Does 3D immersion enhance nursing students’ pharmacology knowledge and satisfaction?

Dr Julie Hanson & A/Prof Patrea Andersen
Background

• Historically nursing and midwifery students have reported difficulty understanding the concept-based science underpinning the interactions between drugs and their targets

• Crucial knowledge - administration and monitoring of the therapeutic and adverse effects of medications [1]

• Immersive three-dimensional technology:
  ★ Enhances understanding of complex scientific concepts [2, 3, 4]
  ★ Motion sickness may limit its use [5]
Technology

CAVE2™ 3D visualisation

- 80 LCD panels (floor to ceiling) placed in an arc of 320°
- 7 m in diameter
- Two-dimensional (2D) standard PowerPoint projected onto 16:9 standard LCD computer screens merged together to form a wall panel
VISUALISATION PROJECTS
Research Aims

- To measure the effectiveness of using a 3D artifact in CAVE2™ on undergraduate nursing and midwifery students’ knowledge of drug receptor binding compared to 2D exposure.

- To elicit student perceptions of satisfaction with their learning using visualisation technologies.

- To elicit self-assessed levels of discomfort, such as headache, dizziness or motion sickness, associated with stereoscopic projection in the CAVE2™ environment.
Sample

**Location:** School of Nursing and Midwifery at a regional university in Southeast Queensland, Australia

**Sample size:** 202 of 226 second-year students enrolled in the Bachelor of Nursing Science degree or Bachelor of Nursing Science and Midwifery dual degree
Methodology & Design

Constructivist epistemology

5 stages (Fig 1.): structured process of review and reflection is paramount to achieving optimal learning [6]
Data collection

Stage 1: Pre-brief - information, informed consent, learning outcomes. Students were advised how to respond in the event of feeling any discomfort during the visualisation.

Stage 2: Pre-test

Stage 3: 2D wide screen viewing or 3D immersive learning experience in CAVE2™ + case study

Stage 4: Post-test

Stage 5: Structured debrief + completion of satisfaction survey
Instruments

The five multiple-choice questions used in the pre- and post-tests:

1. What is the term most commonly used to describe neurotransmitters?
   a. electrical signals; b. nerve impulses; c. action potentials; d. chemical messengers
2. Which neurotransmitter is responsible for parasympathetic effects on the heart?
   a. adrenaline; b. noradrenaline; c. acetylcholine; d. dopamine
3. Name one effect of the sympathetic nervous system on the heart.
   a. decreased conductivity; b. increased force of contraction; c. decreased automaticity; d. decreased heart rate
4. Which receptor sub-type is blocked by a beta-blocker to decrease heart rate?
   a. β1 – adrenoceptors; b. β2 – adrenoceptors; c. – Muscarinic M2 receptors; d. Muscarinic M3 receptors
5. Identify a drug that is classed as a beta-adrenoceptor antagonist.
   a. adrenaline; b. atropine; c. bisoprolol; d. losartan
Instruments – Modified SSES

• Satisfaction with Simulation Experience Scale [7]
• 24 questions (Cronbach alpha 0.77)
• 3 domains
  - Debriefing and Reflection (Questions 1 to 7)
  - Clinical Reasoning (Questions 8 to 11) and
  - Clinical Learning (Questions 12 to 24)
• Minor wording changes were made to 10 of 24 questions to address teaching mode.
• Two questions (Q25 Q26) were added to evaluate the context of the learning experience. These were:
  Q25 “I believe that the visualisation will enhance my understanding of patients conditions and treatment taught in other courses”.
  Q26 “The visualisation caused feelings of discomfort that adversely impacted my ability to engage and learn content”.
• All questions were ranked on a 5 point Likert Scale
  Assigning “Strongly disagree” to 1 and “Strongly agree” to 5
Instruments – Comfort scale

Self-reported comfort ratings

10 point ordinal scale ranging from 1 (no discomfort) to 10 (incapacitating).
## Results – Knowledge acquisition

<table>
<thead>
<tr>
<th>Question</th>
<th>3D immersion (n = 177 for changes)</th>
<th>2D immersion (n = 17 for changes)</th>
<th>P-value comparing 3D and 2D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>% correct: pre 39.7</td>
<td>38.8</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>% correct: post 64.9</td>
<td>29.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% correct: change 25.3</td>
<td>−9.5</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>P-value for change &lt; 0.001</td>
<td>0.480</td>
<td></td>
</tr>
<tr>
<td>Q2</td>
<td>% correct: pre 35.3</td>
<td>27.8</td>
<td>0.702</td>
</tr>
<tr>
<td></td>
<td>% correct: post 60.5</td>
<td>35.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% correct: change 25.1</td>
<td>1.63</td>
<td>0.183</td>
</tr>
<tr>
<td></td>
<td>P-value for change &lt; 0.001</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Q3</td>
<td>% correct: pre 57.6</td>
<td>55.5</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>% correct: post 66.1</td>
<td>76.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% correct: change 8.5</td>
<td>20.9</td>
<td>0.666</td>
</tr>
<tr>
<td></td>
<td>P-value for change 0.097</td>
<td>0.371</td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>% correct: pre 53.3</td>
<td>72.2</td>
<td>0.195</td>
</tr>
<tr>
<td></td>
<td>% correct: post 75.1</td>
<td>70.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% correct: change 21.9</td>
<td>−1.6</td>
<td>0.135</td>
</tr>
<tr>
<td></td>
<td>P-value for change &lt; 0.001</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Q5</td>
<td>% correct: pre 41.3</td>
<td>38.9</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>% correct: post 74.6</td>
<td>76.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% correct: change 33.3</td>
<td>37.6</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>P-value for change &lt; 0.001</td>
<td>0.0412</td>
<td></td>
</tr>
</tbody>
</table>

P-values for comparing pre-immersion scores of each immersion group in the final column computed using a chi-square test. P-values for comparing changes in percentages in the final column computing using Fisher’s exact test by recording the change in each student’s score for that question as −1, 0 or 1. P-values comparing the change within each immersion computed using McNemar’s test. The P-values in bold are < 0.05. Sample sizes differ slightly for each question, and for pre, post and changes in scores. P-values have not been adjusted for multiple testing.
Results – knowledge acquisition

Statistically significant improvement in the post-test scores in the 3D immersion group (Paired t-test; \(P = < 0.001\)).

### Table 3

<table>
<thead>
<tr>
<th></th>
<th>3D-immersion</th>
<th>2D-immersion</th>
<th>(P)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>((n = 177)</td>
<td>((n = 17)</td>
<td></td>
</tr>
<tr>
<td>Pre-test</td>
<td>2.27</td>
<td>2.33</td>
<td>0.868</td>
</tr>
<tr>
<td>Post-test</td>
<td>3.43</td>
<td>2.88</td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>1.16</td>
<td>0.55</td>
<td>0.0013</td>
</tr>
<tr>
<td>(P)-value</td>
<td>&lt; 0.001</td>
<td>0.030</td>
<td></td>
</tr>
</tbody>
</table>

\(P\)-values in the final column are from a t-test. \(P\)-values comparing the change within each immersion computed using a paired t-test. The \(P\)-values in bold are \(< 0.05\).
Results – Satisfaction scores

Students were satisfied with both immersion techniques

Scores for the 3D immersion were higher for each subscale – not statistically significant

Scores for the 3D immersion were higher for each individual SSES question except Question 5 and 14, but the only statistically significantly difference ($P = 0.047$) was for Question 21 “The visualisation enhanced my understanding of the autonomic nervous system and how this system controls resting heart rate”

Q25 “I believe that the visualisation will enhance my understanding of patients conditions and treatment taught in other courses”, the 3D immersion mean (4.05) was higher ($P = 0.121$) than the 2D immersion (2.72)
**Results – Mean satisfaction scores**

Summaries of the ratings out of 5 for the three SESS subscales (Strongly disagree = 1; Strongly agree = 5) for the 3D ($n = 195$) and 2D ($n = 18$) immersion groups.

<table>
<thead>
<tr>
<th></th>
<th>3D: mean</th>
<th>2D: mean</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debrief and reflection</td>
<td>4.18</td>
<td>3.96</td>
<td>0.29</td>
</tr>
<tr>
<td>Critical thinking &amp; clinical reasoning</td>
<td>4.14</td>
<td>3.86</td>
<td>0.11</td>
</tr>
<tr>
<td>Clinical learning</td>
<td>4.03</td>
<td>3.71</td>
<td>0.06</td>
</tr>
</tbody>
</table>
Results – Comfort ratings

The 3D immersion caused little discomfort to students and there is no evidence that the immersion techniques differ in terms of their discomfort proportions (Fisher exact test; \( P = 0.153 \)).

Table 4
The discomfort scores for students exposed to the 3D (\( n = 170 \)) and 2D (\( n = 17 \)) immersion techniques.

<table>
<thead>
<tr>
<th>Discomfort rating</th>
<th>3D: % ((n))</th>
<th>2D: % ((n))</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>78.2% (133)</td>
<td>64.7% (11)</td>
</tr>
<tr>
<td>Minor</td>
<td>11.8% (20)</td>
<td>23.5% (4)</td>
</tr>
<tr>
<td>Moderate</td>
<td>8.8% (15)</td>
<td>5.9% (1)</td>
</tr>
<tr>
<td>Severe</td>
<td>0.6% (1)</td>
<td>5.9% (1)</td>
</tr>
<tr>
<td>Incapacitated</td>
<td>0.6% (1)</td>
<td>0.0% (0)</td>
</tr>
</tbody>
</table>
Effectiveness of three-dimensional visualisation on undergraduate nursing and midwifery students' knowledge and achievement in pharmacology: A mixed methods study

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\section*{ARTICLE INFO}

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\section*{ABSTRACT}

\textbf{Background}: Historically, nursing and midwifery students have reported difficulty understanding the concept-based science underlying the interactions between drugs and their targets. This knowledge is crucial for the administration and monitoring of the therapeutic and adverse effects of medications. Immersive three-dimensional technology is reported to enhance understanding of complex scientific concepts but the physical effects of motion sickness may limit its use.

\textbf{Objectives}: This project compared the effectiveness of three-dimensional immersive visualisation technology with two-dimensional visualisation technology as a teaching method to improve student understanding of a pharmacological concept, and to assess levels of student discomfort and satisfaction associated with the experience.

\textbf{Design}: Traditional lecture content and presentation about drug-receptor binding was followed by exposure to either a two- or three-dimensional artifact visualising β-adrenoceptor binding. Two student groups were compared by type of exposure: Group 1 watched the artifact via a three-dimensional immersive facility and Group 2 on a wide, two-dimensional screen.

\textbf{Setting}: School of Nursing and Midwifery in a regional university in Southeast Queensland, Australia.

\textbf{Participants}: Two hundred and two second year undergraduate nursing and midwifery students.

\textbf{Methods}: The study used mixed methods methodology. Pre- and post-testing of student knowledge was collected using five multiple-choice questions. A post-intervention survey elicited students’ self-assessed perceptions of discomfort and satisfaction with the learning experience.

\textbf{Results}: The three-dimensional immersive learning experience was comparable to the two-dimensional experience in terms of satisfaction and comfort but resulted in statistically significant improvements in post-test scores.

\textbf{Conclusions}: The three-dimensional experience improved understanding when compared to two-dimensional viewing, satisfied students learning needs, and caused minimal discomfort. The results are encouraging in terms of using three-dimensional technology to enhance student knowledge of pharmacological concepts necessary for competency in medication management.
Extension - CAVE vs Handheld device

• Replication of design [8]
• Used same artefact
• Changed the focus of research questions:
  ★ RQ1. What is the effect of the automated virtual environment (CAVE2™) on quiz scores compared to the handheld device?
  ★ RQ2. What is the effect on satisfaction scores with regard to the automated virtual environment (CAVE2™) compared to the handheld device?
  ★ RQ3. What is the effect on comfort ratings between the automated virtual environment (CAVE2™) and the handheld device?
• Changed mode to handheld with use of stereoscopic lenses
Summary of findings

★ Knowledge acquisition, satisfaction scores and comfort ratings were evaluated (n=225)

★ Knowledge acquisition was no different between CAVE2™ and the mobile handheld visualisation mode (n=159 CAVE) (n=66 Handheld)

★ Student satisfaction with debriefing and reflective practice were no different between CAVE2™ and the handheld visualisation mode

★ Student satisfaction with clinical reasoning and clinical learning was greater in the CAVE2™ learning environment

★ Handheld devices caused more general discomfort and negatively impacted learning compared to CAVE2™
Conclusions

- The use of 3D technology was successful in increasing the percentage of students correctly responding to post-test questions.
- Student satisfaction ratings with the visualisation experience were high.
- Minimal discomfort associated with the stereoscopic virtual environment was reported.
- The implementation of immersive 3D visualisation as a teaching strategy in the education in nursing and midwifery is an innovative move to improve and expand the curriculum by providing new opportunities for learning.
References


