The Virtual Folding Embryo: The Educational Impact of 4D Online Resources on Medical Student Learning Outcomes and Perception

Abstract #66

Andrew O. Hull BS[1], Ernesto Salcedo PhD[1,2], Jennifer M. Stratford PhD[3], Marissa N. Hight BA[1], Hailey L. Bunker BS[1], Lisa M.J. Lee PhD[1,2]

[1]University of Colorado Anschutz Medical Campus, Modern Human Anatomy Program, Aurora, CO USA
[2]University of Colorado Anschutz Medical Campus, Department of Cell and Developmental Biology, Aurora, CO USA
[3]University of Colorado Boulder, Department of Psychology and Neuroscience, Boulder, CO USA

Modern Human Anatomy Program
UNIVERSITY OF COLORADO
ANSCHUTZ MEDICAL CAMPUS

Background and Rationale

- Embryology is a foundational subject for understanding the adult anatomy, anatomic variations and congenital conditions.
- Many effective teaching tools include detailed visual aids, but embryology is limited by the availability of 4D visual resources.
- Currently, most resources are limited to 2D illustrations in textbook figures. (Figure 1).
- This project aims to develop a 4D virtual folding embryo model (VFE) and assess its educational value and effect on student perception.
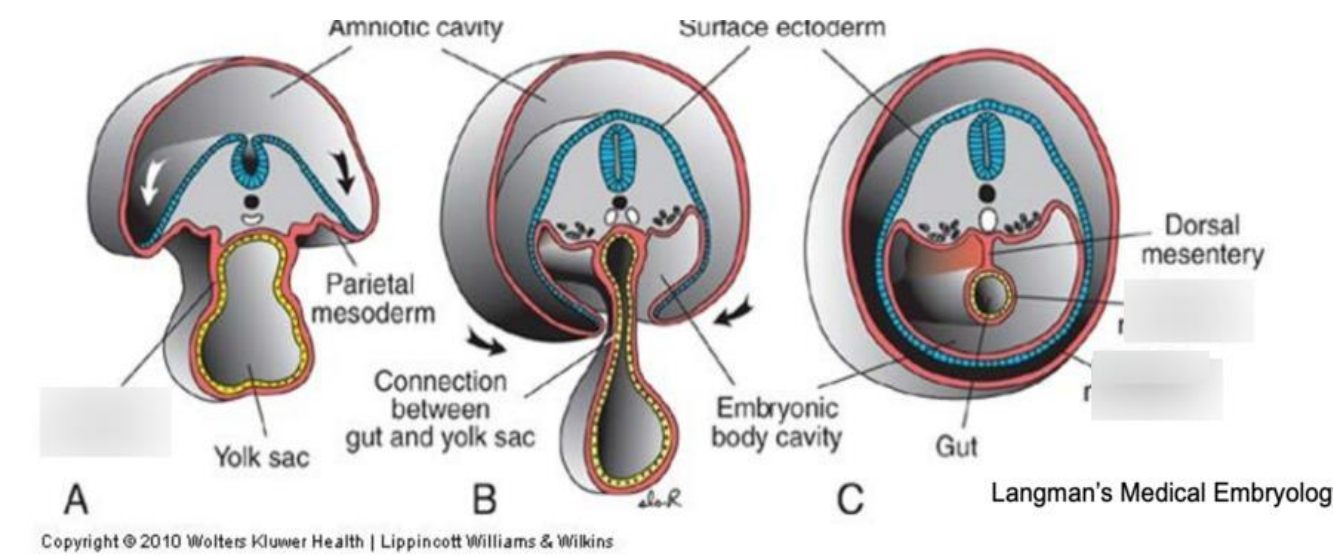
Figure 1: Image depicting 2D illustration of body cavity formation (Langman's Embryology 13th).

Hypothesis

- Interaction with the VFE will improve student learning outcomes regarding body cavity formation compared to the control group, and will result in a positive perception and confidence in the material.

Materials and Methods

Resource Development
- Histological sections obtained from the Carnegie Collection of Embryology were segmented and rendered to create a series of 3D virtual models.
- VEF interface was built on a web browser for student interaction (Figure 2).
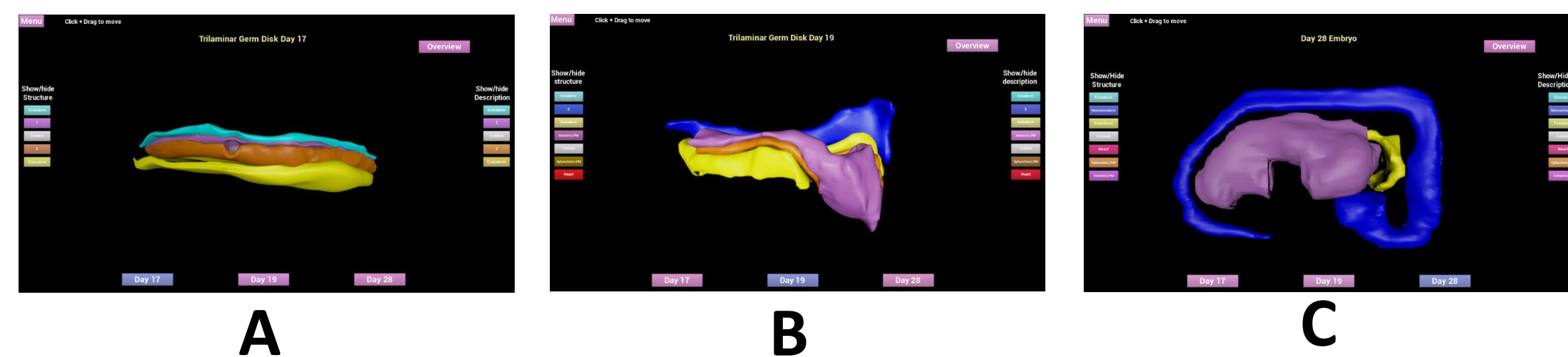
Figure 2: VFE models depicting embryo folding at days 17 (A) , 19 (B), and 28 (C) post fertilization with VFE user interface. Models B and C with removed exterior to see internal organ systems. A, B, and C models correspond with figure 1 timepoints.

Study Design
- Randomized single-blind study with first-year medical students (n=155) conducted (Figure 3).
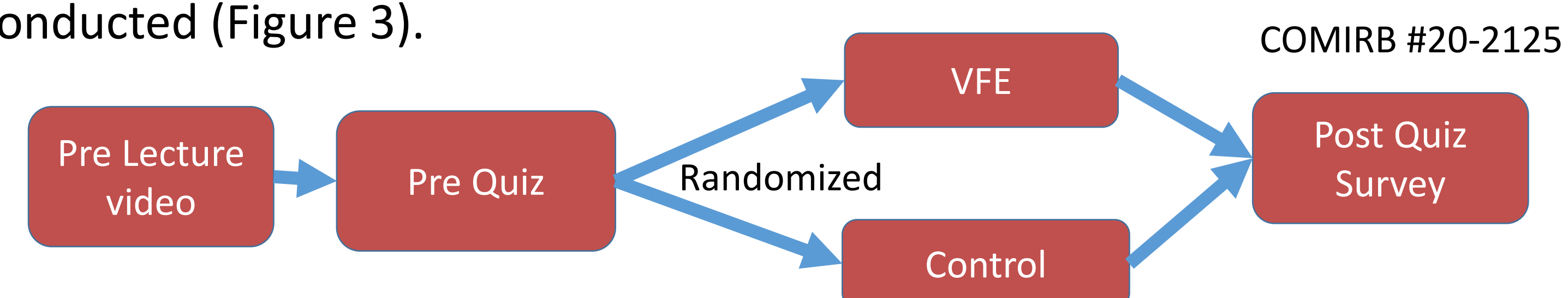
COMIRB #20-2125

Figure 3: Study design: All participants completed a set of prework, then were randomized to interact with either the VFE or the control resource during an active learning session before completing a post quiz and a survey.

Data Analyses
- One-way repeated measure ANOVA performed to determine educational effect before and after VFE interaction and between control and VFE groups.
- Likert scale survey data analyzed on 1-5 scale (1=Strongly disagree, 5=Strongly agree). Thematic analysis preformed on open ended response items.

Learning Outcomes Not Influenced by VFE

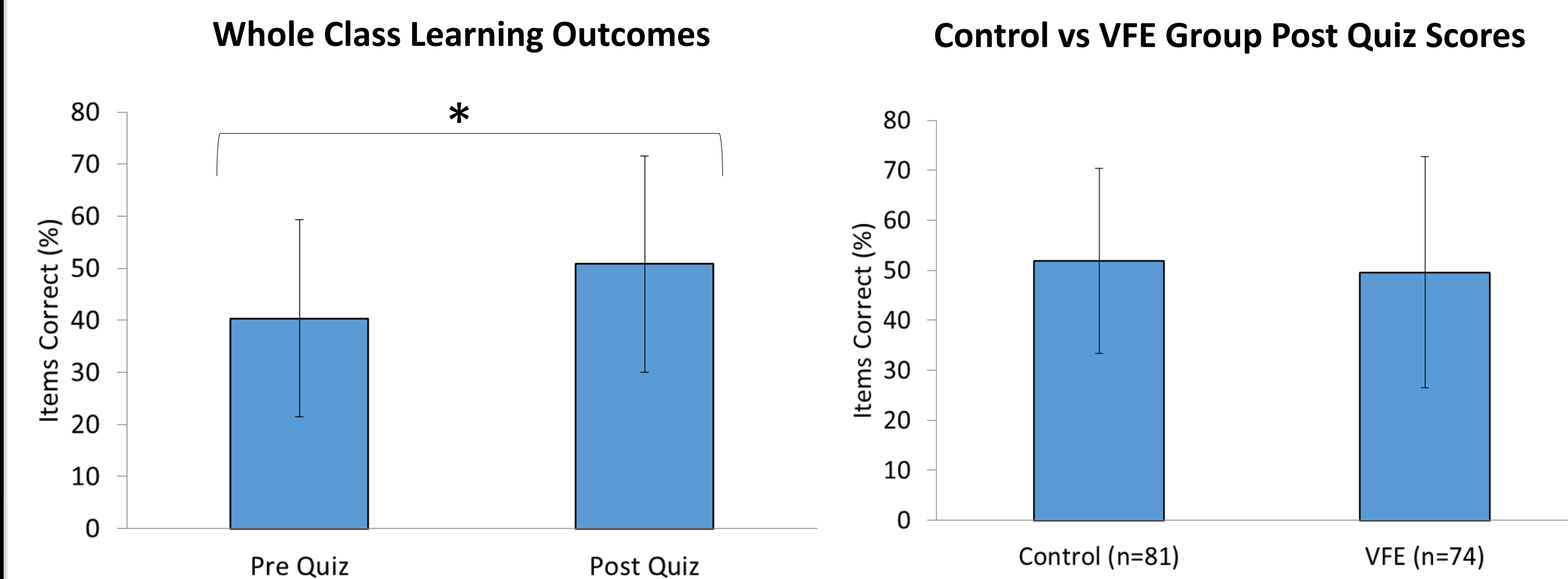**First year medical student cohort showed improvement from pre to post test independent of VFE interaction.**

Figure 3: Pre and post quiz results for 1st year medical student cohort. ANOVA found post quiz correct answers significantly higher than pre quiz. n=155 F(1, 305) = 21.06, p < 0.05, partial h^2 = 0.06, Tukey HSD, p < 0.05.*

Figure 4: Control and VFE post quiz results for 1st year medical student cohort. No statistical difference in post quiz questions answered correctly. n=155 F (1, 150) = 0.46, p = 0.50).

- After the active learning session, the whole class post quiz score average was significantly higher than the pre quiz score average (Figure 3).
- The post quiz scores on body cavity formation was not significantly different between the control and the VFE groups (Figure 4).

Student Perception of VFE Rated Highly

Analysis of Likert scale survey items show high perceived educational value of VFE, but low confidence in material.
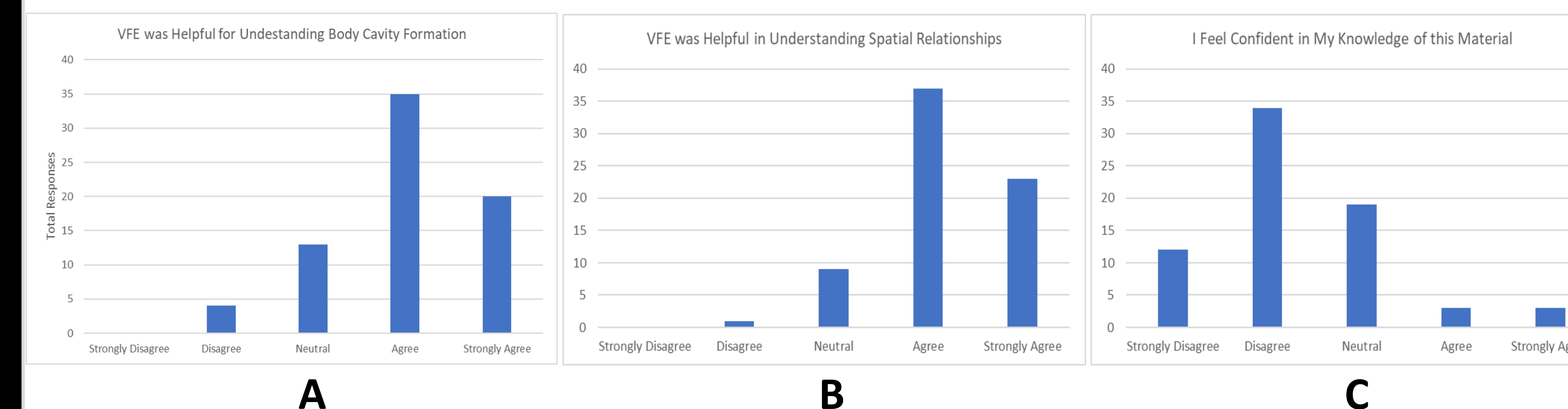
Figure 5: Likert scale reports on perceived helpfulness of understanding organ system development (A), spatial and temporal changes (B), and confidence in understanding organ system (C).

- VFE is perceived high by students in aiding their understanding of the development of the body cavities (Figure 5A).
- VFE is also perceived as effective for helping their understanding of spatial relationships of the body cavity development (Figure 5B).
- After VFE interaction, students responded that their confidence in their own knowledge of body cavity formation is low (Figure 5C).

Student Feedback and Thematic Analysis

- Thematic analysis of survey comments revealed that the spatial and temporal relationships of changing embryonic anatomy, demonstrated by the VFE, was perceived as the strength of the resource (Table 1).
- Faster interface response emerged as a theme for VFE improvement (Table 1).
- Multiple student responses indicate the time of interaction with the VFE was too short to "digest" material (Table 1).

VFE Strengths	"Fantastic model, thank you so much. one of the most difficult things for me to accomplish is orientation when looking at 2D pictures in the book. This was great."	"The interactive model was super helpful! Especially since I struggle with visualizing the three dimensional aspect of the folding and tracking what layers end up where as well as their relationship to one another."	"Visual resources make it much easier to see whats going on!"
Areas of Improvement	"More time to digest the material. The afternoon after a test doesn't give a lot of time to comb through the material."	"The folding tool took a long time to open and moving the structure around was a little difficult."	"We needed more time."

Table 1: Examples of themes from survey comments on perceived strength and weakness of the VFE.

Confounds and Limitations

- Timing of the active learning session and student fatigue.
- Short VFE interaction time during active learning session.
- Active learning session held on the Zoom platform.
- Effects of VFE interaction in small breakout sessions not explored in this study.

Conclusions and Discussion

- Student perception of the VFE was very positive, but performance on quiz score did not improve as a direct result of the VFE.
- Further examination of VFE impact in different educational circumstances is warranted to definitively determine efficacy of this 4D visual resource.
- Future iterations of VFE, including animations, may yield additional insight to efficacy of similar resources.

Acknowledgements