

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

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Abstract:

In human development, normal formation of the body cavity involves intricate interplay of tissues folding from a flat disc form into a complex tube-within-tube 3D structure over a short period of time. Understanding the normal body cavity formation is imperative to understanding anatomic organizations, variations and congenital conditions. Unfortunately, resources that effectively demonstrate changing body cavity anatomy during the folding process are sparse and their educational effectiveness is not well understood. Therefore, an interactive digital resource, the “Virtual Folding Embryo” (VFE), demonstrating the 4-dimensional transformation of the folding embryo was created and its educational value was assessed in a COMIRB exempt (#20-2125) randomized single blind study. As a part of the flipped curriculum, 155 first-year medical students enrolled in an integrated anatomy course first viewed a pre-recorded lecture on embryology of the thorax then completed a quiz to test their foundational knowledge before attending a synchronous online active learning session conducted on the Zoom platform. Students were randomized into small breakout groups of 4-5 students and half of the groups were given access to the VFE, while the other half were given access to a resource demonstrating a different embryonic process. After 15 minutes, all students completed a quiz and an optional survey.

A one-way repeated measures ANOVA revealed a significant increase in the post-quiz performance compared to the pre-quiz in both groups ($F(1, 306) = 21.06, p < 0.05$, effect size $\eta^2 = 0.06$, Tukey HSD, $p < 0.05$). However, there was no significant difference in the improved performance between the experimental and the control groups ($F(1, 150) = 0.46, p = 0.50$), suggesting that engaging in the active learning session resulted in a higher test outcome, but it was independent of the VFE interaction.

Descriptive statistics on the survey indicate that students positively perceived the educational value of the VFE high for its visual content ($n=74$ mean Likert score = 4 ± 0.81 on 5 point agreement scale) and for demonstrating spatial relationship of organ systems (mean = 3.83 ± 0.93). Despite the favorable perception of VFE and improved quiz performance, students rated their level of confidence in the material low (mean = 2.18 ± 0.37). Thematic analysis of survey comments reinforced positive perception of the VFE with emphasis on the 3D nature of the models being beneficial for visualizing anatomic relationships. However, students indicated desire for more time for VFE interaction during the active learning session.

These results do not conclusively demonstrate direct correlation between the VFE and learning outcomes. However, a number of limitations and confounds such as virtual class environment,

short interaction time with the new VFE interface, timing of the active learning session, and group effect may have affected the learning outcomes data. Survey data indicated that students perceived the VFE as helpful to their learning. Therefore, further development and investigation of the VFE under different educational circumstances is warranted to determine efficacy. Virtual 4D resource such as VFE, designed for active learning may hold potential to enrich student engagement in the post COVID-19 era, and serve as a model for creating similar resources in the future.