SIMULATION AND ADVANCED GAMING ENVIRONMENTS: EXPLORING THEIR LEARNING IMPACTS

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ABSTRACT

This paper describes a Pan-Canadian, bilingual, four-year research project investigating the potential of Simulations and Advanced Gaming Environments (SAGEs) to support learning, particularly in light of our knowledge of cognition and learning processes. Project researchers are developing and testing applications in health-related learning for learners including students of medicine and the health professions, teachers, K-12 students, patients, community health workers and the public. Foundational research is investigating conceptual foundations for SAGEs for learning; methodologies and tools for evaluating their learning impact; and leading-edge technologies to support the collaborative, online use of SAGEs including the Internet, handheld devices and wireless technologies. The major outcomes of this initiative will be advances in and widespread dissemination of knowledge and best practices for SAGE-based learning support.

INTRODUCTION

This paper describes "Simulation and Advanced Gaming Environments (SAGE) for Learning," a bilingual, Pan-Canadian Collaborative Research Initiative funded primarily by Canada's Social Sciences and Humanities Research Council (SSHRC) with additional funding from the CANARIE Inc. Advanced Applications Program.

Funded for over $3 million over four years, the SAGE for Learning network (www.sageforlearning.ca) brings together 26 Canadian university-based researchers across 14 institutions in education, cognitive psychology, computer science, educational technology, new digital media, and research/ evaluation methodologies. The project also has 28 key Canadian and international partners. Together, network members are working toward greater theory- and practice-based understanding of the uses of SAGEs to support learning.

The SAGE for Learning network is collaborating closely with partner SAVIE (Société d'apprentissage à vie) Inc. (www.savie.qc.ca) and its Educational Games Central network (http://egc.savie.ca), both hosted in Quebec and directed by Dr. Louise Sauvé (SAGE network Co-Leader). SAVIE has been active for over ten years in research and development projects related to core competencies and creating web-based simulations and games.

PROJECT OBJECTIVES

SAGE for Learning`s research objectives are:

- to build and validate a *common multidimensional taxonomy and conceptual framework* to guide SAGE research;

- to describe the *types and characteristics of learning* that take place through the use of SAGEs;
- to identify, observe, document and model *key cognitive and social processes* that develop, promote or hinder learning in SAGEs;
- to study the capacity of SAGEs to *support learning as described by key learning theories* through adaptation and creation of simulations and games for specific learner groups and tasks;
- to develop and implement *research methodologies and tools* appropriate for describing and assessing SAGE learning processes and outcomes;
- to demonstrate the *application of knowledge* resulting from our research on SAGE impacts in the development, implementation, and testing of prototype SAGEs;
- to pilot the *implementation* of SAGEs in authentic contexts, e.g. schools, businesses, and community settings;
- to study and evaluate the processes and activities that facilitate and support networking and achievement of the short, medium and long-term goals of the SAGE-SRC.

The major outcomes of this initiative will be advances in and widespread dissemination of knowledge and best practices for SAGE-based learning support, specifically including guidelines and methods for (1) SAGE design and testing within the context of learning situations, goals, and models; (2) adaptation of educational methods to include SAGEs; (3) selection of complementary SAGEs and instructional methods using our new taxonomy, and (4) training of Highly Qualified People.

BACKGROUND

The terms "game" and "simulation" have been used somewhat interchangeably in the education and gaming literature, although researchers have attempted to differentiate them and to describe specific characteristics of each which affect learning. Following Crookall et al. (1987), Garris et al. (2002), and Stolovitch (1981), we distinguish among three broad types of activities: (1) *games* - activities that do not attempt to replicate reality, have clearly defined sets of rules including scoring systems, and produce winners and losers; (2) s*imulations* – activities that include exploration and practice within models of reality but without competition, scoring, and winners/ losers; and (3) s*imulation games* - games that are based on simplified but dynamic models of aspects of reality. We believe that this distinction will be useful in creating a conceptual framework that describes and distinguishes these SAGEs.

The phrase "simulation and advanced gaming environments" reflects the transformation that is taking place as games and simulations incorporate new technologies. SAGEs can employ sophisticated, detailed virtual reality representations of physical settings, as in many of today's commercial video games; wireless handheld devices or cell phones that allow instant communication and feedback (e.g., Danesh et al. 2001); game boxes to bring games to the family living room; Internet-based multiplayer games; head-mounted displays; or 3D immersive CAVE environments. Moreover, video game SAGEs have become attractive, even addictive, fixtures of popular culture and vehicles for commercially and politically-motivated "learning" (e.g. Skyworks Technologies 2005, Soussi 2003). The appeal of these technologies fuels our curiosity about their potential to support game- and simulation-based learning.

A number of perspectives provide arguments for the importance of simulations and games for learning, including:

- **Games and technology in our culture:** Understanding learning through games and simulations is important because we face major questions about how our technology-supported education approaches should evolve. Simulations and games are now major forms of entertainment, taking potential learners' time and attention away from books and other media (Livingstone 2002). Global video game sales soared by 25% to $US23 billion in 2003 (USA Today 2005). A

2002 US survey found that at that time, 92% of children and adolescents ages 2-17 played video games, and more than two-thirds of all children ages 2 to 18 lived in a home with a video game system (Kaiser Family Foundation 2002). As well, over 63% of Canadians between the ages of 15 and 69 own a mobile phone (Ericsson 2004). Educators reason that if some of the appeal and ubiquitous nature of these games and technologies can be brought to bear, learning can indeed be transformed.

- **Tested approaches, new technologies:** Simulations and games have long been popular and proven tools for trainers and educators in various venues (Stolovitch 1981, Stolovitch and Thiagarajan 1980). Examples using newer technologies are emerging as powerful tools for learning complex concepts and behaviours (e.g., Rosas et al. 2003, Wargo 2000, Westbrook and Braithwaite 2000). For examples in specific domains, see: Virtual Leader, a simulation for leadership training (Simulearn 2004); Squire's application of Civilization III to American history (Squire, in press); and for anatomy, the Memoros game (CVJE 2003) and The Visible Human Project simulation (NLM 2003).

- **Cognitive and social questions:** Some researchers suggest that learning may be evolving into a much more "unruly," less controlled process than we have been accustomed to in our classrooms (Seely Brown 2002). It has even been suggested that the "game generation" has developed a new cognitive style characterized by multiprocessing, a short attention span, learning through exploration and discovery; several researchers argue that today's games and simulations, with their immersive social experiences, provide the ideal environment for this group's learning (Asakawa and Gilbert 2003, Gee 2003, Prensky 2001).

- **New learning model:** Saethang and Kee (1998) state that utilizing games and simulations reverses the habitual learning process: the learner plays or simulates first, and then understands and generalizes to be able to apply the learning in a new situation. The authors also assert that the traditional teacher and learner roles are transformed in the context of games and simulations: the learner shifts from a passive to active role and from learner to teacher through collaboration with peers. Shaffer et al. (2004) summarize these views, making a compelling argument that video games can transform the future of learning by providing a new learning model to reach new generations of learners.

- **Potential for integrating theory, experience and best practice:** There is a strong theory-based argument for SAGEs for learning. Games and simulations appear to offer many opportunities to improve learning engagement and effectiveness by embodying accepted learning theories. Networked, collaborative simulation and gaming environments can provide interactivity, immersion, motivation, learner control, repeated practice, feedback, and opportunity for reflection, especially useful where authentic experiential learning is infeasible for reasons of cost, access or safety (Kinzie et al. 1996, Ruben 1999, St-Germaine and Leveault 1997). A number of studies have demonstrated the effectiveness of games and simulations for cognitive, emotional and psychomotor learning (e.g. Baranowski et al. 2003, Kirriemuir and McFarlane 2004, Lieberman 2001, Renaud and Stolovitch 1988, Sauvé et al. 2005c). According to these, games and simulations motivate learning, offer immediate feedback, consolidate knowledge, support skills development and application, aid learning transfer, and influence changes in behaviour and attitudes, all pointing to greater learning effectiveness with simulations and games.

Research on SAGEs needs to explore many aspects of their objectives, design, embedded models, learner characteristics, media and technology characteristics, learning processes,

and learning outcomes, most often in the context of a specific learning application. To fully understand and improve learning with SAGEs, we need to identify important variables at all stages of the framework and to investigate their relationships, particularly those that lead to improved learning outcomes and positive impacts. Key to doing this are rigorous evaluation methodologies that test evolving learning strategies and new, more complex learning environments (Grössler 2001, Owston 2000). Yet literature searches show that to date, most SAGE evaluations are merely descriptive papers (Kneebone 2003); many report only learner perceptions and address just the first level of Kirkpatrick's (1994) evaluation framework of learner reaction/ satisfaction, learning, behaviour change, and longer-term results. Moving beyond this level is difficult; Dempsey et al. (2002) observe that much of what occurs in a gaming environment involves complex cognitive processes that may not be easily measured or easily reduced to a few variables, and Grössler (2001) and Kneebone (2003) note that educational evaluation is constrained by our inability to control variables as well as the need to work within curriculum limitations and with limited opportunities for longitudinal study. However, SAGEs also offer possibilities for new data collection and analysis techniques; Kneebone (2003) states that "a key advantage of simulated practice is that it can collect performance data automatically, using objective "metrics" to build up a multifaceted picture of each learner's skill base. Extensive research is needed to develop theory-based, rigorous evaluation tools and methodologies that are appropriate to these new learning environments.

RESEARCH PHASES AND DOMAINS

SAGE for Learning research is being conducted in *descriptive*, *developmental* and *evaluation* phases across its four-year mandate. Its projects are linked together by both this timetable and by a common focus on health applications; project researchers are developing and testing applications in health-related learning for learners including students of medicine and the health professions, teachers, K-12 students, patients, community health workers and the public.

SAGE projects are grouped into three Application domains (*Games*, *Simulations*, and *Simulation Games)*; and three Foundation domains (*Conceptual Foundations*, *Methodologies and Tools*, and *Technologies)*. Research in the foundation domains supports and integrates research in the application domains, as illustrated in Figure 1.

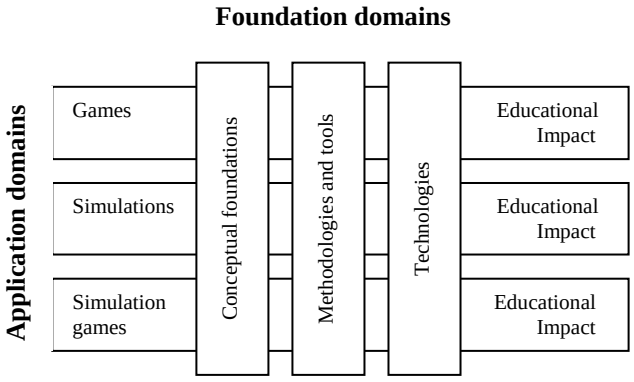

Figure 1. SAGE for Learning Research Domains

RESEARCH PROJECTS

Individual projects are addressing a variety of specific health and medical education applications and foundational issues. Projects include:

- **The impact of online educational games for illness prevention and health promotion** (Project Leader Dr. Louise Sauvé, Télé-université du Québec): This project is working to test existing Educational Games Central "frame games" (game shells such as Tic Tac Toe, Snakes and Ladders (Figure 2), or Mother Goose that let users easily pour content into predefined structures) and to develop and test new advanced game shells. Their goal is to identify and document game characteristics that help or hinder learning, and to analyze the connections between important game variables and health-related learning impact. Researchers have completed a major literature review (Sauvé et al. 2005b) and are now developing three multi-player game shells. Their ultimate goal is to help teachers to easily create

proven, effective and enjoyable games for teaching health concepts.

- **Educational games on the Internet: Tools for trainers in illness prevention and health promotion** (Project Co-leaders Dr. Claire IsaBelle, University of Ottawa, and Dr. Margot Kaszap, Université Laval): Researchers in this project are working to identify, observe, inform and model the main cognitive processes and learning transfer which games can develop or restrict, from the point of view of teacher training related to learning in the health field. They are working with groups to build and test games for training health teachers and students. They have completed a review of 40 games (Sauvé et al. 2005a) as well as a needs assessment and curriculum analysis; the results are now being incorporated into specific games intended to ultimately improve health outcomes for students.

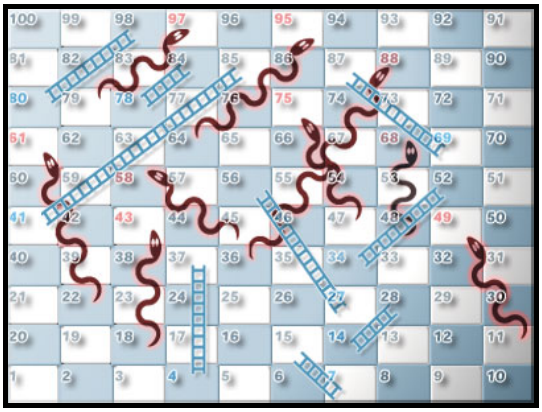

Figure 2. Snakes and Ladders Game Shell in Educational Games Central

- **Collaborative, Online, Multimedia, Problem-based Simulations (COMPS)** (Project Leader Dr. David Kaufman, Simon Fraser University): This project team is exploring the potential of COMPS to support problem-based learning (PBL) for medical student education and for continuing medical education for health professionals. They are designing, developing and testing a full scale, media-rich, narrative-based simulation in which learners can role-play medical professionals and access realistic resources to guide their diagnoses and treatments (Kaufman 2005). This project especially emphasizes patient-centred health care and incorporates collaborator Steve DiPaola's iFACE facial animation software (Figure 3) (Di Paola and Arya 2005) which adds the possibility of creating simulated patients with various gender, ethnic, cultural, personality, or other characteristics. The team is also developing and testing PBL medical case simulations in different forms in WebCT and in a CANARIE-funded simulation software platform entitled ENJEUX-S (see below).

Figure 3. iFACE Facial Animation

- **HEALTHSIMNET** (Project Leader Dr. Michael Dobson, Simon Fraser University): This project is exploring how to create and apply visualization and simulation tools based in activity theory to facilitate learning based on models of complex sets of interactions among interprofessional teams. In their first case study, a model of a set of communications about an HIV/AIDS case reveals competencies and gaps in the professional practices of nurses, physicians, and child welfare workers, as well as legal obstacles and areas in which public health outcomes could be improved through more effective interactions (Dobson et al. 2004).

- **Building classes of entertaining games for health education** (Project Leader Dr. Carolyn Watters, Dalhousie University): Researchers in this project are designing games for children who need to learn to manage chronic diseases. Their goal is to build and test generic game shells that can incorporate content from physicians,

health educators, or parents, resulting in games that are tailored to the needs of individual children or groups dealing with different diseases (Watters et al. 2005). They are also working to identify motivational factors that can be embedded in game design and to understand the importance of 3D vs. 2D and game complexity on learning performance. Because these games are designed to evolve as children grow, this project extends the role of games to support long-term learning in children with chronic disorders.

- **Contagion!** (Project Co-leaders Dr. Suzanne de Castell, Simon Fraser University and Dr. Jennifer Jenson, York University): The researchers in this project are exploring questions of education game design, gender and gaming, content development, and narrative frame through the design, development, and testing of an internet-based educational simulation game (Dotto 2005, Grozav et al. 2005). The game, targeted at 9-12-year-olds, directly complements and extends prescribed learning goals for grades 7-9, with emphasis on human, social, and health sciences. Through anonymous role-play and collaboration, the game is intended to encourage affective, somatic, and procedural dimensions of habitual self-care for health promotion. It is also designed to be used as an interactive tool for exploring professional careers in health care and community work.

- **Conceptual foundations of games, simulations and simulation games** (Project Leaders Dr. Louise Sauvé and Dr. David Kaufman): This project is clarifying the terms used in research on games, simulations, and simulation games by carrying out a review and detailed, comprehensive analysis of the literature. The researchers are developing a multidimensional taxonomy and conceptual framework to describe SAGEs. In addition, they continue to seek answers to a number of questions, including understanding the characteristics which let us distinguish games, simulation games, and simulations, the cognitive, affective, and motivational aspects of games, simulations, and simulation games, as well as the history of electronic games and an understanding of how this history can help future development of this academic area. After a major database search producing over 1300 references, the researchers completed a detailed grid-based analysis of over 450 recent papers on educational games and simulations, focusing on terminology and learning impact. They have published research reports on their analysis and are beginning to present their work widely. They have completed a major project report (Sauvé et al. 2005c), several literature review papers, and a searchable database for SAGE members.

- **New methods for the evaluation of SAGEs** (Project Leader Dr. Ron Owston, York University): Researchers in this project are advancing our ability to measure and evaluate the activities, interactions, and choices that take place while learners use simulations and games online. They have designed and developed the Virtual Usability Lab (VULab) (www.vulab.ca and Owston et al. 2005). VULab is a software tool to remotely capture and analyze a wide variety of usage data on Web-based educational games and simulations. It automates remote collection and integration of such data as user activity logs and online demographic questionnaire responses; it incorporates the use of remotely delivered, automated online queries customized to capture critical use experience and perceptions at key points in the use of gaming and simulation environments. VULab testing has demonstrated that remote collection of a variety of forms of usability data is feasible and the tool can provide valuable feedback to designers of games, simulations, and any interactive website to help them improve their products.

- **Evaluation and analysis of eye movements related to learning in SAGE environments** (Project Leader Dr. Patrice Renaud): Researchers in this project are

seeking to develop a methodology, based on the detection of users' eye movements in learning situations in 2D and 3D environments, which will allow researchers to better understand learning within SAGE environments (Renaud et al. 2004).

- **ENJEUX-S: An advanced on-line educational gaming and simulation environment** (Project Leader Dr. Louise Sauvé): Funded by a $357,000 grant from CANARIE Inc., this project is developing an advanced multimedia, on-line, multi-player game and simulation environment. The web environment (Figure 4) integrates multimedia components (video, voice) with 2D / 3D games and simulations, allowing for instantaneous and simultaneous interaction so that users in any location can play and collaborate (Sauvé et al. 2005d and http://www.savie.qc.ca/enjeux/).

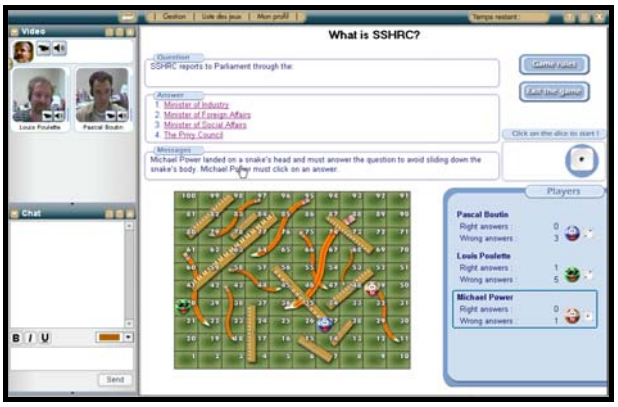

Figure 4. ENJEUX-S Interface

KNOWLEDGE DISSEMINATION

In addition to traditional dissemination channels, the SAGE network has implemented and continues to expand its bilingual public web site (www.sageforlearning.ca) to make its goals, project descriptions and results available to all interested readers. A 2005 SSHRC Outreach Grant is also making it possible for the network to expand into a web-based television/ video station, SAGETV, to further showcase our knowledge about SAGEs for learning.

CONCLUSION

The SAGE network welcomes inquiries about membership and possible collaborative projects. We are open to new partners and researchers who wish to explore and apply SAGEs for learning and to create and share knowledge about how to do this more effectively.

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BIOGRAPHY

Dr. David Kaufman has been a faculty member at Concordia, Simon Fraser, Saint Mary's, and Dalhousie Universities, in the fields of Engineering, Computer Science, and Education. He has served as Director of Course Design for the Open Learning Agency (British Columbia's distance education institution), and has been involved in staff training and organizational development in business, industry, and government settings. Dr. Kaufman has presented hundreds of lectures and workshops at universities in North America, Europe, Asia and South America. He has published extensively with approximately 100 published articles and a co-edited book (Distance Education in Canada, 1986) to his credit.

He has been a reviewer for many journals and professional associations, including the Canadian Journal of Education, Journal of Instructional Development, Canadian Medical Association Journal, Teaching and Learning in Medicine, The Journal of Continuing Education in the Health Professions, and the American Association of Medical Colleges. He was Director of the Medical Education Unit in Dalhousie's Faculty of Medicine, and later served as Director of Faculty Development and Professor in the Division of Medical Education. He was heavily involved, with his colleagues, in transforming the undergraduate medical curriculum from a lecture-based to a problem-based learning approach. Dr. Kaufman was the 1998 recipient of Dalhousie University's Instructional Leadership Award for his efforts in promoting and enhancing teaching.

In July, 2001, he was appointed as Director, Learning & Instructional Development Centre at Simon Fraser University and more recently, Professor in the Faculty of Education. Besides his administrative duties, he continues academic work in the areas of educational research, teaching faculty and graduate students, supervising graduate students, presenting at professional meetings, and serving on university committees. In October, 2003, Dr. Kaufman was awarded an SSHRC INE Collaborative Research Initiative grant of $3 million for four years on Simulation and Advanced Gaming Environments (SAGE) for Learning.