Cavazza et al. 2013
Interactive Storytelling
VP cases to teach physician-patient interaction, communication and empathy.
Descriptive
Medical students in USA.
None.
None.
Development of SG described.

Chan et al.2012
Ultrasound-guided needle placement
Technical trainer with virtual tools and tissues to teach ultrasound-guided needle placement.
RCT: SG vs. C (self-study)
Radiology residents in China; n=21.
Post testing via live simulation.
4, 5
Increased success rate for SG vs. C [mean 33.3% to 68.2% (+34.9%) vs. 20.2% to 37.8% (+17.6%)]. Reduced completion time for SG vs. C [51.5-34.8 (16.9 s) vs. 54.3-42.8 (11.5 s)]. Validated with only inexperienced users: post-test scores improved vs. pre-test.

Covan et al.* *2011
Off-pump Coronary Artery bypass
Multi-player VE, teaching the steps of off-pump coronary artery bypass.
Descriptive
Cardiac surgeons in Canada.
None.
None.
Development of SG described.

Cowan et al. 2010
Total Knee Arthroscopy (TKA) Game
VE teaching the steps of a TKA, with MCQ sub-games interspersed.
Survey
Medical students in Canada.
Post-intervention MCQ, SG performance, survey.
1, 2, 3
Significant pre-test to post-test improvement in scores for two cases (mean 3.8 vs. 4.2, p=0.0007; 1.9 vs. 3.0, p=0.0001), but not the third (mean 2.5 vs. 2.3, p=0.12). Maximum score for traditional teaching with SG vs. SG alone (4.2 vs. 3.0, p=0.0001). No significant difference in time on task, total steps, score, and requests for help when SG placed before vs. after testing, 66% felt that “V-PIN cases helps me better understand the concepts.”

Virtual Pathology Instructor (V-PIN)
Interactive CBS with MCQ: branched narratives with virtual pathology materials that guide learners through diagnosis.
Quasi-experimental (SG at various points in curriculum).
Medical students in USA; n=185.
Post-intervention MCQ, SG performance, survey.
1, 2, 3, 5
Students reported enjoyment and learning with SG. Self-efficacy increased after first [5.9 to 6.57 (p=0.01)] and second SG session [8.0 to 6.77 (p=0.03)]. Mean perceived concentration increased [54.2/100 to 66.6/100 (p=0.06)], with low to moderate mental strain (mean±2.6/10). Significant increase in self-reported situational awareness (SA) [3.4 (2.4-1) to 3.9 (1.4-5), p<0.001], and correlation between SA and concentration (p=0.61) (Spearman rank order correlation, p<0.001). Decreased mean elapsed time between first and last users when compared with first users, but only pre-test (42.8 to 16.2s), vs. (46.8 to 44s), and chest compressions (68 to 49.8 s). No decrease in mean time to call for help. Mean compression fraction increased (42% to 52%) and mean occurrence of protocol violations decreased (5.5 to 1.8). Higher scores in 6mo vs. control [93% (±11%) to 65% (±28%), (p<0.05)], 18mo scores: 73% (±23%). Mean guideline violations 0.2 (±0.5), 1.5 (±1.0). 4.5 (±1) for 6mo, 18mo and control, respectively. Incorrectly delivered chest compressions 54 (±44%), 44 (±48%), 0% for 18mo, and 6mo (p=0.001 control) or 18mo vs. 6mo.

Davidy et al. 2011
Electrolye Workshop
VP cases simulating electrolyte abnormalities, augmented with multimedia. Physiology modeled.
Survey
Residents, physicians in South Africa; n=16.
Usability survey.
1, 2, 3
Mean SUS 78.4/100 (76.8/100). SG would be used by 16/16 participants, 13/16 found it easy to use and well integrated, 2/16 found it cumbersome and 3/16 found navigation difficult. 15/16 found the content scientifically sound and interesting, 9/16 found it realistic; 14/16 reported concept clarity and increased understanding.

De Leo et al. 2014
Game Medical Team Training (GaMaTT)
Multi-player VE teaching inter-professional acute care (microphone communication). Learners manage virtual military and civilian casualties. VP operated remotely by live person. Physiology mapped.
Survey
Air Force National Guard Medical Service in USA, n=29.
Survey.
1, 2, 3
Comparing user characteristics via Independent Television Commission Sense of Presence Inventory using Kendall T test showed: characteristics “how often you play video games” (T(28)=0.458, p=0.65) and “television/film production knowledge” (T(27)=0.516, p=0.01), were significantly related to negative effects (dizziness, nausea, headache, and eyestrain during SG experience). The user characteristic “knowledge of virtual reality” was significantly related to engagement (T(26)=0.463, p=0.01) and negative effects (T(26)=0.404, p=0.05).

Delassire et al. 2010
Cardiac Arrest!
VE where users manage patients requiring advanced cardiac life support skills.
RCT: reading (R) vs. live simulation (S) vs. SG/multimedia group (M)
Paramedic students in India, n=117.
Pre/post MCQ, cardiac arrest live simulation, re-testing at 3 weeks, survey.
1, 2, 3, 5
Significantly higher increases in live simulation post-test scores for S vs. R and M groups compared to pre-test [9% S vs. +5% R vs. +2% M, p<0.05]. Significantly higher scores in MCQ post-test scores for M vs. R, no difference compared to S (+5% M, +3% S, +2% R, p<0.05 for R only). Significantly higher increases in live simulation post-test scores at 3 weeks for M vs. R, no difference compared to S (+4% S, +1% M, -1% R, p<0.05 for R only). Significantly higher increases in MCQ post-test scores at 3 weeks for M vs. R and vs. S (+5% vs. 0% vs. 0%, p<0.05). 95% of S and 84% of M felt their modality should be incorporated into the curriculum. 95% of S and 89% of M reported enjoyment.

Dev et al. 2011
CintiSpace
VE of emergency department. Physiology modeled.
Quasi-experimental
Physicians, students.
Survey.
1, 2, 3
Although numbers not reported, users rated the game as easy to use, realistic, and stimulating.

Diehl et al. 2013, 2015
InsuOnline
VE with diabetic VP. Embedded quizzing and multimedia assets.
Comparison trial: Lecture (L) vs. SG.
Medical students and residents in USA; n=20, n=41.
Pre/post MCQ, re-testing at 3 months.
1, 2, 3, 5
Development of SG and future studies described. Mean SUS score of 88/100 for prototype. 92.5 vs. beta version. Users found the SG to be fun, engaging, challenging, relevant, realistic, and preferable to a lecture. Users said the SG increased knowledge of and confidence with diabetes and insulin, that it would impact how they treated patients with diabetes. Mean knowledge/skills score improved from 68% to 89% in L group (n=23; p=0.001), from 61% to 90% in SG group (n=18; p=0.001). At 3 months, mean score decreased (80% in L group, 78% in SG group; p=0.001 for both), but was significantly higher than baseline (p=0.001 for both). No difference between SG and L groups immediately or 3 months post. Score increment was better for SG (29%) than L (21%); p=0.04). Benefits improved in SG group only.

requiring advanced life support skills.

+1.5, +4.2, p<0.01). 39/40 participants regarded EMSAVE as a valuable ALS refresher tool. 85% of participants were willing to devote 1 hour/month to retrain with the game.
Dugue et al. 2008  The Virtual Home Visit  VE of a patient's home, teaching about geriatric home visits. Timed, with distractors. Learners identify risk factors for falls/harm.  Quasi-experimental  Medical students in Australia; n=56.  Pre/post MCQ, survey.  1, 2, 3, 5  Significantly improved post-test (90 ±5%) vs. pre-test scores (42 ±5%) (p<0.001). 77% of participants played twice, obtaining a change in scores from 250 ±20 points to 400 ±50 points (p<0.001). 100% of participants described home visit as important, but 58% felt they had not had enough training. 78% of participants would recommend the SG, 77% felt it improved knowledge and confidence, 85% considered the experience good or excellent.

Evans et al. 2014  Septris  CBS about sepsis and shock. Used triage test and treat several patients at once, timed. Physiology modeled.  Quasi-experimental  Medical students; residents in USA; n=156.  Pre/post MCQ, satisfaction and survey.  1, 2, 3, 5  Significantly improved post-test score vs. pre-test (5.85, SD = 2.31, to 6.84, SD = 2.88, p<0.001). Self-reported confidence managing sepsis improved (p<0.001) following SG. Over 85% of subjects reported they would or maybe would recommend the SG.

Forseea et al. 2014  e-Baby  VE of an incubator, teaching clinical evaluation of preterm infants' respiratory process. Embedded multimedia assets to share within a Moodle course  Survey  Nurses, nursing students in Australia; n=14.  Satisfaction survey.  1, 2, 3  Development of SG described. 100% found the tool easy to use, enjoyed the didactic component and felt motivated to use it, felt the tool enabled learning preterm oxygenation needs, requested such technologies to be applied to other topics and felt that it helped in their learning. 83% enjoyed learner autonomy, 86% felt feedback was immediate, 7° felt technologies like this could replace teachers.


Gräfland et al. 2014  Medialis  Timed CBS with MCQ augmented with multimedia. Learners diagnose and manage patients with biliary tract disease.  Validation study: performance vs. skill level  Surgeons, trainees in Netherlands; n=41.  Performance during SG: Nurse of solved cases.  4  Surgeons solved more cases correctly (mean 77 %) vs. residents (67 %), interns (60 %), master-degree students (50 %), and bachelor-degree students (39 % (p<0.01). Trainees performed significantly better in second session (median 72 vs. 48 %, p<0.00).

Gräfland et al. 2013  Situational Awareness in Surgical training Game  CBS with text questions augmented with multimedia, teaching management of equipment-related errors.  Quasi-experimental  Surgeons, trainees, n=45.  Usability and satisfaction survey.  1, 2, 3, 4  Majority found SG realistic (84.4%-88.9%), useful (53%), positive (78%) and challenging (60%). 66% would play the SG in their leisure time. Surgeons more likely to perceive the SG as boring than residents and students (23.5% vs. 6.7% and 8.3%; p=0.045).

Gräfland et al. 2014  Laparoscopic Equipment Failure Serious Game  VE simulating a minimally invasive surgery (MIS) unit, testing learner's assessment and management of equipment settings and displays.  Validation study: comparison of performance vs. skill level  Surgeons, trainees, MIS equipment specialists in Netherlands; n=45.  Performance during SG: Number of solved cases.  4  Equipment specialists (ES) solved significantly more equipment problems than medical students (MS), residents (R), and surgeons (S) (68.9% vs. 51.0%, 51.4% and 45.0%, respectively, p<0.01). ES required a median of 1.00 problem-solving steps (IQR 1.00–3.00), S 3.00 (1.00–4.00), R 2.00 (IQR 1.00–4.00), MS 2.00 (IQR 1.00–4.00), Kruskal-Wallis, p<0.03. ES had higher proportion of correct steps (median of 1.00 (IQR 0.50–1.00) vs. S 0.50 (IQR 0.00–1.00) vs. R 0.50 (IQR 0.00–1.00) vs. MS 0.50 (IQR 0.00–1.00). Mann–Whitney U for ES vs. other groups: p<0.01 vs. S; p<0.05 vs. R, and p=0.02 vs. MS.


Hashimoto et al. 2015  Lap Mentor VR  VE simulating laparoscopic cholecystectomies.  RCT: competitive SG vs. control SG (C)  Medical students in UK; n=18.  Time, movements, instrument path length, global rating scale.  1, 2, 3, 5 Time and global rating scale score were not significantly different between groups. Competitive SG group was significantly more dexterous than C and had significantly lower variance in number of movements and instrument path length (p<0.015).

Jalink et al. 2014  Underground world  VE: learner demolishes and rebuilds mine using 2 Wi Remote controllers in laparoscopic tool shells. Trans basic laparoscopic skills, not medical knowledge.  Quasi-experimental  Laparoscopic surgeons at a global conference; n=72.  Speed within SG, satisfaction survey.  1, 2, 3, 4 Experts were 111% faster (p<0.001) than novices. Also, scores of the FLS Peg Transfer test and the Wii Laparoscopy showed a significant, high correlation (r = 0.812, p<0.001). On a 1-to-10 scale, mean score for hardware realism was 7.2, mean score for usefulness as a training tool was 6.4–7.

Janssen et al. 2015  They Know: Anatomy  Multi-player adventure competition, advancement with correctly answering questions about human anatomy.  Survey  Medical students in Australia; n=16. Satisfaction survey, open-ended interviews.  1, 2, 3 89% found the SG engaging. 93% described the SG as challenging. 74% would like to play the SG again if given the opportunity. Participants found the competitive aspects positive, and described subjective improvement in knowledge of anatomy, as well as knowledge of personal strengths and weaknesses.

Kaczmrzczky et al. 2015  Video-based VE teaching and testing acute management of tachyarrhythmias  Survey  Medical students in UK; n=47. Satisfaction survey, open-ended interviews.  1, 2, 3 98% agreed that the use of SGs would support the teaching of acute medicine. Participants enjoyed the interactivity and found the SG a useful aid for knowledge consolidation. Suggested areas for improvement were shortening video length, fixing technical glitches and increasing the detail of the end-game feedback.

Kanthan, Senger et al. 2011  The Path is Right  Testing VE with multimedia for teaching clinical pathology. MCQ, fill-in the blank, and extended matching options.  Quasi-experimental  Medical students in Canada; n=77. Pre/post test: midterm vs. final exam scores.  5, 6 Students given access to game midterm and before final exam. No significant difference in midterms vs. final scores (midterm = 74.31%, range 53.06% - 88.50%, final = 75.52%, range 57.84% - 89.22%).

Katz, Central Venous  VE for performing central venous  Descriptive  Residents, None. None. Development of SG and future studies described.
Kerfoot et al. 2013 | Catheter Game | catheter placement. | students | in USA. |
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<tbody>
<tr>
<td>LeRoy et al. 2008</td>
<td>Spaced-repetition (SE) blood pressure (BP) control game</td>
<td>Competitive MCQ game, learners observed BP at regular intervals and relative scores posted to foster competition among peers. BP recordings of hypertensive patients were evaluated.</td>
<td>RCT: SG users vs. control (identical content online)</td>
<td>Primary care clinicians in USA, n=111.</td>
</tr>
<tr>
<td>Kerfoot, Baker et al. 2012</td>
<td>Urology Content Game</td>
<td>Competitive MCQ game on core urology content, 2 MCQs with feedback emailed daily. MCQs were sent over time and relative scores posted to foster competition.</td>
<td>Quasi-experimental</td>
<td>Urology residents in USA and Canada; n=931.</td>
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<tr>
<td>Kerfoot et al. 2012</td>
<td>Pre-Clinical Content Game</td>
<td>Competitive MCQ game on pre-clinical content, 2 MCQ with feedback emailed daily. MCQs were sent over time and relative scores posted to foster competition.</td>
<td>Quasi-experimental</td>
<td>Medical students in USA; n=731.</td>
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<tr>
<td>Kerfoot et al. 2012</td>
<td>Urology Continuing Medical Education Guidelines Game</td>
<td>Competitive MCQ game on urology guidelines, 2 MCQ with feedback emailed daily. MCQs were sent over time and relative scores posted to foster competition.</td>
<td>RCT: 2 MCQs every 2 days, vs. 4 MCQs every 4 days</td>
<td>Physicians worldwide; n=1470.</td>
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<tr>
<td>Kisakiewicz et al. 2007</td>
<td>Sim-Patient™</td>
<td>VE with single and multiple-casualty cases (bioterrorism, trauma, improvised explosive device). Learners apply triage tags and manage cases. Physiology modeled.</td>
<td>Survey</td>
<td>Military physicians in USA; n=31.</td>
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<tr>
<td>Knight et al. 2010</td>
<td>Trajge Trainer</td>
<td>VE of major incident scenarios where users perform medical checks, tag and assess multiple patients.</td>
<td>RCT: SG vs. C (card sort exercise)</td>
<td>Physicians, nurses, paramedics in UK; n=91.</td>
</tr>
<tr>
<td>Kuprenov et al. 2009</td>
<td>Burn Center</td>
<td>Mass bomb blast casualty disaster VE. Learners stabilize, sort, tag and transport victims, care for patients in intensive care unit.</td>
<td>Descriptive</td>
<td>Trauma surgeons, nurses, therapists in USA.</td>
</tr>
<tr>
<td>Lagro et al. 2014</td>
<td>GeriatrX</td>
<td>Geriatric clinic VE. Users care for VP with fatigue due to iron-deficiency anemia. Users scored on appropriateness and cost-efficiency of care.</td>
<td>RCT: SG vs. C (self-study)</td>
<td>Medical students in Netherlands; n=134.</td>
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<tr>
<td>LeBoy et al. 2008</td>
<td>Virtual ED II</td>
<td>Multiplayer VE with cases simulating SARin exposure or radioactive bomb blast. Communication through microphone.</td>
<td>Survey</td>
<td>Physicians, nurses in USA; n=13.</td>
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<tr>
<td>LeBoy et al. 2008</td>
<td>Peninsula City</td>
<td>Multiplayer VE of a triage area after an explosion. Communication through microphone.</td>
<td>Survey</td>
<td>Paramedics, physicians, nurses in USA; n=16.</td>
</tr>
<tr>
<td>Lim et al. 2008</td>
<td>eNLG (online Neurological Localisation Game)</td>
<td>Modified essay and MCQ of patients with neurological problems, with learners examining and managing patients. Embedded videos.</td>
<td>Survey</td>
<td>Medical students in Singapore; n=76.</td>
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<tr>
<td>Year</td>
<td>Study Title</td>
<td>Methodology</td>
<td>Participants</td>
<td>Outcomes</td>
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<td>2015</td>
<td>SICKO (Surgical Improvement of Clinical Knowledge)</td>
<td>Same game format as Septrix (above), but with timed surgical CBS. Learner triages and prioritizes care, decides whether or not to operate, makes intraoperative decisions.</td>
<td>Medical students, residents and surgeons in USA; n=49.</td>
<td>Performance during gameplay compared across skill level, survey.</td>
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<td>Validation study: comparison of performance vs. skill level.</td>
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<td>1, 2, 3, 4</td>
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<tr>
<td>2013</td>
<td>McKenzie et al.</td>
<td>Game informed Online Learning About Managing Aggression in Health Settings</td>
<td>Embedded multimedia tools including video clips and external websites.</td>
<td>Informed learning activity with VP scenarios involving aggression and balance of tasks in a healthcare setting.</td>
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<td>Comparison trial, not randomized: SG vs. control (didactic 90-minute teaching session).</td>
<td></td>
<td>Clinical psychology students in UK; n=68.</td>
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<tr>
<td>2014</td>
<td>ED Physician Decision Making</td>
<td>VE, users evaluate and manage simulated cases with a mandatory shift. One version contained distracting cases and other audible distractors. Timed, physiology modeled.</td>
<td>RCT: SG with distractors (cognitive load, CL) vs. SG without distractors (control, C).</td>
<td>Emergency physicians in USA; n=209. Performance during game: transfer of learning, number of orders entered, time spent, CT scan rates.</td>
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<td>4, 5</td>
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<tr>
<td>2015</td>
<td>VPs for cancer nursing education</td>
<td>VP simulation scenarios to teach nursing topics in caring for men with prostate cancer.</td>
<td>Survey Nurses, students</td>
<td>Survey.</td>
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<td>1, 2, 3</td>
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<tr>
<td>2007</td>
<td>Cancer Genetics Tower</td>
<td>VE, users progress through levels and complete patient-based tasks.</td>
<td>Survey Medical students in USA; n=17.</td>
<td>Survey.</td>
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<td>1, 2, 3</td>
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<td>2012</td>
<td>GRAPHIC (Games Research Applied to Public Health with Innovative collaboration)</td>
<td>CBS, learners work collaboratively and individually to explore population oral health and the evidence for community initiatives, care for simulated 5-year-old patient in an inner city environment, Middlesbrough.</td>
<td>Survey Dental students in UK, n=not provided.</td>
<td>Satisfaction survey, SG completion.</td>
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<td>1, 2, 3, 6</td>
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<td>2014</td>
<td>ACLS Virtual Reality Simulator</td>
<td>Multiplayer hospital VE, learners communicate via microphone with members (a team of 5, randomly assigned to role) and perform ACLS on VP. CPR simulated via joystick. Two games with differences in amount of feedback (persuasion) given.</td>
<td>Two RCTs: Persuasive (P) vs. minimally persuasive (MP) ACLS-certified physicians in USA; n=989; n=148.</td>
<td>Usability survey.</td>
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<td>1st, 2, 3, 5th</td>
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<td>2010</td>
<td>Stopping the Fountains pre-game + Virtual Orthopedic-Surgery Game</td>
<td>Operating room VE, learners manipulate surgical tools via haptic device. VP present with varying degrees of blood loss, users assess and manage. Physiology modeled.</td>
<td>RCT: SG with and without pre-training elements Orthopedic surgeons, students in China; n=21.</td>
<td>Performance within SG: Time to complete blood management tasks.</td>
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<td>2010</td>
<td>Anatoxes 2.0 Quiz</td>
<td>Interactive MCQ with multimedia, teaching anatomy and physiology of the spine, language, hearing, and swallowing mechanisms.</td>
<td>RCT: SG group vs. control (self-study) Speech Language &amp; Hearing students in Brazil; n=29.</td>
<td>Pre/post MCQ, re-test at 6-months.</td>
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**Summary:**

- **Lin et al. 2015** investigated the impact of a surgical game on learning, finding significant differences across skill levels.
- **McKenzie et al. 2013** used a virtual environment to teach emergency management, noting improvements in performance.
- **Moham et al. 2014** evaluated a decision-making game, highlighting the transfer of learning.
- **Neyte et al. 2015** explored the use of games in nursing education, with reported increases in knowledge.
- **Nicolaidou et al. 2015** assessed a virtual emergency telemedicine system, showing effectiveness.
- **Nosik et al. 2007** utilized a game for cancer genetics education, noting positive outcomes.
- **O’Neill et al. 2012** developed a game for dental students, observing improvements in satisfaction.
- **Vankjura et al. 2014** evaluated a virtual reality simulator, finding improvements in usability.
- **Qin et al. 2010** used a virtual orthopedic surgery game, observing improvements in performance.
- **Rondon et al. 2013** created a quiz game, achieving positive feedback from users.
<table>
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<tr>
<th>Publication</th>
<th>Description</th>
<th>Type</th>
<th>Group</th>
<th>Study Design</th>
<th>Outcome Measures</th>
<th>Results</th>
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<tr>
<td><strong>Schwaab et al.</strong> 2011 Second Life (SL) Case-Based Mock Emergency Medicine Board Examination</td>
<td>Hospital and examination room VE, learners manage cases, communicate via microphone with a faculty examiner at a remote computer (virtual patient). Mock oral American Board of Emergency Medicine examination.</td>
<td>Survey</td>
<td>Emergency residents in USA, n=27.</td>
<td>Satisfaction survey, comparing user experience with SL examination and oral examination.</td>
<td>1, 2, 3 Participants rated SL as: easy to log into (92.6%), navigate (96.3%), fair (100%), objective (100%), conducted efficiently (100%), and realistic (92.6%). 70.3% found it more realistic than the traditional oral examination (70.3%). Participants felt comfortable communication with examiner via remote computer (100%). A majority preferred oral examinations via SL over oral examination and expressed interest in using SL for other educational experiences (66.6 and 92.6%, respectively).</td>
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<td><strong>Schwarz et al.</strong> 2013 Medical Faculties Network (MEFANET)</td>
<td>Timed CBS in basic life support, emergency, anaesthesiology, pain, and critical care, with embedded multimedia. Physiology modeled.</td>
<td>Survey</td>
<td>Medical students in Czech Republic, Slovakia, n=62.</td>
<td>Satisfaction survey.</td>
<td>1, 2, 3 87% of participants agreed or strongly agreed that the SG was an effective tool for learning. 81.4% agreed or strongly agreed that the SG increased knowledge in acute medicine, 74% agreed or strongly agreed that the SG was a better way to study than textbooks, 87% agreed or strongly agreed that the embedded multimedia along with timed stress factor evoked a clinical atmosphere. 85.2% agreed or strongly agreed that they liked using the interactive algorithms at home and in a classroom setting.</td>
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<tr>
<td><strong>Schwid et al.</strong> 2001 VE, learners examine and treat patients during anesthetic emergencies. Physiology modeled.</td>
<td>RCT: SG vs. C (self-study) Anesthesiologist residents in USA, n=31.</td>
<td>Post testing with live simulation.</td>
<td>5</td>
<td>Significantly higher post-test score for SG vs. C group (52.6 ± 9.9 vs. 43.3 ± 5.9, p=0.004).</td>
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<td><strong>Stredney et al.</strong> 1996 Virtual Simulated Epidural Anesthesia</td>
<td>Hospital VE of a simulated patient’s back, for practicing epidural placement, with computer-generated needle.</td>
<td>Survey</td>
<td>Anesthesiologist residents in USA, n=3.</td>
<td>Survey/questionnaire.</td>
<td>1, 2, 3 Participants felt that the interface was comfortable to very comfortable to use, interface was straightforward to use. Participants reported the SG was “too mechanical,” movements were “stif.” Comments for improvement included: need for additional visual cues for orientation, introduction of a method to angle the needle.</td>
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<tr>
<td><strong>Sward et al.</strong> 2008 Pediatric Rotation Game</td>
<td>Testing environment of a web-based, interactive adaptation of an existing board game for general pediatric content.</td>
<td>RCT: SG vs. C (self-study)</td>
<td>Medical students in USA, n=100.</td>
<td>Post-rotation NBME Pediatric Clerkship Exam scores, satisfaction survey.</td>
<td>1, 2, 3, 5, 6 No difference in NBME exam scores, comfort with content (p=0.68), readiness for exam (p=0.52), content presented with enough detail (p=0.17), content relevant to patients (p=0.77), or user questions answered (p=0.47) between groups. 94% felt that SG visuals were attractive. Mean overall reaction to the SG score was 6.59 (SD=0.97). SG favored vs. self-study in understanding content (p&lt;0.001), perceived help with learning (p&lt;0.05), and enjoyment of learning (p=0.008).</td>
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<td><strong>Tubisz et al.</strong> 2015 Zinc Phosphate Cement Virtual Learning Object</td>
<td>Moleule-based VE teaching and testing handling of zinc phosphate cement for dental prostheses.</td>
<td>RCT: Longitudinal SG (15 days) vs. SG (20 minutes) vs. longitudinal reading vs. reading (C)</td>
<td>Dental students in Brazil, n=46.</td>
<td>MCQ and laboratory skill tests.</td>
<td>1, 2, 3, 5 MOCQ post-test showed a significant difference between the longitudinal groups (C 6.0 ± 1.15 and SG 7.33 ± 1.43, p=0.05), but no significant differences between immediate groups. The immediate and longitudinal SG groups finished with lower film thickness than the controls (C 26 ± 9.3 and SG 16.24 ± 5.17, longitudinal C 50 ± 27.08 and longitudinal SG 22.5 ± 9.65, p=0.05 for all groups). SG groups had higher setting times, and the immediate group showed a significant difference (C 896 ± 218.90 and SG 1138.5 ± 177.95, p&lt;0.05 for immediate group).</td>
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<td><strong>Youngblood et al.</strong> 2008 Virtual ED</td>
<td>Multipayer emergency room VE, users examine and treat patients with a team. Users communicate through microphone. Physiology modeled.</td>
<td>RCT: SG vs. C (live simulation)</td>
<td>Medical students, residents in USA, n=30.</td>
<td>Pre/post testing with live cases, satisfaction survey.</td>
<td>1, 2, 3, 5 No significant difference in post-test scores between groups (p=0.40). 75% of SG and 86% of C group reported a change in their feelings about ED teams. 86% of SG and 93% of C group felt immersed. 56% of SG and 78% of C group rated themselves as “confident or very confident” in leading an ED team. Most subjects found their modality “useful” or “very useful” for learning clinical skills and teamwork (100%, 94% SG, 100% C).</td>
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**Abbreviations:** SG = serious game, C= control, VE = virtual environment, VP = virtual patients, CBS = case-based simulation, RCT= randomized controlled trial, MCQ= multiple choice questions, SUS= System Usability Scale, s= seconds.