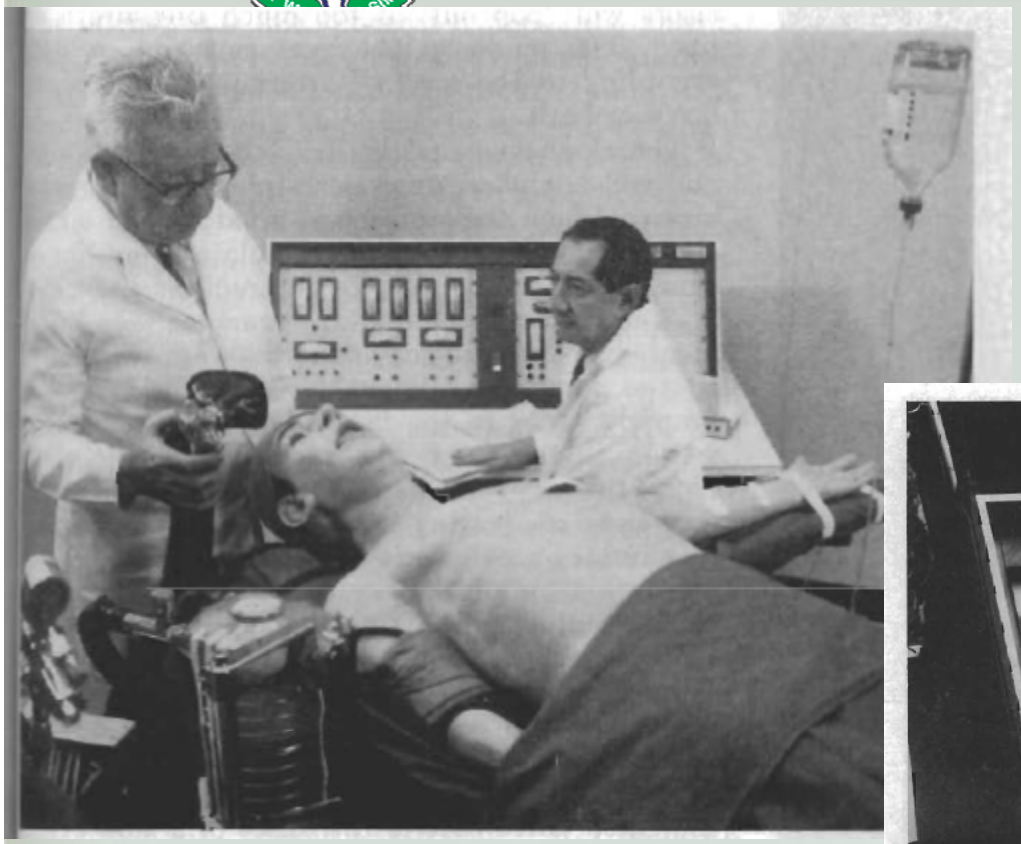
PROGRAM EXECUTIVE OFFICE FOR
SIMULATION, TRAINING & INSTRUMENTATION

Embracing Game Technology for Medical Education

ROGER SMITH
Chief Technology Officer
US Army PEO STRI
http://www.peostri.army.mil/CTO

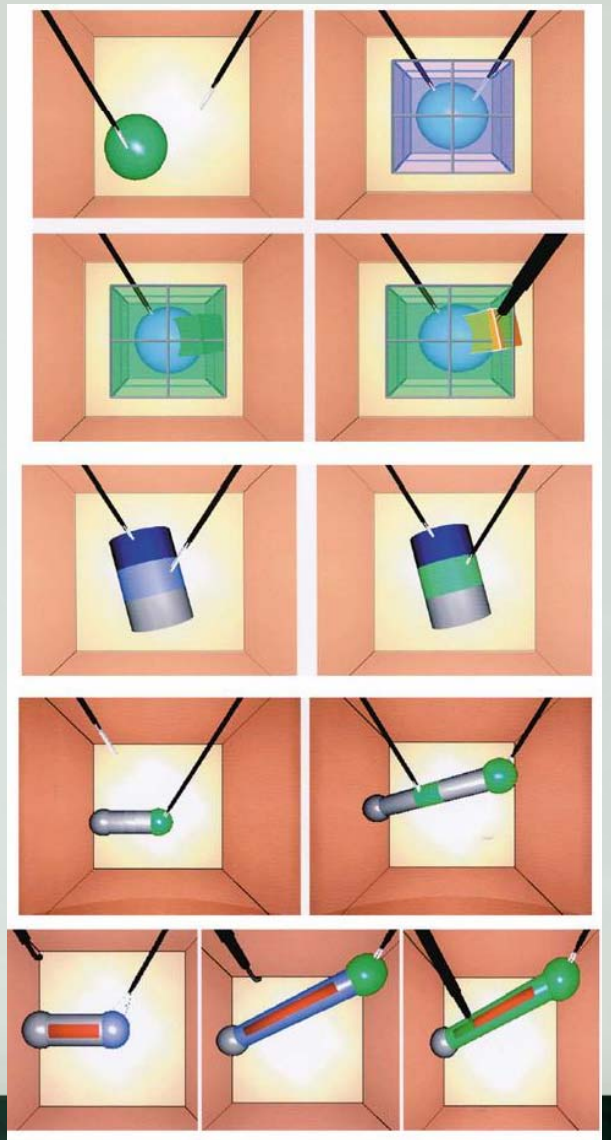
Medical Technology, Training and Treatment (MT3) Conference
Renaissance® Orlando Resort at Seaworld®
May 28-30, 2009

Sim One (1967):
Computers and Mechanics



Denson JS, Abrahamson S. A computer-controlled patient simulator. *Journal of the American Medical Association* 1969; 208:504–8.

MIST-VR (1995+)
Graphics and Virtual Reality



Growing Issue in Medical Education

- Medical procedures are becoming more numerous and more complex – medical knowledge has "hypertrophied" (Cooke, et al, New England J Med, 2006)

- Training residents to a common level of knowledge and competence is already impossible (conversations with Satava, 2008)

“The Perfect Storm”
(Murphy, J of Critical Care, 2007)

- Risk to patient health. (McDougall, 2007)
- Cost is a barrier to training. (Bridges, 1999)
- Availability of training opportunities. (Birden, 2007; Davis, 1999)
- Access to training. (Dunkin, 2007; Spitzer, 1997)
- Limited working hours. (Satava, 2004)
- Ethics of practicing on patients. (Satava, 2004; Murphy, 2007)
- Expectations around computer technologies. (Murphy, 2007)
- Insurance coverage of educational actions. (Satava, 2004)
- Volume of unique procedures. (Reznick & MacRae, 2006)
- Complexity of modern surgery. (McDougall, 2007)
- Quality of VR technology. (Murphy, 2007)
- Professional Acceptance. (Ziv, 2003)
- Learning from Mistakes. (Ziv, 2005)
- Proficiency-based Medicine. (Murray, 2005)

The Next Step in Training

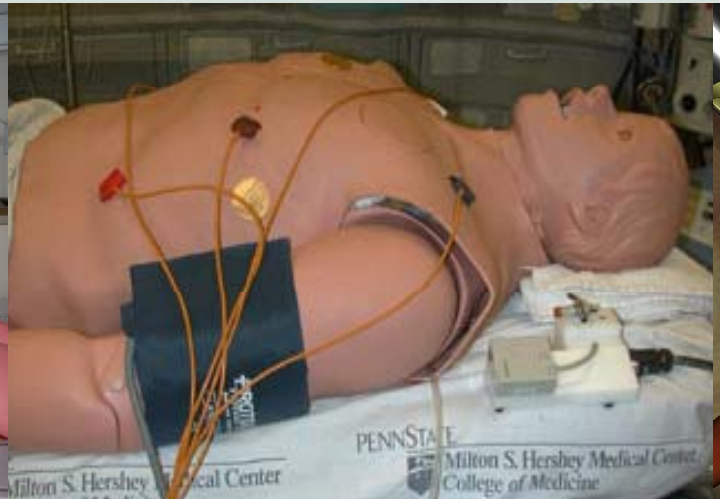
Human

Animal

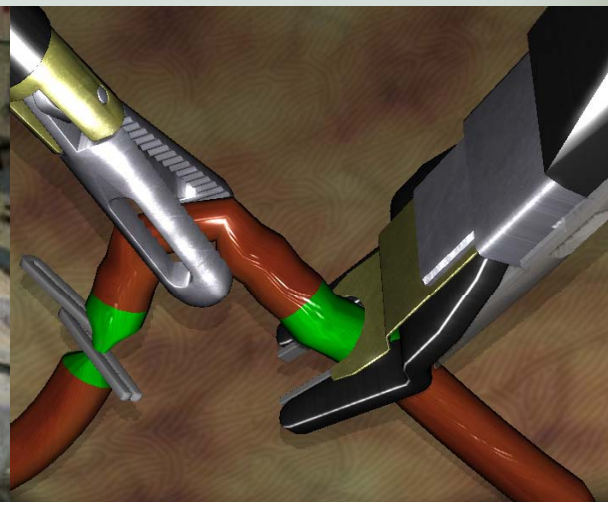
Box Trainer

Mannequin

Simulator



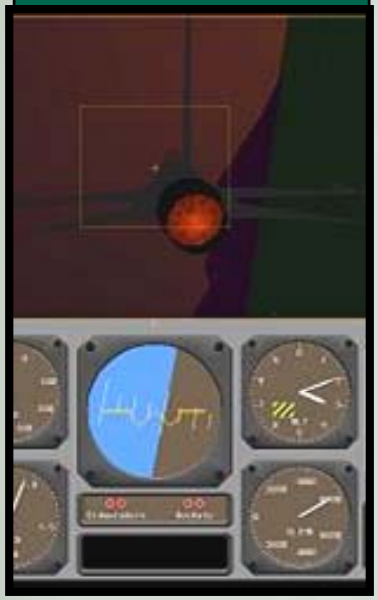
VR/Game Tech



21st Century Simulation

1980's

3D Graphics

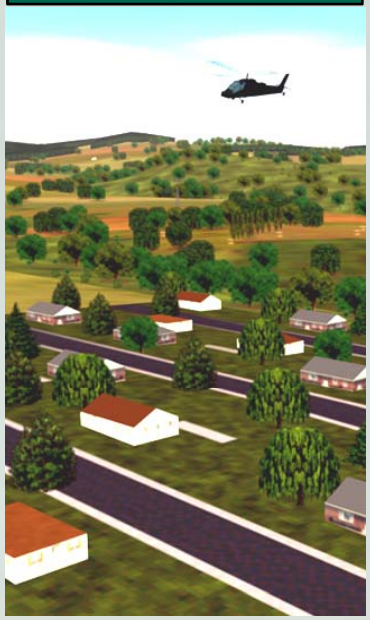


1990's

VR

1990's

Immersive Sim



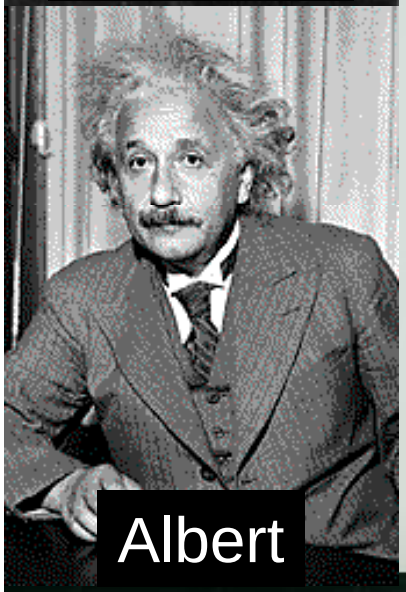
2000's

Game Technology

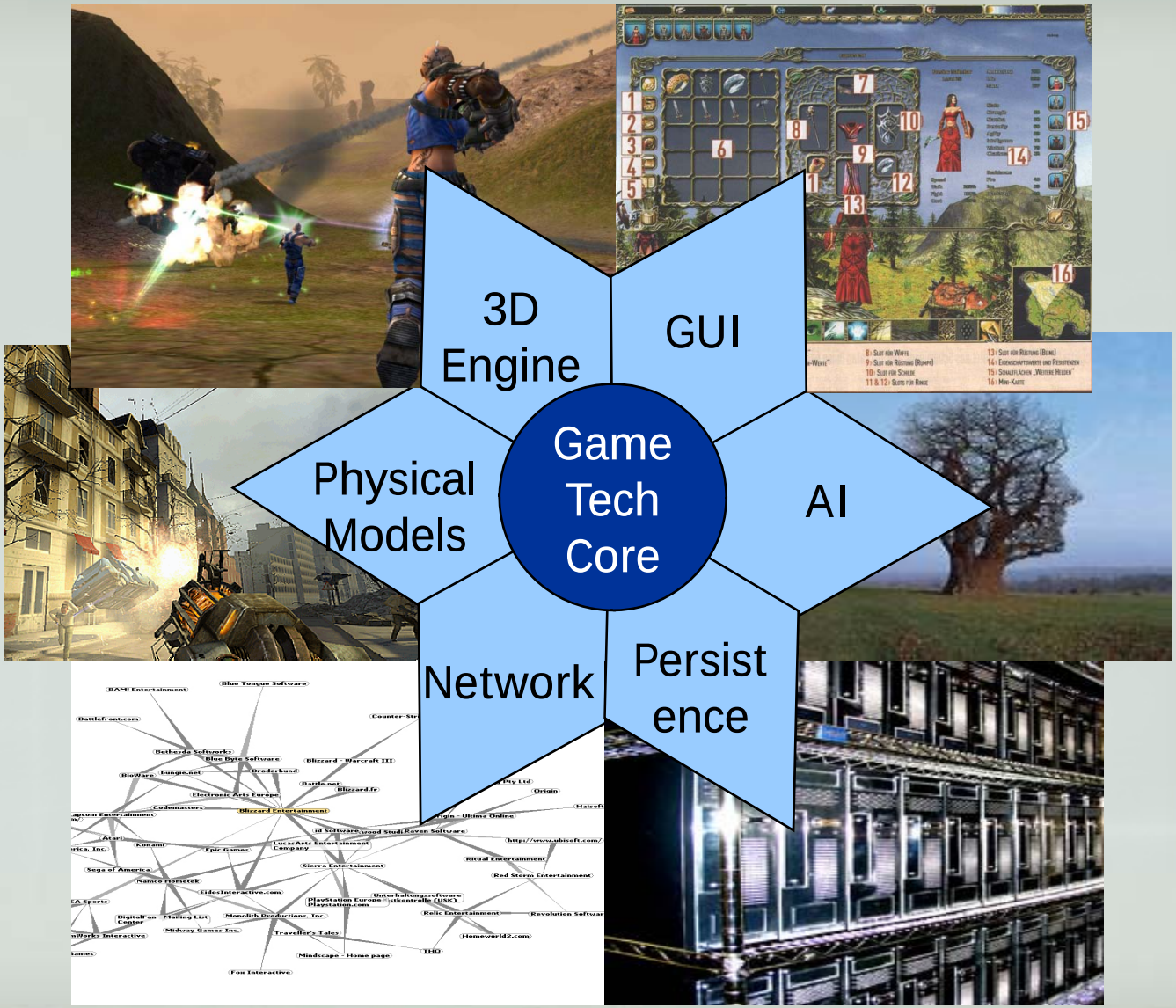
"Nothing endures but change" – Heraclitus, 5th Century BC

Game Technology:
the more successful son of VR

Hermann



Albert



Powerful Motivations

- Motive 1: Lower Cost
- Motive 2: Better Access to Symptoms/Cases
- Motive 3: Reduced Training Time
- Motive 4: Reduced Errors

Similar for Military, Industrial, and Medical Training

Motive 1: Lower Cost

- Teaching students in the OR requires a longer surgery time. (Bridges & Diamond, 1999)
  - Accumulates to 186 hours over a 4 year residency
- The facilities and personnel could be applied to additional revenue generating procedures. (Bridges & Diamond, 1999)
  - Estimate the cost of using the operating room at $257.40 per hour.
  - Adds $47,970 to the cost of medical education.

- Conflicting OR Cost Estimates
  - Cost of the operating room is $1,500 per hour (Frost & Sullivan, 2004)
  - Swedish operating room costs $1,000 per hour (Hyltander, 2003)
  - Rule of Thumb “$250 per 15 minutes” (Satava, 2008)

- Residency Cost may be $186,363 to $279,545

M1: Return on Investment

Category	Description	Fixed Cost	Recurring Over Residency (4 Years)	After Residency (5th Year)	Total over 5 Years
Investment	AccuTouch Simulator	(72,000)	(18,664)	0	(90,664)
Time Savings	Instructor time		23,040	0	23,040
	Additional Procedures		0	114,400	114,400
Reduction in Errors	Complications		0	0	0
	Cancellations		13,600	0	13,600
Faster Time to Competence	Residents generating revenue		78,000	0	78,000
Equipment Breakage	Reduction due to better training		5,428	5,428	10,856
Other Financial Benefits	Reduction in alternative training		4,400	0	4,400
	Revenue from selling time on simulator		93,000	0	93,000
	Total Cost/Benefit	**(72,000)**	**198,804**	**119,828**	**246,632**

Derived from Frost & Sullivan 2004

Motive 2: Better Access

- "The traditional Halstedian apprenticeship model of 'see one, do one, teach one' is no longer adequate to train surgeons, since good laparoscopic skills cannot be developed by merely watching an expert.
- Laparoscopic proficiency is only realized after sufficient practice in the minimally invasive environment. To this end, a variety of approaches have been developed to teach laparoscopic skills outside of the operating room; these methods include practicing on animal models or artificial tissues, training boxes, and virtual reality simulators." (Pearson et al, 2002)
- In laparoscopy, "see one" does not contribute to the learning process. Learning begins with "do one" (Jordan et al, 2001; Gallagher et al, 2001b; Madan & Frantzides, 2007).

M2: Better Access to Symptoms

- Proficiency is reached after 10 to 30 surgeries. Under current teaching methods these occur on animals and live patients. VR systems allow these to be moved off of patients (Grantcharov et al, 2003b and 2004; MacFadyen et al, 1998).

- Repeated practice of procedures, standardized tasks, and objective measurements are all lacking or limited in traditional OR-based training (Grantcharov et al, 2003b and 2004).

- In laparoscopy, observation does little to convey the skills that must be mastered. Only actual practice has been effective at this (Jordan et al, 2001; Gallagher et al, 2001b; Madan & Frantzides, 2007).

Motive 3: Reduced Time

- VR systems can differentiate experienced from inexperienced subjects based on their performance scores (Adamsen et al, 2005).
- MIST-VR simulator can determine which students would never achieve proficiency in laparoscopy and should be dropped from a training program (Gallagher et al, 2004).
- Non-VR trained students are nine times more likely to fail to make progress in their performance than those who use VR in their training (Seymour, 2002).
- Students trained in VR are 29% faster at performing laparoscopic surgeries (Enochsson et al, 2004; and Seymour, 2002).

Motive 4: Reduced Errors

- "There is no excuse for the surgeon to learn on the patient." (William J. Mayo, 1927).
- Laparoscopic surgery has an error rate three times higher than open surgery. Error rate has not decreased over eight years of data. (Huang et al, 2005).
- VR systems can improve performance because surgeons become familiar with the appearance of organs and tissue in a 2D environment (Huang et al, 2005).
- Students trained in VR make up to five times fewer mistakes (Enochsson et al, 2004; and Seymour, 2002).

Conclusion

- There is more evidence that training with computer graphics, VR, and game technology improves medical education than there is for all of military training
  - We spend billions of dollars on this technology for the military
  - We bet soldiers' lives on it
  - There is more evidence that it works in medicine

References (1)

- Cooke, M., Irby, D., Sullivan, W., & Ludmerer, K. (2006, September 28). American medical education 100 years after the Flexner report. *The New England Journal Of Medicine*, *355*(13), 1339-1344.
- Denson JS, Abrahamson S. A computer-controlled patient simulator. *Journal of the American Medical Association* 1969; 208:504–8.
- Satava, R. (2004a, May 19). Disruptive visions: surgical education. *Surgical Endoscopy*, 18(5), 779-781.
- Murphy, J., Torsher, L., & Dunn, W. (2007, March). Simulation medicine in intensive care and coronary care education. *Journal Of Critical Care*, 22(1), 51-55.
- Murray, D., Boulet, J., Kras, J., Woodhouse, J., Cox, T., & McAllister, J. (2004, November). Acute care skills in anesthesia practice: a simulation-based resident performance assessment. *Anesthesiology*, 101(5), 1084-1095.
- McDougall, E. (2007, March). Validation of surgical simulators. *Journal Of Endourology / Endourological Society*, 21(3), 244-247.
- Reznick, R.K. and MacRae, H. (2006, December 21). Teaching surgical skills – changes in the wind. *New England Journal of Medicine*, 355(25), 2664-2669.
- Ziv, A., Ben-David, S., & Ziv, M. (2005, May). Simulation based medical education: an opportunity to learn from errors. *Medical Teacher*, 27(3), 193-199.
- Ziv, A., Wolpe, P., Small, S., & Glick, S. (2003, August). Simulation-based medical education: an ethical imperative. *Academic Medicine: Journal Of The Association Of American Medical Colleges*, 78(8), 783-788.
- Spitzer, V. (1997, Autumn). The visible human: a new language for communication in health care education. *Caduceus*, 13(2), 42-48.
- Dunkin, B., Adrales, G., Apelgren, K., & Mellinger, J. (2007, March 16). Surgical simulation: a current review. *Surgical Endoscopy*, *21*(3), 357-366.
- Davis D, Thomson M, O'Brien M, et al. (1999) Impact of formal continuing medical education: do conferences, workshops, rounds and other traditional continuing education activities change physician behaviour or health care outcomes. *Journal of the American Medical Association*, 282, 867–74.

References (2)

- Birden, H. and Page, S. (2007, August). 21st century medical education. *Australian Health Review*, 31(3), 341-350.
- Hyltander, A. (2003, June). Simulation as a teaching alternative: Utopia or reality. *CAL-aborate*, 10. Retrieved May 1, 2008 from http://science.uniserve.edu.au/pubs/callab/vol10/hyltand.html.
- Frost & Sullivan. (2004). Return on investment study for medical simulation training: Immersion Medical, Inc. Laparoscopy AccuTouch System. Industrial research report available at: http://www.immersion.com/medical/products/laparoscopy/roi/FS_IMMRmed_laparoscopy_ROI_V2.pdf
- Gallagher, H., Allan, J., & Tolley, D. (2001b, November). Spatial awareness in urologists: are they different?. *BJU International*, *88*(7), 666-670.
- Grantcharov, T., Bardram, L., Funch-Jensen, P., & Rosenberg, J. (2003b, July 6). Impact of hand dominance, gender, and experience with computer games on performance in virtual reality laparoscopy. *Surgical Endoscopy*, *17*(7), 1082-1085.
- Jordan, J., Gallagher, A., McGuigan, J., & McClure, N. (2001, October). Virtual reality training leads to faster adaptation to the novel psychomotor restrictions encountered by laparoscopic surgeons. *Surgical Endoscopy*, *15*(10), 1080-1084.
- Madan, A., & Frantzides, C. (2007, January). Substituting virtual reality trainers for inanimate box trainers does not decrease laparoscopic skills acquisition. *JSLS: Journal Of The Society Of Laparoendoscopic Surgeons / Society Of Laparoendoscopic Surgeons*, *11*(1), 87-89.
- MacFadyen, B., Vecchio, R., Ricardo, A., & Mathis, C. (1998, April). Bile duct injury after laparoscopic cholecystectomy. The United States experience. *Surgical Endoscopy*, *12*(4), 315-321.
- Brunner, W., Korndorffer, J., Sierra, R., Dunne, J., Yau, C., Corsetti, R., et al. (2005, January). Determining standards for laparoscopic proficiency using virtual reality. *The American Surgeon*, *71*(1), 29-35.
- McClusky, D., Ritter, E., Lederman, A., Gallagher, A., & Smith, C. (2005, January). Correlation between perceptual, visuo-spatial, and psychomotor aptitude to duration of training required to reach performance goals on the MIST-VR surgical simulator. *The American Surgeon*, *71*(1), 13.

References (3)

- Bridges, M., & Diamond, D. (1999, January). The financial impact of teaching surgical residents in the operating room. *American Journal Of Surgery*, *177*(1), 28-32.
- Grantcharov, T., Kristiansen, V., Bendix, J., Bardram, L., Rosenberg, J., & Funch-Jensen, P. (2004, February). Randomized clinical trial of virtual reality simulation for laparoscopic skills training. *The British Journal Of Surgery*, *91*(2), 146-150.
- Adamsen, S., Funch-Jensen, P., Drewes, A., Rosenberg, J., & Grantcharov, T. (2005, February 2). A comparative study of skills in virtual laparoscopy and endoscopy. *Surgical Endoscopy*, *19*(2), 229-234.
- Enochsson, L., Isaksson, B., Tour, R., Kjellin, A., Hedman, L., Wredmark, T., et al. (2004, November). Visuospatial skills and computer game experience influence the performance of virtual endoscopy. *Journal Of Gastrointestinal Surgery: Official Journal Of The Society For Surgery Of The Alimentary Tract*, *8*(7), 876.
- Seymour, N., Gallagher, A., Roman, S., O'Brien, M., Bansal, V., Andersen, D., et al. (2002, October). Virtual reality training improves operating room performance: results of a randomized, double-blinded study. *Annals Of Surgery*, *236*(4), 458.
- Huang, J., Payandeh, S., Doris, P., & Hajshirmohammadi, I. (2005). Fuzzy classification: towards evaluating performance on a surgical simulator. *Studies In Health Technology And Informatics*, *111*, 194-200.
- Institute of Medicine (1999). *To err is human: Building a safer health system*. Washington, D.C.: National Academy Press.
- Eastridge, B., Hamilton, E., O'Keefe, G., Rege, R., Valentine, R., Jones, D., et al. (2003, August). Effect of sleep deprivation on the performance of simulated laparoscopic surgical skill. *American Journal Of Surgery*, *186*(2), 169-174.

For the Complete Study

- "Investigating the Disruptive Effect of Computer Game Technologies on Medical Education and Training"
  - Roger Smith, August 2008
  - http://www.modelbenders.com/papers/RSmith_Maryland_Dissertation.pdf