British Journal of Educational Technology Vol 48 No 3 2017 842–859
doi:10.1111/bjet.12455

Serious games as a malleable learning medium: The effects of narrative, gameplay, and making on students' performance and attitudes

Varvara Garneli, Michail Giannakos and Konstantinos Chorianopoulos

Varvara Garneli is currently working on her PhD at the Department of Informatics of the Ionian University. Michail N. Giannakos is an Associate Professor at the Department of Computer and Information Science, Norwegian University of Science and Technology (NTNU). His research interests focus on the design and study of emerging technologies and pedagogies in online and hybrid education settings, and their relationship to student and instructor experiences and practices. Konstantinos Chorianopoulos is a maker, researcher, and teacher. He has designed open systems for research and learning. He is teaching at the Ionian University and at the Hellenic Open University. Address for correspondence: Varvara Garneli, Department of Informatics, Ionian University, 7 Tsirigoti Square, 49100, Corfu, Greece. Email: c13garn@ionio.gr

Abstract
Research into educational technology has evaluated new computer-based systems as tools for improving students' academic performance and engagement. Serious games should also be considered as an alternative pedagogical medium for attracting students with different needs and expectations. In this field study, we empirically examined different forms of serious-game use for learning on learning performance and attitudes of eighty 13-year-old students in the first grade of middle school. Divided into four groups of 20 students, each group practiced with a maths video game in three ways. The first group played the storytelling maths game, the second played the same game but with no story and the third played and modified the video game. Finally, a control group practised in a paper-based (traditional) way by solving exercises. Although only minor differences in learning performance were identified, we found significant differences in the attitudes of the students toward learning through the video game. Students who are not motivated by conventional paper-based assignments might be engaged better with the use of a video game. Our findings suggest that video game pedagogy could provide malleable learning for different groups of students using methods that move beyond the conventional tool-based approach.

A video abstract of this article can be viewed at https://www.youtube.com/watch?v=9Kec_mSG-dE.

Introduction
Video games could be considered as a learning medium that engages players and enhances learning (Gee, 2008). Several studies have been conducted concerning different parameters of this research topic (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Rosas *et al*, 2003). Eg, virtual environments, such as Minecraft (Short, 2012) or Roblox (Baszucki & Cassel, 2011), could be implemented in classrooms to enhance learning and promote creativity through a constructionist context (Cipollone, Schifter, & Moffat, 2014). Nevertheless, more research could empirically support and extend the contemporary research on this topic to give useful guidelines to educators and learners.

Practitioner Notes

What is already known about this topic

- A game-based instructional approach provides learners with experiences in a virtual world where learning and mastery could be achieved in an engaging and pleasant way by solving simulations of real world problems.
- Serious video games provide authentic assessment where student's progress could be measured in addition to the successful content mastery.
- A game's story can motivate students to use the educational game and additionally support their intelligence growth.
- A constructionist approach could benefit students while working in carefree and creative settings. Learning by making is harder but it gives more substantial results.
- In a game making pedagogy, learners could acquire skills related to interactive story design, art and computer programming.

What this paper adds

- The use of a serious game seems to be useful for students who do not really like the usual instruction processes.
- In contrast to previous work our findings indicate that the storytelling element in an educational game does not seem to affect the improvement of students' performance.
- Students who modified the game's code would strongly prefer the repetition of this learning activity instead of practicing on paper.

Implications for practice and/or policy

- Video games are an alternative pedagogy which could enhance students learning especially when the conventional methods are ineffective. Their several features could support different students' needs and expectations.
- Computer programming approach could be used in order to motivate multidisciplinary learning in a creative context.

This work aims to investigate students' performance and attitudes in alternative learning settings; ie, using a serious game. From this viewpoint, serious games can be applied in an educational context to motivate students' learning through entertainment (Sawyer & Rejeski, 2002). A fundamental principle of meaningful education is that all students can learn if the appropriate personalized conditions are provided (Robinson, 2009). Research into multiple learning styles has confirmed that students learn in many ways (Murphy, 1992; Spalter, Simpson, Legrand, & Taichi, 2000). This perspective could be crucial for all students, especially those with fewer opportunities or lower performance on standard tests. Serious games have been proposed as a means to promote learning in certain contexts, such as science, technology, engineering and math (STEM) disciplines (Mayo, 2009). However, more research is needed regarding the effectiveness of serious games and the respective teaching practices. Eg, no evidence has been found regarding the effect of students' involvement in the process of game making. Such outcomes could motivate and promote malleable learning; ie, learning that could meet particular or varied needs.

Our methodology is user centered and considers the evaluation of a serious game as a learning medium. We used a video game called Gem Game, which teaches mathematics to children that attend the first class of gymnasium (middle school, 13-year-olds). We measured students' attitudes and learning performance after playing three different versions of the maths game. Because we were limited to 1 hour of school time, students played the game and then completed the respective survey. In one version of the game, students were additionally involved in modifying game elements, which could be an alternative pedagogic approach to serious-game learning.

Purpose of the study

The purpose of this empirical investigation is to measure students' performance and attitudes and to identify potential differences among diverse ways of employing serious games in the practice of learning. The results of this research could provide useful guidelines for learners and educators regarding the use of serious games as a learning medium. Furthermore, we hope to stimulate more research concerning the enrichment of the learning process with alternative malleable mediums and methods.

The paper is structured as follows: in the next section, the relevant literature is reviewed; subsequently, the evaluation methodology employed is presented; following this, the results are discussed; and finally, the findings are summarized.

Literature review

In a technology-based learning setting, several concepts could be presented through animation, music, video or games by using several digital devices such as networks, laptops, Web tools and multiple media (Kozma, 2003). Such digital technologies not only support learning in a new context, but also transform the ways students learn and interpret learning (Säljö, 2010). The current school curriculum, pedagogies and assessments are challenged by this evolution; educators have to deal with the task of implementing such technologies in their classes. However, fitting such digital technologies into the established teaching and learning practices is not as easy as it seems (Säljö, 2010). From another perspective, gaming experience has also been recommended and incorporated to support and enrich the learning process (Hsu & Wang, 2010). Educational video games are considered effective learning mediums in the school environment and beyond; they create malleable contexts in which children have the opportunity to apply higher-order cognitive skills (Virvou, Katsionis, & Manos, 2005). Games can produce engagement and delight in learning (Boyle, 1997); moreover, using video games improves thinking (Aliya, 2002), better illustrates students' performance (Virvou *et al*, 2005) and has the great potential for helping students to improve their learning performance (Huang, Huang, & Tschopp, 2010). However, the potential of video-game-based learning needs more exploration. The empirical research has not provided enough evidence related to the effectiveness of video games as the preferred instructional method for all students (Hays, 2005). Thus, more research is needed to study and assess the impact of this approach on students' learning and attitudes.

Video game-based learning

In every learning experience, specific content needs to be mastered. This content might include information, principles, facts and skills. Educators decide whether they will follow a direct instructional approach or will teach in an indirect manner, using other tools. Serious games are based on the second method, and modern learning theory suggests that this approach is the better one (Gee, 2008). Exploring the benefits and limitations of game-based instructional methods could be useful to both educators and learners. In a direct approach, teachers could use several means, such as their voice and movement, to motivate students and enhance learning. Questions and stories underline important aspects; humour attracts the audience and creates a comfortable learning atmosphere (Nordkvelle, Fritze, & Haugsbakk, 2010). On the other hand, a game-based instructional approach provides learners with experiences in a virtual world. In this case, learning and mastery can be achieved in an engaging and pleasant way (Gee, 2008) by solving simulations of real-world problems (Gee & Shaffer, 2010). Enjoyment could influence the knowledge acquired by the learner (Giannakos, 2013) and increase the learner's interest in a subject

(Iten & Petko, 2014). Moreover, a video game can be an effective instructional method because it provides an authentic assessment that supports various 21st-century skills, such as problem solving, critical thinking and innovation. Eg, feedback could support learners' mentoring and development (Gee & Shaffer, 2010). In particular, video games could engage students with constructive trial-and-error gameplay, which encourages them to repeat their efforts several times to complete the game (Chorianopoulos & Giannakos, 2014). An empirical investigation should confirm and further explore video games' utilities and their contribution regarding successful content mastery. Several serious games can support learning in a variety of learning areas, such as mathematics, physics, geography or electronics. Implementing serious games in the typical school setting could support the adoption of a malleable, learner-centered education (Chorianopoulos & Giannakos, 2014). However, there is no evidence that video games are the preferred instructional method in different situations and requirements (Hays, 2005). Nevertheless, current research has suggested that frequent implementation of reform practices could be critical for students who are lower performers in mathematics (Gilbert *et al*, 2014). From this perspective, more research should explore the influence of a serious-games-based approach regarding students' performance and attitudes.

From this perspective, our first research question is, "What effect does playing serious games have on students' attitudes and performance?"

Motivating students in a storytelling game context

A game-based learning approach includes goals to be achieved and rules to be followed. To accomplish these goals, players must master certain skills, facts, principles and procedures (knowledge content). Assistance should be provided throughout a procedure that allows students to attain knowledge and construct skills (Gee, 2008). Motivating students in a game-based approach is crucial for learning. Motivation refers to the initiation, intensity, and persistence of students' behaviour (Singh, Singh, & Singh, 2012). Nevertheless, students are not always highly motivated. Elements such as competition, collaboration, challenges and fantasy could influence motivation and facilitate learning (Gee, 2008). Previous research has claimed that a game's story can motivate students to use an educational game (Bopp, 2007). In particular, storytelling video games centre on motivating players through goal realization (Hsu & Wang, 2010). The story must be interesting for both genders, and age appropriate (Charsky, 2010). Previous research has claimed that a story could support students' motivation, but not their performance (Hsu & Wang, 2010). Nevertheless, more research should explore and formally evaluate the storytelling utility of video-game-based learning. Its potential benefits and limitations to students' performance and attitudes should be carefully considered by educators.

Therefore, our second research question is, "How does the storytelling game element relate to students' attitudes and performance improvement?"

Motivating students with computer programming/modification

Students' involvement in the game design and development process has been widely applied in introductory computing lessons. The idea of making games for learning is one of the fundamentals of constructionism. A common inspiration for such approaches is the work of Papert and Harel (1991), which stressed the importance of creating a "felicitous" environment to facilitate learning. A constructionist approach could benefit students while working in carefree and creative settings. Learning by making is harder, but it comes with more substantial results (Egenfeldt-Nielsen, 2006). Moreover, game making integrates and promotes skills related to multiple disciplines, such as interactive story design, art and computer programming (Hsu & Wang, 2010), and could be considered a fun and compelling activity (Al-Bow *et al*, 2009). Such creative instructional settings could also provide insightful learning (Navarrete, 2013). Moreover, deep understanding could be achieved through these activities, which integrate modelling, programming and physics (Sengupta & Farris, 2012; Sengupta, Kinnebrew, Basu, Biswas, & Clark, 2013). From this perspective, computer programming could motivate students toward profound learning in several domains. Despite the potential benefits of a computer-programming-based learning, research concerning the idea of employing a game-programming approach for learning maths concepts is limited.

However, learning computer programming can be quite difficult, especially for novices (Kelleher & Pausch, 2005). Computer science educators are working on making introductory programming easier and more interesting (Saeli, Perrenet, Jochems, & Zwaneveld, 2011). Visual programming tools such as Scratch, Kodu and Alice provide accessible graphical interfaces for code construction and program display (Parsons & Haden, 2007). Notably, Resnick, Bruckman and Martin (1996) designed and promoted the Scratch visual programming environment (http://scratch.mit.edu/) as a tool for the creative construction of games, simulations, stories and animations. Scratch can be used to provide young people with a positive, engaging computing experience (Adams, 2010). Additionally, several instructional approaches could be applied in computer programming lessons. A "Use—Modify—Create" instructional approach, eg, could be useful in a game-design and -development setting. The implementation follows three steps: playing to gain experience in games, practising by modifying the game's code and, finally, game development (Werner, Denner, Campe, & Kawamoto, 2012). In such creative approaches, students put their ideas into the project. This experience can be very positive because students become stakeholders in the project and feel that they own part of it (Smith, Cooper, & Longstreet, 2011).

An approach based on the idea of playing/modifying a serious game could boost profound multidisciplinary learning. However, more research should explore and formally evaluate the benefits and limitations of this approach. Erroneous beliefs concerning the most effective learning method could lead to suboptimal approaches of teaching and learning.

Thus, our third research question is, "What is the impact of employing a serious-game playing/modification approach on students' intentions to engage in playing the game?"

Methodology

Setting

The study was conducted in January 2013 at a middle school in north-western Greece. The school is located in an urban area and may be considered typical in terms of the number of students, their reason for attending and the school's infrastructure.

Participants

Learner-centred approaches can be applied in middle-school education to motivate young students at this critical turning point in their lives (Meece, 2003). From this viewpoint, we decided to perform a between-groups teaching experiment with 80 students—53 boys and 27 girls. All participants attended the first grade of middle school and were 13 years old. They formed four groups of 20 students, each of which practised the maths game in three ways. The first group played the storytelling game, the second played the same game but without the story and the third played the storytelling game and was engaged with changing the game code. The last group (the control group) practiced traditionally by solving exercises on paper. Students were divided into four groups based on the alphabetical order of their names, in the same way classes are normally distributed. From this perspective, our sample was randomly distributed (Table 1).

Measurement instruments

Researchers and teachers worked together to decide on the appropriate instruments to use. The intervention was based on the use of Gem Game (http://scratch.mit.edu/projects/10181336/), which is a mathematics game designed for students who attend the first grade of gymnasium

Table 1: Gender, exact means, and standard deviations (SD) of age

	Story game group	No story game group	Coding group	Control group
Boys	12	15	14	12
Girls	8	5	6	8
N	20	20	20	20
Exact mean of age	13.00	13.00	13.00	13.05
SD of age	.000	.000	.000	.224

(middle school, 13 years old). A pretest examined students' performance, and a posttest was given to assess their improvement. In addition, 30 exercises on paper were prepared for students in the control group. These tests and exercises were designed in line with the game's tasks and according to the textbook. Instructions for altering the game code were also prepared for the third group. These instructions aimed to stimulate effective and creative code engagement from these students during the limited time of the intervention. The code modification involved children with concern about a fairy who guided the hero in order to solve a problem. The participants could change the fairy's costume and the dialogue according to their own preferences, so the whole process had nothing to do with the actual maths unit. In addition, a questionnaire (using a 5-point Likert scale ranging from *strongly disagree* to *strongly agree*) measured students' attitudes of immersion (IMM) in the game and their intention to participate (ItP) in the game. Table 2 lists the questionnaire items used to measure each factor, and the source from which the items were adapted.

We also prepared questions for a semistructured interview with some students regarding their motivations regarding the respective teaching practice and their opinion on STEM topics. The semistructured interview guide can be found in the Appendix.

The preceding data and the observations provided the vehicle for interpreting, validating and discussing the results.

Procedure

In this research, we examine the effect of the storytelling element and game-making pedagogy on learning performance and attitudes. We employed the maths Gem Game, which was designed to support specific school curricular goals in a motivating and engaging way. The game includes a short story (see Figure 1) in which the main character is dealing with a problem (his dog has

Table 2: Attitudes toward information and communications technology (ICT) education questionnaire

Factors	Items (questions)	Source
Intention to participate (ItP)	Do you intend to repeat this activity? Do you think that this activity should become part of the normal teaching procedure? Do you hope that this practice will continued to be used in the future?	Giannakos (2013)
Immersion (IMM)	Did you forget the time while you were practising? Did you pay any attention to what was happening around you as long as you were practising? Did you forget any problems you have while you were practising?	Fu, Su, and Yu (2009)

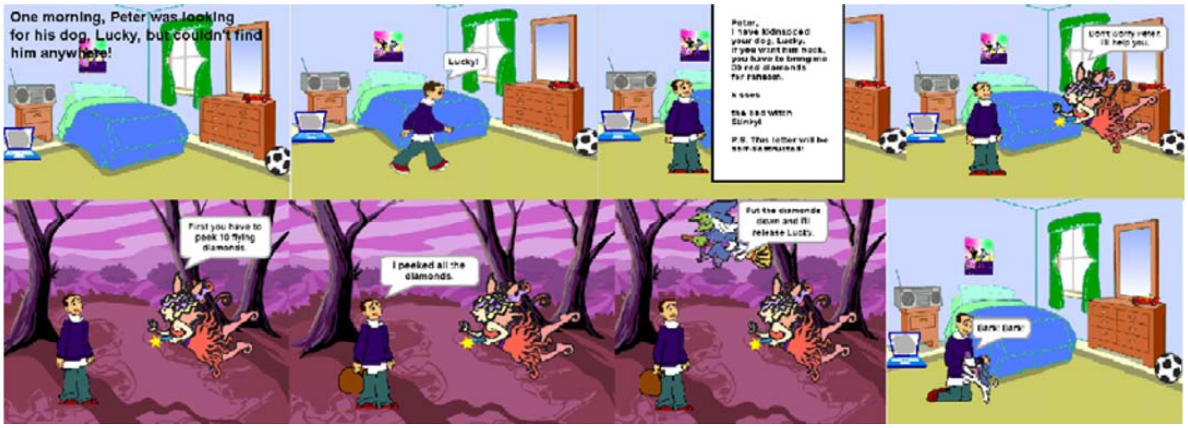

Figure 1: Screenshots of storytelling in the Gem Game

been kidnapped). By solving problems, the main character has to collect 30 diamonds to win the game. The game's format incorporates narrative elements aimed at motivating players (Bopp, 2007).

The education context of the game focuses on the addition and subtraction of integers, which is based on the school's curriculum. The player performs the respective additions and subtractions to collect diamonds; to do so, the player scrolls horizontally through numbered lines. When the player makes a mistake, he or she can continue typing from the new position. The game's three stages increase in difficulty: the first level has only positive integers, the second has only negative integers and the last has both positive and negative integers. Each level is completed when the player collects 10 diamonds (see Figure 2).

First, the students were informed that they would practise a specific unit of mathematics and that they would complete the pretest. Afterward, they practised according to the treatment groups they belonged to (story, no story, coding, control). The aforementioned approaches were all student centered and aimed at motivating and enhancing the students' learning and answering this study's research questions. At the end of the treatment, students in the control team were informed of the correct answers to the test to make the procedure similar to the rest of the treatments, which involved receipt of immediate feedback due to the interactive nature of the game.

In addition, the third group not only played the game but also engaged in code modification. In particular, students received instructions about how to make changes to the heroes of the story and the dialogue between them. Students had the chance to experiment with and decide for themselves on the final version of the storytelling part of the game (see Figure 3). After this, all teams completed the posttest and the questionnaire. Finally, semistructured interviews were conducted.

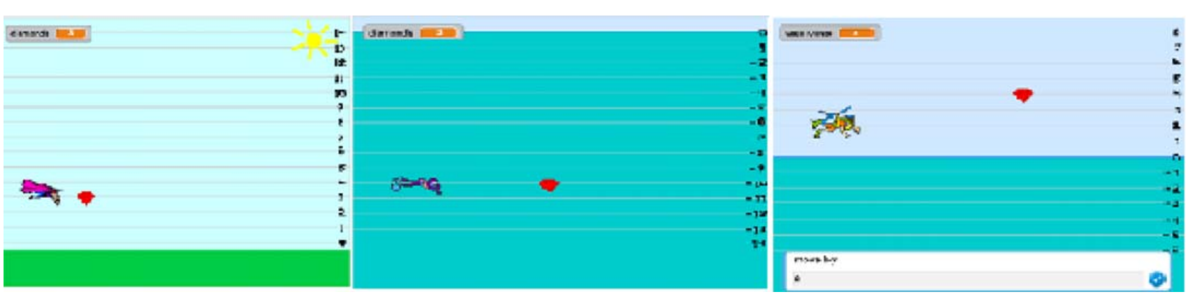

Figure 2: Screenshots of the three stages of Gem Game

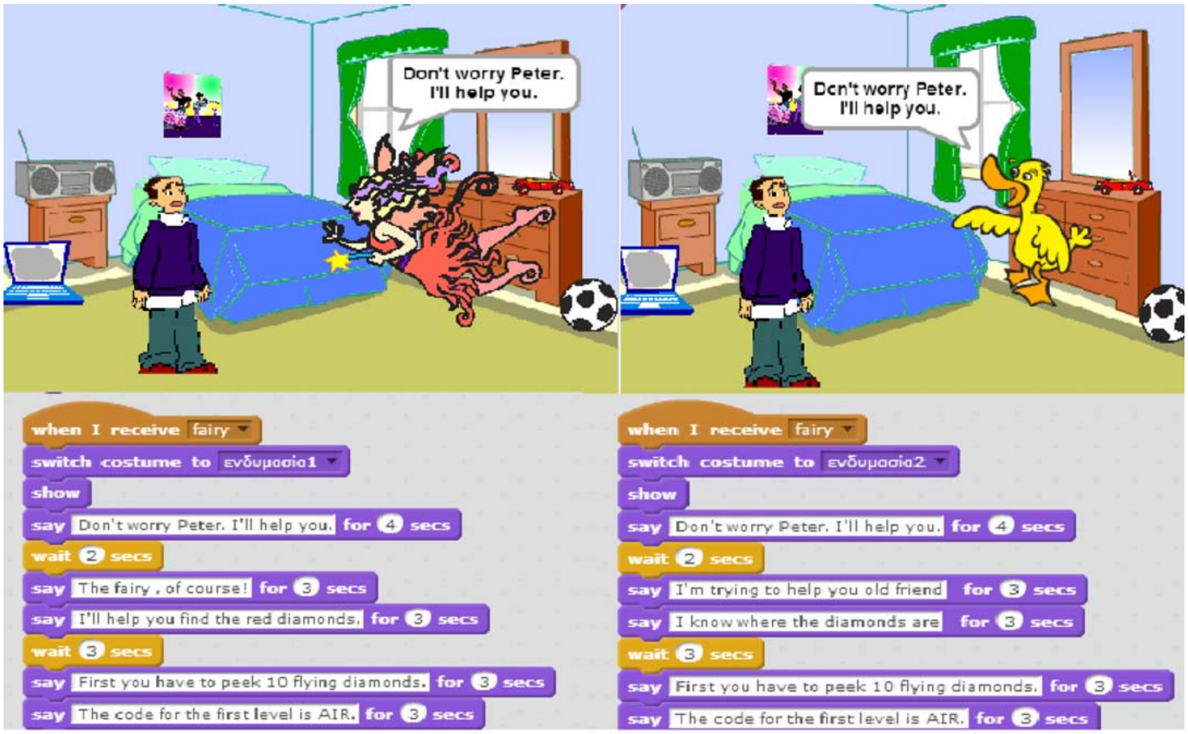

Figure 3: Example of how students altered the game scenario in the scratch environment and part of the code's modification

The empirical study was conducted in the context of secondary education. The respective maths unit and the use of a programming environment were part of the curriculum. The research was conducted 2 weeks after the students had finished the relevant maths unit at school. Students used the scratch environment to play games for 1 hour to become familiar with it, as well as with using video games. Moreover, the Scratch programming environment could be used for both playing and programming. From this perspective, the code-modification parameter could be easily explored.

This setting might be interesting for educators and researchers because all the instructional approaches were student centered and were conducted in real classroom conditions. Moreover, using the Scratch environment gave us the opportunity to better explore this research's parameters. However, the limit of 1 hour in the school environment may have given rise to unexpected issues.

Data analysis

As mentioned earlier, 80 middle-school students were involved in the evaluation of the study and were divided into four groups: two playing groups and one coding group (experimental groups), and a traditional instruction group (control group). A first step was to assess the convergent validity of the study as per Fornell and Larcker's (1981) procedures. In particular, Cronbach's α (CR) indicators were applied, as were interitem correlation statistics for the items of the variable to check the reliability of the scales. The reliability of the measures was evaluated by measuring its factor loading onto the underlying construct. Finally, the average variance was extracted to assess the convergent validity.

To examine the research hypotheses regarding the effect of playing and coding serious games on students' attitudes, we performed the Games–Howell post hoc test (Games & Howell, 1976), which does not rely on homogeneity of variance. We used the same test to examine what effect using different serious games has on students' improvement. In particular, the Games–Howell test was applied again to the four groups to explore the improvement of students who seemed to need more practice in the examined maths unit. We defined those students who made more than two mistakes in their pretest answers as low performers. Moreover, the same process was followed separately for the girls who were low performers. This decision was based on a researchers' observation; girls chose to stop playing, if they were facing difficulties concerning the maths unit but not the boys. Finally, we evaluated the differences in attitudes of the low performers among the four groups.

In addition, this study gathered information from an informal conversation/interview with students and observations conducted by the researchers and teachers. The semistructured interviews were conducted at the end of each didactic intervention with those students who wanted to participate. The researchers guided the conversation to probe different aspects of students' motivation, attitudes and learning performance throughout the treatments. The educators not only based their interviews on a carefully designed protocol (see Appendix), but also encouraged students to talk about their experience. Informal handwritten notes of students' answers were made by the researchers during the interviews. Finally, a content analysis of the qualitative data was conducted. This analysis consisted of two phases: in the first phase, all the interesting phrases within the informal notes were underlined. The second phase included an extended discussion among the researchers to code the study's results. A coding schema was then developed; this consisted of three categories: students' motivation, attitudes regarding mathematics and computing education. Because of time limitations, we decided to use also teachers' observations before, during and after the intervention to triangulate the research findings.

Results

Reliability, validity, and descriptive analyses of our measures

We followed Fornell and Larcker's (1981) procedures to assess the convergent validity of our study. First, the reliability of the scales was checked. CR indicators were applied in addition to interitem correlation statistics for the items of the variable. As Table 3 shows, the results of the test revealed acceptable indices of internal consistency in all the factors.

Second, we proceeded to evaluate the reliability of each measure via its factor loading into the underlying construct. A factor loading of 0.7 has been found (Hair, Thatham, Anderson, & Black, 2006) to be a good indicator of validity at the item level. The factor analysis identified two distinct factors: (1) IMM and (2) ItP. In addition, we used one single-item factor derived from the pretests, (3) prior learning performance (PLP), and one derived from the posttests, (4) game learning performance (GLP) (Table 3).

Table 3: Summary of measurement scales

		Mean	*SD*	*Loadings*	*CR*	*AVE*
Immersion	IMM1	2.68	1.46	0.814	0.867	0.75
	IMM2	2.40	1.44	0.905		
	IMM3	2.42	1.51	0.875		
Intention to participate	ItP1	3.03	1.36	0.873	0.755	0.64
	ItP2	2.56	1.40	0.778		
	ItP3	2.88	1.21	0.742		
Prior learning performance	PLP	9.76	2.29	–	–	–
Game learning performance	GLP	9.88	2.20	–	–	–

Table 4: Testing the effect of different video game pedagogies on students' attitudes

		(I)Mean (SD)	*(J) Control group mean (SD)*	*Mean differ. (I–J)*	*Std. Error*	*Sig.*
ItP	Story game group	2.68 (1.22)	2.23 (1.10)	.450	.367	.615
	No story game group	3.02 (0.94)		.783	.323	.090
	Coding group	3.35 (0.78)		**1.117**	**.301**	**.004***
IMM	Story game group	2.58 (1.34)	2.32 (1.30)	.267	.417	.919
	No story game group	2.22 (1.32)		.100	.414	.995
	Coding group	2.88 (1.26)		.567	.404	.507

*The mean difference is significant at the .05 level.

The third step for assessing the convergent validity pertains to the average variance extracted (AVE). AVE measures the overall amount of variance that is attributed to the construct in relation to the amount of variance attributable to measurement error. Convergent validity is considered adequate when the AVE is equal to or exceeds 0.50 (Segars, 1997).

Relation among different game types and students' attitudes

We examined the research questions regarding the effect of playing and coding serious game on students' ItP and IMM. We performed the Games–Howell post hoc test, which does not rely on homogeneity of variance, on the experimental and the control groups. All statistical analyses reported were conducted with a significance level of .05. As can be seen from the outcome data in Table 4, being in the coding group had an impact on students' ItP, whereas it did not have an impact on students' IMM. No impact was found on either ItP or IMM in the playing groups.

Relation among different game types and students' attitudes with low performers and girls

In this research, the effect of different serious-game use on students' improvement was examined. We performed the Games–Howell post hoc test, which does not rely on homogeneity of variance, on the experimental and the control groups. In particular, to detect the improvement of students who needed more practice in the maths unit, the Games–Howell test was applied again to the four groups in different ways: first for students who had made more than two mistakes in their pretests (defined as low performers) and second for girls who were low performers. The results showed evidence of a difference in the performance improvement. After the analysis of the results, we found that the girls in the control group who were low performers on the pretest had better results after the traditional practise (Table 5).

According to our findings, girls who performed poorly on the pretest improved more by using the traditional method than by playing the game in any manner. Thus, the storytelling element in an educational game does not seem to affect the improvement of students' performance. In addition, the performance of students who changed the game code did not improve in the maths

Table 5: Testing the effect of different video game pedagogies on low-performing girls' improvement

		(I) Mean (SD)	*(J) Control group mean (SD)*	*Mean differ. (I–J)*	*Std. error*	*Sig.*
Improvement	Story game group	0.67 (1.53)	0.40 (1.14)	.267	1.519	.993
	No story game group	0.00 (0.82)		.400	.653	.925
	Coding group	4.00 (0.00)		**3.600**	**.510**	**.007***

*The mean difference is significant at the .05 level.

Table 6: Testing the effect of different video game pedagogies on low-performing students' attitudes

		(I) Mean (SD)	(J) Control group mean (SD)	Mean differ. (I–J)	Std. error	Sig.
ItP	Story game group	2.33 (1.50)	1.57 (1.01)	.767	.593	.582
	No story game group	2.83 (1.01)		**1.267**	**.432**	**.039***
	Coding group	3.63 (0.35)		**2.063**	**.339**	**.00***
IMM	Story game group	2.19 (1.74)	1.60 (1.14)	.585	.683	.827
	No story game group	1.92 (1.48)		.317	.560	.941
	Coding group	2.89 (1.13)		1.289	.521	.102

*The mean difference is significant at the .05 level.

posttest. However, they indicated a strong preference for the repetition of this learning process in the future, instead of practising on paper.

We also evaluated the differences in attitudes of the low performers in the conventional pretests among the four groups. As can be seen from the outcome data in Table 6, the no story and coding features had an impact on students' ItP, while having no significant differences on students' IMM.

Qualitative insights of the study

Data from the student interviews and teachers' observations were used to triangulate the research findings. A semistructured interview guide was used for the in-depth personal interviews with the students. The interview questions were designed to probe different aspects of motivation, attitudes and learning for each different treatment. For instance, students were asked why they wanted to participate in the learning activity, and whether the serious game helped them to improve their mathematical skills. Moreover, some of the questions particularly concerned students who faced difficulties in successfully completing the game. Eg, we asked some of the girls why they stopped playing the game, and asked the boys whether, despite the difficulties faced, the gameplay experience was enjoyable. Finally, interesting findings were obtained from the students' opinions about the use of educational technology at school or the meaning of computing education for them. Each interview session was conducted at the end of the intervention. Interview notes from each session were made by the researcher. In addition, notes were made regarding students' reactions and comments before and during the activity. After the interviews were conducted and the notes had been digitalized, it became clear that the point of saturation had been reached: interviewing more informants was not expected to provide radically different or more in-depth material. Approximately half of the corpus represented interviews with boys, and the rest were interviews with girls. We then proceeded with a content analysis. The content analysis enabled us to sift through large volumes of data and systematically identify properties, attributes and embedded patterns. The technique is considered useful in identifying and analysing issues in gathered data (Maguire & Bevan, 2002). We first identified patterns in the answers by reviewing the notes, and then tried to match the common ones into patterns and describe them to explain, as far as possible, the quantitative results. The purpose of collecting qualitative data was to provide insights into, and explanations for, some of the quantitative findings.

In particular, most students who took part in the semistructured interviews were familiar with playing video games, and were looking forward to participating in this activity, which they considered amusing. The students were experienced with many commercial games (eg, Assassin's Creed, League of Legends), and they mentioned that Gem Game was interesting and was based on familiar game mechanics. As a result, they did not become frustrated because of the educational content. According to our observations, students seemed enthusiastic about the idea of gameplay in school, particularly in the coding group. They did not ask any help from the teachers, but they wanted to share their achievements with others. Most students who successfully completed the game did not want to play again, and asked for another game to play. On the other hand, boys who needed more time to complete the game continued to play, and did not complain about the game activity. At the same time, most girls who faced difficulties chose to stop playing. When answering our questions, these girls mentioned that the game was difficult for them and that they did not want to play anymore.

Notably, students did not really believe that a game could help them in a typical school context; the idea that such activities could be conducted under normal school conditions seemed odd to them. Moreover, they did not believe that playing a game would have any influence on their maths performance. However, most of them mentioned that they enjoyed the intervention and that this activity made mathematics, as well as the educational software used in the learning process, more interesting to them. The students supported the idea of using video games at school, mentioning that it might make learning more fun. They were also positive about the possibility of introducing similar activities in other STEM courses.

The students' opinions about computing education also changed, especially for those in the coding group. This result could be explained by students' intentions to learn programming being very high (73%), and the fact that no significant difference was found between the boys' and girls' answers. In particular, the modification phase of the experiment made the students very enthusiastic. They enjoyed having the chance to change the game's story and wanted to share their work. Most of them did not want to leave the class without the promise that the activity would be repeated.

Discussion

Video-game-based learning

Our findings might facilitate teachers in the preparation of malleable, personalized learning tools and activities. Particularly, this research shows that girls who needed more practise in this particular maths unit improved more by using the traditional method than by playing the game. On the other hand, the qualitative analysis confirmed that there was no difference in boys' improvement after using the different practise modes. This may be because girls spend less time playing video games and have different preferences (Hartmann & Klimmt, 2006). Researchers (eg, Baenninger & Newcombe, 1995) have indicated that the gender difference, eg, arises because boys are more familiar and experienced with video games. Another study (Bonanno & Kommers, 2005) revealed that females prefer puzzle, adventure and managerial games, whereas males prefer sport, strategy and role-playing games. These differences can be explained by the systematic differences in girls and boys on neurocognitive tests relevant to digital games (Bonanno & Kommers, 2005). In addition, males consider games as more useful learning tools because they accommodate their neurocognitive propensities (Casey, 1996). According to these results, using a serious game seems to be helpful for boys who do not really like traditional instruction processes. It is possible that the indirect learning approach and the role of failure in a serious-game learning context do not discourage those who need more practise. On the contrary, it encourages them to keep trying to achieve better performance (Gee, 2008).

The students' practise was based on a serious game inspired by a side-scroller arcade-game format. However, evaluation of the students' learning performance did not provide many significant results, meaning that there was not enough time, that the sample was not large enough to reveal differences, or that there were no differences between groups with equal skills. This negative result has been reported by previous related research (Elliott, Adams, & Bruckman, 2002).

Moreover, the 1 hour period appeared inadequate to improve pupils' performance in whatever way they practised. This result confirms the importance of duration and repetition in the learning process (Skinner, 1954). The reliability could have been improved had the children's practise been repeated several times. Thus, the most important dependent variable in the serious-game context was the attitude of the students and, in particular, their feelings of engagement and fun with the activity.

Motivating students in a storytelling-game context

In contrast to previous work (Kelleher, Pausch, & Kiesler, 2007), these findings indicate that the storytelling element in an educational game does not seem to affect students' performance. Despite the constructive trial-and-error structure of the game, no improvement was found regarding students' performance or their motivation to repeat their practise. Encouraging messages could be used more to better support students' efforts (O'Rourke, Haimovitz, Ballweber, Dweck, & Popović, 2014). Moreover, students who practised without storytelling preferred replaying the game to working in the traditional way. One explanation for this result is that the plot and the story are effective only if they keep evolving (Bopp, 2007). Otherwise, the storytelling element might have a negative influence on repetition of the practice.

Motivating students with computer programming/modification

According to our research design, one of the four groups modified the game's code. In particular, after playing the three levels of the game, the students had the chance to alter its scenario. Our results indicated that the students who modified the game's code strongly preferred the repetition of this learning activity instead of practising on paper. Learning approaches, such as using Minecraft, which encourage students' creativity and understanding of concepts (Cipollone *et al*, 2014) or teaching programming by making an action game (Becker, 2001) might thus be more effective compared to the traditional approaches.

Because of the time constraints of the didactic intervention, the students only played and modified the game. According to our observations, the impact on students' attitudes was positive because their intention to remain engaged with the game by refining and testing the code increased. Additionally, the teachers were able to confirm the successful implementation of the instructional approach in the typical school environment. Playing the game gave the students enough information about video-game design features without the need for a lesson on the subject. On the other hand, the game's code modification in the constructionist environment of Scratch provided the opportunity for creative experimentation in the limited time of 1 hour of didactic time. The constructionist view of this intervention significantly influenced students' attitudes and, specifically, their ItP again in similar activities. From this point of view, computer programming could be used as a motivational tool in other disciplines, such as mathematics. The lower performance results of this group might be explained by the fact that the coding activity did not have any connection with the maths unit.

In conclusion, some of the most important dependent variables in the serious-game context are associated with students' attitudes and, in particular, their feelings regarding engagement with a learning activity that meets their needs. Moreover, teachers who were responsible for applying the aforementioned approaches had some interesting comments about the students' initial reactions. In particular, when the children were informed that they would practise mathematics with an educational game, they became very excited. On the contrary, children who solved exercises on paper seemed somewhat nervous, and asked about the influence of this practise on their grades.

Limitations and future research directions

To carry out the didactic intervention, students were divided into four, randomly assigned, groups. Nevertheless, our study's results suggest that this separation of students might not have been the most effective. Instead, our findings suggest that students should be organized according to their learning style (Dunn, 1990). Triantafillou, Pomportsis and Demetriadis (2013), eg, proposed an adaptive educational system to support the different means of information processing (cognitive style). Similarly, a student who has been reluctant to study maths in the traditional way could be assigned to a study group that is playing or coding games. Educators should deploy alternatives to engage various learning types (Chorianopoulos & Giannakos, 2014).

Most notably, we evaluated students' performance by having all students complete a paper-based test. This assessment captured only a snapshot of the students' development; however, new ways of learning first need new types of assessment. Video games could be an authentic assessment system because they are based on the actual learning process (Gee & Shaffer, 2010). Similarly, the coding group should be evaluated using a game-coding posttest (Brennan & Resnick, 2012). Therefore, we suggest that the lack of differences in the learning performance of students might be more an effect of the assessment medium than of the learning treatment. Eg, students who practised with the maths video game should have also had the same maths video game used as their posttest. Further research should be conducted regarding the assessment tests that could support the new learning context.

Finally, the overall picture of the effect of students' involvement in the process of coding games could guide educators to use more teaching tools to assist students to achieve learning in a creative way. Further research should engage the students with code that is closely connected to the respective curricular topic. Other parameters that could be explored are longer duration of practice, additional curricular topics and issues such as age-appropriateness, students' needs and expectations and more complex programming curricula.

In summary, our study provides evidence regarding the students' performance and attitudes through the lens of different usage types of serious games; however, some limitations exist. First, the generalizability of these results must be carefully considered because the field study was conducted in a specific context (eg, content, age). Because the self-report method was used to measure students' attitudes, the results might be subject to common method bias. However, this study also explored students' performance, which reduced the common method bias. In addition, the introduction of other in-depth methods, such as interviews and observations, provided a complementary picture of the findings.

The implications of this research concern enrichment of the learning process with alternative malleable media and methods. Further research should study the social interactions that occur between learners. Because education stands on a social science pillar, the design of serious games should also consider their social embedding in everyday school and informal learning practices.

Conclusion

Educational technology has enriched the learning process to improve students' academic performance. In this work, the effect of an alternative, learner-centred setting, a maths game, was examined. In addition to playing two versions of the serious game (with and without story), students had the chance to engage with the game code by altering its scenario in the Scratch environment.

Based on these findings, some guidelines for employing serious games as a learning medium can be summarized. We found that some students could benefit from alternative pedagogic techniques such as a video-game-based approach. In particular, using serious games could be an effective tool for students who are not motivated by the traditional learning practice of working on paper.

Moreover, a game programming/modification approach could be used to motivate multidisciplinary learning in a creative context. Different teaching techniques could motivate and engage different types of students in the learning process. Overall, applying a variety of teaching tools and practices to provide malleable learning could be useful.

Acknowledgements

The authors would like to thank all of the students and the school staff for their participation in the didactic intervention.

Statements on open data, ethics and conflict of interest

In the reported research, the appropriate procedures were followed according to institutional contexts and ethics. Every student participated in the study voluntarily. Data obtained from the students were fully anonymous, and derived through pre and posttests, surveys and observation. The survey did not contain questions of a personally sensitive nature. The collected data were analyzed in an aggregate manner and used exclusively for educational and research purposes. There is no conflict of interest between this study, and the data set sharing is a natural extension of open access, after request from the authors.

References

Adams, J. C. (2010). Scratching middle schoolers' creative itch. In Proceedings of *the 41st ACM Technical Symposium on Computer Science Education*, Milwaukee, WI (pp. 356–360). New York, NY, USA: ACM.

Al-Bow, M., Austin, D., Edgington, J., Fajardo, R., Fishburn, J., Lara, C. *et al*. (2009). Using game creation for teaching computer programming to high school students and teachers. *ACM SIGCSE Bulletin*, *41*(3), 104–108.

Aliya, S. K. (2002). The role of computer games in the development of theoretical analysis, flexibility and reflective thinking in children: a longitudinal study. *International Journal of Psychophysiology*, *45*, 149.

Baenninger, M., & Newcombe, N. (1995). Environmental input to the development of sex-related differences in spatial and mathematical ability. *Learning and Individual Differences*, *7*, 363–379.

Baszucki, D. B., & Cassel, E. S. (2011). *U.S. Patent No. 7,874,921*. Washington, DC: U.S. Patent and Trademark Office.

Becker, K. (2001). Teaching with games: the Minesweeper and Asteroids experience. *Journal of Computing Sciences in Colleges*, *17*(2), 23–33.

Bonanno, P., & Kommers, P. A. (2005). Gender differences and styles in the use of digital games. *Educational Psychology*, *25*(1), 13–41.

Bopp, M. (2007). Storytelling as a motivational tool in digital learning games. In T. Hug (Ed.), *Didactics of microlearning. Concepts, discourses and examples* (pp. 250–266). Münster, Germany: Waxmann, V.

Boyle, T. (1997). *Design for multimedia learning*. London, UK: Prentice Hall.

Brennan, K., & Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. In Annual Meeting of the American Educational Research Association (Vancouver, BC, Canada, April 13–17).

Brunner, C., Bennett, D., & Honey, M. (1998). Girl games and technological desire. In A. Cassell & H. Jenkins (Eds), *From Barbie to Mortal Kombat: Gender and computer games* (pp. 72–89). Cambridge, MA: MIT press.

Casey, M. B. (1996). Gender, sex, and cognition: considering the interrelationship between biological and environmental factors. *Learning and Individual Differences*, *8*(1), 39–53.

Charsky, D. (2010). From edutainment to serious games: a change in the use of game characteristics. *Games and Culture*, *5*(2), 177–198.

Chorianopoulos, K., & Giannakos, M. (2014). Design principles for serious video games in mathematics education: from theory to practice. *International Journal of Serious Games*, *1*(3), 51–59.

Cipollone, M., Schifter, C. C., & Moffat, R. A. (2014). Minecraft as a creative tool: a case study. *International Journal of Game-Based Learning (IJGBL)*, *4*(2), 1–14.

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education*, *59*(2), 661–686.
Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*, 297–334.
Djaouti, D., Alvarez, J., Jessel, J. P., & Rampnoux, O. (2011). Origins of serious games. In M. Minhua, A. Oikonomou, & J. Lakhmi (Eds), *Serious games and edutainment applications* (pp. 25–43). London, UK: Springer.
Dunn, R. (1990). Rita Dunn answers questions on learning styles. *Educational Leadership*, *48*(2), 15–19.
Egenfeldt-Nielsen, S. (2006). Overview of research on the educational use of video games. *Digitalkompetanse*, *1*(3), 184–213.
Elliott, J., Adams, L., & Bruckman, A. (2002). No magic bullet: 3D video games in education. In Proceedings of *International Conference of the Learning Sciences* (pp. 23–26). Seattle, Washington. Retrieved March 14, 2016, from http://www.cc.gatech.edu/home/asb/papers/conference/aquamoose-icls02.pdf
Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*, 39–50.
Fu, F. L., Su, R. C., & Yu, S. C. (2009). EGameFlow: a scale to measure learners' enjoyment of e-learning games. *Computers & Education*, *52*(1), 101–112.
Games, P. A., & Howell, J. F. (1976). Pairwise multiple comparison procedures with unequal n's and/or variances: a Monte Carlo study. *Journal of Educational and Behavioral Statistics*, *1*(2), 113–125.
Gee, J. P. (2008). Learning and games. *The Ecology of Games: Connecting Youth, Games, and Learning*, *3*, 21–40.
Gee, J. P., & Shaffer, D. W. (2010). *Looking where the light is bad: video games and the future of assessment* (Epistemic Group Working Paper, 2010-02). Madison, WI: University of Wisconsin-Madison.
Giannakos, M. N. (2013). Enjoy and learn with educational games: examining factors affecting learning performance. *Computers & Education*, *68*, 429–439.
Gilbert, M. C., Musu-Gillette, L. E., Woolley, M. E., Karabenick, S. A., Strutchens, M. E., & Martin, W. G. (2014). Student perceptions of the classroom environment: relations to motivation and achievement in mathematics. *Learning Environments Research*, *17*(2), 287–304.
Hair, J. F., Tatham, R. L., Anderson, R. E., & Black, W. (2006). *Multivariate data analysis* Vol. 6. Upper Saddle River, NJ: Pearson Prentice Hall.
Hartmann, T., & Klimmt, C. (2006). Gender and computer games: exploring females' dislikes. *Journal of Computer-Mediated Communication*, *11*(4), 910–931.
Hays, R. T. (2005). *The effectiveness of instructional games: a literature review and discussion* (Technical Report 2005-004). Orlando, FL: Naval Air Warfare Center Training Systems Division.
Hsu, H. Y., & Wang, S. K. (2010). Using gaming literacies to cultivate new literacies. *Simulation & Gaming*, *41*(3), 400–417.
Huang, W. H., Huang, W. Y., & Tschopp, J. (2010). Sustaining iterative game playing processes in DGBL: the relationship between motivational processing and outcome processing. *Computers & Education*, *55*(2), 789–797.
Iten, N., & Petko, D. (2014). Learning with serious games: is fun playing the game a predictor of learning success? *British Journal of Educational Technology*, *47*, 151–163. doi:10.1111/bjet.12226
Kelleher, C., & Pausch, R. (2005). Lowering the barriers to programming: a taxonomy of programming environments and languages for novice programmers. *ACM Computing Surveys*, *37*(2), 83–137.
Kelleher, C., Pausch, R., & Kiesler, S. (2007). Storytelling alice motivates middle school girls to learn computer programming. In Proceedings of *the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1455–1464). San Jose, CA: ACM.
Kozma, R. B. (2003). Technology and classroom practices: an international study. *Journal of Research on Technology in Education*, *36*(1), 1–14.
Maguire, M., & Bevan, N. (2002). User requirements analysis: a review of supporting methods. In J. Hammond, T. Gross, & J. Wesson (Eds), *IFIP WCC 2002. IFIP* Vol. 99 (pp. 133–148). Boston, MA: Springer.
Mayo, M. J. (2009). Video games: a route to large-scale STEM education? *Science*, *323*(5910), 79–82.
Meece, J. L. (2003). Applying learner-centered principles to middle school education. *Theory into Practice*, *42*(2), 109–116.

Murphy, J. (1992). Effective schools: legacy and future directions. In D. Reynolds, & P. Cuttance (Eds.), *School effectiveness research, policy and practice* (pp. 164–170). London: Cassell.
Navarrete, C. C. (2013). Creative thinking in digital game design and development: a case study. *Computers & Education*, *69*, 320–331.
Nordkvelle, Y. T., Fritze, Y., & Haugsbakk, G. (2010). *The visual in teaching—from Bologna to YouTubiversity* (pp. 59–71). Medien-Wissen-Bildung: Explorationen visualisierter und kollaborativer Wissensräume, University of Innsbruck. Retrieved March 14, 2016 from http://media.brainity.com/uibk2/amab2010/images/down/MWB09_Proceedings.pdf#page=64.
O'Rourke, E., Haimovitz, K., Ballweber, C., Dweck, C., & Popović, Z. (2014). Brain points: a growth mindset incentive structure boosts persistence in an educational game. In Proceedings of *the 32nd Annual ACM Conference on Human Factors in Computing Systems* (pp. 3339–3348). New York: ACM.
Papert, S., & Harel, I. (1991). Situating constructionism. *Constructionism*, *36*, 1–11.
Parsons, D., & Haden, P. (2007). Programming osmosis: knowledge transfer from imperative to visual programming environments. In Mann, S., & Bridgeman, N. (eds.) Proceedings of the 20th Annual Conference of the National Advisory Committee on Computing Qualifications. (pp. 209–215), Hamilton, New Zealand.
Resnick, M., Bruckman, A., & Martin, F. (1996). Pianos not stereos: creating computational construction kits. *Interactions*, *3*(5), 40–50.
Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K. *et al*. (2009). Scratch: programming for all. *Communications of the ACM*, *52*(11), 60–67.
Robinson, K. (2009). *The element: how finding your passion changes everything*. Penguin group. [Kindle edition]. Retrieved March 14, 2016, from http://www.kimhartman.se/wp-content/uploads/2013/10/The-Element-by-Ken-Robinson-summary.pdf.
Rosas, R., Nussbaum, M., Cumsille, P., Marianov, V., Correa, M., Flores, P. *et al*. (2003). Beyond Nintendo: design and assessment of educational video games for first and second grade students. *Computers & Education*, *40*(1), 71–94.
Saeli, M., Perrenet, J., Jochems, W. M., & Zwaneveld, B (2011). Teaching programming in secondary school: a pedagogical content knowledge perspective. *Informatics in Education-An International Journal*, *10*(1), 73–88.
Säljö, R. (2010). Digital tools and challenges to institutional traditions of learning: technologies, social memory and the performative nature of learning. *Journal of Computer Assisted Learning*, *26*(1), 53–64.
Sawyer, B., & Rejeski, D. (2002). Serious games: improving public policy through game-based learning and simulation. Foresight and Governance Project, Whitepaper for the *Woodrow Wilson International Center for Scholars Publication*, Retrieved March 14, 2016, from https://www.wilsoncenter.org/sites/default/files/ACF3F.pdf.
Segars, A. H. (1997). Assessing the unidimensionality of measurement: a paradigm and illustration within the context of information systems research. *Omega*, *25*(1), 107–121.
Sengupta, P., & Farris, A. V. (2012). Learning kinematics in elementary grades using agent-based computational modeling: a visual programming-based approach. In Proceedings of *the 11th International Conference on Interaction Design and Children* (pp. 78–87). New York, NY, USA: ACM.
Sengupta, P., Kinnebrew, J. S., Basu, S., Biswas, G., & Clark, D. (2013). Integrating computational thinking with K–12 science education using agent-based computation: a theoretical framework. *Education and Information Technologies*, *18*(2), 351–380.
Short, D. (2012). Teaching scientific concepts using a virtual world—Minecraft. *Teaching Science—the Journal of the Australian Science Teachers Association*, *58*(3), 55–58.
Singh, S., Singh, A., & Singh, K. (2012). Motivation levels among traditional and open learning undergraduate students in India. *The International Review of Research in Open and Distributed Learning*, *13*(3), 19–40.
Skinner, B. F. (1954). The science of learning and the art of teaching. *Harvard Educational Review*, *24*, 86–97.
Smith, T., Cooper, K. M., & Longstreet, C. S. (2011). Software engineering senior design course: experiences with agile game development in a capstone project. In Proceedings of *the 1st International Workshop on Games and Software Engineering (GAS'11)* (pp. 9–12). New York, NY, USA: ACM.

Spalter, A. M., Simpson, R. M., Legrand, M., & Taichi, S. (2000). Considering a full range of teaching techniques for use in interactive educational software: a practical guide and brainstorming session. In 30th IEEE Frontiers in Education Conference, 2000. FIE 2000, SID 19-SID 24, Vol 2, Kansas City, MO.

Triantafillou, E., Pomportsis, A., & Demetriadis, S. (2003). The design and the formative evaluation of an adaptive educational system based on cognitive styles. *Computers & Education*, *41*(1), 87–103.

Virvou, M., Katsionis, G., & Manos, M. (2005). Combining software games with education: evaluation of its educational effectiveness. *Educational Technology & Society*, *8*(2), 54–65.

Werner, L., Denner, J., Campe, S., & Kawamoto, D. C. (2012). The fairy performance assessment: measuring computational thinking in middle school. In Proceedings of *the 43rd ACM Technical Symposium on Computer Science Education(SIGSCE '12)* (pp. 215–220). New York:ACM.

Appendix: Semistructured Interview Guide

Capturing answers: Recording of answers will be done through taking notes. This procedure allows the interviewer to highlight key points to probe further and may make the production of the final notes and their evaluation quicker because there is no need to wade through large files of transcripts.

Develop a rapport with the respondent: Obtaining meaningful information from respondents will be easier if they are comfortable opening up to the interviewer. This can be done by asking nonprobing questions related to their hobbies, their spare time and so on.

Ask questions that lead detailed answers: It is important that you phrase questions in a way that gets respondents to provide detailed answers, rather than simple "Yes" or "No" answers.

Examples of questions:

- Do you play video games? If you do, which are your favorite ones?
- Do you think that Gem Game is an interesting video game?
- Could you mention some difficult or easy parts of this experience?
- Were you anxious about playing an educational game?
- Do you think that this video game is related to maths?
- Was Gem Game helpful regarding your maths skills?
- Did the use of technology increase your interest in maths?
- What is the meaning of computer science for you?
- Do you use computer apps in your daily life?
- Did the use of an educational game change your opinion regarding computer education?

It is good to have a set of questions to hand, but the interviewer needs to also be prepared to expand on or probe the predetermined questions as the need arises. This is the essence of qualitative interviews.

End the interview: Deciding when to end an interview may depend on a number of factors. Eg, interviewers may feel that they have exhausted their questions, and that they are no longer getting new information or if the respondent seems tired or has other commitments to attend to. It is good practice for interviewers to summarize the key points that they feel the respondent has provided, because this gives the respondent a final chance to expand or clarify any points. Finally, it is important to thank the respondent for their time and to provide them with the interviewer's contact details. Depending on circumstances, it may also be worth letting respondents know how they can obtain the project reports because this provides them with a sense of ownership of the material that they have shared.