

## Supplementary Appendix

Studies identified during the literature review search						
PAPER REFERENCE	AIM	SUB - SPECIALTY (IF MENTIONED)	STUDY DESIGN	CATEGORY OF INTEREST	KEY RESULTS	CONCLUSION
Factors Impacting Initial Arthroscopy Performance and Skill Progression in Novice Trainees. By: Cychosz, Chris C; Tofte, Josef N; Johnson, Alyssa; et al. The Iowa orthopaedic journal Volume: 39 Issue: 1 Pages: 7-13 Published: 2019	To: 1) identify trainee characteristics that may have an impact on initial arthroscopy skill and performance; and 2) identify trainee characteristics affecting their ability to improve through training on an arthroscopy simulator.	Orthopaedic arthroscopy	Exploratory, non-randomised	Transition to performance on simulation	At the time of the initial diagnostic knee arthroscopy, performance was most strongly correlated with how often an applicant currently plays video games and how often they have played video games in the past. However, this was only a weak correlation ( $r = 0.29$ and $0.24$ , respectively).	This study demonstrates that baseline arthroscopy performance correlates most highly with 3D video game experience.
Naked-eye box trainer and training box games have similar training effect as conventional video-based box trainer for novices: A randomized controlled trial.	To compare the training efficiency of the naked eye box trainer, training box games and conventional video based box trainer in training laparoscopic suturing skills.	Laparoscopic surgery	RCT	Piloting a video game	The three training models were well acceptable and all could improve the acquisition of laparoscopic suturing and knotting skill in novices.  Using the structured procedure-specific checklist, there was no significant difference in scores between	Naked eye box trainer and training box games produce similar training effect as the conventional video based box trainer. The naked eye box trainer may serve as a convenient way for novice trainees to

<p>By: Lin, Chun-Chi; Huang, Sheng-Chieh; Lin, Hung-Hsin; et al.</p> <p>American journal of surgery Volume: 216 Issue: 5 Pages: 1022-1027 Published: 2018-Nov (Epub 2018 May 24)</p>					<p>these three groups (<math>P = 0.977</math>).</p>	<p>acquire laparoscopic suturing technique skills before video-based simulation.</p>
<p>SAGES Mini Med School: inspiring high school students through exposure to the field of surgery.</p> <p>By: Rosser, James C Jr; Legare, Timothy B; Jacobs, Charles; et al.</p> <p>Surgical endoscopy Volume: 32 Issue: 10 Pages: 4235-4243 Published: 2018-Oct (Epub 2018 Apr 02)</p>	<p>The SAGES Mini Med School (SMMS) was designed to expose high school students to the field of surgery through mentoring, knowledge transfer, and hands-on experience with simulation. The objective of this paper is to profile the evolutionary development, performance metrics, and satisfaction queries of this innovative effort.</p>	<p>Laparoscopic and general surgery (open)</p>	<p>Exploratory, non comparative study</p>	<p>Exposure to students and prospective trainees</p>	<p>For the Super Monkey Ball task, 60 students participated with an average score of 73.0 s (SD = 53.9; range 59.1-87.0; median = 74). Sixty students participated in the Surgeons Knot and Pea Drop tasks with average times of 26.6 s (SD = 19.3; range 21.7-31.6; median = 21.0) and 113.8 s (SD = 65.9; range 96.6-131.0; median = 101.0), respectively. Sixty students participated in the Instrument Tie and 56 students participated in the Peg Transfer stations with average times of 51.7 s (SD = 34.5; range 42.8-60.6; median = 39.5) and 173.1 s (SD = 25.0; range 166.4-</p>	<p>The SMMS program showed that the students had an excellent aptitude for the performance of validated surgical subtasks with high satisfaction, and increased consideration of a career in medicine/surgery. Long-term studies are needed to evaluate the impact on workforce recruitment.</p>

					179.8; median = 180.0), respectively. 51 (83.6%) agreed that the Mini Med School made them more likely to consider a career in medicine. When asked if the program made them more likely to consider a career in surgery 42 (68.8%) agreed. All 61 respondents (100%) said that they would recommend the program to others.	
<p>Playing to your skills: a randomised controlled trial evaluating a dedicated video game for minimally invasive surgery.</p> <p>By: Harrington, Cuan M; Chaitanya, Vishwa; Dicker, Patrick; et al.</p> <p>Surgical endoscopy Volume: 32 Issue: 9 Pages: 3813-3821 Published: 2018-Sep (Epub 2018 Feb 14)</p>	<p>Evaluate for skill acquisition associated with a commercially available dedicated laparoscopic video game (Underground) and its unique (laparoscopic-like) controller for the Nintendo®Wii U™ console</p>	Laparoscopy	RCT	Transition to performance on simulation	<p>The video gaming group demonstrated significant improvements in thirty-one of the metrics examined including dominant (<math>P \leq 0.004</math>) and non-dominant (<math>P &lt; 0.050</math>) instrument movements, pathlengths (<math>P \leq 0.040</math>), time taken (<math>P \leq 0.021</math>) and end score [<math>P \leq 0.046</math>, (task-dependent)].</p>	<p>Our work revealed significant value in training using a dedicated laparoscopic video game for acquisition of virtual laparoscopic skills. This novel serious game may provide foundations for future surgical developments on gameconsoles in the home environment</p>

<p>Saving robots improves laparoscopic performance: transfer of skills from a serious game to a virtual reality simulator.</p> <p>By: IJgosse, Wouter M; van Goor, Harry; Luursema, Jan-Maarten</p> <p>Surgical endoscopy Volume: 32 Issue: 7 Pages: 3192-3199 Published: 2018-Jul (Epub 2018 Jan 18)</p>	<p>We establish construct validity for the laparoscopic serious game Underground by comparing laparoscopic simulator performance for a control group and an Underground training group.</p>	Laparoscopy	RCT	Piloting a video game	<p>We chose task duration as a proxy for laparoscopic performance . The Underground group outperformed the control group on all three LapSim tasks: Camera navigation <math>F(1) = 12.71, P &lt; .01</math>; Instrument navigation <math>F(1) = 8.04, P &lt; .01</math>; and Coordination <math>F(1) = 6.36, P = .01</math></p>	<p>We demonstrated skills transfer between a serious game and validated laparoscopic simulator technology. Serious gaming may become a valuable, cost-effective addition to the skillslab, if transfer to the operating room can be established.</p>
<p>Evaluation of App-Based Serious Gaming as a Training Method in Teaching Chest Tube Insertion to Medical Students: Randomized Controlled Trial.</p> <p>By: Haubruck, Patrick; Nickel, Felix; Ober, Julian; et al.</p> <p>Journal of medical Internet research Volume: 20 Is</p>	<p>Was to investigate the serious gaming approach in teaching medical students an emergency procedure (chest tube insertion) using the app Touch Surgery and a modified objective structural assessment of technical skills (OSATS).</p>	Thoracic tube insertion	RCT	Piloting a video game	<p>The intervention group performed significantly better than the control group (Intervention group: 38.0 [I50=7.0] points; control group: 30.5 [I50=8.0] points; <math>P &lt; .001</math>). The intervention group showed significantly improved economy of time and motion (<math>P = .004</math>), needed significantly less help (<math>P &lt; .001</math>), and was more confident in handling of</p>	<p>Serious games are a valid and effective tool in education of operative performance in chest tube insertion. We believe that serious games should be implemented in the surgical curriculum, as well as residency programs, in addition to traditional learning methods.</p>

sue: 5 Pages: e195 Published: 2018 May 21					instruments ( $P<.001$ ) than the control group.	
<p>Identification of New Tools to Predict Surgical Performance of Novices using a Plastic Surgery Simulator.</p> <p>By: Kazan, Roy; Viesel-Mathieu, Alex; Cyr, Shantale; et al.</p> <p>Journal of surgical education Published: 2018-Apr-09 (Epub 2018 Apr 09)</p>	The objective of this study is to identify new tools that could predict surgical performance of novices on a mammoplasty simulator.	Plastic surgery	Exploratory, Non randomised	Transition to performance on simulation	Correlation studies showed significant association between Perplexus Epic, Star Wars Racer, Super Monkey Ball scores and the modified OSATS score with $r_s = 0.8491$ ( $P < 0.001$ ), $r_s = -0.6941$ ( $P = 0.005$ ), and $r_s = 0.7309$ ( $P < 0.003$ ), but not with the Mikado score $r_s = -0.0255$ ( $P = 0.9$ ).	This study identified a combination of skill games that correlated to better performance of novices on a surgical simulator.
<p>Laparoscopic skills assessment: an additional modality for pediatric surgery fellowship selection.</p> <p>By: Hazboun, Rajaie; Rodriguez, Samuel; Thirumoorathi, Arul; et al.</p> <p>Journal of pediatric surgery Volume: 52 Issue: 12 Pages: 1904-1908 Published: 2017-Dec (Epub 2017 Sep 05)</p>	The Pediatric Surgery fellowship selection is a multi-layered process which has not included assessment of surgical dexterity.	Paediatric laparoscopic surgery	Exploratory, Non randomised	Selection	Playing a musical instrument correlated with faster knot tying ( $P=0.03$ ). No correlation was identified between knot tying time and either video game experience ( $P=0.4$ ) or passing the FLS exam ( $P=0.78$ ). Laparoscopic skills assessment lead to significant reordering of rank list ( $P=0.01$ ).	Playing a musical instrument correlated with faster knot tying. No correlation was identified between laparoscopic performance and passing the FLS exam or other activities traditionally believed to improve technical ability.

<p>Prior video game utilization is associated with improved performance on a robotic skills simulator. By: Harbin, Andrew C; Nadhan, Kumar S; Mooney, James H; et al. Journal of robotic surgery Volume: 11 Issue: 3 Pages: 317-324 Published: 2017-Sep (Epub 2016 Nov 16)</p>	<p>whether volume or timing of VGE (video game experience) had any impact on RSS (robotic skills simulator) performance.</p>	<p>Robotic / Minimally invasive surgery cardiothoracic</p>	<p>Exploratory, Non randomised</p>	<p>Transition to performance on simulation</p>	<p>Univariate analyses revealed significant differences between heavy and non-users in all five performance metrics. These trends disappeared as the period of VGE went further back.</p>	<p>Our study showed a positive association between video game experience and robotic skills simulator performance that is stronger for more recent periods of video game use.</p>
<p>The benefits of being a video gamer in laparoscopic surgery. By: Sammut, Matthew; Sammut, Mark; Andrejevic, Predrag International journal of surgery (London, England) Volume: 45 Pages: 42-46 Published: 2017-Sep (Epub 2017 Jul 19)</p>	<p>Previous studies have not conclusively shown a positive correlation between video game experience and improved ability to accomplish visual-spatial tasks in laparoscopic surgery. This study was an attempt to investigate this relationship.</p>	<p>Laparoscopy</p>	<p>Case control</p>	<p>Transition to performance on simulation</p>	<p>The gamer group had statistically significant better results in maintaining the laparoscopic camera horizon <math>\pm 15^\circ</math> (<math>P</math> value = 0.009), in the complex ball manipulation accuracy rates (<math>P</math> value = 0.024) and completed the complex laparoscopic simulator task in a significantly shorter time period (<math>P</math> value = 0.001). Although</p>	<p>The results show that previous video-gaming experience improved the baseline performance in laparoscopic simulator skills.</p>

					prior video gaming experience correlated with better results, there were no significant differences for camera accuracy rates ( $P$ value = 0.074) and in a two-handed laparoscopic exercise task accuracy rates ( $P$ value = 0.092)	
Effect of fine-motor-skill activities on surgical simulator performance. By: Chung, Anthony T; Lenci, Lucas T; Wang, Kai; et al. Journal of cataract and refractive surgery Volume: 43 Issue: 7 Pages: 915-922 Published: 2017-Jul	To determine the effect of fine motor activity and nondominant-hand training on cataract surgical simulator (EyeSi) performance.	Cataract Surgery (EyeSi)	Prospective controlled trial.	Transition to performance on simulation	Of the 33 students, regular video game players had greater baseline scores than nonplayers on navigation ( $P = .021$ ) and bimanual tasks ( $P = .089$ ). All participants showed statistically significant improvements in all 3 tasks at follow-up after a single baseline evaluation on the surgical simulator (navigation: $P = .004$ ; forceps: $P < .001$ ; bimanual: $P = .004$ ). Nondominant-hand training with daily activities did not show statistically significant differences for dominant hands or nondominant hands.	Regular video game play enhanced baseline microsurgical performance measured on the surgical simulator. Simulation performance improved significantly in the intervention group and control group after 1 session on the simulator. Although not statistically significant, training the nondominant hand with daily activities showed a trend toward improved navigation

						and bimanual performance.
<p>Training in Basic Laparoscopic Surgical Skills: Residents Opinion of the New Nintendo Wii-U Laparoscopic Simulator.</p> <p>By: Overtoom, Evelien M; Jansen, Frank-Willem; van Santbrink, Evert J P; et al.</p> <p>Journal of surgical education Volume: 74 Issue: 2 Pages: 352-359 Published: 2017 Mar - Apr (Epub 2016 Oct 25)</p>	<p>We evaluate the residents' opinion of a new laparoscopic simulator for the Nintendo Wii-U platform.</p>	Laparoscopy	Prospective questionnaire study.	Piloting a video game	<p>The hand-eye coordination was regarded most useful for training with a mean of 3.92 (standard deviation 0.93) and the game was considered most suitable for residents in the first part of their postgraduate training with a mean of 3.73 (standard deviation 0.97). Both groups differed especially concerning their opinion of the usefulness of the game as a training tool</p>	<p>Most residents liked the new serious game for the Nintendo Wii-U. The usefulness and suitability as a laparoscopic training tool were rated at an acceptable to high level. However, the game does require improvements such as inclusion of a good scoring system before it can be integrated in resident training curricula.</p>
<p>Impact of Super Monkey Ball and Underground video games on basic and advanced laparoscopic skill training.</p> <p>By: Rosser, James C Jr; Liu, Xinwei; Jacobs, Charles; et al.</p>	<p>Profiles the comparison of correlations between previously validated Super Monkey Ball (SMB) and recently introduced Underground (U) video game on the Nintendo Wii U to multiple validated tasks used for</p>	Laparoscopy	Exploratory, non-randomised	Piloting a video game	<p>The SMB score had a moderate correlation with intracorporeal suturing (<math>P = 0.39</math>, <math>P &lt; 0.01</math>), and the final score involving all three tasks (<math>P = 0.39</math>, <math>P &lt; 0.01</math>), but low correlations with Pea Drop Drill and FLS Peg Transfer (<math>P = 0.11</math>, <math>0.18</math>, <math>P &lt; 0.01</math>). The U score had a</p>	<p>In this study, SMB had a very significant correlation with intracorporeal suturing. U demonstrated more of a correlation with basic skills. At this point, our conclusion would be that both are effective</p>



Surgical endoscopy Volume: 31 Issue: 4 Pages: 1544-1549 Published: 2017-04 (Epub 2016 Sep 08)	developing basic and advanced laparoscopic skills				small correlation with intracorporeal suturing and final score ( $P = 0.09, 0.13, P < 0.01$ ). However, there were correlations between U score and Pea Drop Drill, and FLS Peg Transfer ( $P = 0.24, 0.27, P < 0.01$ , respectively).	for laparoscopic skill training, and they should be used in tandem rather than alone.
A serious game skills competition increases voluntary usage and proficiency of a virtual reality laparoscopic simulator during first-year surgical residents' simulation curriculum. By: El-Beheiry, Mostafa; McCreery, Greig; Schlachta, Christopher M Surgical endoscopy Volume: 31 Issue: 4 Pages: 1643-1650 Published: 2017-04 (Epub 2016 Aug 29)	Assess the effect of a serious game skills competition on voluntary usage of a laparoscopic simulator among first-year surgical residents' standard simulation curriculum.	Laparoscopy	Case control	Motivation of trainees	The competition cohort overwhelmingly (76 %) stated that they were not motivated to deliberate practice by competition. Median total simulator usage time was 132 min (IQR = 214) in the competition cohort compared to 89 (IQR = 170) in the control cohort.	A simple serious games skills competition increased voluntary usage and performance on a laparoscopic simulator, despite a majority of participants reporting they were not motivated by competition.
Asymmetry in Dominant / Non-Dominant Hand Performance	The current study examined dominant versus non-	Orthopaedic surgery	Exploratory, non RCT	Transition to performance	A virtual reality Tetris game was performed with the arthroscopic camera and	Virtual reality games which incorporate progressive cognitive

<p>Differentiates Novices from Experts on an Arthroscopy Virtual Reality Serious Game. By: Pedowitz, Robert; Nicandri, Gregg; Tuchschnid, Stefan</p> <p>Studies in health technology and informatics Volume: 220 Pages: 289-94 Published: 2016</p>	<p>dominant hand performance on a virtual reality serious game in a group of expert arthroscopic surgeons (n=15) compared to a group of orthopedic surgery residents (n=10).</p>			<p>on simulation</p>	<p>arthroscope in one hand, using an arthroscopic grasping tool in the opposite hand to manipulate the virtual Tetris blocks onto the game grid. A second run was performed after swapping instruments between hands. The order of hand testing was randomized. There was no statistically significant difference in exercise time, grasper path length, or camera path length between the right and left hands of the expert surgeons. In contrast, there were statistically significant differences in all of these parameters between the two hands for the orthopedic surgery residents, with better performance when the grasping tool was used in the dominant hand.</p>	<p>loading could be used to facilitate training, automation, and objective assessment of surgical motor skills.</p>
<p>Gamification in thoracic surgical education</p>	<p>In an effort to stimulate residents and trainers to increase their use of</p>	<p>Thoracic surgery</p>	<p>Prospective cohort</p>	<p>Motivation of trainees</p>	<p>Top Gun." Over 3 years, there were 43 baseline and 34 final submissions. In all areas of</p>	<p>This gamification approach focused on technical and cognitive</p>

<p>on: Using competition to fuel performance. By: Mokadam, Nahush A; Lee, Richard; Vaporciyan, Ara A; et al. The Journal of thoracic and cardiovascular surgery Volume: 150 Issue: 5 Pages: 1052-8 Published: 2015-Nov (Epub 2015 Jul 26)</p>	<p>simulation training and the Thoracic Surgery Curriculum, a gamification strategy was developed in a friendly but competitive environment.</p>				<p>assessment, there was demonstrable improvement. There was increasing evidence of simulation as seen by practice and ritualistic behavior. Finalists reported increased use of the Thoracic Surgery Curriculum by an average of 10 hours per week in preparation.</p>	<p>skills, has been successfully implemented, and has encouraged the use of simulators and the Thoracic Surgery Curriculum.</p>
<p>Analysis of the learning curve for transurethral resection of the prostate. Is there any influence of musical instrument and videogame skills on surgical performance ? By: Yamacake, Kleiton Gabriel Ribeiro; Nakano, Elcio Tadashi; Soares, Iva Barbosa; et al. Turkish journal of urology Volume: 41 Issue: 3 Pages: 132-7 Published: 2015-Sep</p>	<p>To evaluate the learning curve for trans urethral resection of the prostate (TURP) among urology residents and study the impact of video game and musical instrument playing abilities on its performance.</p>	Urology	Prospective cohort study	Transition to performance on simulation	<p>Those experienced in playing video games presented superior resection speed (0.45 g/min) when compared with the novice (0.35 g/min) and intermediate (0.38 g/min) groups (<math>P=0.112</math>). Musical instrument playing abilities did not affect the surgical performance.</p>	<p>Speed of resection, weight of resected tissue, and percentage of resected tissue improve significantly and the incidence of capsular lesions reduces after the performance of 10 TURP procedures. Experience in playing video games or musical instruments does not have a significant effect on outcomes.</p>

<p>Predicting Microsurgical Aptitude.</p> <p>By: Osborn, Heather A; Kuthubutheen, Jafri; Yao, Christopher; et al.</p> <p>Otology &amp; neurotology : official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology Volume: 36 Issue: 7 Pages: 1203-8 Published: 2015-Aug</p>	<p>No method currently exists to predict who will possess an aptitude for microscopic surgery. Our goal was to determine whether performance can be predicted by background experiences or skills.</p>	ENT	Retrospective cohort study.	Selection	<p>Forty-six students were assessed. There was no correlation between video gaming and improved microsurgical performance. Rather, video gamers obtained worse scores, although this difference did not reach significance. The majority of students played a musical instrument.</p>	<p>No improvement in microsurgical aptitude was seen in subjects who had a history of video gaming or musical instrument playing.</p>
<p>Face validity of a Wii U video game for training basic laparoscopic skills.</p> <p>By: Jalink, Maarten B; Goris, Jetse; Heineman, Erik; et al.</p> <p>American journal of surgery Volume: 209 Issue: 6 Pages: 1102-</p>	<p>Although the positive effects of playing video games on basic laparoscopic skills have been studied for several years, no games are actually used in surgical training. This article discusses the face validity of the first video game and custom-made hardware,</p>	Laparoscopy	Prospective cohort	Piloting a video game	<p>On a 1-to-10 scale, the mean score for hardware realism was 7.2 and the mean score for usefulness as a training tool was 8.4. Participants did not mind the fact that the workspace does not look like an abdominal cavity, but do have some trouble with the absence of tactile feedback.</p>	<p>We obtained face validity for both the hardware and the usefulness of Underground, a video game made for training basic laparoscopic skills.</p>

6 Published: 2015-Jun (Epub 2015 Jan 20)	which takes advantage of these effects.					
<p>More than a camera holder: teaching surgical skills to medical students.</p> <p>By: Abbas, Paulette; Holder-Haynes, Juliet; Taylor, Deborah J; et al.</p> <p>The Journal of surgical research Volume: 195 Issue: 2 Pages: 385-9 Published: 2015-May-15 (Epub 2015 Jan 28)</p>	<p>We introduced a laparoscopic skills course to medical students to provide hands-on experience. We hypothesized that the course will improve basic laparoscopic skills and increase interest in a surgical career.</p>	Laparoscopy	Exploratory, non comparative	Motivation	<p>One hundred one students participated with 82 students documenting preinstruction and postinstruction peg transfer times. There was an overall improvement in median transfer times after instruction (before 63 s [interquartile range {IQR} 46-84.5] versus after 50.5 s [IQR 39-65.2], <math>P &lt; 0.001</math>).</p> <p>A similar trend was observed between students with and without prior VG use. Of the 50 students who completed both surveys, there was no significant increase (pre-24% versus post-34%, <math>P = 0.29</math>) or decrease (pre-32% versus post-22%, <math>P = 0.13</math>) in interest in a surgical career after the course.</p>	<p>A laparoscopic course for medical students is effective in improving laparoscopic skills. Although male gender and VG use may be associated with better intrinsic skills, instruction and practice allow female students and non-VG users to "catch up."</p>

<p>Validity evidence for Surgical Improvement of Clinical Knowledge Ops: a novel gaming platform to assess surgical decision making.</p> <p>By: Lin, Dana T; Park, Julia; Liebert, Cara A; et al.</p> <p>American journal of surgery Volume: 209 Issue: 1 Pages: 79-85 Published: 2015-Jan (Epub 2014 Oct 22)</p>	<p>SICKO (Surgical Improvement of Clinical Knowledge Ops) is a novel gaming platform developed to address this critical need. A pilot study was performed to collect validity evidence for SICKO as an assessment for surgical decision making.</p>	<p>General surgery</p>	<p>Prospective cohort</p>	<p>Piloting a video game</p>	<p>Mean total game scores for the novice, junior resident, senior resident, and expert groups were 5,461, 8,519, 11,404, and 13,913, respectively (<math>P = .001</math>). Survey results revealed high scores for realism and content.</p>	<p>SICKO holds the potential to be not only an engaging and immersive educational tool, but also a valid assessment in the armamentarium of surgical educators.</p>
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