Background & Rationale

Human embryology is essential and highly integrated into both the basic sciences and the clinical domain. Embryology is a convoluted and challenging subject to teach and learn due to the abstract, multidimensional developmental processes that occur rapidly. Currently, most embryology courses attempt to teach these four dimensional concepts with didactic lectures using mostly two dimensional images (Figure 1A, 1B). Other forms of visual resources for embryology are scarce and lack dimensional diversity. Recent studies have shown better learning outcome in gross anatomy when virtual or physical visual models were used with lecture.1,2 To that end, 3D virtual and 3D printed models were created to improve the visualization of embryological heart development3 and better understand the anatomical relationships of a complete embryo. The goal of this study was to assess the educational impact and perceived value of 3D virtual and 3D printed models for learning embryology in graduate/medical/dental school courses.

Methods

Part 1: Assessing Educational Impact and Perceived Value of 3D Virtual and Printed Heart Tube Models

First-year Medical Students, MSMSA students, and Dental students at the University of Colorado Anschutz Medical Campus were recruited to participate in interactive sessions with the 3D virtual and printed heart tube models (Figure 2A, 2B). Comparisons between two quiz scores, before and after interactive sessions with models yielded measurable learning outcomes. Perceived educational value was measured by survey analytics. Statistical analyses were performed on the quantitative data (ANOVA/Post Hoc) to determine significance and thematic analyses were performed on the qualitative data.

Part 2: Complete Embryo Segmentation and Modeling

Embryo was segmented and modeled using Fiji, Maya, and Geomagic. Animations were generated in Maya. Virtual model was uploaded to Sketchfab. Models were printed using a Lulzbot 3D printer and Connex printer via Prototronics.

Results: Part 1

Quantitative Data Analyses

Pre-Quiz vs. Post-Quiz Scores of all participants

<table>
<thead>
<tr>
<th>Pre-Quiz</th>
<th>Post-Quiz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>60</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>10</td>
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</tbody>
</table>

Average Percent Increase of Pre/Post Quiz Results Based on Educational Resource Used

<table>
<thead>
<tr>
<th>Educational Resource</th>
<th>Average Percent Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D Virtual Models</td>
<td>20%</td>
</tr>
<tr>
<td>3D Printed Models</td>
<td>15%</td>
</tr>
<tr>
<td>Both 3D and 3D Printed Models</td>
<td>25%</td>
</tr>
<tr>
<td>Unreported</td>
<td>10%</td>
</tr>
</tbody>
</table>

Qualitative Data Analyses

Survey Questions

1. Virtual Heart Tube Animation
2. 3D Printed Heart Tube Models

Complete Embryo Segmentation

Conclusions and Future Directions

• Quantitative analyses indicate that interacting with printed and/or virtual models yield learning in the absence of didactic lecture.
• Qualitative analyses indicate students preferred printed models for visualization of the heart development processes.
• Survey results indicate that students want more embryo models (virtual and printed), depicting other developmental periods and embryonic stages.
• The complete virtual and printed embryo model was successfully constructed and will be used in future studies in order to determine the educational value.
• Limitations such as the format of the interactive session (group work effect, study tool deployment, and self-reporting) issues will be better controlled for in the future studies.

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References