one or two more steps, and it's right there…everything is pretty intuitive, pretty easy to use. No, difficulties there. I think every medical student will be able to figure it out without a problem."

- **Perceived user satisfaction and motivation attributed to interactive 3D visualization design**
  (Super-ordinate Theme: User Satisfaction and Visuospatial)

"Definitely very satisfied. I think it really shows that three-dimensional structure and that's something that, going back to first- and second-year anatomy, that 3D structure is not something you can really understand from an anatomy textbook. That's something that I would spend some time in the anatomy lab, really trying to learn and figure out. And I think this gives you an opportunity to do that outside of the lab as well at home, and anywhere else while studying."

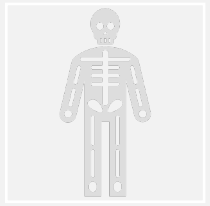
Usability and technical problems contributed to feelings of frustration and cumbersome during the dissection activity.

> “Not satisfied” (experienced latency on their laptop at the start of the CW dissection activity and during use of the pen tool). "I could have done better", and "software could have been smoother itself."

Location and the requirement to click on “X” or “Done” to exit or transition between modes was not intuitive *(Super-ordinate Theme: Ease of Use and Learnability)*
Cut tool was not always precise and required repeat attempts to achieve desired cut selection *(Super-ordinate Theme: Ease of Use and Learnability)*
Undo submenu was not intuitive as you had to hold down the undo button for the submenu to appear *(Super-ordinate Theme: Learnability)*
The Screens tab which is a part of a tabbed menu *(Super-ordinate Theme: Learnability)*
Lag with use of the app *(Super-ordinate Theme: Interface-Technical)*

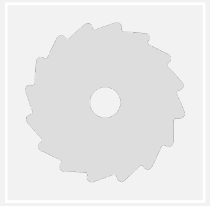
- **Design elements, features, and functionalities that contributed to student satisfaction and motivation**

"…definitely motivated me a lot just because before I had used Complete Anatomy, I had been used to just looking at 2D pictures where I couldn't move it and rotate it around to look at it from the different angles. So now that I have used Complete Anatomy and I know of the different tools I can use, I know that I can really enhance my learning experience because I can look at it more from the view of what it would actually be like in real life…



Ability to see structures and dense systems (i.e. musculoskeletal system) as up-close and in-depth as desired with rich 3-dimensional visualizations where the user can travel through the anatomy (i.e. intestines).

(Super-ordinate Theme: Visuospatial, CA vs. Cadaver)



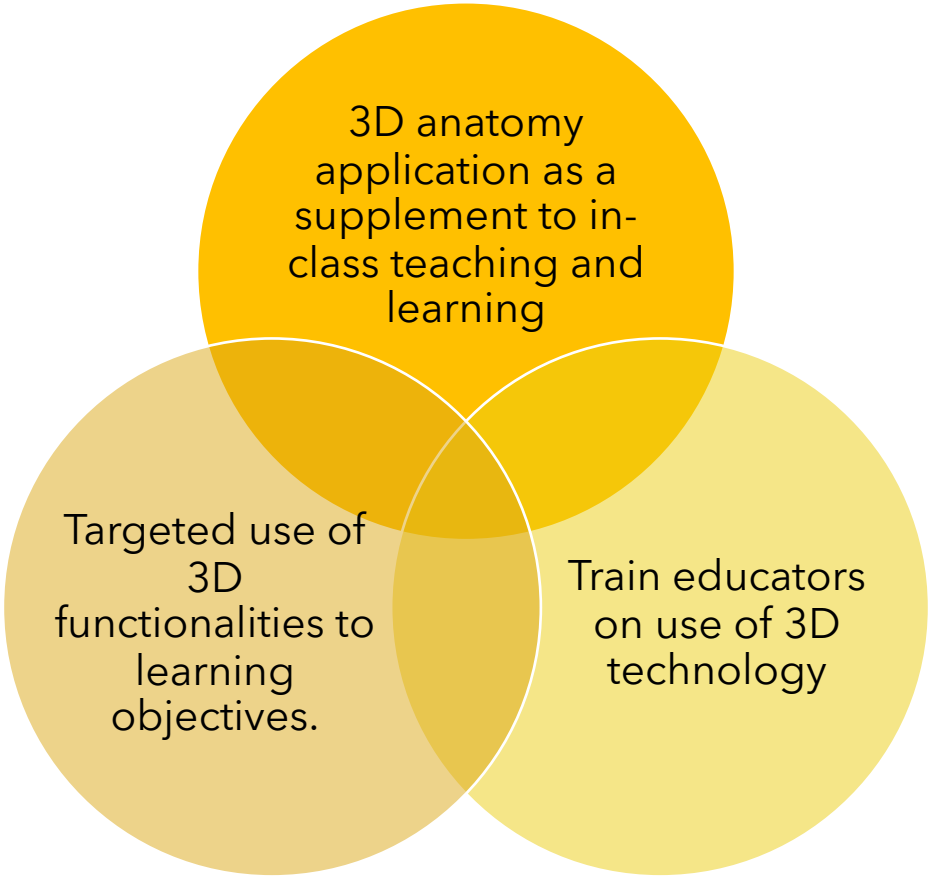
Ability to perform non-destructive dissections. With cadaver dissections, the user can only perform the cuts once whereas, with a virtual solution, the learner can perform the dissections as many and as often as needed.

(Super-ordinate Theme: CA vs. Cadaver)

- **3D virtual anatomy can offer a unique learning experience**

"see the heart pumping in 3D and see how the valves actually sat cause I don't think I really can spatially figure that out."

RECOMMENDATIONS



FUTURE STUDY

01

Use the long version of the Flow State Scale to understand each flow dimension.

02

Conduct the study as part of the entire duration of the anatomy course and assess how the flow experience impacts student learning performance.

03

Conduct study with students who perform both human dissections and virtual dissections for a direct assessment and comparison between the two methods.

Questions?

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