Enhancing learning through an online secondary school educational game

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Version 1

Abstract

This paper consists of four sections: (1) the problems associated with asthma in the province of Quebec and across Canada; (2) the theoretical framework for the learning enhanced by our online educational game entitled *Asthme: 1,2,3...Respirez!* (*Asthma: 1,2,3...Breath!)*, created by adapting the popular board game *Parcheesi,* and intended for students in a senior secondary school health education program (14 to 18 years old); (3) the methods employed, including a description of the educational game, the quasi-experimental research protocol, the sample, the variables being studied, the measurement instruments, the pilot study, the procedures, and the data analysis, and (4) the results of the experiment and discussion of the results. The results of the paired t-tests showed significant improvements in a variety of cognitive skills after students played the game on laptops in their classrooms for 40-60 minutes. No differences were found between males and females. These results are encouraging for teachers who wish to use educational digital games in their classrooms.

Keywords: educational game, learning, asthma:

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Introduction

As part of a larger project financed by the Social Sciences and Humanities Research Council of Canada (SSHRC) from 2008-11, this study examined the impact of an online educational game on cognitive learning. The purpose of this particular study was to determine whether playing an online educational game resulted in improved cognitive skills around the topic of asthma. Two primary research questions were addressed: (1) Is there an improvement in secondary school students' cognitive skills as a result of playing an online educational game? (2) Are there differences between males and females in cognitive skills developed by the game? Starting from the popular board game *Parcheesi*, an online game was created for a senior secondary school health education program for students between the ages of 14 and 18 years.

This paper comprises four parts: (1) the problems associated with asthma in the province of Quebec and in Canada; (2) the theoretical framework for the learning enhanced by our online educational game entitled *Asthme: 1,2,3...Respirez!* (*Asthma: 1,2,3...Breath!)*, created by adapting the popular board game *Parcheesi,* and intended for students in a senior secondary school health education program (14 to 18 years old); (3) the methods employed, including a description of the educational game, the quasi-experimental research protocol, the sample, the variables being studied, the measurement instruments, the pilot study, the procedures, and the data analysis, and (4) the results of the experiment and discussion of the results.

Health Education: The Problem of Asthma

Asthma is one of the more prevalent chronic diseases in Canada, affecting more than 10% of the population. The consequences of this disease are numerous and the human and socio-economic costs that result from this are enormous. Despite numerous efforts to develop practical guides based on available evidence, gaps still remain in our understanding of the assessment and treatment of asthma.

Two pan-Canadian studies (Blais et al, 2001; Conseil du Médicament du Québec, 2003) involving thousands of asthmatic people have shown that less than 50% achieve an adequate control of asthma, contrary to their own belief and that of health professionals that treat them, that their asthma is under control.. The insufficient management of asthma is responsible for a high rate of emergency room visits or doctor appointments,

hospitalizations and specialist consultations. These data show the importance of intervening with the Canadian population by proposing health education programs adapted to the needs of the population, and focussed as much on prevention as on therapy. Given the serious problem of asthma in Canada and its considerable repercussions, particularly among young people, it is essential to offer interventions especially through health education. Health education is a process that aims to increase the motivation of people to look after their own health and to be aware of their environment. It aims to increase knowledge, modify attitudes, and develop skills, that is, to encourage responsible decision-making and beliefs about what is beneficial to one`s self (Caron, Bouchard et Renaud, 2001). From this perspective, we need to offer youth concrete skills to look after their own health. Some studies (Boulet et al., 2004; Lemière et al., 2004) have shown that with a better understanding of asthma and its optimal treatment, those suffering from this disease as well as their significant others can greatly improve their mastery and control over asthma. Improving the treatment of asthma is among the priorities of organizations such as Health Canada and the Quebec Medication Council. It is in this context that we conducted a study to assess the impact of an online game, *Asthma: 123...Breath!* on the cognitive skills acquisition of senior secondary school students.

21st Century Learning

A slogan has recently become popular in the world of education - *21st century learning* - and there appears to be a consensus growing about the meaning of this term. An extensive project led by *The Partnership for 21st Century Skills* (2009) proposed a framework for 21st century learning describing student outcomes and support systems. Their report asserts that every implementation of 21st century skills first requires the development of core academic subjects and understanding. However, more importantly, within the context of this development students must learn essential (21st century) skills such as critical thinking, problem solving, communication and collaboration. Added to these skills are creativity and innovation, information, media and technology skills, and various life and career skills. The authors then suggest a variety of 21st century support systems necessary to ensure student mastery of these 21st century skills. Three elements are particularly relevant to the online educational game used in this study. These are: (1) emphasizes useful feedback on student performance embedded into everyday learning; (2) enables innovative learning methods that integrate the use of supportive technologies, inquiry learning, problem-based approaches. And higher order thinking skills; and (3) engages students with the real world data...actively engaged in solving meaningful problems. The game developed in this study provides directly these support elements to students and emphasize the 21st century learning skills such as critical thinking, problem-

solving, communication, collaboration and using technology effectively for learning. Relevant and immediate feedback is provided during the game.

Impact of Digital Games as Tools for Health Education

Cognitive Skills

Most studies examining cognitive skills show that games have a positive impact on the way learners build mental schemas. Games can help the learner with cognitive skills such as problem solving, visualizing concepts, and establishing links (Aspinwall & Shaw, 2000; Gee, 2003; Kafai, 2001; Kaufman & Sauve, 2010; Koirala & Goodwin, 2000; Meel, 2000; Steinman & Blastos, 2002). Therefore, games allow the learner to integrate new materials and new concepts in a more intuitive manner and also help the learner organize previously acquired information in a more comprehensive manner. These studies also provide evidence in support of 21st century cognitive skills such as integrating knowledge, developing skills such as accessing prior knowledge, facilitating the identification of key points in the content, helping the player understand differences and similarities in key points, and allowing the player to find conceptual links and analogies. These skills assist the learner in mentally structuring the knowledge they acquire.

Brown et al. (1997) determined that a game to manage diabetes in young people aged 8-16 years showed a positive effect on their feeling of control in their ability to manage their diabetes, an increase in dialog with their parents, daily monitoring of their blood samples, and an improvement in their consumption of healthy foods. Barab et al. (2005) assert that digital games help young people to become more autonomous and better understand relationships of cause and effect, particularly in areas that affect the decisions they must make. Therefore, our study examined the learning enhanced by an online educational game.

The emergence of the Internet and the growing possibilities available through the use of computers (including video games) provide many opportunities for society and for learning. Several recent studies show that games have positive influences on learning, particularly on the structuring of knowledge (Evreinova, Evreinova & Raisamo, 2006; Lennon & Coombs, 2006; Shaftel, Pass & Schnabel, 2005) and the integration of information (Haas et al, 2006; Padgett et al, 2005; Purushotma, 2005). However, other studies (e.g. Baldaro et al, 2004; Barab et al, 2005) note a negative result or limited impact these games have on cognitive and affective learning. Shreve (2005) is an enthusiast when it comes to the introduction of educational computer games in the classroom but emphasizes the difficulties associated with their use. For example, it is difficult to follow the progress of multiple learners in a

game while they are all using one assigned computer (the teacher then has difficulty controlling the group) and the games do not always adequately respond to the educational objectives determined by teachers.

However, according to Klopfer et al. (2009), digital games and social networking are changing the way we communicate, and thus how we think, work and play. He argues that videogames are highly motivating and engaging for students, they allow students to retain, connect, and transfer learning from these experiences to future learning and experiences. Shaffer et al. (2004) found that digital games have the ability to draw students in, to allow them to collaborate easily with each other, using a language within a medium that is easy to understand. An interesting review by Lieberman (2009) of digital games for young children found that digital games can improve learning, enhance cognitive skills, increase social interactions, and motivate and improve self-care and health behaviours. Steinnkuehler and Duncan (2009) analyzed the scientific reasoning skills displayed by players in an online game (World of Warcraft) and reported that players engaged in high level thinking and discussion, and consequently improved their leaning.,

Fournier et al. (2006) also believe that it is possible to learn while playing. Our systematic analysis of the literature on the impact of games on learning (Sauvé et al, 2008a) supports his comments. Methodological weaknesses as well as problems with the definitions of concepts and operational variables do not currently permit us to clearly identify the real efficacy that games have on learning. This study aimed to assess the efficacy of a game, conceived by teachers and health practitioners for prevention and promotion of health, in terms of cognitive skills acquisition of students aged 14 to 18. It tried to answer the following question: What type of cognitive learning resulted from use of an online educational game?

In more specific terms, this paper will present the results of our research, particularly those that had as an objective to determine the learning promoted by an online educational game, and whether there is a difference in learning according to gender.

Theoretical Framework

In this section, we will first examine how games can promote the structuring of knowledge and then, we will identify how the games allow for the integration of information. The choice of these two aspects of cognitive learning is based on the scope of studies done in the recent years on the subject and the generally positive results that emerged (Sauvé, Kaufman & Renaud, 2007). Also, these cognitive skills are foundational to effective learning and are essential to critical thinking and problem solving.

Educational effectiveness is defined by positive consequences from the use of a game on participant knowledge, attitudes or psychomotor skills. It takes into account the relationship between the results of using a game for learning and the initially-stated objectives (Blouin & Bergeron, 1997).

As for *learning*, our definition corresponds to many dictionary definitions; the acquisition of knowledge or skills or attitudes with the help of experience, practice or study. Learning outcomes are measured in terms of the knowledge, attitudes and skills acquired by students as a result of learning, although this paper focuses solely on knowledge and cognitive skills.

Structuring of knowledge

Structuring of knowledge is a cognitive skill that refers to the construction and organization of knowledge, schemas (mental models), or representations by the learner in order to understand a concept or a given situation. Studies have shown that games (computer, video, serious, classic) reinforce or improve the structuring of knowledge. Some studies conclude that games have positive results on the "structuring of knowledge" (e.g. Evreinova, Evreinova & Raisamo, 2006; Lieberman, 1998, 2001; Lennon & Coombs, 2006; Mondozzi & Harper, 2001; Rosas et al, 2003). They mention specifically that the participation of the learner in the game improves or reinforces their knowledge of the subject matter at hand. Other authors (e.g., Fukuchi et al, 2000; Miller, Lehman & Koedinger, 2000; Mondozzi & Harper, 2001) reiterate this conclusion based on comparative experiments (pre-tests and post-tests on the game's subject of focus). Starting with results from previous studies (Blum & Yocom, 1996; De la Cruz, Cage & Lian, 2000; Holton et al, 2001). Shaftel, Pass and Schnabel (2005) obtained positive results when they tested with a mathematics game. Ravenscroft (2007), testing in the domain of secondary school kinematics instruction, also determined that an educational game allowed students to improve their understanding of the concepts being taught. In most cases, authors note that the games they used with their students helped assimilate the information being learned.

Other studies (e.g., Gee, 2003; Steinman & Blastos, 2002) show that games have positive results on the way learners build schemas in their minds. This helps the learner with problem solving, visualizing concepts, establishing links, etc. Therefore, the game allows the learner to integrate new materials and new concepts in a more intuitive manner and also helps the learner organize previously acquired information in a more comprehensive manner. While examining the structuring of mathematical knowledge Shaftel, Pass and Shnabel (2005, p. 32) stated that games "can provide an environment to come into contact with incorrect solutions, which are nevertheless

meaningful steps in gathering elements of mathematical knowledge." Lastly, certain authors (e.g., Asakawa & Gilbert, 2003; De Grandmont, 2005) mentioned that games develop the structuring of knowledge, without defining the concept, nor presenting experiment results.

To confirm that the *Asthma: 1,2,3...Breath!* game results in knowledge structuring, we established some indicators of analysis based on the links that the learner is able to establish between elements and concepts or schemas according to Andrieu and Bourgeois (2003). We defined the following indicators:

- the capacity to call upon prior knowledge, or establishing a link (sequential or chronological) between prior knowledge and information acquired during the learning process;
- the capacity to locate key elements of the subject under study, as in identifying theoretical or declaratory knowledge of a given subject and to put it in logical order. This link corresponds to a hypothetical relationship between several elements of the same contents;
- an increased awareness of the differences and similarities between the various elements of the subject being studied, establishing a link based on the principle of contradiction. This link comes into play in the operations of distinction, selection, sorting and classification;
- the capacity to establish links across concepts, as in developing a cause-and-effect link between two or more ideas or concepts. This can also work in the other direction, starting with the result and discovering and establishing the cause;
- the capacity to establish an analogy or comparison between two additional pieces of information, either contradictory or complementary, in order to gain understanding.

In our study, the students were asked throughout the game to respond to questions and learning activities about asthma. One objective is to structure their knowledge.

Integration of Knowledge

Several studies confirm that games have a positive impact on the integration of knowledge. Certain authors (e.g., Barnett et al, 2005; Green, 2002; Higgins & Barkley, 2004; Krajewsky & Piroli, 2002; Moyer & Bolyard, 2003) define the integration of knowledge in learners as the capacity to develop links in an intuitive or non-intuitive manner thanks to the game. Therefore the game supports the development of the capacity to transfer knowledge acquired in other contexts. Other authors (e.g., De Grandmont, 2005; Markey, Power & Booker, 2003; Ravenscroft

& Matheson, 2002; Silverman et al, 2002; Vandeventer & White, 2002) attribute the integration of information to a general increase in the learner's knowledge.

We noted that the majority of studies discussing the effectiveness of games on the integration of knowledge did not define or hardly defined indicators to measure the development of knowledge integration. Only two articles developed the subject further; Wissman and Tankel (2001) mentioned the capacity for appropriation as being an element of measurement of knowledge integration; Sauvé, Renaud and Hanca (2008b) used the degree of acquisition of declaratory knowledge to measure the level of integration of knowledge from a game among students at the secondary level. As for retention, no authors mentioned this aspect in their studies.

Under such conditions it is difficult to determine whether games do lead to knowledge integration and various authors deal with this in different ways. Taking into account this methodological weakness, we have retained one indicator of the effectiveness for analysis in our study. The indicator selected was the capacity for the learner to apply his or her declarative knowledge in a given context. By declarative knowledge we mean "knowledge which allows a person to assimilate ideas and facts in a particular domain" (Brien, 1994, p. 207). In our study, the students will apply concepts, indicative propositions, the sum of interrelated propositions and metacognitive knowledge pertaining to asthma through different situations which will allow them to integrate knowledge acquired while playing the game. We formulated the following question: Does the *Asthma: 1,2,3...Breath!* game aid secondary school students to integrate knowledge on asthma?

In order to ensure that the learner structures and integrates his or her knowledge. Frété (2002) states that games offer a question and response structure which encourages drill and practice, as well as association questions accompanied by a reward system. Detective games, mystery solving games and adventure games are particularly effective. In the case of this study, a board game based on Parcheesi using different types of question and response structures was used.

Gender in Digital Games

Playing games is the most common activity for 6 to 13 year olds using a computer (Kirriemuir & McFarlane, 2004). The differences between girls and boys, in terms of involvement in games and what this says about them is, according to Frété (2002), the most highly debated topic for researchers examining games as learning tools. Gros (2003) states that computer games are designed for boys between the ages of 8 and 14. Research shows that the majority of young gamers are at the elementary school level and early secondary levels after which numbers decline

(Kirriemuir & McFarlane, 2004; McFarlane et al, 2002; Williamson & Facer, 2004). However, this tendency is contradicted by other studies (ESA, 2004) which show that the average age of the majority of computer gamers is 29 years old.

Boys and girls enjoy playing computer games equally (Mitchell & Savill-Smith, 2004). Studies show that boys are more interested in learning when they are involved in a game (ESA 2004; Roberts et al, 1999; Subrahmanyam et al, 2001). In Quebec, an inquiry clearly revealed that male adolescents aged 12 to 17 in Quebec are significantly more involved in online games (70.7%) than female adolescents (40.6%) (Lamy, 2004). The difference between boys and girls in gaming seems more pronounced after the age of 13 (Gros, 2003).

Many studies have come to the conclusion that girls and boys have different interests and preferences, although these generalizations have been criticized (Jensen & de Castell, 2010). Kafai (2001) states that boys emphasize competition when they play educational games while girls focus on the learning objectives to be attained. Girls prefer games that require cooperation while boys prefer games that emphasize competition (Cassell & Jenkins, 1998). Girls enjoy playing educational games while boys generally prefer realistic games with violent themes (Cesarone, 1998). Girls prefer games that allow them to recreate common family-life themes while boys prefer fantasy games (Gros, 2003; Subrahmanyam & Greenfield, 1998; Vail, 1997). Girls appreciate sharing information and boys prefer reaching goals to demonstrate mastery and accomplishment (Ching et al, 2000, cited in Blumberg & Sokol, 2004). Boys play computer games more than girls do and are more confident using technology in general (Jensen & de Castell, 2006). Considering that schools are integrating technology into the learning environment, what effect will the introduction of computer games in secondary schools have on learning for boys and girls? The few recent studies considering gender and game-based learning outcomes have consistently shown no significant outcome differences between males and females. Vogel et al.'s (2006) meta-analysis notes that three studies comparing males and females found no significant differences. Another meta-analysis (Ke, 2009) finds that some (generally qualitative) research has reported gender difference in terms of game-based learning performance and game design preference, while other work (mostly experimental and comparative in nature) has not. Ke suggests that possibly gender influences game play and learning processes more than learning outcomes. Papastergiou 2009, experimenting with a high school computer science game, found that boys were more involved and experienced with, liked, and knew more about computer gaming, but the learning gains that boys and girls achieved through the use of the game did not differ significantly, and the game was found to be equally motivational

for boys and girls. Anderson (2008), studying how fifth-grade students learning about science concepts, with the Quest Atlantis computer game, found that although there were gender differences in game play, overall, student learning outcomes improved from pre- to post-assessments for all students and there were no observable gendered differences with respect to test scores.

Methods

This section provides a description of the educational game, sample, quasi-experimental research design, variables being studied, the measurement instruments, the pilot study, the procedures, and the data analysis

The Game – Asthma: 1,2,3…Breath!

As mentionned earlier, the online game (Figure 1) was created based on the generic Parcheesi board game. Details of the game creation process, using the ADDIE model, are presented in extensive detail elsewhere (Sauvé, 2010a,b). Designed by medical and asthma experts as well as specialists in online game design, *Asthma:1,2,3…Breath!* has the following cognitive objectives : (1) describe asthma and its symptoms; (2) differentiate among the various treatments for asthma and describe their effects; (3) identify the factors that trigger asthma in order to prevent it, and (4) identify the allergies that affect young people with asthma and describe ways to reduce their effects on the affective domain, the objective is to sensitize young people to the problems caused by asthma and to make them more prevention-oriented towards persons with asthma in their environments.

To operationalize these objectives, 90 questions were inserted into the game, grouped into the following four content categories: (1) Prevention: predisposition, knowledge of the disease and its symptoms; (2) Control: absence or minimum symptoms during the day, no symptoms at night and in the morning, using the emergency pump less than four times per week,, ability to perform normal activities and sports, test for normal pulmonary function, etc.; (3) Triggering factors: cold air, tobacco smoke, strong odors, air pollution, emotions and stress, etc.; and (4) Allergies:: domestic animals, mites, pollen, dust, etc. Each category contains questions that measure indicators of knowledge.

This particular game builds on the earlier frame games developed by the co-author and her team (Sauvé, 2010). These earlier games were adaptations of popular board games and used only closed questions measuring knowledge acquisition. However, the Parcheesi game in this study was developed specifically to enhance 21st century skills such as critical thinking and problem solving. It also addressed other 21st century skills such as communication,

teamwork, and using technology. To do this, we built into the game the capability to present video case scenarios requiring higher order cognitive skills to respond correctly.

Two game modes are possible: single computer or network. By definition, the single computer game mode requires only one computer. This mode however, allows multiple people to play together, taking turns using the same keyboard. The network game mode is used when players are in different locations, each using their own computer.

Figure 1. Game Board for Asthme : 1, 2, 3… Respirez! (Asthma: 1,2,3...Breath!)

The game integrates feedback mechanisms by providing the following elements:

- for every learning activity, there is a feedback mechanism according to whether the question was answered correctly or incorrectly;
- for every player's move, the computer displays instructions or game rules;

- for every navigational error, the computer displays a message to correct or reorient the user.

To begin the game, each team clicks the dice in a random order to determine who will start the game. The team that rolls the highest number starts the game. Each team that succeeds in a learning activity gains points. The point system varies according to the time taken to complete the activity. There are two ways to win in the game. (1) Be the first player to move his or her four tokens to the central area of the board and then succeed in the final learning activity; or (2) Be the player with the most points when the per-determined time runs out. Figure 2 illustrates how the questions are presented in the game.

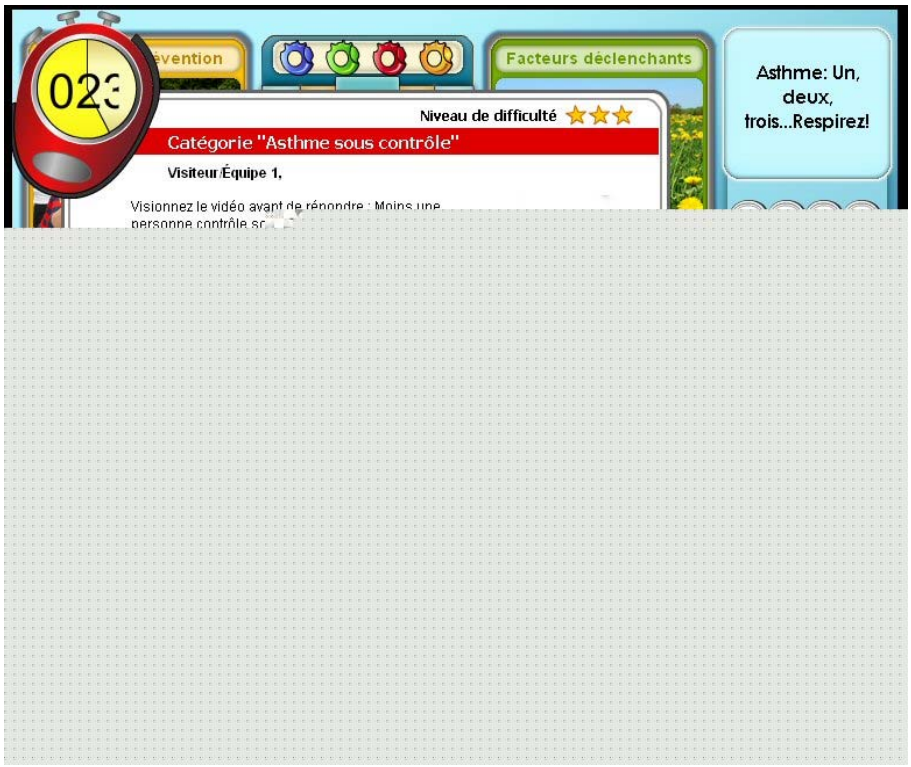

Figure 2.Example of a cognitive-type question

Participants

The sample of participants comprised a convenience sample of 133 secondary school students: 73 students in Quebec and 60 students in the francophone school district of the province of British Columbia in grades 9, 10 and 11. This number clearly exceeded the number required for adequate power, since there were originally only six variables to compare and this provided more than 20 participants per variable. The sample was drawn from school class groups, and all students from each class group were invited to participate. All participants in this experiment

knew they were involved in this research process and signed a consent form to confirm that they agreed to participate in the experiment.

Research Design

The research design used in the research is based on a single group, pre- and post-test design, that allowed us to measure if the game *Asthma:1, 2, 3...Breath!* enhanced learning by comparing prior cognitive skills before the game with those acquired after playing the game.

Research Questions and Hypotheses

The first question addressed in this study was: Does the game *Asthma: 1,2,3…Breath!* enhance the cognitive skills of structuring and integration of knowledge about asthma of senior secondary school students. We hypothesized that the more the educational game *Asthma: 1, 2, 3… Breath!* uses activities which require players to call upon prior knowledge, facilitate the identification of key points in the subject matter, support the understanding of differences and similarities in key points of the subject matter, and allow them to find conceptual links and analogies, the more players will be able to structure and integrate knowledge. The second question was: Are there differences in learning between males and females as a result of playing the game. We hypothesized that since this game was based on the popular `parlour`game (*Parcheesi) and previous research showed no differences, that* there would be no differences between males and females.

Measurement Instruments and their Administration

In order to attain the research objectives, the main concepts were defined and operationalized with specific indicators that allowed us to devise research instruments in the form of statements. To respond to the first objective of the study, "evaluating the type of learning enhanced by online educational games," five indicators were used: (1) the capacity to call upon prior knowledge, or establishing a link (sequential or chronological) between prior knowledge and information acquired during the learning process (4 items) [e.g., Asthma will disappear during adolescence]; (2) an increased awareness of the differences and similarities between the various elements of the subject being studied, establishing a link based on the principle of contradiction (3 items) [e.g., Which of the following is an indicator of asthma-various choices are given such as 'the capacity to do normal activities and play sports/ coughing]. This link comes into play in the operations of distinction, selection, sorting and classification; (3) the capacity to locate key elements of the subject under study, as in identifying theoretical or declaratory knowledge of a given subject and to put it in logical order (9 items) [e.g., With current availability of new drugs, asthma can be

cured]. This link corresponds to a hypothetical relationship between several elements of the same contents; (4) the capacity to establish links across concepts, as in developing a cause-and-effect link between two or more ideas or concepts (5 items) [e.g., persons with asthma can stop taking their medication once their symptoms have disappeared]. This can also work in the other direction, starting with the result and discovering and establishing the cause and (5) the capacity to establish an analogy or comparison between two additional pieces of information, either contradictory or complementary, in order to gain understanding (14 items) [e.g., Which of the following factors are allergens, irritants, inflammatory: domestic animals, etc.]. To verify whether these indicators had an impact on learning, a total of 24 statements relating to the subject were developed and validated by medical and asthma specialists and then pilot tested as described below.

In order to ensure that the online educational game developed for the final experimental study is appropriate for the target audience, a pilot test was conducted with secondary school students using the Learner Verification and Revision (LVR) methodology (Komoski, 1979; 1984). This methodology is a type of formative evaluation during a pilot test that complements expert review and collects both process and outcome data from learners that inform changes that need to be made prior to implementation. Two groups of secondary school students (Grades 9 and 10), totalling 40 students, participated in the pilot test of the game.

The results showed a very high level of satisfaction with the game design, pedagogical readability in the game, and user-friendliness. Finally, several comments from the students allowed us to revise some of the instructions and the general operation of the game. Also, since the pre- and post-test knowledge tests were developed for the final experiment, we conducted a pilot test with our target audience to assure ourselves that the knowledge that was structured by playing the game was not already acquired by students prior to playing the game. We also conducted a reliability analysis as well as item analysis. The results showed that 25% to 48% of students knew the content of the learning materials about the domain of asthma The data also showed that certain questions were answered correctly by all students and/or correlated poorly with the total test score. These questions were replaced in the final version of the questionnaire. In the final version of the test, a total of 21 questions were presented but some required a series of responses, resulting in a total score of 35. Question types were multiple choice, true/false, and selecting from a list.

Procedures

Permissions were obtained from the Quebec City school district, a French language district, and the British

Columbia francophone school district, a province-wide school district that provides French language instruction to residents whose children speak French as their first language and wish to have them educated in this language. Ethics approval also was obtained from both universities. The researchers then arranged with individual schools, two in Quebec and two in British Columbia, to have the students play the game and complete a series of tests and questionnaires prior to and after playing the game. Students played the game on the schools` laptop computers for 40-60 minutes.and then took approximately 30-40 minutes to complete the instruments.

Two versions of the printed 24-item measurement instrument were used at different points in this experiment. *Prior to the experiment,* a test of cognitive skills regarding knowledge about asthma was administered one week before playing the game. This was done to establish a baseline. *After the experiment,* the pre-test questionnaire was re-administered during the week after the experiment in order to determine changes in knowledge as a result of playing the game. The order of the questions in the questionnaire was modified so that students could not rely on remembering their pre-test responses.

Data Analysis

Data analyses were conducted using PASW 18 (formerly SPSS) for Windows. Descriptive statistics, paired t-tests, independent samples t-tests, and reliability analysis (Alpha) were run.

Results

Table 1 provides details about the respondents in the study. There appears to be a reasonably good gender, age, and grade distribution in our sample. Also, the test scores did not violate the assumption of a normal distribution.

Table 1.

Respondent background characteristics

	Quebec (n=73)	BC (n=60)	Combined (n=133)
Gender			
• Male	33 (45.2%)	29 (48.3%)	62 (46.6%)
• Female	40 (54.8%)	31 (51.7%)	71 (53.4%)
Total	73 (100.0%)	60 (100.0%)	133 (100.0%)
Age			

• 14 years	9 (12.3%)	23 (38.3%)	32 (24.1%)
• 15 years	23 (31.5%)	25 (41.7%)	48 (36.1%)
• 16 years	16 (21.3%)	11 (18.3%)	27 (20.3%)
• 17 years	23 (31.5%)	0	23 (17.3%)
• 18 years	2 (2.7%)	1 (1.7%)	3 (2.3%)
Total	73 (100.0%)	60 (100.0%)	133 (100.0%)
School grade			
Grade 9	28 (38.4%)	32 (53.3%)	60 (45.1%)
Grade 10	12 (16.4%)	28 (46.7%)	40 (30.1%)
Grade 11	33 (45.2%)	0	33 (24.8%)
Total	73 (100.0%)	60 (100.0%)	150 (100.0%)

Table 2.

Paired-samples t-tests on cognitive skills pre- and post-tests:

All respondents excluding control group

	Pre-test % score	Post-test % score	t-value	p-value
	mean (sd)	mean (sd)		
Cognitive skill (n=133)				
Subscale 1 Accessing prior knowledge]	7.31 (1.29)	7.69 (1.53)	2.62	.010
Subscale 2 Discriminatory links, i.e., similarities and differences	7.35 (2.68)	8.47 (2.68)	5.20	.000
Subscale 3 Making causal links	4.86 (1.62)	6.41 (1.10)	11.42	.000
Subscale 4 Making conditional links between two elements*	--	--	--	--
Subscale 5 Establishing analogies	26.20 (3.97)	26.09 (4.53)	-.24	.811
Knowledge total (out of 82)	51.21 (7.11)	55.15 (7.15)	6.07	.000

*The alpha reliability of this subscale was too low and so the results have not been reported

The reliability coefficients of the subscales and total test were determined using Cronbach`s alpha, a measure of internal consistency. The Alpha coefficients for the five subscales of the pre-test were respectively: .21,

.64, .47, .12, .51 and .72 for the total test. For the post-test, the alpha coefficients were: .46, .70, .27, .03, .74 and .81 for the total test. Results for subscale 4 have not been reported due to the unacceptably low alpha coefficients on both pre- and post-tests. The relatively low alpha coefficients on all scales may be due to the small number of items on each subscale.

The results in Table 2 show that there was a significant improvement on three of the four cognitive skill subscales as well as the total score (t (134)=6.07; p=.000). (In order to strengthen these results, we compared the BC classes that played the game (n=60) with one BC class (n=17) that did not play the game. The results were statistically significant (exp. group`s mean (sd)= 53.80 (7.66) versus control group 44.65 (14.19); t (76)=2.56, p=.019. There was no significant difference on the pre-test (p=.57).)

Finally, we used independent samples t-tests to compare males versus females on both pre-test and post-test. No significant differences in learning were found between males and females on the three subscales and total score (mean(sd) for males=67.86 (7.71) and for females= 64.32 (9.02); t(114)= .45; p=.66.

Discussion

Asthma: 1, 2, 3…Breath! is an educational game developed by family doctors, asthma specialists, expert game developers, and researchers. Regarding the ergonomics of the game, the results showed that students had a very high level of appreciation for the design, user-friendliness, and readability of the game. The game board was seen as visually appealing, as were the various elements—tokens, rules, instructions, stopwatch, and questions. The game's instructions, rules and game play were reported as easy to understand. The content of the questions was interesting and questions used a vocabulary appropriate for students.

The results of the experimental study with respect to knowledge were positive in three of the four cognitive skill subscales and the total test score. Statistically significant gains were made from pre-test to post-test on the total score as well as in the following three areas: (1) the capacity to call upon prior knowledge; ; (2) understanding of the differences and similarities between various elements of the subject studied (3) identification of key elements and establishing causal links in the subject being studied. These results provide support for using this genre of videogame in education.

In comparing the subscale and total scores between males and females, no significant differences were found. This confirms that males and females can learn equally well from this genre of videogame which is

consistent with the previous studies reviewed earlier. This is not surprising since males and females have traditionally played and enjoyed popular board games such as Parcheesi.

There were several limitations in this study that cause us to view these positive results with caution. First, although the alpha coefficient for the total test was acceptable, the alpha coefficient for some of the subscales was low. Secondly, the noise level in several classes was high and students sometimes had difficulty hearing the audio associated with the video clips on their computers. It could be argued that this is strength since the study was conducted in an authentic setting. Another issue is the constraints of class scheduling, that allowed limited time for playing the game (40-60 minutes typically) and some of this time was used to get started Finally, the relatively high levels of prior knowledge introduced the possibility that the cognitive skills measured were actually a measure of domain knowledge. Despite these issues, we were surprised and pleased to find that students 'cognitive skills were enhanced after playing the game.

These results are encouraging for teachers who wish to use these types of games in their classrooms to improve the learning of their students. The results are also encouraging since this game provides several elements that support 21st century learning, as described earlier, and these elements in the game appear to enhance the 21st century skills of critical thinking and problem solving. Also, the game play requires collaboration and communication among the four students playing the game together and provided immediate feedback. However, more work needs to be done to examine the impacts of this and other game genres on students' attitudes and motivation as well as the influence of learning styles. Also, questions about retention and transfer should be addressed. In future articles, we will report other results from the other data collected in this study with respect to these variables.

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References

Anderson, J. L. (2008). *The kids got game: Computer/video games, gender and learning outcomes in science classrooms.* Unpublished Ph.D. dissertation, Boston College. Available at http://escholarship.bc.edu/dissertations/AAI3318135

Andrieu, B., & Bourgeois, I. (2003). Interaction enseignant-élèves au cours des TPE, les dynamiques du processus de structuration des connaissances [Teacher-student interaction during independent study projects: Dynamics in the process of structuring knowledge]. In C. Larcher & A. Crindal (Eds.), *Structuration des connaissances et nouveaux dispositifs d'enseignement* (pp. 40-45). Paris: Institut national de recherche pédagogique.

Asakawa, T., & Gilbert, N. (2003). Synthesizing experiences: Lessons to be learned from Internet-mediated simulation games. *Simulation & Gaming*, *34*(1), 10-22.

Aspinwall, L., & Shaw, K. L. (2000). Enriching students' mathematical intuitions with probability games and tree diagrams. *Mathematics Teaching in the Middle School, 6*(4), 214-220.

Baldaro, B., Tuozzi, G., Codispoti, M., & Montebarocci, O. (2004). Aggressive and non-violent videogames: Short-term psychological and cardiovascular effects on habitual players. *Stress and Health*, *20*(4), 203-208.

Barab, S. A., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun. *Educational Technology Research and Development*, *53*(1), 86-107.

Barnett, D. J., Everly, G. S. Jr., Parker, C. L., & Links, J. M. (2005). Applying educational gaming to public health workforce emergency preparedness. *American Journal of Preventive Medicine*, *28*(4), 490-495.

Blais, R., Grégoire, J. P., Rouleau, R., Cartier, A., Bouchard, J., & Boulet, L. P. (2001). Ambulatory use of inhaled beta(2)-agonists for the treatment of asthma in Quebec: A population-based utilization review. *Chest*, *119*(5), 1316 - 1321.

Blouin, M., & Bergeron, C. (1997). *Dictionnaire de la réadaptation, tome 2: termes d'intervention et d'aides techniques.* Québec, QC, Canada: Les Publications du Québec.

Blum, H. T., & Yocom, D. J. (1996). A fun alternative: Using instructional games to foster student learning. *TEACHING Exceptional Children*, *29*(2), 80-63.

Blumberg, F. C., & Sokol, L. M. (2004). Boys' and girls' use of cognitive strategy when learning to play video games. *The Journal of General Psychology, 131*(2), 151-158.

Boulet, L. P., Thivierge, R. L, Bellera, C., Dorval, E., & Collet, J. P. (2004). Physicians' assessment of asthma control in low vs. high asthma-related morbidity regions. *Journal of Asthma 2004*, *41*(8), 613-624.

Brien, R. (1994). *Science cognitive et formation*. Québec, Canada: Presses de l'Université du Québec.

Brown, S. J., Lieberman, D. A., Gemeny, B. A., Fan, Y. C., Wilson, D. M., & Pasta, D. J. (1997). Educational video game for juvenile diabetes: Results of a controlled trial. *Medical Informatics, 22*(1), 77-89.

Caron Bouchard, M., & Renaud, L. (2001). *Pour mieux réussir vos communications en promotion de la santé*. Montréal : Institut national de santé publique du Québec.

Cassell, J., & Jenkins, H. (Eds.) (1998). *From Barbie to Mortal Kombat*. Boston: The MIT Press.

Cesarone, B. (1998). *Video games: Research, ratings, recommendations.* Chicago: ERIC Clearinghouse on Elementary and Early Childhood Education.

Conseil du Médicament du Québec (2003). http://www.cdm.gouv.qc.ca/fr/.

De Grandmont, N. (2005) *Pédagogie du jeu…philosophie du ludique* [Game pedagogy …ludic philosophy]. Retrieved January 15, 2007 from http://cf.geocities.com/ndegrandmont/index.htm.

De la Cruz, R. E., Cage, C. E., & Lian, M.-G. J. (2000). Let's play mancala and sungka! *TEACHING Exceptional Children*, *32*(2), 38-42.

Entertainment Software (ESA). (2004). *ESA'S 2004 Essentials facts about the computer and video game industry*. Retrieved April 9, 2005, from http://www.theesa.com/files/EFBrochure.pdf.

Evreinova, T. G., Evreinov, G., & Raisamo, R. (2006). An alternative approach to strengthening tactile memory for sensory disabled people. *Universal Access in the Information Society*, *5*(2), 189-198.

Fournier, M., Wendling, T., Craipeau, S., Legout, M.-C., Auray, N., Vincent, S., et al. (2004). À quoi sert le jeu ? [What use are games?] *Sciences humaines*, *152*, 19-45.

Frété, C. (2002). *Le potentiel du jeu vidéo pour l'éducation* [The potential of vidéo games for éducation]. Unpublished Master's thesis, Université de Genève Faculté de Psychologie et des Sciences de l'Education, TECFA (Technologies de la Formation et de l'Apprentissage).

Fukuchi, S. G., Offutt, L. A., Sacks, J., & Mann, B. D. (2000). Teaching a multidisciplinary approach to cancer treatment during surgical clerkship via an interactive board game. *The American Journal of Surgery*, *179* (4), 337-340.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave MacMillan.

Green, D. A. (2002). Last one standing: Creative, cooperative problem solving. *Teaching Children Mathematics*, *9*(3), 134-139.

Gros, B. (2003). The impact of digital games in education. *First Monday*, *8*(7). Retrieved February 19, 2005, from http://www.firstmonday.dk/issues/ issue8_7/xyzgros/.

Haas, J. P., Quiros, D., Hyman, S. R., & Larson, E. L. (2006). Use of an innovative game to teach and reinforce hand hygiene compliance among healthcare workers. *American Journal of Infection Control, 34*(5), E52-E53.

Higgins, M. M., & Barkley, M. C. (2004). Improving effectiveness of nutrition education resources for older adults. *Journal of Nutrition for the Elderly*, *23*(3), 19-54.

Holton, D., Ahmed, A., Williams, H., & Hill, C. (2001). On the importance of mathematical play. *International Journal of Mathematical Education in Science and Technology*, *32*(3), 401-415.

Jensen, J., & de Castell, S. (2006). You're going to die: Gender, performance and digital game play. In V. Uskov (Eds.), *Proceedings of the International Conference on Computers and Advanced Technology in Education,* Lima, Peru.

Jensen, J., & de Castell, S. (2010). Gender and digital gameplay: Theories, oversights, accidents, and surprises. In Kaufman, D., & Sauvé, L. (Eds.) (2010). *Educational gameplay and simulation environments: Case studies and lessons learned.* Hershey, PA: IGI Global.

Kafai, Y. B. (2001, October). *The educational potential of electronic games: From games–to–teach to games–to–learn.* Paper presented at the Playing by the Rules Conference, Chicago. Retrieved November 5, 2004, from http://culturalpolicy.uchicago.edu/conf2001/papers/kafai.html.

Kaufman, D., & Sauvé, L. (Eds.) (2010). *Educational gameplay and simulation environments: Case studies and lessons learned.* Hershey, PA: IGI Global.

Ke, F. (2009). A qualitative meta-analysis of computer games as learning tools. In R. Ferdig (Ed.), *Handbook of research on effective electronic gaming in education* (pp. 1-32). Hershey, PA: IGI Global.

Kirriemur, J., & McFarlane, C. A. (2004). *Literature review on games and learning: A report for NESTA Futurelab*. Retrieved November 5, 2004, from http://www.nestafuturelab.org/research/ reviews/08_01.htm.

Klopfer et al. (2009).

Koirala, H. P., & Goodwin, P. M. (2000). Teaching algebra in the middle grades using Mathmagic. *Mathematics Teaching in the Middle School, 5*(9), 562-566.

Komoski, P. K. (1979). Counterpoint: Learner verification of instructional materials. *Educational Evaluation and Policy Analysis, 1*(3), 101-103.

Komoski, P. K. (1984). Formative evaluation. The empirical improvement of learning materials. *Performance & Instruction Journal, 22*(5), 3-4.

Krajewsky, P. R., & Piroli, V. B. (2002). Something old, something new, something borrowed, something blue: Active learning in the classroom. *Journal of Library Administration*, *36*(1-2), 177-194.

Lamy, C. (2004). *NetAdos 2004 - Sondage réalisé auprès des ados québécois & de leurs parents* [Poll of Québécois adolescents and their parents]. Québec: CEFRIO. Retrieved October 6, 2007, from http://www.cefrio.qc.ca/rapports/NetAdos_ 2004_rapport.pdf.

Lemière, C., Bai, T., Balter, M., Bayliff, C., Becker, A., Boulet, L. P., et al. (2004). Adult asthma consensus guidelines update 2003. *Canadian Respiratory Journal 2004*, *11*(Suppl. A): 9A-18A.

Lennon, J. L., & Coombs, D.W. (2006). Child-invented health education games: A case study for dengue fever. *Simulation & Gaming*, *37*(1), 88-97.

Lennon, J. L., & Coombs, D.W. (2007). The utility of a board game for dengue haemorrhagic fever health education. *Health Education*, *107* (3), 290-306.

Lieberman, D. A. (1998, July). *Health education video games for children and adolescents: Theory, design, and research findings.* Paper presented at the annual meeting of the International Communication Association, Jerusalem, Israel.

Lieberman, D. A. (2001). Management of chronic pediatric diseases with interactive health games: Theory and research findings. *Journal of Ambulatory Care Management*, *24*(1), 26-38.

Lieberman, D.A., Fisk, M.C., Biely, E. (2009). Digital games for young children ages three to six: From research to design. *Computers in the Schools*., 26: 4, 299-313.

Macfarlane, A., Sparrowhawk, A., & Heald, Y. (2002). *Report on the educational use of video games: An exploration by TEEM (Teachers Evaluating Educational Multimedia) of the contribution which games can make to the education process.* Retrieved August 23, 2003, from http://www.teem.org.uk/publications/teem_gamesined_full.pdf.

Markey, C., Power, D., & Booker, G. (2003). Using structured games to teach early fraction concepts to students who are deaf or hard of hearing. *American Annals of the Deaf*, *148*(3), 251-258. Retrieved November 5, 2004, from http://www.gallaudet.edu/~ossweb/annals/.

Meel, D. E. (2000). Sum go here and sum go there. *Mathematics Teaching in the Middle School, 6*(4), 236-239.

Miller, C. S., Lehman, J. F., & Koedinger, K. R. (1999). Goals and learning in microworlds. *Cognitive Science*, *23*(3), 305-336.

Mitchell, A., & Savill-Smith, C. (2004). *The use of computer and video games for learning: A review of the literature.* London, UK: Learning and Skills Development Agency. Retrieved November 5, 2004, from http://www.lsda.org.uk/files/PDF/1529.pdf.

Mondozzi, M. A., & Harper, M. A. (2001). In search of effective education in burn and fire prevention. *Journal of Burn Care & Rehabilitation*, *22*(4), 277-281.

Moyer, P. S., & Bolyard, J. J. (2003). Classify and capture: Using Venn diagrams and tangrams to develop abilities in mathematical reasoning and proof. *Mathematics Teaching in the Middle School*, *8*(6), 325-330.

Padgett, L. S., Strickland, D., & Coles, C. D. (2005). Case study: Using a virtual reality computer game to teach fire safety skills to children diagnosed with fetal alcohol syndrome. *Journal of Pediatric Psychology 31*(1), 65-70.

Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. *Computers & Education, 52* (1), 1-12.

The Partnership for 21st Century Skills (2009). Retrieved on November 29, 2010 from http://www.p21.org/index.php

Purushotma, R. (2005). Commentary: You're not studying, you're just… *Language Learning & Technology*, *9*(1), 80-96.

Ravenscroft, A. (2007). Promoting thinking and conceptual change with digital dialogue games. *Journal of Computer Assisted Learning, 23*(6), 453-465.

Roberts, D. F., Foehr, U. G., Rideout, V. J., & Brodie, M. (1999). *Kids and media at the new millennium: A comprehensive national analysis of children's media use*. Menlo Park, CA: Kaiser Family Foundation.

Rosas, R., Nussbaum, M., Cumsille, P., Marianov, V., Correa, M., Flores, P.A., et al. (2003). Beyond Nintendo: design and assessment of educational video games for first and second grade students. *Computers & Education, 40*(1), 71-94.

Sauvé, L., Renaud, L., & Hanca, (2008b). *Étude de cas auprès des élèves du secondaire: apprentissage des ITS à l'aide d'un jeu éducatif en ligne* (research report). Québec, Canada: SAVIE and SAGE.

Sauvé, L., Renaud, L., Kaufman, D., & Sibomana, F. (2008a). *Revue systématique des écrits (1998-2008) sur les impacts du jeu, de la simulation et du jeu de simulation sur l'apprentissage. Rapport final* [Systematic review of the literature on the impacts of games, simulations and simulation games. Final report. Québec: SAGE and SAVIE.

Sauvé, L., Kaufman, D. & Renaud, L. (2007, June). *A systematic review of the impact of games and simulations on learning.* Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications 2007 (ED-MEDIA), Vancouver, Canada.

Sauvé, L. (2010a). Initial Analysis for Creating a Generic Online Educational Game Shell. In D. Kaufman & L. Sauvé (Eds.) (2010). *Educational gameplay and simulation environments: Case studies and lessons learned.* Hershey, PA: IGI Global.

Sauvé, L. (2010b). Designing a Generic Educational Game Shell. In D. Kaufman & L. Sauvé (Eds.) (2010). *Educational gameplay and simulation environments: Case studies and lessons learned.* Hershey, PA: IGI Global.

Shaffer, D., Squire, K., Halverson, R., & Gee, J. (2004). Video games and the future of learning. University of Wisconsin-Madison and Academic Advanced Distributed Learning Co-Laboratory. http://www.academiccolab.org/resources/gappspaper1.pdf

Shaftel, J., Pass, L., & Schnabel, S. (2005). Math games for adolescents. *Teaching Exceptional Children*, *37*(3), 27-33.

Shreve, J. (2005, April/May). Let the games begin. Video games, once confiscated in class, are now a key teaching tool if they're done right. *Edutopia*, 29-31.

Silverman, B. G., Holmes, J., Kimmel, S., & Branas, C. (2002). Computer games may be good for your health. *Journal of Healthcare Information Management*, *16*(2), 80-85.

Steinkuehler, C. & Duncan, S. (2009). Informal scientific reasoning in online virtual worlds. *Journal of Science Education & Technology*. DOI: 10.1007/s10956-008-9120-8.

Steinman, R. A., & Blastos, M. T. (2002). A trading-card game teaching about host defence. *Medical Education*, *36*(12), 1201-1208.

Subrahmanyam, K., & Greenfield, P.M. (1998). Computer games for girls: What makes them play? In J. Cassell & H. Jenkins (Eds.), *From Barbie to Mortal Combat: Gender and computer games.* Cambridge, MA: MIT Press.

Vandeventer, S. S., & White, J. A. (2002). Expert behavior in children's video game play. *Simulation & Gaming*, *33*(1), 28-48.

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research, 34* (3), 229-243.

Williamson, B., & Facer, K. (2004). More than 'just a game': The implications for schools of children's computer games communities. *Education*, *Communication, & Information*, *4*(2/3), 255.

Wissmann, J. L. & Tankel, K. (2001). Nursing student's use of a psychopharmacology game for client empowerment. *Journal of Professional Nursing*, *17*(2), 101-106.