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A Study on Exploiting Commercial Digital Games into School Context

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ABSTRACT

Digital game-based learning is a research field within the context of technology-enhanced learning that has attracted significant research interest. Commercial off-the-shelf digital games have the potential to provide concrete learning experiences and allow for drawing links between abstract concepts and real-world situations. The aim of this paper is to provide evidence for the effect of a general-purpose commercial digital game (namely, the "Sims 2-Open for Business") on the achievement of standard curriculum Mathematics educational objectives as well as general educational objectives as defined by standard taxonomies. Furthermore, students' opinions about their participation in the proposed game-supported educational scenario and potential changes in their attitudes toward math teaching and learning in junior high school are investigated. The results of the conducted research showed that: (i) students engaged in the game-supported educational activities achieved the same results with those who did not, with regard to the subject matter educational objectives, (ii) digital game-supported educational activities resulted in better achievement of the general educational objectives, and (iii) no significant differences were observed with regard to students' attitudes towards math teaching and learning.

Keywords

Commercial off-the-shelf games, Game-supported educational activities, School math teaching and learning

Introduction

Digital game-based learning is a research field within the wider context of technology-enhanced learning that has attracted, during the last few years, the interest of both the research and educational community (Kirriemuir & McFarlane, 2004; Sandford & Williamson, 2005; Sandford et al., 2006; Van Eck, 2007, Chen & Chan, 2010). Connolly and Stansfield (2007) define digital game-based learning as "the use of a computer games-based approach to deliver, support and enhance teaching, learning, assessment, and evaluation", whereas Prensky (2007, pp. 145–146) stresses the additional educational value of digital game-based learning by defining it as an approach based on the integration of educational content into digital games and leading to the achievement of the same or better results, in comparison to traditional instructional approaches. Furthermore, Chen and Wang (2009) focus on the motivational aspect of digital games and their potential to facilitate active construction of knowledge by defining digital game-based learning as "an effective means to enable learners to construct knowledge by playing, maintain higher motivation and apply acquired knowledge to solve real-life problems".

Research interest regarding digital game-based learning can be first of all attributed to the fact that digital games engage and motivate people of all ages (Saulter, 2007). Furthermore, by simulating real-world situations (Winn, 2002) and presenting ill-defined problems (Klopfer, 2008, p. 17; Whitton, 2010, p. 51), general-purpose commercial games bare the potential to situate players' activities within authentic and meaningful contexts (Prensky, 2007, p. 159; Gee, 2007, pp. 71–110; Whitton, 2010, p. 46) and offer opportunities for learning by applying trial-and-error approaches (Oblinger, 2004; Prensky, 2007, pp. 158–159; Chen & Shen, 2010). Players are able to engage in active explorations, formulate and test hypotheses within the virtual world of the game, and, based on feedback, confirm or reject them (Gee, 2007, p. 105).

The engagement and motivation that games offer alongside with their potential to provide concrete learning experiences has attracted significant research interest with regard to the integration of commercial games into formal educational settings as well as the development and use of specially-designed educational games (Kirriemuir & McFarlane, 2004; Sandford & Williamson, 2005; Van Eck, 2006). While there is a large number of research studies considering the use of educational digital games for delivering educational content (e.g. Rosas et al., 2003; Williamson Shaffer, 2006; Bottino et al., 2007; Ke, 2008; Sisler & Brom, 2008; Lim, 2008; Annetta et al., 2009; Papastergiou 2009; Tuzun et al., 2009), there are relatively few studies investigating methods of integrating commercial off-the-shelf digital games into existing teaching practices (e.g. Squire & Barab, 2004; Egenfeldt-Nielsen, 2005; Sandford et al., 2006; Robertson & Miller, 2009; Tanes & Cemalcilar, 2009).

In this context, the aim of this paper is to provide evidence for the effect that commercial simulation games can have on the achievement of standard curricula educational objectives when used as part of wider sets of appropriately designed educational activities. More specifically, our work focuses on investigating the influence of a commercial business simulation game (namely, the "Sims 2 – Open for Business") on achieving educational objectives related to the subject matter of Mathematics as well as general educational objectives defined by standard taxonomies. Furthermore, students' opinions about the use of the selected digital game and potential changes in their attitudes toward math teaching and learning in junior high school are investigated.

Literature review

Digital game-based learning research investigates, among others, methods of integrating digital games (commercial or educational) into existing teaching practices with the purpose to facilitate the achievement of standard curricula educational objectives, increase students' motivation, and develop positive attitudes toward specific subjects and/or school education in general (e.g. Rosas et al., 2003; Squire & Barab, 2004; Egenfeldt-Nielsen, 2005; Williamson Shaffer, 2006; Bottino et al., 2007; Ke, 2008; Robertson and Miller, 2009; Papastergiou 2009; Tuzun et al., 2009). In particular for Mathematics teaching and learning at school level there are a number of studies mainly focusing on the implementation and evaluation of educational designs aiming at the achievement of subject matter educational objectives with the support of specially-designed educational games (Rosas et al., 2003; Williamson Shaffer, 2006; Bottino et al., 2007; Ke, 2008).

Evidence provided from research shows that using educational games as part of Mathematics teaching at school level can be at least as effective as non-gaming approaches with regard to the achievement of subject matter educational objectives (Rosas et al., 2003; Williamson Shaffer, 2006; Ke, 2008). By engaging students in long-lasting game-supported educational activities there is potential for enhancing the development of problem-solving skills and achieving improved results in mathematics exams (Bottino et al., 2007). With regard to the need for supporting students draw links between school-based mathematics and real-world situations (Lowrie, 2005), Williamson Shaffer (2006) shows that using role-playing educational games for designing and implementing meaningful activities allows for providing students with concrete examples highlighting potential uses of abstract mathematical concepts and procedures in specific domains. In this context, Ke (2008) stresses the need for appropriate educational designs targeting at framing the use of educational games by claiming that monitoring activities with games and supporting them by supplementary tools and/or resources are necessary for the achievement of intended learning outcomes. To this end, she provides evidence indicating that students do not use feedback provided from games in order to reflect on their actions and hence lack opportunities for constructing and evaluating new knowledge.

Continuing with the effects that innovations based on the use of digital games can have on school math education, most studies demonstrate significant increase in students' motivation as well as their interest toward the subject matter of Mathematics and/or school education in general (Rosas et al., 2003; Williamson Shaffer, 2006; Ke, 2008; Lim, 2008; Robertson & Miller, 2009). Important issues that have been highlighted are the improvement of relationships between students (Robertson & Miller, 2009) as well as improvement of communication and collaboration between students and teachers (Rosas et al., 2003). Positive effects have also been noticed with regard to students' discipline, on task concentration, peer collaboration, perseverance in task completion (Rosas et al., 2003), and responsibility (Rosas et al., 2003; Robertson & Miller, 2009).

Finally, there is a small number of studies targeting at providing evidence for the impact of game-supported educational innovations on the development of Mathematics related skills and competencies (e.g. Bottino et al., 2007; Robertson & Miller, 2009). More specifically, Robertson and Miller (2009) present research findings showing positive effects of puzzle games on elementary school students' mental computational skills such as accuracy and speed in conducting numerical operations, whereas Bottino et al. (2007) claim that appropriate educational designs, supported by the use of educational games, can promote the development of critical thinking skills by engaging students in formulation and testing of hypotheses, reflection activities, and drawing inferences.

As evidenced by the literature review there is a significant number of research studies focusing on the effects that specially-designed educational games can have when used either in the context of school math education (e.g. Rosas et al., 2003; Williamson Shaffer, 2006; Bottino et al., 2007; Ke, 2008) or as part of teaching subjects other than Mathematics (e.g. Papastergiou, 2009; Annetta, 2009; Tuzun et al., 2009). On the other hand, there are relatively few studies investigating the potential use of general-purpose commercial games in the context of school-based education in general (e.g. Squire & Barab, 2004; Egenfeldt-Nielsen, 2005; Sandford et al., 2006; Tanes & Cemalcilar, 2009) and even less with regard to Mathematics teaching and learning at school level in particular (e.g. Robertson & Miller, 2009). Thus, the main purpose of our study is to investigate methods of integrating commercial off-the-shelf digital games, and more specifically simulation games, into the context of Mathematics teaching by proposing and implementing an appropriately designed scenario of game-supported educational activities and providing evidence for their effect on achieving standard curriculum educational objectives.

Design and implementation of research

Research questions

Based on the literature review, we propose the following questions to be researched for the purpose of our study:

- **RQ1:** Is the proposed educational design, based on the use of the commercial business simulation game "Sims 2 – Open for Business", more effective than a non-gaming approach in terms of achieving standard curriculum mathematics educational objectives?
- **RQ2**: Is the proposed educational design, based on the use of the commercial business simulation game "Sims 2 – Open for Business", more effective than a non-gaming approach in terms of achieving general educational objectives, as defined by standard taxonomies?
- **RQ3**: What are students' opinions about the use of the game "Sims 2-Open for Business" in the context of Mathematics teaching and do their attitudes toward school math teaching and learning change after having participated in the proposed game-supported educational activities?

Research method and study participants

The method that was employed for researching the aforementioned questions was field experiment with one experimental and one control group and the assignment of a post-test (Cohen, Manion & Morrison, 2008, p. 278). Field experiment is a variation of the experimental method, commonly used in cases of empirical studies conducted in educational settings (Cohen, Manion & Morrison, 2008, p. 274). It allows for investigating potential effects of educational innovations (often in comparison to other mainstream practices) as well as observing interactions taking place in natural settings and hence it is considered as appropriate for the purpose of our study.

Our study participants were 59 students (N = 59), at the age of 13–14 years old, attending the second grade of a private junior high school located in Athens, Greece. Students belonged to two different classes (classes A and B), one of which (class A) was the experimental group (number of students = 30) whereas the other (class B) was the control group (number of students = 29).

Research instruments

Questionnaires

Background questionnaires and post-questionnaires were used in the beginning and at the end of our research respectively in order to gather data for shaping students' profile and investigate potential changes in their attitudes toward school math teaching and learning. The background questionnaire consisted of three parts and a total number of 31 questions with the first two parts including thirteen Likert type questions regarding attitudes toward the use and usefulness of computers in the educational process (Texas Center for Educational Technology, 2010) and eight questions regarding students' involvement in gaming activity (Pew Internet & American Life Project, 2010) respectively. The third part included 10 Likert type questions targeting at investigating attitudes toward school math teaching and learning (Kislenko et al., 2005) in the beginning of our research.

The post-questionnaire was used after the implementation of the game-supported educational scenario. It consisted of two parts with its first part being the same with the third part of the background questionnaire and its second part including the following two open-ended questions:

- **Q1**: What is your opinion about the use of the game in the context of Mathematics teaching?
- **Q2**: Do you believe that the use of the game helped you, in any way, to understand better the mathematical concepts that were taught?

Post-test

Tests are research instruments which, in the context of digital game-based learning research are most commonly used for the assessment of subject matter educational objectives (e.g. Rosas et al., 2003; Ke, 2008; Egenfeldt-Nielsen, 2005; Papastergiou, 2009). For the purpose of our study, a post-test targeting at the assessment of subject matter educational objectives was assigned to students of both groups. It contained matching pairs of items, true/false statements, as well as two open-ended questions, and its design was based on proposed good practice standards (Cohen, Manion & Morrison, 2008, pp. 426–429).

Worksheets

In game-supported educational designs, learners' activities with games are often supplemented by tools such as worksheets (Sandford et al., 2006; Ke, 2008) which are used with the aim to facilitate necessary reflection activities. In the context of our research, worksheets, designed by researchers, were used by students in order to formulate hypotheses, write down the results of their hypotheses' testing, and provide explanations for observed results. This instrument was used for gathering data and providing evidence for the effect of the proposed educational design on the achievement of general educational objectives.

Selection of digital game and pedagogical framework

The game that was selected to support the proposed educational activities was "Sims 2–Open for Business", a commercial business simulation game which engages players in activities requiring data monitoring, strategic thinking, decision making, as well as planning and performing actions related to managing a business and keeping customers satisfied. The game allows players to set price of products, hire employees based on specific criteria and assign tasks to them by taking into consideration their talents and interests. As a simulation game it depicts a simplified version of reality (Herz, 1997, pp. 215–223). Sophisticated graphics and advanced sound effects help to create a rich and interactive environment in which players have a sense of control (Herz, 1997, pp. 215–223) and are offered opportunities to get engaged in active explorations, hypotheses testing, and discovery of causal relationships between game variables.

Exploiting digital games for educational purposes requires careful consideration of a number of issues that can ensure the alignment of game features with the intended learning outcomes. Thus, selecting an appropriate pedagogical approach for framing the game-supported educational activities is considered as highly important. The pedagogical approach that was employed in the context of our study was the problem-solving model (Eggen & Kauchak, 2006, pp. 252–259).

Problem-based learning involves the assignment of ill-defined, real-world problems to students (Whitton, 2010, p. 50) who are prompted to collaborate in order to design, implement, and evaluate strategies for solving them (Eggen & Kauchak, 2006, p. 250). Educational designs based on the problem-solving model allow for engagement in authentic and meaningful activities in the context of which learners are able to draw links between abstract concepts and real-world practices, as well as, to develop skills that can be further applied to other contexts (Eggen & Kauchak, 2004). Furthermore, games and simulations are considered as digital tools, commonly employed by instructors when developing educational designs based on the problem-solving paradigm (de Freitas, 2006).

Game-supported educational design

The design of both study groups' educational scenarios was based on a common pedagogical approach, namely the problem-solving model. The intended educational objectives, as well as, the activities that were designed to facilitate their achievement are described in the following two sections.

Educational objectives

In our experiment, the subject matter educational objectives, explicitly described by the Greek National Curriculum (2003), refer to linear functions (namely "y = ax" and "y = ax + b") and they relate to: (i) drawing the graphs of linear functions on a set of cartesian axes, (ii) finding the slope of a line when the algebraic type of the corresponding linear function is provided, (iii) finding the points of intersection between the graph of a linear function and the two axes, and (iv) finding the algebraic type of a linear function when specific data are given (e.g. the slope of the line and a point on the graph).

General educational objectives are aligned with the upper levels of the cognitive domain of Bloom's taxonomy (namely "analysis", "synthesis", and "evaluation") and can be achieved by designing and implementing educational activities targeting at involving students in actions like: (i) comparing and contrasting, (ii) explaining reasons for, and (iii) evaluating results (Falconer et al., 2006).

Scenarios of educational activities

The problem-solving model consists of five phases of educational activities (Eggen & Kauchak, 2006, pp. 252–259) as shown in Figure 1.

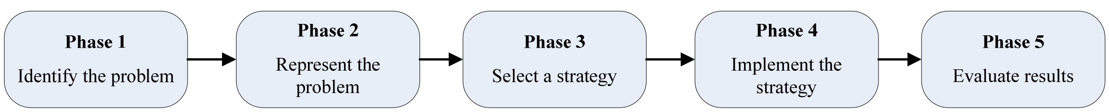

Figure 1. Phases of educational activities of the problem-solving model

However, when integrating digital games into the educational process it is important to design and implement appropriate activities targeting at familiarizing students with the selected game (Sandford et al., 2006; Whitton, 2010, p. 82). In the case of the experimental group's educational scenario, an additional phase of activities was inserted between phases one and two of the problem-solving model as shown in Figure 2.

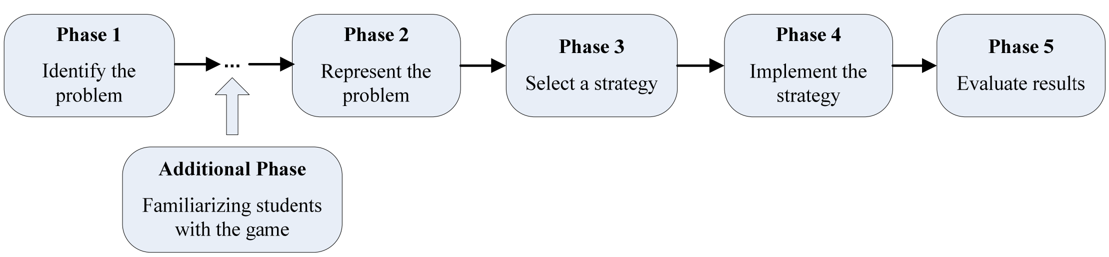

Figure 2. Phases of educational activities of the experimental group's scenario

Activities of the experimental group's educational scenario were described by adopting the DialogPlus taxonomy of educational activities and are summarized in Table 1 below. As indicated by the brief description of activities in Table 1, students of the experimental group (class A) were assigned a problem targeting at investigating issues related to the management of an enterprise. For testing alternative solutions to the given problem, students were divided into six groups and two sessions of educational activities (of two didactic hours each), fully supported by the selected game, were implemented.

Table 1. Phases and activities of the experimental group's scenario

Phase	Implemented Educational Activities
Phase 1: Identify the problem	The teacher: • makes a brief description of the game-supported educational activities that will be implemented, • presents the intended educational objectives, • presents the problem to be solved.
Phase 2: Familiarizing students with the game	The teacher: • makes a brief presentation with regard to the content and objectives of the game, • performs a live, in class, demonstration of the game. Students interact with the game in order to familiarize themselves with the interface and the actions that can be performed.
Phase 3: Represent the problem	A class-based discussion takes place where students express their opinions with regard to issues related to the given problem's solution. The teacher with the support of students constructs a mind map depicting relations between these issues.
Phase 4: Select a strategy	A class-based discussion takes place with regard to actions that students should perform, with the support of the selected game, in order to test potential solutions to the problem. Design of an action plan.
Phase 5: Implement the strategy	Students: • collaborate in order to test solutions within the virtual world of the game, • work out arithmetic examples in order to investigate causal relationships between specific game variables and try to derive the underlying algebraic formulas. The teacher: • monitors students' activities with the game and provides support with regard to the implementation of the agreed plan of actions, • presents new mathematical concepts related to linear functions.
Phase 6: Evaluate results	Students: • collaborate in order to develop their final proposals-solutions to the given problem, • present their final proposals.

Members of each group were prompted to select a virtual enterprise and investigate effects of actions that the game allows for (e.g. hiring employees and assigning tasks to them, setting prices for products, increasing employees' salaries etc) on the status of their business. To this end, they were asked to formulate hypotheses, test them within the virtual world of the game, confirm or reject these hypotheses, provide explanations for observed results, and develop final proposals-solutions to the given problem. As part of formulating their hypotheses, students were expected to explicitly describe actions to be performed, with regard to their virtual enterprise's management, and anticipated results. After having applied the proposed actions, students used feedback provided from the game in order to compare the status of their business before and after the testing of hypotheses and hence confirm or reject them. Figure 3 illustrates the type of feedback that the game provides with regard to the virtual enterprise's status.

Figure 3. Feedback regarding the status of virtual enterprise

Providing explanations for observed results allowed for reflecting upon performed actions as well as discovering causal relationships between performed actions and their outcomes. The development of final proposals was the result of the evaluation of actions performed within the virtual world of the game and their effects on the status of the virtual enterprise. Figure 4 shows the actions that students performed with the support of the selected game.

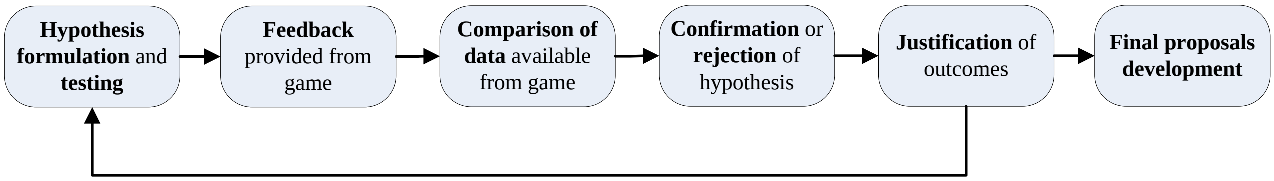

Figure 4. Actions performed with the support of game

With regard to subject matter educational objectives, students of the experimental group were asked to work out arithmetic examples which would help them derive algebraic formulas that highlight relationships between specific game variables (e.g. “wholesale cost of a product” and “retail cost of a product”). These activities served as a starting point for the presentation of new mathematical concepts by the teacher (related to linear functions) and students were provided with concrete examples targeting at helping them draw links between abstract mathematical concepts and variables of the game. Figure 5 illustrates the framework that was adopted for the design and implementation of the experimental group’s game-supported educational scenario.

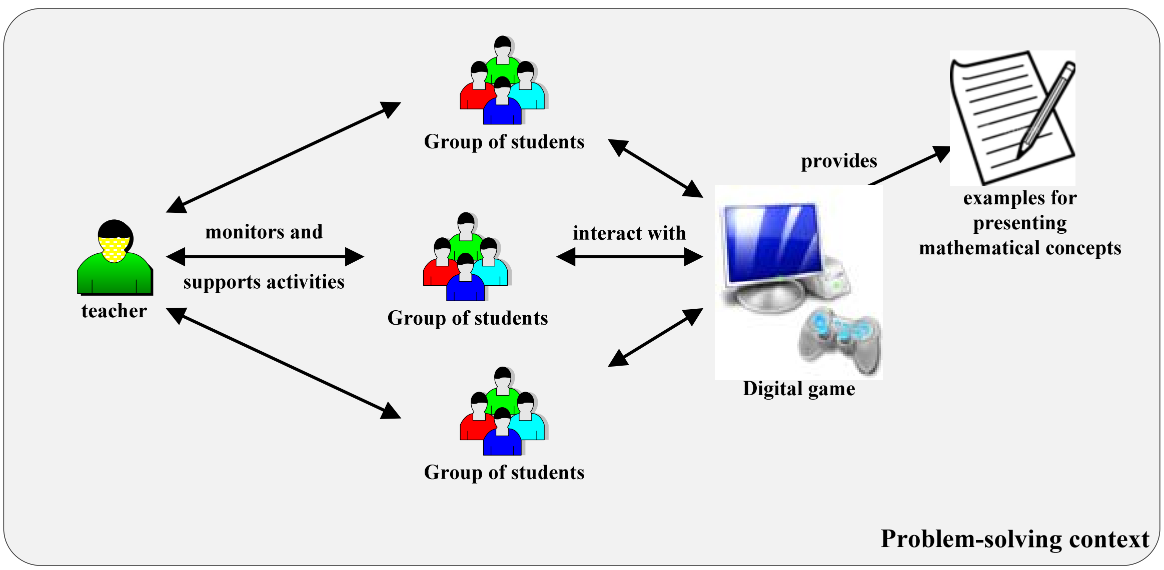

Figure 5. Framework for the design of game-supported activities

The control group’s scenario of educational activities was also based on the problem-solving model with students being presented with a problem similar to that of the experimental group’s. More specifically, students of the control group (class B) were assigned the role of a computer store’s sales manager and prompted to collaborate in order to develop a proposal for a potential customer. By considering issues such as specifications imposed by the client, cost of material, salaries and expertise of employees, profit percentage, and time needed to satisfy the customer’s request, they were asked to develop alternative solutions to the given problem and finally propose the one that would best meet the aforementioned criteria. For the investigation of alternative solutions to the given problem, students were provided a period of time equal to that of the experimental group. Necessary data could be extracted from websites and printed material provided by the teacher.

Research results

Describing students' profile

Participating students were at the age of 13–14 years old when our study was conducted and they are coming from families with an average or high socio-economic background. As evidenced by data gathered from background questionnaires, our research subjects were familiar with the use of computers, which constituted an integral part of their everyday life and culture, and reported that they are convinced that digital technology can have a positive effect on the achievement of educational objectives. With regard to their involvement in digital gaming activity, 98.2% of the total sample reported playing digital games, with the frequency of the gaming activity ranging from many times a day to a few times a month (94.5% of the total sample) and its duration from 1 to 4–5 hours per time (96.3% of the total sample).

As far as students' background mathematics knowledge is concerned, final grades at the end of the previous school year were taken into account and the two groups' mean scores were compared. The mean score of the experimental group was 79.46% (SD = 11.574), whereas the mean score of the control group was 78.97% (SD = 12.563). The t-test (Cohen, Manion & Morrison, 2008, pp. 543–546) that was conducted revealed no significant differences between the two study groups' mean scores (t = 0.156, df = 55, two-tailed, p = 0.877).

Effect on the achievement of subject matter educational objectives

The effect of the proposed game-supported educational design on the achievement of standard curriculum mathematics educational objectives was measured by conducting the t-test in order to compare the mean scores of the two groups' post-tests. Results are analytically presented in Table 2.

Table 2. Assessment results from both study groups' post-tests

	Group	N	Mean	Std. Deviation	Std. Error Mean
Groups' scores	Experimental Group	29	60.52%	19.335	3.590
	Control Group	28	57.86%	27.770	5.248

As far as the comparison of the two groups' mean scores is concerned, Levene's test showed that no equal variances could be assumed (p = 0.006 < 0.05) and the results of the t-test corresponding to this case, which are analytically presented in Table 3, revealed no significant differences between the two study groups' mean scores (t = 0.418, df = 48.041, two-tailed, p = 0.678).

Table 3. Results of the t-test conducted for comparing the post-tests' scores

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper
Groups' scores	Equal variances assumed	8.309	.006	.421	55	.675	2.660	6.319	-10.004	15.324
	Equal variances not assumed			.418	48.041	.678	2.660	6.359	-10.125	15.445

Effect on the achievement of general educational objectives

Monitoring students' activities with games in order to ensure the achievement of the intended educational objectives (Torrente et al., 2009, pp. 1–18) as well as developing specific criteria for assessing students' performance in the context of problem-based educational scenarios (Eggen & Kauchak, 2006, pp. 273–276) are considered as highly important. To this end, we used appropriately designed worksheets for supporting educational activities with the selected game and employed specific assessment criteria, fully aligned with the general educational objectives. Assessment criteria as well as their alignment with the game-supported educational activities and the intended educational objectives are presented in Table 4.

Table 4. Criteria for assessing the experimental group's worksheets

Digital game-supported activities	Educational objectives	Assessment criteria
Hypotheses formulation	-	Clear distinction between actions to be performed and anticipated results (criterion 1). Formulation of hypothesis in an explicit way (criterion 2).
Comparison of data provided from game menus before and after the testing of hypotheses	Compare and contrast	Use of feedback provided from the game (criterion 3).
Justification of results	Explain reasons for	Adequate justification of outcomes based on feedback provided from the game (criterion 4).

Results from the assessment of the game-supported educational activities are presented in Table 5. Results are presented for each one of the six groups that students of the experimental group formed and for each one of the two sessions of game-supported activities.

Table 5. Results from the assessment of the experimental group's worksheets

	1st session of game-supported activities						2nd session of game-supported activities					
Groups of students	A	B	C	D	E	F	A	B	C	D	E	F
criterion 1	☑				☑		☑	☑			☑	☑
criterion 2	☑		☑		☑		☑	☑	☑		☑	☑
criterion 3	☑	☑	☑	☑	☑		☑	☑	☑	☑	☑	☑
criterion 4	☑		☑	☑			☑		☑	☑		☑

Data presented in Table 5 show that most groups' activities fulfilled the employed criteria as well as an improvement in performance during the second session. Furthermore, the final solutions that students of the experimental group proposed indicated successful engagement in the evaluation of performed actions' outcomes and hence positive effect of the game-supported educational activities on the achievement of the related objective (namely "evaluating results").

As far as the control group is concerned, students' activities were assessed by employing equivalent criteria fully aligned with the intended educational objectives. Assessment criteria as well as their alignment with performed activities and intended educational objectives are displayed in Table 6.

Table 6. Criteria for assessing the control group's worksheets

Educational activities	Educational objectives	Assessment criteria
Comparison of alternative solutions to the given problem	Compare and contrast	Use of data from available resources (criterion 1).
Development of final proposal-solution to the given problem	Explain reasons for, evaluate results	Adequate justification based on data from available resources (criterion 2). Final proposals based on criteria provided by the teacher (criterion 3).

Assessment results for each one of the six groups that students of the control group formed showed that only one of them managed to develop more than one alternative solution to the given problem. As a consequence, most of the control group's students did not manage to engage in actions requiring comparison and contrasting of alternative solutions (criterion 1) and consequently actions requiring justification (criterion 2) and evaluation of results (criterion 3). Thus, achievement of the intended general educational objectives cannot be inferred in this case.

Students' opinions about the use of the game and investigation of changes in attitudes toward school math teaching and learning

Students' opinions about the use of the business simulation game "Sims 2-Open for Business" were investigated by the assignment of two open ended questions (they are analytically presented in the game-supported educational design section) after the implementation of the proposed educational scenario. As evidenced by the analysis of answers that were provided to the first question (namely "*What is your opinion about the use of the game in the context of Mathematics teaching?*"), students reported that the implementation of the game-supported educational activities was pleasant and innovative, attracted their interest, and provided opportunities for investigating and understanding real-world situations. Furthermore, there were answers highlighting the proposed educational design's effect on understanding mathematical concepts as well as the limited duration of the implemented activities. The main issues that were revealed from students' answers as well as their frequencies are presented in Table 7 below.

Table 7. Answers provided to the first of the two open-ended questions

Issues highlighted by students' answers	Frequencies
Interesting and innovative approach to the lesson	55.2 %
Effect on understanding the mathematical concepts that were taught	51.7 %
A pleasant way to make the lesson	27.6 %
Opportunities for investigating and understanding real-world situations	20.7 %
Time constraints	17.2 %

Table 8. Answers provided to the second of the two open-ended questions

Students' answers	Frequencies
The use of the selected digital game helped me understand the mathematical concepts that were taught.	37.9 %
The use of the selected digital game helped me partially understand the mathematical concepts that were taught.	17.2 %
The use of the selected digital game did not help me understand the mathematical concepts that were taught.	44.8 %

With regard to the answers that were provided to the second question (namely "*Do you believe that the use of the game helped you, in any way, understand better the mathematical concepts that were taught?*"), 55.2% of participating students reported that their involvement in the game-supported educational activities had a positive effect on understanding the mathematical concepts that were taught, whereas 44.8% of the experimental group's students reported no positive effect of the game. The answers that students provided as well as their frequencies are analytically presented in Table 8 above.

The effect of the game-supported educational scenario on students' attitudes toward school math teaching and learning was measured by comparing their replies to the 10 Likert type questions included in the third part of the background questionnaire and the first part of the post-questionnaire. The comparison was conducted by employing the Wilcoxon test (Cohen, Manion & Morrison, 2008, pp. 552–554) which results are presented in Table 9 below.

Data presented in Table 9 above show that no significant differences were found in the replies that students provided to 8 out of the 10 questions before and after the implementation of the educational activities. Thus, no significant changes in attitudes toward school math teaching and learning were observed.

Table 9. Results of the Wilcoxon test

Statement	Z	Asymp. Sig. (2-tailed)	Statistically significant difference?
The way the subject of Mathematics is taught is interesting.	-.309[a]	.757	NO
The way the subject of Mathematics is taught helps me understand the concepts which are taught.	-.598[a]	.550	NO
The way the subject of Mathematics is taught helps me understand its usefulness.	-2.306[a]	.021	YES
The subject of Mathematics is useful for me in my life.	-.922[a]	.357	NO
Mathematics helps me understand life in general.	-1.844[a]	.065	NO
Mathematics can help me make important decisions.	-.124[a]	.901	NO
Good mathematics knowledge makes it easier to learn other subjects.	-.291[a]	.771	NO
The subject of Mathematics is important.	-.741[a]	.458	NO
It is important for someone to be good at Maths in school.	-2.211[a]	.027	YES
The subject of Mathematics is boring.	-1.006[a]	.314	NO

a. Based on positive ranks.

Conclusions – Discussion

As evidenced by the analysis of research data, the use of the selected game in the context of an appropriate educational design facilitated the achievement of general educational objectives and was equally effective with the non-gaming approach in terms of achieving standard curriculum mathematics educational objectives. The fact that there are research findings showing that educational games can be as effective as non-gaming approaches, with regard to the achievement of Mathematics related objectives, (e.g. Rosas et al., 2003; Ke, 2008) allows us to infer that not only specially-designed educational games but also general-purpose commercial games can contribute to the achievement of standard curriculum mathematics educational objectives when used as part of appropriately designed activities.

By designing and implementing meaningful activities with the support of the selected game we offered opportunities for engaging students in problem-solving actions. Students were able to formulate and test their own hypotheses, observe the outcomes of their actions, compare and contrast data available from the game, justify and evaluate outcomes of performed actions. Feedback provided from the game as well as its potential to simulate unexpected events were specific features that informed students' actions within the game world. Supporting game-based activities with appropriately designed worksheets provided the necessary structure and allowed for reflection. As evidenced by the results of our research, students of the experimental group outperformed their control group counterparts with regard to achieving general educational objectives. Thus, commercial simulation games, as opposed to educational games, can be considered as highly interactive environments providing learners with structure and authentic learning contexts. With the support of our findings we can confirm statements highlighting the contribution of commercial off-the-shelf digital games to the achievement of educational objectives aligned with the upper levels of standard taxonomies (Van Eck, 2006).

Finally, participating students commented on the innovative character of the game-based scenario and reported positive effects on understanding real-world situations. However, the limited duration of the proposed educational design did not probably allow for the establishment of intended links between abstract mathematical concepts and real-world situations, at least not to the degree that was expected. Furthermore, expectations that students were likely to have from such an innovation, especially if we consider their gaming experience, can provide explanations for the fact that their attitudes toward school math teaching and learning did not overall change. On the other hand, it must be noticed that digital gaming is generally considered as a leisure activity with no potential implications for learning (Rieber, 1996) and thus the effectiveness of digital game-based learning should be evidenced by further research. To this end, larger scale and longer term research is proposed with an emphasis on the design and implementation of activities highlighting links between school-based mathematics and real-world situations and allowing for interdisciplinary approaches.

References

Annetta, L.A., Minogue, J., Holmes S.Y. and Cheng, M.T. (2009). Investigating the impact of video games on high school students' engagement and learning about genetics. *Computers and Education*, *53*(1), 74–85.

Bottino, M. et al. (2007). Developing strategic and reasoning abilities with computer games at primary school level. *Computers and Education*, *49*(4), 1272–1286.

Chen, M.P. and Wang, L.C. (2009). The effects of types of interactivity in experimental game-based learning. *Proceedings of 4th International Conference on eLearning and Games,Edutainment 2009*, Banff, Canada, 273–282.

Chen, Z.H. and Chan, T.W. (2010). Using Game Quests to Incorporate Learning Tasks within a Virtual World. *Proceedings of 10th IEEE International Conference on Advanced Learning Technologies 2010*, Sousse, Tunisia, 750–751.

Chen, M.P. and Shen, C.Y. (2010). Game-play as Knowledge Transformation Process for Learning. *Proceedings of 10th IEEE International Conference on Advanced Learning Technologies 2010*, Sousse, Tunisia, 746–747.

Cohen, L., Manion, L. and Morrison, K. (2008). *Research methods in education*. New York: Routledge.

Connolly, T.M. and Stansfield, M.H. (2007). From eLearning to games-based eLearning: Using interactive technologies in teaching an IS course. *International Journal of Information Technology Management*, *26*(2/3/4), 188–208.

De Freitas, S.I. (2006). Using games and simulations for supporting learning. *Learning, Media and Technology*, *31*(4), 343–358.

Egenfeldt-Nielsen, S. (2005). *Beyond edutainment: Exploring the educational potential of computer games*. Ph.D. Dissertation, University of Copenhagen, Copenhagen, Denmark.

Eggen, P. and Kauchak, D. (2004). *Educational psychology: Windows on classrooms* (6^{th} ed.). Upper Saddle River, NJ: Merrill/Prentice Hall.

Eggen, P. and Kauchak, D. (2006). *Strategies for teachers: Teaching content and thinking skills*. Boston: Pearson Education Inc.

Falconer, I. et al. (2006). *Learning activity reference model – pedagogy*. University of Dundee, University of Southampton and Intrallect Ltd, UK.

Gee, J.P. (2007). *What videogames have to teach us about learning and literacy*. New York: Palgrave McMillan.

Greek National Curriculum (2003). *Mathematics Syllabus*. Greek Ministry of Education, Athens, Greece.

Herz, J.C. (1997). *Joystick Nation: How Videogames Ate Our Quarters, Won Our Hearts, and Rewired Our Minds*. London, UK: Little Brown and Company.

Ke, F. (2008). A case study of computer gaming for math: Engaged learning from gameplay?, *Computers and Education*, *51*(4), 1609–1620.

Kirriemuir, J. and McFarlane, A. (2004). *Literature review in games and learning*. Futurelab, Bristol, UK.

Kislenko, K. et al. (2005). *"Mathematics is important but boring": Students' beliefs and attitudes towards mathematics*. Retrieved April 21, 2010, from http://fag.hia.no/lcm/papers/Kislenko.pdf.

Klopfer, E. (2008). *Augmented Learning: Research and design of mobile educational games.* Cambridge, MA: MIT Press.

Lim, C.P. (2008). Global citizenship education, school curriculum and games: Learning Mathematics, English and Science as a global citizen. *Computers and Education*, *51*(3), 1073–1093.

Lowrie, T. (2005). Problem solving in technology rich contexts: Mathematics sense making in out-of-school environments. *Journal of Mathematical Behavior*, *24*(3-4), 275–286.

Oblinger, D. (2004). The next generation of educational engagement. *Journal of Interactive Media in Education*, *2004*(8), 1–18.

Papastergiou, M. (2009). Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation. *Computers and Education*, *52*(1), 1–12.

Pew Internet and American Life Project. *Gaming & civic engagement - Survey of teens/parents*. Retrieved April 21, 2010, from http://www.pewinternet.org/pdfs/PIAL%20Gaming%20FINAL%20Topline.pdf.

Prensky, M. (2007). *Digital Game-Based Learning*. Minnesota: Paragon House.

Rieber, L.P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology, Research, and Development*, *44*(1), 43–58.

Robertson, D. and Miller, D. (2009). Learning gains from using games consoles in primary classrooms: A randomized controlled study. *Procedia-Social and Behavioral Sciences*, *1*(1), pp. 1641–1644.

Rosas, R. et al. (2003). Beyond Nintendo: A design and assessment of educational video games for first and second grade students. *Computers and Education*, *40*(1), 71–94.

Sandford, R. and Williamson, B. (2005). *Games and Learning*. Futurelab, Bristol, UK.

Sandford, R. et al. (2006). *Teaching with games: Using commercial off-the-shelf computer games in formal education*. Futurelab, Bristol, UK.

Saulter, J. (2007). *Introduction to video game design and development*. New York, NY: McGraw-Hill/Irwin.

Sisler, V. and Brom, C. (2008). Designing an educational game: Case study of 'Europe 2045', in Z. Pan, A.D. Cheok, & W. Muller (Eds.), *Transactions on Edutainment I,* Berlin, Germany: Springer-Verlag.

Squire, K. and Barab, S. (2004). Replaying history: engaging urban underserved students in learning world history through computer simulation games. *Paper presented at the 6th International Conference on Learning Sciences, Santa Monica, CA.*

Tanes, Z. and Cemalcilar, Z. (2009). Learning from SimCity: An empirical study of Turkish adolescents. *Journal of Adolescence*, *33*(5), 731–739.

Texas Center for Educational Research. *Computer attitudes questionnaire*. Retrieved 21 April 2010 from http://www.tcet.unt.edu/pubs/studies/survey/caqdesc.htm.

Torrente, J. et al. (2009). 'Coordinating Heterogeneous Game-Based Learning Approaches in Online Learning Environments', in Z.P. Adrian, D. Cheok, & W. Muller (Eds.), *Transactions on Edutainment II*, *Volume 2*, Berlin, Germany: Springer-Verlag.

Tuzun, H. et al. (2009). The effects of computer games on primary school students' achievement and motivation in geography learning. *Computers and Education*, *52*(1), 68–77.

Van Eck, R. (2006). Digital Game-Based Learning: It's not just the Digital Natives who are restless. *Educause Review*, *41*(2), 16–30.

Van Eck, R. (2007). Building Artificially Intelligent Learning Games. In D. Gibson, C. Aldrich, & M. Prensky (Eds.) *Games and Simulations In Online Learning* (pp. 271-307), Herhey, PA: Information Science Publishing.

Whitton, N. (2010). *Learning with Digital Games: A practical guide to engaging students in higher education.* New York, NY: Routledge.

Williamson Shaffer, D. (2006). Epistemic frames for epistemic games. *Computers and Education*, *46*(3), 223–234.

Winn, W. (2002). Current trends in educational technology research: The study of learning environments. *Educational Psychology Review*, *14*(3), 331–351.