Educational Gaming and Simulation: Current Research and Efforts in Assessment
Prepared by Barton Pursel
Undergraduate Education and Instructional Researcher
The Schreyer Institute for Teaching Excellence

Special thanks to Jimmy Xie, Graduate Assistant

NOTE: this packet was primarily created for faculty interested in the assessment of educational games and simulations, but does contain general resources as well.

Introduction

This document is meant to serve as a starting point for researchers interested in designing, developing, implementing and/or assessing the use of an educational game or simulation. The document includes a variety of resources, including several recent articles related to educational gaming and simulation, article summaries, variables from past research, Penn State University-specific resources and a short summary of efforts in serious game validation. The table of contents below will guide you to each section. If you have any questions or comments, please email them to Bart Pursel (pursel@psu.edu).

Contents

The Schreyer Institute for Teaching Excellence
The Pennsylvania State University

Current Research

This section details current research in the field of educational gaming and simulation use. This section is simply a snapshot of relevant research based on current requests from Penn State Faculty: this is NOT an exhaustive literature review. Included below are several meta-analysis, that do cover a wide variety of research topics related to educational gaming and simulation use.

Meta-analysis

(Kebritchi and Hirumi 2008) – This articles examines 50 articles and 55 educational games as part of an analysis of pedagogy as it relates to modern computer games. The value of the analysis is in linking specific game examples to specific pedagogies, which should help efforts in future educational game design.

(Vogel, Vogel et al. 2006) – The authors from Central Florida provide an investigation of traditional teaching methods compared to the use of games and simulations for learning. The article provides a wide variety of variables that past researchers examined, as well as characteristics (such as gender) that may have in impact on learner gains when using interactive technology.

(O'Neil, Wainess et al. 2005) – This article focuses specifically on linking learning outcomes models to computer games, through a review of relevant literature. Two theoretical frameworks represent the focus: Kirkpatrick's levels of evaluation and the CRESST model of learning. These two frameworks represent the lens the authors use to analyze outcomes claimed in past journal articles related to games and learning.

(Gosen and Washbush 2004) – Gosen and Washbush provide an extensive overview of literature examining various assessment methodologies for measuring the effectiveness of experiential learning. Validity of measures and critiques are offered.

Assessment

(Clarke-Midura and Dede 2010) – Chris Dede has been involved in the use of immersive technologies for learning for over a decade. Along with Clarke-Midura, this article provides a close examination of assessment strategies used with technology (heavy on examples of technology implementations), then focuses on much of Dede's early work in immersive virtual worlds for education to help develop a framework for 'virtual performance assessments'.

(Feinstein 2001) – This article is a specific research study focusing on the assessment of a simulation used in foodservice education. The author not only focuses on the assessment, but provides a nice narrative of the entire process, from the design, development and implementation of the simulation through to the variables of measure and the assessment outcomes.

Variables

Some of the articles above provide a snapshot of some variables of focus in educational gaming and simulation studies. The table below lists specific variables and citations to studies that focus on those variables.

The Schreyer Institute for Teaching Excellence
The Pennsylvania State University

Variable	Citation(s)	Notes
Group/Team cohesion	(Glass and Benshoff 2002)	Not necessarily a game article, but does contain an instrument to measure group cohesion.
Motivation	(Wang and Reeves 2007)	Includes Likert-type scale to measure motivation.
Learning styles	(Rapeepisarn, Wong et al. 2008)	Article deals with matching genres of games to learning styles.
Satisfaction	(Hiltz, Fjermestad et al. 2006)	Used to measure satisfaction in virtual teams, B. Pursel modified to measure satisfaction while using a 3D virtual world.
Teaching methods (comparisons)	(Bayraktar 2001; Laffey, Espinosa et al. 2003; Hoadley 2009)	Most of these articles show up in the (Vogel, Vogel et al. 2006) meta-analysis, comparing games to various other teaching methods.
Interactivity and media richness	(Wong, Shen et al. 2007)	Study examines the effectiveness of various instructional methods, including a game, replay, hypertext and text.
Social presence	(Kort, IJsselsteijn et al. 2007)	The article argues that games be a form of social presence technology, and the authors offer the development of a self-report measure of social presence called the "Social Presence in Gaming Questionnaire"

Research Instruments
Below are a handful of instruments used in past studies related to some of the variables above.

Glass and Benshoff's (2002) Group cohesion
Please tell us which of the following statements best describe you and your group

	Not at all like my group	A little like me/my group	A lot like me/my group	Exactly like me/my group
We get along well together				
We feel good about our team				
We enjoy helping each other				

We stick together during challenges				
I feel like my group will keep me safe				
We encourage each other in the challenges				
I feel like I fit in my group				
I want to work on more challenges with my group				
We help each other on the challenges				

Wang and Reeve's (2007) motivation questions

Quality and quantity of learning	S. disagree	Disagree	Neutral	Agree	S. Agree
The [sim/game] software helped me complete my assignment					
The software provided me with enough information to do the assignment					
I am satisfied with the quality of information that I received about _____ through this software					
Using software, like the [game/sim] software, to learn about [topic] is boring					
My motivation to learn about [topic] is greater than my motivation to learn about most other units					
I hope teachers will use more software like this in my courses					
Figuring out the path I already completed was difficult					
The screen design was appealing					
I understand the different conditions of [topic] after using the software					

(Burke and Chidambaram 1999) Social Presence scales

This scale is a 7-pt. Likert scale

I would classify my interactions with my team as	Cold	Warm
I would classify my interactions with my team as	Insensitive	Sensitive
I would classify my interactions with my team as	Impersonal	Personal
I would classify my interactions with my team as	Unsociable	Sociable
I would classify my interactions with my team as	Distant	Close
I would classify my interactions with my team as	Unexpressive	Expressive
I would classify my interactions with my team as	Unemotional	Emotional

Penn State Specific Resources

Penn State contains several resources related to gaming and simulation use. Below is a list of resources that may assist in the design, development and implementation of educational games and simulations.

Educational Gaming Commons (EGC) – This is a university-wide service initiative from Education Technology Services. The initiative is staffed with instructional designers and programmers that work on various faculty projects through the EGC's engagement initiative. The EGC also operates and maintains a gaming lab, located in Findlay Commons 6A. This lab contains 8 PCs with current gaming software as well as stations with all the major gaming consoles and popular games. Faculty can reserve the room for both teaching and research purposes. Contact gaming@psu.edu for more information.

Schreyer Institute for Teaching Excellence (SITE) – The Schreyer Institute offers Teaching Support Grants each spring semester. These grants allow instructors to propose specific projects related to teaching and learning, such as the design, implementation or assessment of a wide variety of teaching innovations. Past winners have included faculty interested in designing and implementing educational games. Information on the grant process can be found on the Institute's website:
http://www.schreyerinstitute.psu.edu/Grants/
Email pursel@psu.edu for more information.

Courses related to games – Penn State does not offer any specific program around game design or game development. To date, courses are offered in the College of IST (IST 446), Visual Arts and Communications, all dealing with games. The IST course focuses on game design, while the communications courses focus on the business and communicative aspects of video games. Visual Arts, specifically the interdisciplinary digital studio (iDS) program, offers courses on such topics as concept art and 3D animation, and many courses allow students to focus on games as the context for course projects.

Gaming clubs on campus – Penn State has a wide variety of gaming clubs on campus. Some of the clubs that are directly or indirectly related to gaming include:

- IST game design club - http://gdc.ist.psu.edu/
- Urban Gaming Club - http://urbangaming.org/
- Association for Computer Machinery - http://www.psu-acm.org/
- The gaming association of penn state (GAPS) - http://www.clubs.psu.edu/up/gaps/

More clubs likely exist, including a group of students working on various mods (modifications) of games including building parts of Penn State University in various game platforms, such as Source.

The Schreyer Institute for Teaching Excellence
The Pennsylvania State University

Journals and Organizations

Below is a list of journals and organizations that have interest in simulations and games in education. Most of the organizations below host annual or special-interest conferences. This is not an exhaustive list. For a larger list of educational technology journals (including RSS feeds for most journals), check http://edtechdev.wordpress.com/journals/.

Journals:
1. Simulation & Gaming - http://sag.sagepub.com/
2. Educational Technology, Research and Development - http://www.aect.org/Intranet/Publications/index.asp
3. Journal of Technology Research - http://www.aabri.com/jtr.html
4. Journal on Research and Technology in Education - http://www.iste.org/Content/NavigationMenu/Publications/JRTE
5. Technology, Pedagogy and Education - http://www.informaworld.com/smpp/title~content=t716100724

Organizations and special interest groups with an interest in games and simulations for learning:
1. Educause - http://www.educause.edu/
2. The Serious Games Initiative - http://www.seriousgames.org/
3. New Media Consortium - http://www.nmc.org/
4. Games, Learning and Society - http://www.gameslearningsociety.org/
5. North American Simulation and Gaming Association - http://www.nasaga.org/

The Schreyer Institute for Teaching Excellence
The Pennsylvania State University

Validation research for educational games and simulations

By Jimmy Xie and Bart Pursel
Graduate Assistant
The Schreyer Institute for Teaching Excellence

Brief Introduction

Simulations and games have been used by educators to supplement traditional teaching for more than 40 years, yet little research has been conducted to validate this approach. According to several scholars, assessment of educational effectiveness is an important issue in the field of simulations and games in education. A reasonable number of past studies attempted to assess the effectiveness of simulations and games in education. Unfortunately, except a very few studies, such attempts at validation have not been very vigorous.
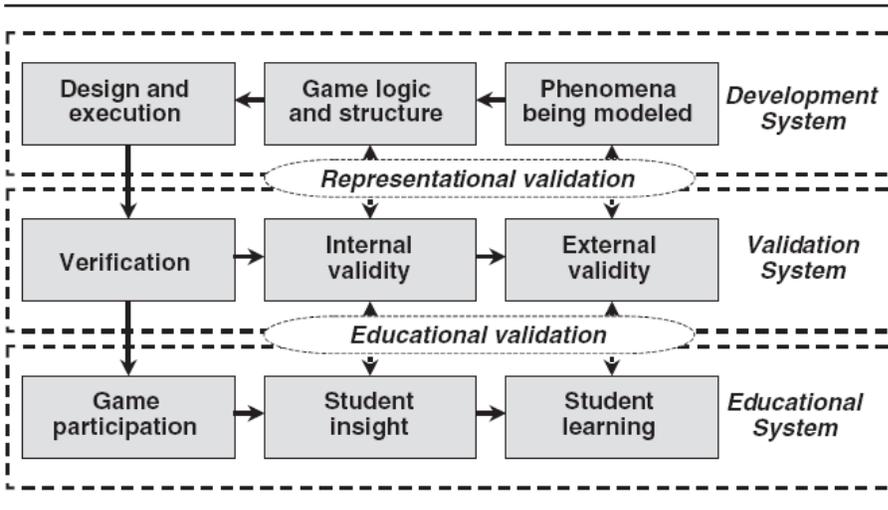
Concept and Types of SG Validation

FIGURE 3:   Two Patterns of Simulation Game Validation

Source: (Feinstein and Cannon 2002)

The Schreyer Institute for Teaching Excellence
The Pennsylvania State University

		Target of validation	
		System	**Education**
Context	**Internal**	Internal representational validity	Internal educational validity
	External	External representational validity	External educational validity

Note: Internal validity is the basis for external validity

Representational Validation

Representational validation refers to the process of assessing the game/simulation system development.

Internal representational validation

Internal representational validity refers to whether the game/simulation functions as it is intended to. Examples:

- Whether the change in one condition effectively cause the change in another condition (i.e., the pre-specified cause-effect relationship)
- Whether the game/simulation provide all the pre-specified scenario information

External representational validation

External representational validity indicates whether the game/simulation design and function corresponds to the relevant phenomena outside the simulation/game (i.e., real world situation).

Example:

- Whether the decision factors included in a game/simulation are similar to those in the real world
- Whether the cause-effect, or interactive relationships specified in the game/simulation resembles to those in the real world

Educational Validation

Educational validation refers to the process of assessing learning resulting from the game/simulation.

Internal educational validation

Internal educational validity indicates to what extent learners achieve the learning/performance/skills expected by the game/simulation (e.g., decision-making skill, prediction accuracy, cooperation, motivation). Or in other words, to what extent does the game/simulation influence the learners in terms of achieve the learning/performance/skills as intended or expected. The measures can be either the performance indicator provided by the game/simulation (e.g., total sales, total profit), or the ones designed based on the expected outcomes from the game/simulation.

Example:

- Whether the SG improve students' motivation to learn consumer behavior as intended
- Whether SG improves students' knowledge about different stakeholders in health care system

External educational validation

External educational validation refers to whether the learning/skills expected by the game/simulation matters or relevant in the real world?

Example:

- Whether the game/simulation performance correlates to the individual career success
- Whether the characteristics of a successful user of a game/simulation correlate to those of successful individuals in the real world?

Representational validity is the basis of educational validity. However, a high representational validity does not necessarily lead to high educational validity. On the contrary, high representational validity (e.g., high fidelity and complexity) may lead to low educational validity (i.e., poor learning) for certain learners.

Some people may approach the validation in a simpler way by assessing the game/simulation in terms of a series of desirable learning outcomes/skills, and see which one(s) the game/simulation is effective in improving.

A further step for educational validation

How does the educational validity of games/simulations correlate to traditional pedagogy methods?

The Schreyer Institute for Teaching Excellence
The Pennsylvania State University

Four Important Issues in game/simulation Assessment (Gosen and Washbush 2004)

1) Design issue: pre-post test, experimental, quasi-experimental design, randomization.

2) Incomplete definition of the nature of learning and a lack of systematic efforts to obtain these objective measurements. The best way to assess these approaches is by defining what is to be learned from a teaching objectives standpoint and by developing objective measures of the construct to detect if the participants learned what they were supposed to from the experience.

3) The third prescription regarding measurement is that learning measures should be tied to explicit learning goals.

4) The measures should be valid.
   - Show evidence of reliability between the results obtained at one time to those obtained later when applied to the same subject.
   - Be able to discriminate between individuals possessing different skills or performance levels.
   - Show convergence with other instruments measuring the same constructs.
   - Yield normative scores for different populations.

Possible Research Design (for Educational Validation)

Experimental/Quasi-Experimental design

   - Within-subject pre-post test (Gentry et al 2001)
   - Between-subject post test design (i.e., control vs. treatment groups)
   - Between-subject and within-subject mixed design
   - Control of covariates during the comparison (e.g., GPA)

Qualitative design

   - Note taking from game/simulation facilitator and his/her assistant(s)
   - Videotape the proceeding of the game/simulation
   - Reflection paper/journal writing (Petranek, Corey et al. 1992; Petranek 2000)

Measurement (for Educational Validation)

<u>Experiential Learning</u>

   - Objective learning test (Blake 1990; Burns, Rubin et al. 1990; Spect and Sandlin 1991; Gentry, Iceton et al. 2001; Premi and Shannons 2001)
   - Skills/learning proposed/expected by the SG (e.g., forecasting skill, elementary skill)

The Schreyer Institute for Teaching Excellence
The Pennsylvania State University

- Theory-based objective test (Burns, Rubin et al. 1990)based upon Bloom's cognitive domain taxonomy; (Kraiger, Ford et al. 1993)
- Perceived learning measures (Dedeke 1999; James 2000; Rocha 2000; Beaumie, Williams et al. 2002)
- Behavioral measures (i.e., students' behavior or actions in and out of class after SG)(Herbert and Landin 1996; Gentry, Iceton et al. 2001)
- Other measures
  - Confidence (Manoque, Brown et al. 1999)
  - Enjoyment (Dedeke 1999)
  - Moral reasoning (Smith, Strand et al. 2002)
  - Group cohesion (Glass and Benshoff 2002)
  - Self regulation and peer self-esteem (Nichols and Steffy 1999)

Simulation/Gaming

- Course exam on different topics (Raia 1966; Whiteley and Faria 1989; Faria and Whiteley 1990; Wellington and Faria 1991)
- Essay exams policy making principles and facts (Wolfe and Guth 1975; Gosen, Washbush et al. 1999)
- Game inherent learning goals (Scott, Strickland et al. 1992; Gosen, Washbush et al. 1999; Gosen, Washbush et al. 2000; Gosen and Washbush 2004) self-report learning do not covariate with learning score.
- General theory-based learning measurement + game inherent learning goals (Bloom, Englehart et al. 1956; Feinstein 2001)
- Perception of learning: (Comer and Nichols 1996; Herz and Merz 1998; McHaney, White et al. 2002)
- Attitude toward simulation, course, and curriculum (Leonard and Leonard 1995)
  - Self-efficacy(Tompson and Dass 2000)
  - Perception of course structure, game parameters, and effort and performance exerted (Hergert and Hergert 1990)
  - Satisfaction (Washbush and Gosenpud 1991; White and Riesen 1992)
  - Survey of the curriculum (Zalatan and Mayer 1999)

Potential Research Questions

- Assess the effectiveness of SG in promote student learning
- Examine the group differences in terms of learning from SG
- Examine the relationships between perception of various SG attributes and learning
- Can assess the relationships between latent individual psychographics (e.g., tech-savvy, need for interaction, etc.) and learning from SG.
- Can assess the relationships between the students' other behavioral characteristics and learning from SG.
- Since the game was only a part of the course, then a possibility could be using a control vs. treatment group. Some received GS first and others traditional first

References

Bayraktar, S. (2001). "A meta-analysis of the effectiveness of computer-assisted instruction in science education." Journal of Research on Technology in Education **34**(2): 173-188.

Beaumie, K., R. Williams, et al. (2002). "Student perceptions of interactive learning modules." Journal of Research on Technology in Education **34**: 453-473.

Blake, C. G. (1990). "The effects of instructional strategies on the learning of organizational theory by a large university class." Journal of Instructional Psychology **17**: 59-64.

Bloom, B. S., M. D. Englehart, et al. (1956). Taxonomy of educational objectives: The classification of educational goals, Handbook 1: The cognitive domain. New York, David McKay.

Burke, K. and L. Chidambaram (1999). "How much bandwidth is enough? A longitudinal examination of media characteristics and group outcomes." MIS Quarterly **23**(4): 557-579.

Burns, A. C., R. S. Rubin, et al. (1990). "Computer-aided exercises vs. workbook exercises as learning facilitator in the principles of marketing course." Developments in Business Simulation and Experiential Exercises **17**(29-33).

Clarke-Midura, J. and C. Dede (2010). "Assessment, Technology, and Change." Journal on Research and Technology in Education **42**(3): 309-328.

Comer, L. B. and J. A. F. Nichols (1996). "Simulation as an aid to learning: How does participation influence the process?" Developments in Business Simulation and Experiential Exercises **23**: 8-14.

Dedeke, A. (1999). "Design, integration, and student evaluation of response papers in an introductory management course." Journal for Education of Business **77**: 211-214.

Faria, A. J. and T. R. Whiteley (1990). "An empirical evaluation of the pedagogical value of playing a simulation game in a principles of marketing course." Developments in Business Simulation and Experiential Exercises **17**: 53-57.

Feinstein, A. H. (2001). "An assessment of the effectiveness of simulation as an instructional system in foodservice." Journal of Hospitality & Tourism Research **25**(4): 421-443.

Feinstein, A. H. and H. M. Cannon (2002). "Constructs of simulation evaluation." Simulation & Gaming **33**(4): 425-440.

Gentry, M., J. Iceton, et al. (2001). "Managing challenging behavior in the community: Methods and results of interactive staff training." Health & Social Care in the Community **9**: 143-150.

Glass, J. S. and J. M. Benshoff (2002). "Facilitating group cohesion among adolescents through challenge course experiences." Journal of Experiential Education **25**(2): 268-277.

The Schreyer Institute for Teaching Excellence
The Pennsylvania State University

Gosen, J. and J. Washbush (2004). "A review of scholarship on assessing experiential learning effectiveness." Simulation & Gaming **35**(2): 270-293.

Gosen, J., J. Washbush, et al. (1999). "A test bank for measuring total enterprise simulation learning." Developments in Business Simulation and Experiential Exercises **25**: 82-92.

Gosen, J., J. Washbush, et al. (2000). "Initial data on a test bank assessing total enterprise simulation learning." Developments in Business Simulation and Experiential Exercises **26**: 166-171.

Herbert, E. P. and D. Landin (1996). "Practice schedule effects on the performance and learning of low- and high-skilled students: An applied study." Research Quarterly for Exercise and Sport **67**: 52-58.

Hergert, M. and R. Hergert (1990). "Factors affecting student perceptions of learning in a business policy game." Developments in Business Simulation and Experiential Exercises **17**: 92-96.

Herz, B. and W. Merz (1998). "Experiential learning and the effectiveness of economic simulation games." Simulation & Gaming **29**: 238-250.

Hiltz, S. R., J. Fjermestad, et al. (2006). Asynchronous virtual teams: Can software tools and structuring of social processes enhance performance? Human-Computer Interaction and Management Information Systems: Applications. D. Galletta and P. Zhang. New York, M.E. Sharpe.

Hoadley, T. A. (2009). "Learning advanced cardiac life support: A comparison study of the effects of low- and high-fidelity simulation." Nursing Education Perspectives **30**(2): 91-95.

James, P. (2000). "The influence of a period of environment oriented work on students' perception of their learning style." Environmental Education Research **6**: 157-165.

Kebritchi, M. and A. Hirumi (2008). "Examining the pedagogical foundations of modern educational computer games." Computers & Education **51**: 1729-1743.

Kort, Y. A. W. d., W. A. IJsselsteijn, et al. (2007). Digital games as social presence technology: Development of the social presence in gaming questionnaire (SPGQ). PRESENCE 2007 Conference, Barcelona.

Kraiger, K., J. K. Ford, et al. (1993). "Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation." Journal of Applied Psychology **78**(2): 311-328.

Laffey, J. M., L. Espinosa, et al. (2003). "Supporting learning and behavior of at-risk young children: Computers in urban education." Journal of Research on Technology in Education **35**(4): 423-441.

Leonard, T. L. and N. J. Leonard (1995). "Graduates' views on the use of computer simulation games versus cases as pedagogical tools." Developments in Business Simulation and Experiential Exercises **22**: 83-87.

The Schreyer Institute for Teaching Excellence
The Pennsylvania State University

Manoque, M., G. A. Brown, et al. (1999). "Improving student learning in root canal treatment using self-assessment." International Endodontic Journal **32**: 397-405.

McHaney, R., D. White, et al. (2002). "Simulation project success and failure: Survey findings." Simulation & Gaming **33**: 49-66.

Nichols, J. D. and B. E. Steffy (1999). "The evaluation of success in an alternative learning programme: Motivational impact vs. completion rate." Educational Review **51**: 207-219.

O'Neil, H. F., R. Wainess, et al. (2005). "Classification of learning outcomes: evidence from the computer games literature." The Curriculum Journal **16**(4): 455-474.

Petranek, C. (2000). "Written debriefing: The next vital step in learning with simulations." Simulation & Gaming **31**(1): 108-118.

Petranek, C., S. Corey, et al. (1992). "Three levels of learning in simulatoins: Participating, debriefing, and journal writing." Simulation & Gaming **2**(23): 174-185.

Premi, J. and S. I. Shannons (2001). "Randomized controlled trial of an educational program for individualized learning." Journal of Continuing Educaion in Health Professions **17**: 245-249.

Raia, A. P. (1966). "A study of the educaitonal value of management games." Journal of Business **39**: 339-352.

Rapeepisarn, K., K. W. Wong, et al. (2008). The relationship between game genres, learning techniques and learning styles in educational computer games. Technologies for E-Learning and Digital Entertainment Nanjing, China.

Rocha, C. J. (2000). "Evaluating experiential teaching methods in a policy practice course: The case for service learning to increase political participation." Journal of Work Education **36**(53-63).

Scott, T. W., A. J. Strickland, et al. (1992). MICROMATIC: A management simulation. Boston, Houghton Mifflin.

Smith, C. A., S. E. Strand, et al. (2002). "The influence of challenge course participation on moral and ethical reasoning." Journal of Experiential Education **25**: 278-280.

Spect, L. B. and P. K. Sandlin (1991). "A comparison of the effects of experiential learning activities and traditional lecture classes." Developments in Business Simulation and Experiential Exercises **17**: 214.

Tompson, G. H. and P. Dass (2000). "Improving students' self-efficacy." Simulation & Gaming **31**: 22-41.

Vogel, J. J., D. S. Vogel, et al. (2006). "Computer gaming and interactive simulations for learning: a meta-analysis." Journal of Educational Computing Research **34**(3): 229-243.

The Schreyer Institute for Teaching Excellence
The Pennsylvania State University

Wang, S.-K. and T. C. Reeves (2007). "The effects of a web-based learning environment on student motivation in a high school earth science course." Educational Technology, Research and Development **55**(2): 169-192.

Washbush, J. B. and J. Gosenpud (1991). "Student attitudes about policy course simulation." Developments in Business Simulation and Experiential Exercises **18**: 105-110.

Wellington, W. J. and A. J. Faria (1991). "An investigation of the relationship between simulation play, performance level and recency of play on exam scores." Developments in Business Simulation and Experiential Exercises **18**: 111-115.

White, C. S. and R. D. V. Riesen (1992). "Computer management and some correlates of student's satisfaction." Developments in Business Simulation and Experiential Exercises **19**: 225.

Whiteley, T. R. and A. J. Faria (1989). "A study of the relationship between student final exam performance and simulation game participation." Simulation & Games **20**: 44-64.

Wolfe, J. and G. Guth (1975). "The case approach vs. gaming in the teaching of business policy: An experimental evaluation." Journal of Business **48**: 349-364.

Wong, W. L., C. Shen, et al. (2007). Serious video game effectiveness. Proceedings of the international conference on advances in computer entertainment technology, Slazburg, Austria, ACM.

Zalatan, K. A. and D. F. Mayer (1999). "Developing a learning culture: Assessing changes in student performance and perception." Developments in Business Simulation and Experiential Exercises **26**: 45-51.

The Schreyer Institute for Teaching Excellence
The Pennsylvania State University