Computers & Education 53 (2009) 603–622

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Exploring the potential of computer and video games for health and physical education: A literature review

Marina Papastergiou *

University of Thessaly, Department of Physical Education and Sport Science, Karyes, 42100 Trikala, Greece

ARTICLE INFO

Article history:
Received 25 September 2008
Received in revised form 22 January 2009
Accepted 1 April 2009

Keywords:
Interactive learning environments
Applications in subject areas
Learning communities
Human–computer interface

ABSTRACT

This study aims at critically reviewing recently published scientific literature on the use of computer and video games in Health Education (HE) and Physical Education (PE) with a view: (a) to identifying the potential contribution of the incorporation of electronic games as educational tools into HE and PE programs, (b) to present a synthesis of the available empirical evidence on the educational effectiveness of electronic games in HE and PE, and (c) to define future research perspectives concerning the educational use of electronic games in HE and PE. After systematically searching online bibliographic databases, 34 relevant articles were located and included in the study. Following the categorization scheme proposed by [Dempsey, J., Rasmussen, K., & Lucassen, B. (1996). *The instructional gaming literature: Implications and 99 sources*. University of South Alabama, College of Education, Technical Report No. 96-1], those articles were grouped into the following four categories: (a) research, (b) development, (c) discussion and (d) theory. The overviewed articles suggest that electronic games present many potential benefits as educational tools for HE and PE, and that those games may improve young people's knowledge, skills, attitudes and behaviours in relation to health and physical exercise. Furthermore, the newly emerged physically interactive electronic games can potentially enhance young people's physical fitness, motor skills and motivation for physical exercise. The empirical evidence to support the educational effectiveness of electronic games in HE and PE is still rather limited, but the findings present a positive picture overall. The outcomes of the literature review are discussed in terms of their implications for future research, and can provide useful guidance to educators, practitioners and researchers in the areas of HE and PE, and to electronic game designers.

1. Introduction

Playing computer and video games (henceforth collectively called 'electronic games') is a very popular free-time activity among children and adolescents (Mumtaz, 2001; Nippold, Duthie, & Larson, 2005), and those games seem to have a prominent role in the culture of young people (Dorman, 1997). Furthermore, electronic games increasingly attract the interest of educationalists. Specifically, it is believed that the intrinsic motivation that young people show towards electronic games could be combined with educational content and objectives into what Prensky (2001) calls 'digital game-based learning'.

Several authors (e.g. Gee, 2003; Malone, 1980; Prensky, 2001) maintain that this mode of learning can be more enjoyable, more interesting, and, thus, more effective than traditional learning modes. Electronic games have several advantages over other instructional media, the main one being their extremely compelling and engaging nature (Malone 1980), and constitute potentially powerful learning environments for a number of reasons (Oblinger, 2004): (a) they can support multi-sensory, active, experiential, problem-based learning, (b) they favour activation of prior knowledge given that players must use previously learned information in order to advance, (c) they provide immediate feedback enabling players to test hypotheses and learn from their actions, (d) they encompass opportunities for self-assessment through the mechanisms of scoring and reaching different levels, and (e) they are increasingly becoming social environments involving communities of players. As regards the latter, in recent years, various networked games, such as massively multi-player online games, have emerged, paving the way for a new collaborative model for learning (Herz, 2001). The players of such games learn from interacting among themselves both within the game environment (e.g. through forming online teams) and around it (e.g. through sharing

* Tel.: +30 2431 0 47069; fax: +30 2431 0 47042.
E-mail address: mpapas@uth.gr

0360-1315/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.compedu.2009.04.001

game-related information and resources). Several empirical studies that evaluated the impact of the use of electronic games within disciplines such as mathematics, science, language, geography, and computer science, have shown positive outcomes in terms of student motivation and learning effectiveness in relation to curricular objectives (e.g. Klawe, 1999; Papastergiou, 2009; Rosas et al., 2003; Virvou, Katsionis, & Manos, 2005).

However, in the areas of Health Education (HE) and Physical Education (PE) playing electronic games has often been seen with skepticism (e.g. Bale, 1994; Funk & Buchman, 1995), and, in the research literature, it has been traditionally associated with various risks for both mental and physical health. Among the reported negative consequences of electronic gaming on young people's health are: provocation of seizures, tendon injuries and social introversion in case of excessive playing, and promotion of aggressive behaviour as a result of playing violent video games (Dorman, 1997; Gentile, Lynch, Linder, & Walsh, 2004). Many authors (e.g. Luepker, 1999; Parizkova & Chin, 2003; Riviere, 2004; Sothern, 2004) also place electronic gaming among sedentary activities and argue that, in the last decades, such activities, combined with poor nutritional choices, have been important contributing factors to the decrease in young people's physical activity and the alarming rise of overweight and obesity, with detrimental consequences for youth's health. Certain empirical studies that investigated the relationships among obesity, participation in physical activities and electronic gaming on large samples of children and adolescents (Carvalhal, Padez, Moreira, & Rosado, 2007; Shingo & Takeo, 2002; Vandewater, Shim, & Caplovitz, 2004; Wilson, 2004) seem to corroborate this assertion reporting that lower levels of physical activity and higher levels of weight were associated with more time dedicated to electronic gaming. Nevertheless, other studies on similar samples (Biddle, Gorely, Marshall, Murdey, & Cameron, 2004; Kahn et al., 2002; Lager & Bremberg, 2005; Marshall, Biddle, Gorely, Cameron, & Murdey, 2004; Telama, Nupponen, & Piéron, 2005; Wang, Chia, Quek, & Liu, 2006) contrast those findings reporting no relationships between electronic gaming and obesity or physical activity or even aggressive behaviour. The findings of those latter studies combined with the afore-mentioned advantages of digital game-based learning, the positive outcomes of studies that evaluated the use of electronic games within other disciplines, and the often-expressed need to incorporate Information and Communication Technology (ICT) into HE and PE (Bailey, 2001; Neuhauser & Kreps, 2003; Stidder, 2004), as a means to innovate relevant programs rendering them more motivational and effective with young people, call for an exploration of the potential of electronic gaming in the areas of HE and PE.

Electronic games seem to hold promise for HE and PE. HE interventions targeted at youth usually aim at increasing health-related knowledge and, above all, positive health-related behaviours, and in order to achieve this goal, innovative, ICT-based applications that are motivational, personally relevant, entertaining and specifically tailored to the learning styles of today's youth are urgently needed, as they are more likely to positively impact young people compared to traditional didactic interventions (Casazza & Ciccazzo, 2006). An answer to this need could be the use of electronic games for the purposes of HE interventions. Indeed, early research on the exploitation of electronic games as means for providing HE to children and adolescents has shown encouraging results (Paperny & Starn, 1989; Rubin et al., 1986). As far as PE is concerned, sport video games, such as simulations of basketball, football, tennis and other sports, which allow their players to virtually participate in athletic activities, are very popular among young people (Kim & Hyungil, 2007), and could perhaps serve as instructional tools. Furthermore, in recent years, a new type of electronic games, 'exergames', which involve physical activity as a means of interacting with the game, have emerged (Lieberman, 2006). Various, innovative exertion interfaces -as opposed to conventional, standard electronic game interfaces (namely keyboard, mouse, joystick, gamepad) – are used in those games, such as electronic dance pads, motion platforms, bicycle ergometers, haptic devices and motion-tracking cameras, which allow the player to control the game through his/her motor actions. Perhaps, the most well-known example is the dance simulation game Dance Dance Revolution (DDR), by Konami Corporation (http://www.konami.co.jp), the basic interface to which is a square dance pad on the floor with multi-directional sensor arrows. DDR requires the player to dance to a variety of songs, guided by watching scrolling directional arrows on the screen, which correspond to arrows on the pad that he/she has to step upon in synchronization with the music. DDR can be played in arcades, video game consoles or personal computers, supports single- and multi-player options as well as several difficulty levels, and is becoming increasingly popular among young people, rallying lively player communities (Lieberman, 2006). Electronic games, such as DDR, clearly, are not sedentary, and could be exploited within PE programs to promote physical activity. Finally, Streisand (2006), based on concrete examples of electronic games that can be exploited within HE or PE, such as Re-Mission, a game on cancer (by HopeLab, http://www.re-mission.net/), and the exergame device Eyetoy (by Sony Computer Entertainment Inc., http://www.scei.co.jp/), argues that electronic games, formerly considered enemies of health and physical activity, are now turning into valuable tools for the promotion of health, fitness and exercise.

It, thus, seems that electronic games could be used within the framework of HE and PE programs to improve the health and physical status of today's youth. However, this assertion needs to be further supported by relevant theory, application experiences and, above all, by empirical evidence. Nevertheless, to the best of the author's knowledge, no comprehensive overview of the scientific literature on the use of electronic games in HE and PE has been published thus far.

The central question that this study attempts to answer is whether and how the power of electronic gaming can drive children, adolescents and young adults towards adopting a healthier lifestyle and becoming more physically active for life. The aim of the study is to critically review recently published literature on the use of electronic games in HE and PE with a view:

(a) to identifying the potential benefits of the incorporation of electronic games as educational tools into HE and PE programs,
(b) to presenting a synthesis of the empirical evidence available thus far on the educational effectiveness of electronic games in HE and PE,
(c) to defining future research perspectives concerning the educational use of electronic games in HE and PE based on the overviewed literature.

The study is unique in that it presents an overview of the recently published literature on the use of electronic games in both HE and PE, two closely interconnected disciplines, while taking into account both electronic games with standard interfaces and the newly emerged physically interactive electronic games with exertion interfaces. The study can provide useful guidance to educators, practitioners and researchers in the areas of HE and PE as well as to electronic game designers who consider undertaking the creation of electronic games for HE or PE.

2. Method

For the purposes of the study, a literature search was undertaken in April 2008 in the following international online bibliographic databases: (a) ISI Web of Knowledge, (b) EBSCO Host (consisting of: Academic Search Complete, SPORTDiscus with Full Text, PsycINFO, GreenFILE, Shock & Vibration Digest), (c) PubMed, (d) ERIC, and (e) EdITLib Digital Library for Information Technology and Education. The search string used was: (''physical education'' OR ''health education'' OR sport) AND (''computer game'' OR ''video game'') AND (teaching OR learning OR education). Searches were limited to articles published in journals and conference proceedings, in English, from 2000 onwards. The latter limitation was posed due to the rapid changes in ICT, in general, and in electronic gaming technologies, in particular. Furthermore, a number of journal and proceedings articles on ICT in HE or PE (written in English, from 2000 onwards), that were located during searches in the afore-mentioned databases, were examined and those relevant to electronic gaming were also considered. Given that the study focused on the examination of electronic games as potential educational tools within HE or PE, articles located through the database searches that did not fall within that focus were excluded from consideration. For instance, these were: articles generally addressing ICT in HE or PE (e.g. DerVanik, 2005), articles referring to electronic gaming in relation to sedentary behaviours (e.g. Kahn et al., 2002), articles on the influence of electronic games on human functions and development (e.g. Ziegler, 2007), articles on the process of learning how to play electronic games (e.g. Shewokis, Krane, Snow, & Greenleaf, 2001), articles focusing on technical aspects of electronic games (e.g. Brown, 2003), and articles on electronic gaming and professional medical training (e.g. Harper et al., 2007). Articles referring to electronic games for specific socio-cultural contexts and special needs populations (e.g. Baxter, Seagram, & Amory, 2006) were also excluded. Finally, a total of 34 articles were included in the review.

A typology by which the 34 articles could be categorized was sought. The categorization scheme proposed by Dempsey, Rasmussen, and Lucassen (1996) in their review of the general instructional gaming literature was adopted for the needs of the present study. This scheme, which was also used in Dempsey, Lucassen, Gilley and Rasmussen (1993–1994), defines the following five categories (Dempsey et al., 1996, p. 5): (a) Research (systematic approaches in the study of gaming targeted at explaining, predicting or controlling particular phenomena or variables), (b) Theory (articles that explain the basic concepts or aspects or derived outcomes of gaming), (c) Reviews (syntheses of articles concerning general or specific aspects of gaming), (d) Discussion (articles that state or describe experiences or opinions with no empirical or systematically presented evidence), and (e) Development (articles that discuss the design or development of games or projects involving gaming). Specifically, for the categorization of the articles, the following criteria were applied in this study. Articles comprising empirical research related to gaming in HE or PE were assigned to the 'Research' category. Articles comprising theoretical analyses of concepts, aspects or outcomes of gaming in relation to HE or PE were placed in the 'Theory' category. Articles presenting syntheses of articles concerning gaming in HE or PE, conducted according to explicit methodology, were placed in the 'Review' category. Articles reporting on opinions and experiences regarding gaming in HE or PE, with no empirical or systematically presented evidence, were assigned to the 'Discussion' category. Finally, articles reporting on the design or development of games for HE or PE or on relevant projects were assigned to the 'Development' category. The articles were grouped into those five categories according to their primary focus. Of the 34 articles overviewed, 19 were placed in the 'Research' category, 3 in the 'Theory' category, 8 in the 'Discussion' category and 4 in the 'Development' category, whereas no reviews were found, which highlights the originality of the present study. As in other reviews of the general instructional gaming literature (Dempsey, Lucassen, Gilley, & Rasmussen, 1993–1994; Hays, 2005), in this study, there were fewer articles in the 'Development' and 'Theory' categories than in the 'Research' and 'Discussion' categories. This may happen because instructional gaming is a relatively new domain of educational technology and for authors to address relevant development and theoretical issues, a substantial empirical base must be first created.

A second level of categorization was applied within the 'Research' category. Specifically, further thematic subcategories were defined according to the common themes of the selected articles. As in other reviews of the electronic learning literature (Hrastinski, 2008), those subcategories were iteratively developed while reviewing the articles. Each thematic subcategory was labeled with the broader disciplinary area -HE or PE (including sport)- and topic area (e.g. nutrition education, fitness) to which its articles refer. As already mentioned in the introduction, the intended target audience of the present study are educators, practitioners, researchers and electronic game designers in the areas of HE and PE. It was, therefore, judged that dividing the selected research articles into thematic subcategories would help each member of this audience easily review the potential benefits, empirical findings and future research perspectives regarding electronic gaming in his/her specific area and topic of interest. A similar thematic subcategorization of empirical research articles was also performed in Hays' (2005) review of the general instructional gaming literature.

The selected articles were read and summarized using the research aims of this study as a guide. Specifically, in order to approach the first two aims of the study, the following information was drawn from each article (if provided in the article): (a) potential benefits of electronic games as educational tools in HE or PE, and (b) major empirical findings related to the actual effectiveness of electronic games in HE or PE. Furthermore, if an article provided information on the design characteristics of games, the design process of games or the conditions for the effective exploitation of games within HE or PE, this information was included in the summary. Within each category or subcategory, those summaries were, then, synthesized with a view, on the one hand, to draw conclusions on the educational effectiveness of games in HE or PE, and, on the other hand, to approach the third research aim of this study, namely to define future research perspectives regarding the use of electronic games in HE and PE on the basis of the summarized articles.

3. Results

In what follows, the overviewed articles are presented according to the following main categories: 'Research', 'Development', 'Discussion' and 'Theory'. Special emphasis is placed on the 'Research' category, which encompasses articles presenting empirical findings.

3.1. Research

The 19 articles of this category comprise research studies on electronic gaming in HE and PE. Table 1 (see Appendix) presents those articles. For each article, the following information is shown on Table 1: (a) *column 1:* the thematic subcategory and author(s) of the article,

and the identity of the game used in the research reported in the article, namely its title, the objective for which the game was used, and its type (computer game or video game), (b) *column 2:* the research aim, (c) *column 3:* the research sample, (d) *column 4:* the research design, and (e) *column 5:* the major research findings.

As an aid to the reader, Table 2 provides a summary of the overviewed research articles. For each article, Table 2 shows the following attributes: (a) *column 1:* the author(s) of the article, (b) *column 2:* the subcategory of the article (as numbered in the rest of the present paper), (c) *column 3:* the technological interface (standard interface or exertion interface) of the game used, (d) *column 4:* whether or not the game is multiplayer (i.e. can support two or more simultaneous players), (e) *column 5:* the type of learning outcomes for which the game was used, (f) *column 6:* the type of learners by whom the game was used, (g) *column 7:* whether or not the game was compared to other form of instruction (having equivalent objectives and content), (h) *column 8:* whether or not participants' individual characteristics were examined, and (i) *column 9:* the main conclusion drawn from the article regarding the educational effectiveness of the game. The attributes of columns 3 and 4 were introduced by the author, whereas those of columns 5, 6, 7 and 8 were suggested in the typology by Dempsey et al. (2006).

Within each thematic subcategory, articles appear in chronological order both in Tables 1 and 2.

In what follows, the 19 articles are further presented and discussed, in relation to the aims of this study and according to the thematic subcategories which emerged.

3.1.1. HE/Disease awareness, prevention and management

The articles of this subcategory comprise evaluative studies of the use of electronic games within general and condition-specific HE programs addressing disease awareness, prevention and treatment and targeted at children, adolescents and young adults. In what follows, the potential benefits of games for HE, mentioned in those articles, are presented first, followed by summaries of the articles including evaluation outcomes regarding the actual effectiveness of games. Finally, the conclusions and future research perspectives drawn from the overview of the articles are discussed.

The potential benefits of electronic games for HE are outlined in certain of the articles (Beale, Kato, Marin-Bowling, Guthrie, & Cole, 2007; Yawn et al., 2000) and mainly in Lieberman (2001) as follows: (a) games can support interactive, experiential learning, which can improve players' health-related self-efficacy and behaviours, (b) games are particularly motivational for young people, who may be difficult to influence through traditional HE interventions, (c) games can provide individualized feedback on health choices, (d) games can support progress at one's own pace, (e) games can offer opportunities for social interaction and health-related social support both within the game and around it, which can enhance players' motivation to improve health behaviours, (f) games can offer unlimited opportunities to rehearse self-care skills, which may favour the transfer of those skills to real-life situations.

The articles report on the following games and evaluation outcomes. Bartholomew et al. (2000) report on an adventure game, designed according to Bandura's (1986) social cognitive theory and targeted at enhancing asthma self-management skills. The game was enjoyed by the children and adolescents of the sample and was proven effective in enhancing their asthma-related knowledge and behaviours, while reducing hospitalizations. Yawn and colleagues (2000) present a space adventure game, within which children can learn about asthma symptoms and treatment through completing missions in alien worlds that embed relevant learning material. Children had participated in the game design process by providing information and desired game features. The game was proven highly motivational and effective in helping children improve their asthma-related knowledge. Hornung, Lennon, Garrett, DeVellis, Weinberg and Strecher (2000) report on a game aimed at skin cancer prevention, which features cartoon characters that model various sun-safety behaviours. Children had participated in the multi-disciplinary game design team by providing information and desired game characteristics. The game was found to be engaging and more effective than traditional instruction in significantly increasing children's skin cancer knowledge and positive sun-protection attitudes, although no significant changes in sun-protection behaviours were noted. In a similar study, Hewitt, Denman, Hayes, Pearson, and Wallbanks (2001) describe an adventure game in which children can learn about skin cancer and sun protection. The game was found to have a significant positive influence on children's knowledge, attitudes and behavioural intentions regarding skin cancer prevention, and was just as successful as, and considerably more enjoyed than, an equivalent printed workbook. Five evaluative studies of three action-oriented adventure games, targeted at children and adolescents, are presented in Lieberman (2001) and in prior papers (Brown et al., 1997; Lieberman, 1995; Lieberman, 1997; Tingen, Grimling, Bennett, Gibson, & Renew, 1997). The games concern asthma and diabetes awareness and management, and smoking prevention. In the first game, players have to successfully manage the asthma of the two main characters (dinosaurs in quest of a stolen wind machine). In the second game, players have to keep the two main characters (diabetic elephants in a summer camp) in optimal condition. In the third game, players guide a doctor within the virtual body of a smoker to clear substances such as tar. The games, which were designed with a view to avoiding explicit provision of health-related content and directives and to primarily being motivational through incorporating compelling gameplay elements created by professional game designers, offer players opportunities to actively engage in taking health-related decisions, to experience the relevant consequences, to communicate with other persons and to rehearse health-related practices. The games were much enjoyed by their target audiences and yielded enhanced health-related knowledge, attitudes, self-efficacy regarding self-care behaviours, and social interactions. Beale et al. (2007) present a game based on self-modeling theory (Dowrick, 1999) and aimed at helping young people with cancer acquire illness-related knowledge and self-care skills. The game, which was designed with a view to primarily being entertaining for its target audience, members of which had participated in the multi-disciplinary design team, was given the look and feel of a commercial video game, while implicitly embedding educational content. The players complete missions within the bodies of virtual patients, killing cancer cells using weapons while preserving ammunition. The evaluation of the game with adolescents and young adults showed a significant positive impact on their knowledge of cancer, whereas another study (Beale, Marin-Bowling, Guthrie, & Kato, 2006) showed that it was well-accepted by them.

As deduced from the synthesis of the afore-presented outcomes and from Table 2, electronic games are effective in promoting knowledge acquisition, development of positive attitudes and positive behavioural changes within the framework of HE programs addressing disease awareness, prevention and management, and targeted at children, adolescents and young adults. This conclusion seems to support the alleged potential benefits of electronic gaming for HE. However, as suggested by the findings by Hornung and colleagues (2000), the goal of positively impacting behaviours through electronic gaming is perhaps the harder to attain, and, hence, should receive special emphasis in future research. Methodological limitations (e.g. small samples, small intervention durations) were noted in certain of the articles. Furthermore, as shown on Table 2, only half of this subcategory's articles compared electronic gaming to other forms of instruction.

Table 2
Summary of research articles concerning electronic games in HE and PE.

Author(s)	Sub-category	Interface	Multi-player	Type of learning outcomes	Type of learner	Comparison	Individual characteristics	Conclusion on effectiveness
Bartholomew et al. (2000)	3.1.1.	Standard	No	Knowledge, behaviours, quality of life	Children, adolescents	No	Age, disease severeness	Game was effective (particularly for older participants and those with lower disease severeness)
Hornung et al. (2000)	3.1.1.	Standard	No	Knowledge, attitudes, behaviours	Children	Yes	No	Game was more effective than conventional instruction in terms of knowledge and attitudes, but no difference in terms of behaviours
Yawn et al. (2000)	3.1.1.	Standard	No	Knowledge	Children	No	No	Game was effective
Hewitt et al. (2001)	3.1.1.	Standard	No	Knowledge, attitudes, behaviours	Children	Yes	No	Game was as effective as printed workbook
Lieberman (2001)	3.1.1.	Standard	Yes[a]	Knowledge, attitudes, behaviours, self-efficacy, social support	Children, adolescents	Yes (Study 2)	No	Games were effective (Study 2: Game was more effective than videotape)
Beale et al. (2007)	3.1.1.	Standard	Yes[a]	Knowledge	Adolescents, adults	No	Age, gender, gaming experience	Game was effective (no individual differences)
Turnin et al. (2001)	3.1.2.	Standard	No	Knowledge, behaviours	Children	Yes	Weight	Game was more effective than conventional instruction (no individual differences)
Cullen et al. (2005)	3.1.2.	Standard	No	Behaviours	Children	No	Age, gender, ethnicity, education	Game was effective (no individual differences)
Munguba et al. (2008)	3.1.2.		No	Knowledge, metacognition, intrinsic motivation	Children	Yes	No	Game was at least as effective as board game in terms of knowledge and motivation, but less effective in terms of metacognition
Silk et al. (2008)	3.1.2.	Standard	No	Knowledge	Adults	Yes	No	Game was less effective than website
Tuzun (2007)	3.1.3.	Standard	Yes	Active learning	Adolescents	No	No	Game was effective
Ciavarro et al. (2005)	3.1.4.	Standard	No	Knowledge	Children, adolescents	No	No	Game was effective
Goodman et al. (2006)	3.1.4.	Standard	No	Knowledge	Children, adolescents	No	Age	Game was effective (no individual differences)
Fery and Ponserre (2001)	3.1.5.	Standard	No	Motor skills	Adults	No	No	Game was effective under certain conditions
Tan et al. (2002)	3.1.6.	Exertion	Yes[b]	Fitness	Adults	No	Gender	Game was marginally effective (no individual differences)
Unnithan et al. (2006)	3.1.6.	Exertion	Yes[b]	Fitness	Children, adolescents	No	Weight	Game was effective (particularly with overweight participants)
Sell et al. (2007)	3.1.6.	Exertion	Yes[b]	Fitness	Adults	No	Gaming experience	Game was effective (particularly with experienced participants)
Chin et al. (2008)	3.1.6.	Exertion	Yes	Motivation for exercise	Children	Yes	No	Game was more effective when combined with multiplayer class
Russell (2007)	3.1.7.	Exertion	N/A[c]	Fitness	N/A[c]	No	N/A[c]	Game effectiveness presupposes teachers' training

[a] Two-player options.
[b] Used in single-player mode in the study.
[c] Not applicable.

Future research should, thus, be conducted on the basis of such comparisons, and should overcome methodological limitations, with a view to providing more valid outcomes regarding the educational effectiveness of games. Nevertheless, as shown on Table 2, the findings of this subcategory's articles that did include comparisons suggest that digital game-based learning is at least as effective as or even more effective than conventional instructional media in positively influencing young people's health-related knowledge, attitudes and behaviours. In addition, the afore-mentioned findings provide empirical support for the assumption that digital game-based learning promotes learners' enjoyment and engagement in the learning process, and is more appealing to young people than conventional instructional media. It should also be noted that most of the afore-presented games clearly follow the 'entertainment-first' approach, resemble the challenging adventure electronic games that young people play in their everyday lives, and were designed according to sound theoretical principles from the areas of health promotion, instructional design and game design by relevant multi-disciplinary teams with the participation of members of the target audiences. Those elements (focus on enjoyment and challenge, professional theory-based design, relevance and appropriateness for the target audience) seem to account for the effectiveness of the games. As shown on Table 2, only two of this subcategory's articles (Beale et al., 2007; Lieberman, 2001) concern games with multi-player options. An important associated finding reported in Lieberman (2001) is that those options had a positive influence on players' health-related social interactions and support. This encouraging finding calls for giving special future research emphasis on the potential of multi-player games for HE. Finally, as deduced from Table 2, only two of this subcategory's articles examined differences in the effectiveness of games as to learners' individual characteristics, and reported equivocal findings. Individual differences, thus, deserve to be further investigated with a view to producing games that are effective in helping young people with different characteristics learn about, prevent and manage disease.

3.1.2. HE/Nutrition education

The articles of this subcategory comprise evaluative studies of electronic games specifically designed to cover nutrition. The articles report on the following games and outcomes regarding game effectiveness. Turnin et al. (2001) describe a game, through which primary school children learn about food categories and ingredients by helping the game characters prepare nutritionally balanced meals. The students that used the game enjoyed it and exhibited significantly better dietary knowledge and behaviours compared to those that received conventional nutritional instruction. Cullen, Watson, Baranowski, Baranowski, and Zakeri (2005) report on an adventure game designed according to Bandura's (1986) social cognitive theory and aiming at increasing Fruit, Juice and Vegetable (FJV) intake. Within the game, which is also presented in Baranowski et al. (2003), the child has to face various challenges in his/her pursuit to becoming a knight in order to save a fantastic kingdom from invaders who destroy fruit and vegetable crops. Developers of children's games and children from the intended target group had contributed to the game's design. The game was found to be successful in increasing FJV consumption. A comparative study of two games on the food pyramid (a single-player video game and a multi-player non-digital board game) is presented in Munguba, Valdes, and da Silva (2008). Within the video game, the child has to organize his/her daily diet (according to his/her weight and height) by selecting foods, which causes changes to the avatar's body according to the calories ingested. The games were found to be equally motivational and both helped children learn about the food pyramid. The board game was more efficient in developing children's metacognitive strategies. However, children were significantly more attentive while playing the video game. Silk et al. (2008) present a game designed according to casual games (e.g. quiz/trivia) and aimed at helping young and older mothers make more informed food choices. The evaluative study showed that a website with equivalent content performed significantly better than the game with the women of the sample in terms of likeability and learning outcomes.

As deduced from the afore-presented overview and from Table 2, the first three of this subcategory's studies, which were targeted at children, indicate that electronic games are effective in spurring children's motivation, and in inducing positive dietary learning outcomes and behaviours, in the field of nutrition education. Electronic games can, thus, play an important role in this critical field, in an era where obesity has reached epidemic proportions. As regards comparison of games with other media for nutrition education interventions, two of the three studies (Munguba et al., 2008; Turnin et al., 2001), which included such comparisons, yielded rather equivocal findings. Specifically, the results reported by Turnin et al. (2001) suggest that digital game-based learning is more effective than conventional instruction, a finding which supports the respective conclusion drawn from subcategory 3.1.1. However, the results reported by Munguba and colleagues (2008) suggest that, perhaps, other media may be more effective than electronic games. Those equivocal findings, coupled with the fact that methodological limitations (e.g. use of self-report instruments) were noted in certain of the studies, call for further future research that surpasses such limitations and explores the impact of electronic gaming on young people's nutritional knowledge and, above all, actual nutritional behaviours, in comparison to other media. Regarding game design, as in the case of most of the games of subcategory 3.1.1., the games used in this subcategory's first three studies were exploration- and activity-based, and an adventure game (Cullen et al., 2005), designed according to sound behavioural change theory by a multi-disciplinary team including members of the target audience, was found to be particularly effective, which highlights the importance of theory-based and audience-centered game design. The findings of the fourth study (Silk et al., 2008), which was the only one to target adults, contrast those of the other three studies, and suggest that the benefits of electronic gaming may not be equal for all audiences, depending on factors such as age and electronic gaming experience. Those findings put forward three issues that have already been stressed in this paper. Firstly, that it is crucial that game design stems from an assessment of the audiences' needs and experiences. Secondly, that more research is needed on the effectiveness of electronic games in comparison to other instructional media. Thirdly, that differences in the effectiveness of electronic games in relation to learners' individual characteristics should be further investigated. Finally, it should be noted that, as shown on Table 2, none of the games of this subcategory had any multi-player options. An interesting future research perspective would be the investigation of the potential of multi-player games for nutrition education.

3.1.3. HE/First-aid education

In a study that does not only examine the learning outcomes of electronic games, but also the challenges associated with their introduction into real classrooms, Tuzun (2007) reports on the evaluation of the use of three video games, one of which was aimed at teaching first-aid concepts to secondary school students. Within the game environment, which includes basic collaborative capabilities, students have to complete inquiry-based and experiential activities (e.g. relevant to injuries) as part of a problem-based narrative. According to the findings of this qualitative study, a transition from teacher-centered to learner-centered pedagogy took place in the classroom, and the students enjoyed the game, collaborated through discourse and actively engaged in problem-solving and decision-making. However,

it was ascertained that designing educational electronic games is a complex task, and that powerful computer and networking infrastructures are needed to support the use of such games in schools.

Those findings, apart from supporting the motivational appeal and educational effectiveness of electronic games in HE, also suggest that electronic games can act as factors of change for the educational system, yielding positive pedagogical changes towards more active learning modes. The design of the game used in the overviewed study encourages exploratory, activity-based learning, and this approach may account for the positive outcomes obtained. Furthermore, the game includes multi-player capabilities, which may also have contributed in its effectiveness. However, the exact contribution of the multi-player modality cannot be determined. As already mentioned and as deduced from Table 2, the potential of multi-player gaming for HE has been very little investigated thus far, and deserves to be further researched. An interesting future research perspective could be the comparison between single-player and multi-player modes of the same game as to their educational effectiveness. Finally, the overviewed study identifies issues that need to be addressed for an effective integration of electronic games into schools, and raises certain practical questions. In particular, the complexity of educational game design and the need for a constantly up-to-date ICT infrastructure denote that there is a substantial cost associated with digital game-based learning.

3.1.4. PE/Injury awareness during sporting activities

The two similar articles in this subcategory refer to electronic games designed to cover the symptoms, risks and management of injury during sporting activities. The first study (Ciavarro, Meanley, Bizzocchi, & Goodman, 2005) refers to a sports action video game simulating an actual hockey game and designed according to the principles of situated cognition (Brown, Collins, & Duguid, 1989). The game primarily focuses on entertainment while facilitating unintentional, implicit learning about concussion, by placing the player in simulated real-life situations in the form of movie-style cutscenes, which are expected to favour knowledge acquisition and transfer to real-life sporting contexts. The game was found effective in educating pre-adolescents and adolescents about concussions. In the second study, Goodman, Bradley, Paras, Williamson, and Bizzocchi (2006) describe a video game modelled after Tetris, in which the descending blocks of the popular game are substituted by icons representing either concussion symptoms or symptoms not related to concussion. This game also supports unintentional learning, and its evaluation showed that it successfully conveyed information about concussions to pre-adolescents and adolescents.

The results of those studies suggest that electronic games are effective in favouring knowledge acquisition regarding injury during sporting activities. As far as game design is concerned, as in other studies of the previous subcategories, in the studies of this subcategory, theory-based design was undertaken and the 'entertainment-first' approach was followed, which was proven successful with the goal of knowledge acquisition. An interesting, but yet untested, hypothesis behind the design of the first of the games is that knowledge acquired within simulated -in the video game- contexts is likely to be transferred to corresponding real-life contexts outside the video game. The empirical testing of this hypothesis constitutes an interesting future research perspective as far as topics such as injury awareness or first-aid are concerned. Finally, it should be noted that the findings of those studies would be better supported if certain methodological limitations (e.g. absence of testing of long-term knowledge retention) were addressed, and if the impact of the described games were evaluated in comparison to that of other forms of instruction having the same learning objectives and content.

3.1.5. PE/Acquisition of motor skills

In a study unique in that it examines how a motor skill experienced within the virtual environment of a sport video game can be transferred to the actual playing of the real game, Fery and Ponserre (2001) investigate the impact of two different methods of adjusting the virtual player's putting force within a video game simulating the real-world golf game (an analogue method that consists of focusing on the virtual player's movement and a symbolic one that consists of focusing on a movement of a gauge representing the virtual player's putting force) and two different intentions of use of the video game (intentional learning and simple enjoyment) on the players' putting skill in real-world golf playing. The results showed that the video game was effective in the acquisition of the actual putting skill only when the symbolic method, which allowed players to sense the execution of putting instead of just observing it, was used and mainly when the players intentionally used the game for learning.

It can, thus, be deduced that sport simulation games are effective in favouring the acquisition of motor skills and their transfer to real-world contexts under certain conditions. However, this argument remains to be further supported by empirical research, given that this study is the only one among the overviewed ones to address the issue. It should also be noted that the findings of this study somehow contrast with the assertion made on the basis of the positive findings of the studies of previous subcategories (3.1.1., 3.1.2. and 3.1.4.), namely that educational games are most motivational and effective, in terms of positively impacting knowledge and behaviours, when their design follows the 'entertainment-first' approach. It, thus, seems that when the objective is knowledge acquisition or behavioural change, games that support unintentional, implicit learning are more suitable, whereas when it comes to specific motor skill acquisition, as in the case of the study overviewed in this subsection, the game should encourage intentional learning and should explicitly present - and let the player sense – the targeted skill through appropriate simulation.

3.1.6. PE/Improvement of fitness

Contrary to the articles overviewed thus far, which concern electronic games with standard interfaces, the articles of this and the next subcategory concern exergames. More specifically, the articles of this subcategory refer to potential benefits of exergames, and focus on the evaluation of the impact of exergame use by children, adolescents and young adults on physical and affective outcomes.

The following potential benefits of exergames are mentioned in this subcategory's articles: (a) exergames can increase young people's motivation for exercise, (b) exergames can provide alternative modes of physical activity, and (c) exergames can help combat obesity.

Regarding the actual effectiveness of exergames in relation to fitness objectives, the following outcomes were obtained. Tan, Aziz, Chua, and Teh (2002) investigated the intensity, energy cost and safety of playing the arcade version of the dance simulation game DDR, on medium mode, in relation to the American College of Sports Medicine (ACSM) recommendations (Pollock et al., 1998) on the quantity and quality of exercise for developing and maintaining cardiorespiratory fitness, with a sample of young, fit college students. The results showed that there was no risk of injury and that the exercise intensity met the ACSM standards, although marginally, which denotes that one has to play for extended periods of time (e.g. through using the home version) for improvement or maintenance of cardiorespiratory fitness or for losing weight. In a similar study, Unnithan, Houser, and Fernhall (2006) investigated the exercise intensity of overweight and normal

weight children and adolescents while playing the home version of DDR, at its least difficult level, in relation to the ACSM recommendations. DDR was proven successful in increasing all participants' heart rates within the range of ACSM standards for achieving an aerobic workout and improving cardiorespiratory endurance. Furthermore, overweight children were found to expend more energy during DDR play compared to non-overweight ones. Sell, Lillie, and Taylor (2007) further explored the relationship between energy expenditure and DDR playing, as a function of DDR playing experience, with a sample of healthy college students. The study showed that all participants enjoyed DDR more than treadmill walking and achieved or came close to the ACSM minimal recommendations for daily physical activity and energy expenditure, with experienced players exhibiting higher enjoyment and higher caloric expenditure than inexperienced ones, which can be attributed to the capacity of the former to play at a higher intensity level. Finally, Chin, Paw, Jacobs, Vaessen, Titze and van Mechelen (2008) examined the effect of a weekly supervised multi-player class of a dance simulation video game (not specified in the article) on the motivation of children with low fitness levels to play the game in the home. Interestingly, among children who attended the multi-player class -in addition to playing the game at home- the dropout rate was lower and cumulative play duration was higher than among children who only used the game at home.

Pulling together the findings of those studies, and as also deduced from Table 2, it derives that exergames are appealing to young people and effective in helping them improve their fitness levels and develop motivation for physical exercise. This supports the assertion that exergames may constitute ideal vehicles for promoting regular physical activity among children, adolescents and young adults, who may be reluctant to participate in traditional types of exercise. Furthermore, the findings suggest that as a player's exergame proficiency increases through practice, enjoyment and health benefits increase as well, and, most importantly, that exergames are efficient in helping populations who most need them, such as overweight children and adolescents, improve their physical condition. Those findings support the alleged potential benefits of exergames. However, as deduced from the afore-presented overview, the number of empirical studies to support the effectiveness of exergames is still small, and research has, thus far, been limited to dance simulation video games (mainly DDR), and is mostly based on small samples and assessments of the short-term effects of exergames. Therefore, further empirical investigation is needed, based on longitudinal research designs and larger samples, with a special focus on populations most in need of exercise (e.g. youngsters who are overweight or exhibit low fitness levels and aversion towards physical exercise), on the impact of exergames on physical and affective outcomes. Possible topics of future research are, for instance: (a) the conditions (e.g. duration of play, intensity level, single- or multi-player mode) under which exergames can confer maximal improvements in fitness and reductions in body weight, and (b) the impact of exergames on players' attitudes towards physical exercise and on their motivation to engage in other physical and athletic activities. Finally, as shown on Table 2, only one of the overviewed studies (Chin et al., 2008) was focused on the examination of the impact of the multi-player mode of an exergame, yielding the important finding that this mode maximizes motivation for gameplay, and, hence, for physical exercise. This finding indicates that, at least in the case of young people that find it difficult to adhere to physical activity (as the low fitness children of the study's sample), some form of guided and socially interactive use of an exergame is needed to sustain their motivation. This should be taken into account both in PE practice and in future research.

3.1.7. PE/Educators' knowledge and attitudes regarding electronic games

In the only study that examined educators' perceptions and attitudes regarding electronic games, Russell (2007) investigated PE teachers' knowledge, experience and anticipated scholastic usage of nine specific exergames. The study, which did not involve actual usage of the games, showed that, as a whole, teachers lacked knowledge and experience regarding exergames and that levels of anticipated usage were low. Younger teachers and those with more favorable attitudes towards educational technology exhibited greater knowledge, experience and anticipated usage.

Those findings suggest that although the new technology of exergames is promising for the innovation of PE curricula (as suggested by the overview presented in the previous subsection), for its effective integration into educational settings, the important issue of educators' training should be addressed first -including educators' actual exposure to the technology- with a view to ensuring its maximal didactical exploitation. If PE teachers are not capable of exploiting exergame technology, then the educational effectiveness of exergames is seriously compromised.

3.2. Development

Table 3 presents a summary of the articles that were assigned to the 'Development', 'Discussion' and 'Theory' categories. For each article, Table 3 shows: (a) *column 1:* the author(s), (b) *column 2:* the category, and (c) *column 3:* the main topic of the article. Within each category, articles appear in chronological order in Table 3.

The four articles in the 'Development' category concern the design, development and evaluation process of electronic games for HE, addressing the methodology that should guide the process and the essential components that should be incorporated into the game design with a view to ensuring the educational effectiveness and motivational appeal of such games.

In the first article, Lockyer, Wright, Curtis, Curtis, and Hodgson (2003) argue that a grounded, iterative, multi-phase method of design and development that includes all stakeholders and is based on constant formative evaluation should be adopted during the creation of a game for HE, with a view to maximizing its appeal and effectiveness. The authors exemplify this approach by reporting on the creation of a game aimed at helping primary school children acquire knowledge and skills regarding diet, exercise, and the balance of energy intake and expenditure. The initial design began by interviewing children, teachers and parents of the target group about understandings and behaviours regarding diet and exercise, and suggestions regarding game features. On the basis of the findings, a prototype was developed and formatively evaluated with children. In the second article, Shrimpton and Hurworth (2005) stress that rigorous evaluation of an electronic game designed for HE is essential in ensuring game effectiveness, and report on the evaluation methodology of an adventure game aimed at helping young people recover from psychosis. The evaluation, which was performed by multimedia, game and instructional designers as well as by psychosis experts and young people who had experienced psychosis, revealed the need for substantial redevelopment of the game, and showed that successful games designed for HE should be as sophisticated and audience-aware as commercial electronic games. The importance of formative evaluation is also stressed in the third article (Louise, Renaud, & Kaufman, 2008), which reports on the creation of an electronic game targeted at

Table 3
Development, discussion and theoretical articles concerning electronic games in HE and PE.

Author(s)	Category	Main Topic
Lockyer et al. (2003)	Development	Design and development of an electronic game for HE
Timpka et al. (2004)	Development	Components that should be incorporated into the design of electronic games for HE
Shrimpton and Hurworth (2005)	Development	Expert evaluation of an electronic game for HE
Louise et al. (2008)	Development	Expert evaluation of an electronic game for HE
Fiorentino-Holland and Gibbone (2005)	Discussion	Potential benefits of a game that simulates sports situations for scholastic PE
Mohnsen (2005)	Discussion	Potential benefits of exergames and proposals for their exploitation in scholastic PE
Trout and Zamora (2005)	Discussion	Potential benefits of exergames and proposals for their exploitation in scholastic PE
Borja (2006)	Discussion	Opinions, experiences and pilot findings on the potential of exergames for school students
Hayes and Silberman (2007)	Discussion	Potential benefits of commercial sport video games for PE, and practical implementation issues
O'Hanlon (2007)	Discussion	Opinions, experiences and pilot findings on the potential of exergames for school students
Partridge et al. (2007)	Discussion	Exergames and simulations as means to promote physical activity in schools
Trout and Christie (2007)	Discussion	Presentation of various exergames and their potential benefits for scholastic PE
Hemphill (2005)	Theory	Physically interactive sport video games as instances of sport
Schott and Hodgetts (2006)	Theory	Potential of the communities formed within and around electronic gameplay for HE
Jenson and De Castell (2008)	Theory	Evolution of game interfaces, and potential benefits of physically interactive sport video games

facilitating secondary school students' learning about prevention of sexually transmitted infections. Finally, Timpka, Graspemo, Hassling, Nordfeldt, and Eriksson (2004) explore how the design of action-adventure electronic games -a game genre very popular among young people- can inform the design of games for HE. In particular, the game components that maximize young people's motivation for gameplay are sought so that those components can be incorporated into the design of effective games for HE. Based on observations from and interviews with adolescents, the authors identify four such components: (a) narrative space: the virtual environment for the gameplay, (b) narrative: the scenario of the gameplay, (c) spectacular features: fun and engaging multimedia effects, and (d) gameplay scripts: the challenge and competition in gameplay. The last component was ascertained to be the most motivational.

The afore-presented overview indicates that the educational effectiveness and motivational appeal of an electronic game designed for HE and targeted at young people largely depend on the design, development and evaluation approach followed during the creation of the game. Specifically, as deduced from the overview, the following issues should be taken into consideration during game creation. Firstly, game design should originate from the intended target audiences' health-related conceptions and practices as well as from their gameplay-related preferences, which are forged by the experience of playing electronic games during leisure time. Secondly, game design should incorporate the exact elements that render commercial electronic games so popular and engaging with young people, with an emphasis on challenge and competition. Thirdly, continuous formative evaluation of the game is needed as to interface design, gameplay and instructional issues. Formative evaluation should be performed both by experts and members of the intended target audience, and its results should inform the design and development of the game. Those considerations were taken into account -to a lesser or greater extent- in the design of several of the already overviewed games of the 'Research' category (e.g. Beale et al., 2007; Cullen et al., 2005; Lieberman, 2001; Yawn et al., 2000), the evaluations of which with young people within HE programs yielded positive results regarding educational effectiveness and motivational appeal, thus, corroborating the arguments formulated in the articles of this category.

3.3. Discussion

Seven out of the eight articles of this category concern the incorporation of exergames into scholastic PE and its potential benefits (with six out of the seven referring to DDR, either exclusively or in conjunction to other exergames), whereas the eighth article discusses the potential benefits of commercial sport video games with standard interfaces for PE curricula.

In two similar articles, Mohnsen (2005) and Trout and Zamora (2005) comment on the potential benefits of exergames and provide concrete proposals for the exploitation of DDR (game console version) by entire classes, such as the rotating stations arrangement (students rotate through stations, one of which is DDR), and DDR uses that can help students understand health-related fitness concepts (e.g. use in 'workout' mode, which provides caloric expenditure estimates). Borja (2006) and O'Hanlon (2007) cite PE teachers' and experts' opinions and experiences as well as preliminary findings of pilot studies on USA students, according to which, DDR attracts students' interest, enhances students' cardiovascular performance, helps students lose weight, and, as far as overweight children are concerned, confers increases in aerobic capacity, better weight management and more willingness and confidence to participate in physical activities. Fiorentino-Holland and Gibbone (2005) present Virtual Gym, an application that simulates actual gameplay situations (drawn from football, basketball, etc.) to which students have to respond physically. According to the authors, Virtual Gym entices students to exercise and promotes their physical activity levels, motor skill competency and conceptual understanding of movement principles. Trout and Christie (2007) comment on the potential benefits of exergames, present five popular exergames, and discuss practical issues regarding exergame integration into schools (e.g. suggest the rotating stations arrangement in case of budgetary limitations). Partridge, Blair, and Leidman (2007) also view exergames as solutions for infusing physical activity into schools. Finally, Hayes and Silberman (2007) present the potential benefits of commercial sport video games with conventional interfaces (e.g. Madden NFL 2005 by EA Sports, http://www.easports.com/), which comprise sophisticated simulations of sports and physical activities, for PE curricula, and discuss practical implementation issues (e.g. game cost).

The potential benefits of exergames, as outlined in the overviewed articles and mainly in Trout and Christie (2007), are as follows. Exergames: (a) can be enjoyable tools for complementing traditional PE activities, (b) can increase students' motivation for exercise, (c) can promote students' physical activity, (d) can improve students' fitness levels, (e) can help students lose weight, (f) can favour understanding

of physiological concepts and movement principles, (g) can enhance students' motor skills, (h) can be used for sport-specific training, (i) can accommodate both low- and high-ability students, having several difficulty levels, (j) can allow students self-practice in a less threatening and competitive environment than that of traditional team-based PE activities, and (k) can promote social interaction and teamwork through multi-player modes.

The potential benefits of commercial sport video games with conventional interfaces, as outlined in Hayes and Silberman (2007), are as follows. Those games: (a) can engage students in motivational activities that they may want to try in real-world, (b) can help students develop mental models of successful athletic performance that may be transferred to real-world athletic activities, (c) can help students learn the terminology and tactics in sports and physical activities, (d) can support differentiated instruction adaptable to students' ability levels, (e) can allow practice in a psychologically and physically safe environment, which may increase self-confidence on the real athletic field, and (f) can foster collaboration and teamwork both within gameplay, through multi-player modes, and around it, through online affinity groups.

As deduced from the overview of this category's articles, electronic games (both with exertion and standard interfaces) have many potential benefits for PE. Regarding exergames, collective agreement among the authors of the articles is that those games can enrich scholastic PE curricula and can confer important affective, physical and cognitive benefits to students. Certain of those benefits were also mentioned in the empirical studies of subcategory 3.1.6. Furthermore, the encouraging pilot findings regarding the positive impact of exergames on students, which are reported in this category's articles, seem to support the empirical findings of subcategory 3.1.6., and to corroborate certain of the alleged potential benefits of exergames (namely that such games can increase motivation for exercise, and can confer improvement of fitness levels and weight loss). However, as already mentioned in Section 3.1.6, the empirical evidence to support the effectiveness of exergames is still limited. Each of the afore-presented potential benefits, thus, still remains to be empirically validated by extensive research in schools, and constitutes an interesting topic for future research. For instance, possible research topics include the investigation of the impact of exergames on students': (a) enjoyment and motivation for physical exercise, (b) physical activity and fitness levels, (c) weight, (d) understanding of PE concepts, (e) acquisition of motor skills, and (f) teamwork and social skills, in comparison with traditional PE activities and with a special focus on 'at-need' students (e.g. overweight). Regarding sport simulation video games with standard interfaces, the afore-presented overview suggests that those games can enhance students' motivation, confidence, understanding and performance regarding actual sports and physical activities. Nevertheless, the alleged potential benefits of those games also need to be empirically validated, given that very limited empirical evidence on their educational effectiveness exists thus far (see subcategory 3.1.5). The potentially positive impact of those games resides on the hypothesis that the motivation, knowledge and skills developed within the simulated world of the game are transferred to the real world, a hypothesis that has to be empirically tested. Future research should, for instance, address the impact of those games on students': (a) motivation and self-confidence to engage in real-world sports and physical activities, (b) conceptual and procedural knowledge of sports and physical activities, and (c) acquisition of specific real-world motor skills. As a concluding remark, it should be noted that both exergames and conventional sport video games can be useful within PE curricula, and could be used complementarily, each type of game having its strong point: exergames can make students really 'sweat', whereas conventional sport video games can favour students' conceptual understanding of sport. Finally, as deduced from the overview, for the effective integration of both types of games into scholastic curricula, practical issues, such as that of game cost, should be addressed.

3.4. Theory

This final category comprises three theoretical articles. Two of them focus on the recent advances in game interfaces which have led to the emergence of exergames, while the third one focuses on the promise of the social dimensions of electronic gaming for health interventions.

Hemphill (2005) explores the possibility that sport video games (e.g. football, racing or skiing games) be considered instances of sport. The author emphasizes the recent transition in the technology of game interfaces, from conventional visual and auditory interfaces to sophisticated interfaces that increasingly include substantial physical movement, and demonstrates that the bodily dexterity and skill required by certain contemporary video games justifies their qualification as sport. Along similar lines, Jenson and De Castell (2008) point out that electronic gaming has recently undergone an important epistemological shift from simulation to imitation. Specifically, although until recently the player's action (e.g. key pressing) was translated into simulated on-screen action, new game interfaces allow physically active, embodied play that imitates on-screen action, thus, offering players opportunities to actually practice sports and exercise their body. After also referring to the great promise of exergames for the promotion of physical exercise, Schott and Hodgetts (2006) focus on the social, communal and participative dimensions of electronic gaming, and, specifically, on the important -but yet unexplored in HE- potential of the communities formed both within the actual gameplay of specific games and around it (e.g. fan websites). According to the authors, existent communities that pertain to games not apparently related to nor specifically designed for HE (e.g. massively multi-player online games) should be exploited for the promotion of health-related knowledge, skills, behaviours and social support among young people.

The articles of this category provide theoretical support for the great potential benefits of physically interactive video games and multi-player, networked games for PE and HE respectively. The potential benefits of exergames for PE have been documented in the previous subsection and it has already been stressed that they still remain to be empirically explored. For instance, an interesting research topic could be the effectiveness of exergames in sport skill acquisition. Based on the findings by Fery and Ponserre (2001) (see subcategory 3.1.5), which showed that the visual simulation of a sport skill, within a video game with a standard interface, was effective in favouring the acquisition of the actual sport skill, one could hypothesize that exergames, which enable embodied rehearsal of sport skills, would be even more effective. Regarding multi-player games and HE, it has already been stressed (in Sections 3.1.1, 3.1.2 and 3.1.3) that the potential of such games specifically designed for HE is promising and should be further researched. However, the article by Schott and Hodgetts (2006) adds another interesting research perspective, given that it refers to the promising potential of gaming communities formed on the basis of existent games, not specifically designed for HE. A related future research topic could be the evaluation of the impact of the use of popular massively multi-player online environments, such as for instance Second Life (http://secondlife.com/), for socially interactive health interventions targeted at young people.

4. Conclusions

This study was aimed at presenting a review of recently published literature on the use of electronic games in HE and PE with a view to identifying the potential contribution of those games as educational tools within those disciplines, to synthesizing relevant empirical findings, and to indicating future research perspectives.

The conducted review suggests that electronic games present many potential benefits for HE and PE, which have been detailed in this paper (see Sections 3.1.1., 3.1.6. and 3.3). Pulling together those benefits, it derives that major common strengths for both disciplines, which may positively influence young people' knowledge, skills, attitudes and behaviours in relation to health and physical exercise, are the unique motivational appeal that those games possess as well as the opportunities that they offer for active, exploratory and experiential learning of concepts and skills, for rehearsal of skills within a safe environment, for individualized feedback and differentiated instruction, and for learning through social interactions. In addition, the new generation of physically interactive electronic games seems to be particularly valued in the overviewed literature (see Sections 3.1.6, 3.3 and 3.4) as it can provide opportunities for actual physical exercise and motor skill learning within PE contexts.

The empirical evidence to support the effectiveness of electronic gaming in HE and PE is still rather limited. However, as deduced from the conducted overview and from Table 2, overall it presents a positive picture. As far as HE is concerned, the empirical studies (see Sections 3.1.1, 3.1.2, and 3.1.3) converge in that educational electronic games are effective in promoting young people's engagement in the learning process as well as knowledge acquisition, positive health-related attitudes and positive behavioural changes. Furthermore, the overview overall suggests that electronic gaming is more appealing than and at least as effective as conventional instructional media in positively influencing health-related knowledge, attitudes and behaviours. Nevertheless, it should be noted that, as also shown on Table 2, the effectiveness of electronic games in comparison to other, digital or non-digital, media for delivering HE is not always greater, which perhaps indicates that games should be used to complement other media within HE programs. As far as PE is concerned, the few empirical studies conducted thus far also present a positive picture. Specifically, research on electronic games with standard interfaces (see Sections 3.1.4 and 3.1.5) demonstrates that such games are effective in favouring knowledge acquisition and even motor skill acquisition, whereas research on the newly emerged exergames (see Section 3.1.6) indicates that they are appealing, motivational and effective in producing fitness and health benefits. As in the case of HE, electronic games are viewed as supplementary to other forms of physical activity used within PE programs, which supports the assertion that electronic games should not be considered a substitute for regular physical activities (Wang & Perry, 2006).

As deduced from the overview (see Sections 3.1.1, 3.1.2, 3.1.4, and 3.2), the design of games to be used for knowledge acquisition, attitudinal change or behavioural change in HE or PE should fulfill certain conditions to ensure game appeal and educational effectiveness. Specifically, theory-based, iterative design, which is informed by the intended target audiences, and which aims at facilitating entertaining, unintentional learning, while incorporating gameplay features that maximize young people's motivation, is needed. As derived from Section 3.1.5, games targeted at motor skill acquisition, a common educational objective in PE, should enable the player to sense the targeted skill through appropriate simulation or, ideally, as suggested in Sections 3.3 and 3.4, through embodied practice. The overview also indicates that the successful incorporation of electronic games into scholastic HE and PE programs raises certain practical issues, such as the issues of cost and educators' training (see Sections 3.1.3, 3.1.7 and 3.3). Appropriate models of funding should, thus, be adopted to cover the design, development or purchase costs of electronic games for HE and PE. Such costs could perhaps be covered by co-operations among schools, game production companies and academic departments interested in researching the use of electronic games in HE or PE. The latter could also play an active role in game design by providing valuable scientific guidance. It is also important that educators (especially older ones and those not familiar with digital technologies) be adequately trained in the use and didactical exploitation of electronic games in HE and PE. Teacher training and professional development programs could perhaps be organized within the framework of the aforementioned co-operations.

This study opens up interesting future research perspectives, which have been detailed in this paper. Regarding HE, as commented in Sections 3.1.1 and 3.1.2, more empirical support is needed on the impact of educational electronic games on their players' health-related knowledge, skills and, overall, behaviours, in comparison with other media for imparting HE. For instance, a topic of paramount importance, which, as deduced from Table 1, has been scarcely investigated thus far, is smoking prevention for children and adolescents through electronic gaming. Recently, a sophisticated virtual reality environment aimed at debunking smoking was presented (Brown, 2003). It would be useful to devise gaming environments targeted at the same aim and runnable on schools' ICT infrastructures, and to evaluate their effectiveness in comparison with other media regarding smoking prevention. Regarding PE, as derived from the overview (see Sections 3.1.4, 3.1.5, 3.1.6, 3.3 and 3.4), further empirical evidence is needed on the effectiveness of electronic gaming in terms of cognitive and physical outcomes, motor skill acquisition and motivation for physical exercise. In particular, the newly emerging exergames deserve to receive special focus. Furthermore, the potential of multi-player electronic gaming to spur motivation, support collaborative learning and foster social support among young people within HE and PE programs has hardly been researched thus far, is particularly promising and, clearly, merits further investigation (as highlighted in Sections 3.1.1, 3.1.2, 3.1.3, 3.1.6 and 3.4). Finally, as derived from the overview (e.g. see Sections 3.1.1 and 3.1.2), there is still limited empirical evidence on individual differences in the motivational appeal and effectiveness of electronic games in HE and PE. Such differences should be further investigated with a view to informing both the design of electronic games and the way in which those games are introduced into HE and PE programs targeted at various audiences.

It should be acknowledged that this study was based on 34 articles located by using specific search criteria and bibliographic databases. Other criteria and databases would, perhaps, have yielded more articles. The study should, thus, be considered as an attempt to explore the potential of electronic gaming for HE and PE, rather than a complete overview.

This study has shown that electronic games do have the power to help young people adopt a healthy lifestyle and become physically active for life. It is hoped that the study will provide useful guidance to educators, practitioners and researchers in the areas of HE and PE, as well as to electronic game designers, and that it will inform their future professional practices and research.

Appendix

Table 1.

Table 1
Research articles concerning electronic games in HE and PE.

Subcategory and Author(s) of the Article, Identity of the Game	Aim	Sample	Research Design	Major Findings
HE/Disease awareness, prevention and management Author(s): Bartholomew et al. (2000) *Title:* Watch, Discover, Think and Act *Objective:* Asthma self-management *Type:* Computer game	Quantitative evaluation of the impact of the game on asthma-related knowledge, behaviours and quality of life.	133 children and adolescents, in USA, aged 7 to 17 years, both boys and girls.	Participants were randomized into 2 groups: (a) experimental group (n=70) that used the game for about 8 months, and (b) usual-care group (n=63) that followed a regular healthcare program. Participants and their parents were interviewed and surveyed before and after the interventions.	The experimental group had a significant enhancement in asthma knowledge and self-management behaviours for older participants and those with higher respective pretest scores. It also had reduced symptoms, for participants with milder asthma, and significantly lower rate of hospitalizations.
HE/Disease awareness, prevention and management Author(s): Hornung et al. (2000) *Title:* Playing it safe in the sun *Objective:* Skin cancer prevention *Type:* Computer game	Quantitative evaluation of the impact of the game on knowledge, attitudes and behaviours regarding sun exposure.	192 students in one primary school in N. Carolina,USA, aged 7 to 10 years, both boys and girls.	Participants were randomized into 3 groups: (a) computer game intervention group (n=76), (b) teacher-led intervention group (n=47), and (c) control group (no intervention) (n=69). The interventions were one-time events. Measures were taken before, immediately after and 7 months after the interventions through self-report questionnaires.	There was a significant increase in the knowledge and attitudes scales for the game group, between pretest and posttest. Improvement in the behaviour scale was not significant. The game group scored significantly higher in the knowledge and attitudes scales and slightly higher in the behaviour scale compared to the other groups, in the posttest. The follow-up yielded similar results, but the difference in attitudes was no longer significant.
HE/Disease awareness, prevention and management Author(s): Yawn et al. (2000) *Title:* Air Academy:™ The Quest for Airtopia *Objective:* Asthma symptoms awareness	Quantitative evaluation of the impact of the game on asthma-related knowledge.	87 students in one primary school in Minnesota, USA, aged 9 to 10 years, both boys and girls.	Participants were randomized by intact classes into 2 groups: (a) experimental group (2 classes) that used the game for 6 weeks, and (b) control group (1 class) that followed the regular HE curriculum. Asthma knowledge was assessed before, immediately after and 4 weeks after the	There was a significant increase in scores for the experimental group and no change for the control group between pretest and posttest. The experimental group scored significantly higher than the control group in the posttest.

Type: Computer game			intervention through self-report questionnaires.	The follow-up showed that the experimental group retained the knowledge gained.
HE/Disease awareness, prevention and management Author(s): Hewitt et al. (2001) *Title:* Sun-safe *Objective:* Skin cancer prevention *Type:* Computer game	Quantitative evaluation of the impact of the game on knowledge, attitudes and behaviour regarding sun protection.	374 primary school students in the UK, aged 10 to 11 years.	Participants were randomized into 2 groups: (a) computer intervention group (n=128), (b) printed workbook group (n=142), and (c) control group (no intervention) (n=104). The interventions were one-time events. Measures were taken before, immediately after and 6 weeks after the interventions through self-report questionnaires.	The reported results concern the follow-up: Regarding knowledge, all groups significantly increased their scores, but the game group did not differ significantly from the other groups. Regarding attitudes and behaviours, both intervention groups scored significantly better than the control group, but there was not a significant difference in scores between the computer and the workbook group.
HE/Disease awareness, prevention and management Author(s): Lieberman (2001) *Titles:* Bronkie the Bronchiasaurus, Packy & Marlon, Rex Ronan *Objectives:* Asthma self-management, diabetes self-management, smoking prevention *Type:* Video games	Five studies on the quantitative or qualitative evaluation of the impact of the games on appeal, knowledge acquisition, and changes in self-esteem, self-efficacy, social support, attitudes and behaviours.	*Study 1:* 50 asthma patients in Stanford, USA, aged 6 to 16 years. *Study 2:* 14 asthma patients in San Francisco, USA, aged 8 to 13 years. *Study 3:* 6 asthma and 15 non-asthma patients, aged 5 to 18 years, nurses and clinical staff in San Francisco, USA. *Study 4:* 59 diabetes patients in Stanford, USA, aged 8 to 16 years.	*Study 1:* Each participant used the video game for 40 minutes. Before and after, the participant and parent completed a questionnaire and, one month later, they were interviewed. *Study 2:* Participants were randomly assigned to spend 30 minutes either playing the video game or watching a videotape about asthma. They were surveyed before and after. *Study 3:* Participants used the game for 3 months. After the intervention, the staff was surveyed on the game use. *Study 4:* Participants were randomly assigned to take home for 6 months	*Study 1:* In the posttest and follow-up, there were significant improvements in participants' asthma knowledge, self-care behaviour and communication with parents and friends. *Study 2:* The video game group showed greater enjoyment, equal improvement in asthma knowledge and significantly greater asthma self-efficacy compared to the videotape group. *Study 3:* The participants liked the game, which improved their self-esteem, asthma knowledge and communication among them and with the staff. *Study 4:* The treatment group improved

(*continued on next page*)

Table 1 (*continued*)

Subcategory and Author(s) of the Article, Identity of the Game	Aim	Sample	Research Design	Major Findings
		Study 5: 12 children in Georgia, USA, aged 10 to 11 years.	either the health video game or a pinball video game. Participants and their parents were surveyed at the start and 3 and 6 months later. *Study 5:* The children played the video game at home for one week keeping journals. After the intervention, they participated in focus groups.	in diabetes self-efficacy, self-care and communication with parents, and had a 77% decline in medical visits, whereas the control group had no decline. The treatment group enjoyed the game as highly as the control group. *Study 5:* The children found the game very appealing. They gained a better understanding of the negative effects of smoking and their anti-smoking attitudes were intensified.
HE/Disease awareness, prevention and management Author(s): Beale et al. (2007) *Title:* Re-Mission *Objective:* Cancer awareness *Type:* Video game	Quantitative evaluation of the impact of the game on cancer-related knowledge.	375 adolescent and young adult cancer patients in USA, Canada and Australia, aged 13 to 29 years, both male and female.	Participants received either: (a) a commercial video game with no cancer content (n=179) or (b) both the commercial game and Re-Mission (n=196). Both groups played for an hour weekly for 3 months. Cancer knowledge was assessed before, one month after and 3 months after the beginning of the interventions through self-report questionnaires.	The scores of both groups improved significantly over the 3 months, with a significantly larger increase in the scores of the Re-Mission group.
HE/Nutrition education Author(s): Turnin et al. (2001) *Title:* Alimentary my dear Joe *Objective:* Food pyramid knowledge, balanced meals intake *Type:* Computer game	Quantitative evaluation of the impact of the game on dietary knowledge and behaviour.	1876 primary school students in France, aged 7 to 12 years, both boys and girls, 76% normal weight, 13% overweight, 11% obese.	Participants were randomly assigned to either: (a) the experimental group (n=1003) that accessed the game and received teacher-led nutritional instruction, or (b) the control group (n=873) that only received teacher-led nutritional instruction. Duration of the interventions was 5 weeks (2 hours weekly) for both groups. After the interventions, dietary knowledge, habits and intake were assessed through self-report questionnaires and diet records.	The experimental group exhibited significantly better dietary knowledge, dietary intake and eating habits compared to the control group.

HE/Nutrition education Author(s): Cullen et al. (2005) *Title:* Squire's Quest! *Objective:* Fruit, Juice, Vegetable (FJV) intake *Type:* Computer game	Quantitative evaluation of the impact of the game on dietary behaviour.	1578 primary school students in Houston, USA, aged 8 to 12 years, both boys and girls.	Participants were randomly assigned to either: (a) the experimental group (n=785) that used the game, or (b) the control group (n=793) that did not receive any program. Duration of the intervention was 5 weeks. Dietary intake was assessed before and after the intervention through self-report diet records.	The students of the experimental group consumed 1.0 FJV servings more per day compared to the students of the control group.
HE/Nutrition education Author(s): Munguba et al. (2008) *Title:* Not supplied *Objective:* Food pyramid knowledge *Type:* Video game	Quantitative and qualitative comparative evaluation of the impact of two games (video game, board game), both concerning the food pyramid, on learning, metacognition and intrinsic motivation.	200 children in one primary school in Brazil, aged 8 to 10 years, both boys and girls.	Each student took part in the games, which were used separately and then combined, at weekly 30-minute sessions over a 4-month period. Learning, metacognition and motivation were studied before, during and after playing the games through interviews, observations and focus groups.	Both games were efficient in promoting the learning of nutritional concepts. Metacognitive strategies were significantly more prevalent in the board game, although participants were significantly more attentive while playing the video game. No significant differences were found in motivation.
HE/Nutrition education Author(s): Silk et al. (2008) *Title:* The Fantastic Food Challenge *Objective:* Food pyramid knowledge, food choice awareness *Type:* Computer game	Quantitative comparative evaluation of three modalities for the delivery of nutrition education (computer game, website, pamphlet) -comprising identical content- as to likeability and knowledge acquisition.	155 mothers in Michigan, USA, aged 18 to 50 years.	Participants were randomly assigned to one of three conditions: (a) computer game, (b) website, or (c) pamphlet. They spent 20-30 minutes in the assigned condition. Likeability was assessed immediately after the interventions, whereas nutrition knowledge was assessed before, immediately after and 2 weeks after, through questionnaires.	The website was liked significantly more than the other conditions. The website group achieved significantly higher nutrition knowledge scores than the game group. No differences in knowledge retention were noted between posttest and follow-up.
HE/First-aid Education Author(s): Tuzun (2007)	Qualitative investigation of the core issues and challenges regarding the introduction of video games in schools.	22 secondary education students in Turkey (9th grade), both boys and girls.	Participants used the game within an obligatory course taught 2 hours weekly. The research instruments used were observations, field notes, students' and	The game design process was challenging and time-consuming. Powerful computers and networks are needed for running the games.

(*continued on next page*)

Table 1 (*continued*)

Subcategory and Author(s) of the Article, Identity of the Game	Aim	Sample	Research Design	Major Findings
Title: Not supplied *Objective:* First-aid knowledge *Type:* Video game			teachers' interviews, and students' online discourse archives.	Students actively engaged in information searching, inquiry, decision making and problem-solving. Students enjoyed learning.
PE/Injury awareness during sporting activities Author(s): Ciavarro et al. (2005) *Title:* Heads Up Hockey *Objective:* Concussion symptoms awareness *Type:* Video game	Quantitative evaluation of the impact of two versions of the game on knowledge about concussion symptoms.	39 male hockey players in Canada, aged 11 to 13 years.	Participants were assigned to either: (a) the experimental group (n=18) that played a version of the game with cutscenes, or (b) the control group (n=21) that played a version of the game without cutscenes. Duration of both play sessions was 25 minutes. After the sessions, concussion knowledge was assessed through self-report questionnaires.	The experimental group scored significantly higher than the control group in the knowledge test.
PE/Injury awareness during sporting activities Author(s): Goodman et al. (2006) *Title:* Symptom Shock *Objective:* Concussion symptoms awareness *Type:* Video game	Quantitative evaluation of the impact of two versions of the game on knowledge about concussion symptoms.	130 male hockey players in Canada, aged 11 to 17 years.	Participants were assigned to either: (a) the experimental group that played a version of the game with icons of symptoms and non-symptoms, or (b) the control group that played a version of the game with icons of animals or faces. Duration of both play sessions was 6 minutes. After the sessions, concussion knowledge was assessed through self-report questionnaires.	The experimental group scored significantly higher in the knowledge test than the control group.
PE/Acquisition of motor skills Author(s): Fery & Ponserre (2001) *Title:* Not supplied *Objective:* Golf skill acquisition *Type:* Video game	Quantitative evaluation of the impact of two different methods of force control in putting within the video game (analogue, symbolic) and two different intentions of use of the video game (learning, entertainment) on performance of the	50 male university students with no prior golf experience in France (mean age: 19.7 years).	Ten of the participants were assigned to a control group that received no instruction. The rest were assigned to 4 ten-person experimental groups: (a) analogue-learning, (b) analogue-entertainment, (c) symbolic-learning, and (d) symbolic-entertainment. Those 4 groups used the game for 10 days. Before and after the interventions, all	Both symbolic groups significantly outperformed the control group. The learning group significantly outperformed the enjoyment group only when it used the symbolic method.

	putting skill in real-world golf.		participants were asked to hole 10 putts on an actual green.	
PE/Improvement of fitness Author(s): Tan et al. (2002) *Title:* DDR (arcade version) *Objective:* Aerobic fitness, weight management *Type:* Video game	Quantitative evaluation of the intensity, energy cost and safety of playing DDR in relation to the ACSM (American College of Sports Medicine) guidelines on the quantity and quality of exercise for developing and maintaining cardiorespiratory fitness.	40 college students with good fitness levels in Singapore (mean age: 17.5 years), both males and females.	Participants had their heart rate and oxygen consumption measured, first, during maximal treadmill exercise and, then, during a one-week period of DDR use at a self-selected level of difficulty within the DDR 'medium mode'. They were monitored for injuries during and after the use.	The dance intensity just met the minimum ACSM recommendations. No injuries were noted.
PE/Improvement of fitness Author(s): Unnithan et al. (2006) *Title:* DDR (game console version) *Objective:* Aerobic fitness, weight management *Type:* Video game	Quantitative evaluation of the effects of playing DDR on energy cost, energy expenditure and cardiorespiratory fitness in relation to the ACSM recommendations for developing and maintaining cardiorespiratory fitness.	22 children and adolescents, aged 11 to 17 years, both boys and girls, 10 over-weight and 12 non-overweight.	Cardiorespiratory measurements were taken, first, during a maximal treadmill walking test and, then, during 12 minutes of DDR use at the least difficult level of the 'workout mode'.	While playing DDR, overweight participants had a higher energy expenditure compared to non-overweight ones. For both groups, heart rate (HR) intensity met the minimum ACSM recommendations, whereas maximal oxygen uptake (VO2max) did not meet the recommendations.
PE/Improvement of fitness Author(s): Sell et al. (2007) *Title:* DDR (game console version) *Objective:* Caloric expenditure, motivation for physical activity *Type:* Video game	Quantitative evaluation of the effects of playing DDR on energy expenditure in relation to the ACSM recommendations for daily physical activity and energy expenditure.	19 healthy male college students, in Utah, USA (mean age: 21.8 years), 12 experienced and 7 inexperienced DDR players.	Participants completed, first, a maximal graded treadmill test and, then, a 30-minute DDR session. Researchers recorded heart rate (HR), rating of perceived exertion (RPE), respiratory exchange rate (RER), oxygen consumption (VO2), total steps (TS30), and overall enjoyment.	Participants experienced in DDR exhibited significantly higher HR, RPE, RER, VO2, TS30, total and relative energy expenditure and exercise intensity compared to inexperienced ones. They also expressed a significantly greater level of enjoyment. All participants exceeded or came close to the ACSM minimum recommendations, and preferred playing DDR over treadmill walking.
PE/Improvement of fitness	Quantitative evaluation of two modes of a dance	27 primary school students with low fitness	Participants were randomly assigned to either: (a) a home group (n=14) that	11 children dropped out mainly because of technical difficulties or boredom.

(*continued on next page*)

Table 1 (*continued*)

Subcategory and Author(s) of the Article, Identity of the Game	Aim	Sample	Research Design	Major Findings
Author(s): Chin et al. (2008) *Title:* Not supplied *Objective:* Motivation for physical activity *Type:* Video game	simulation video game (single-player, single-player plus multi-player) as to motivation to play the game (assessed by daily play duration and dropout during the study).	levels in the Netherlands, aged 9 to 12 years, both boys and girls.	played the video game at home, and (b) a multi-player group (n = 13) that played the game at home and participated in a weekly one-hour multi-player class. Participants logged the daily home playing time on a calendar for 12 weeks. Physiological measurements and assessment of children's physical activity were performed 6 and 12 weeks after the beginning of the interventions. After the 12 weeks, focus groups were conducted on children's experiences with the game.	Dropout was significantly lower in the multi-player group than in the home group. During the 12 weeks, the multi-player group played approximately twice as long as the home group.
PE/Educators' knowledge and attitudes regarding electronic games Author(s): Russell (2007) No actual usage of any game	Quantitative assessment of PE educators' knowledge, skills, attitudes and anticipated usage of video games within the PE curriculum.	36 PE educators from primary and secondary schools in Missouri, USA (mean age: 36.6 years), both males and females.	For each of 9 state-of-the-art video games with exertion interfaces, teachers were asked to rate their knowledge, experience, comfort and anticipated usage of the game through self-report questionnaires.	Teachers had very little knowledge of, experience, and comfort with the specific video games, and, thus, little anticipated usage of them. Younger teachers and those with more favourable attitudes towards educational technology had more positive attitudes towards the games.

References

Bailey, R. (2001). *Teaching physical education: A handbook for primary & secondary school teachers*. London: Kogan Page.
Bale, J. (1994). *Landscapes of modern sport*. Leicester, UK: Leicester University Press.
Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.
Baranowski, T., Baranowski, J., Cullen, K., Marsh, T., Islam, N., Zakeri, I., et al. (2003). Squire's Quest! Dietary outcome evaluation of a multimedia game. *American Journal of Preventive Medicine, 24*(1), 52–61.
Bartholomew, L., Gold, R., Parcel, G., Czyzewski, D., Sockrider, M., Fernandez, M., et al. (2000). Watch, discover, think, and act: Evaluation of computer-assisted instruction to improve asthma self-management in inner-city children. *Patient Education and Counseling, 39*(2/3), 269–280.
Baxter, D., Seagram, R., & Amory, A. (2006). The γKhozi game environment: Demonstrations of two edventures. In E. Pearson & P. Bohman (Eds.), *Proceedings of world conference on educational multimedia, hypermedia and telecommunications 2006* (pp. 2513–2516). Chesapeake, VA: AACE.
Beale, I., Kato, P., Marin-Bowling, V., Guthrie, N., & Cole, S. (2007). Improvement in cancer-related knowledge following use of a psychoeducational video game for adolescents and young adults with cancer. *Journal of Adolescent Health, 41*, 263–270.
Beale, I., Marin-Bowling, V., Guthrie, N., & Kato, P. (2006). Young cancer patients' perceptions of a video game used to promote self-care. *International Electronic Journal of Health Education, 9*, 202–212.
Biddle, S., Gorely, T., Marshall, S., Murdey, I., & Cameron, N. (2004). Physical activity and sedentary behaviours in youth: Issues and controversies. *Journal of the Royal Society for the Promotion of Health, 124*(1), 29–33.
Borja, R. (2006). Dance video games hit the floor in schools. *Education Week, 25*(22), 1–14.
Brown, S. (2003). Smoke and mirrors: A virtual reality debunking environment. *Annual Review of Cybertherapy and Telemedicine, 1*, 37–44.
Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42.
Brown, S., Lieberman, D., Gemeny, B., Fan, Y., Wilson, D., & Pasta, D. (1997). Educational video game for juvenile diabetes: Results of a controlled trial. *Medical Informatics, 22*(1), 77–89.
Carvalhal, M., Padez, M., Moreira, P., & Rosado, V. (2007). Overweight and obesity related to activities in Portuguese children, 7–9 years. *European Journal of Public Health, 17*(1), 42–46.
Casazza, K., & Ciccazzo, M. (2006). Improving the dietary patterns of adolescents using a computer-based approach. *Journal of School Health, 76*(2), 43–46.
Chin, M., Paw, A., Jacobs, W., Vaessen, E., Titze, S., & van Mechelen, W. (2008). The motivation of children to play an active video game. *Journal of Science and Medicine in Sport, 11*, 163–166.
Ciavarro, C., Meanley, J., Bizzocchi, J., & Goodman, D. (2005). Embedding educational content between gameplay: An example from a sports action videogame. In P. Kommers & G. Richards (Eds.), *Proceedings of world conference on educational multimedia, hypermedia and telecommunications 2005* (pp. 3825–3828). Chesapeake, VA: AACE.
Cullen, K., Watson, K., Baranowski, T., Baranowski, J., & Zakeri, I. (2005). Squire's Quest: Intervention changes occurred at lunch and snack meals. *Appetite, 45*(2), 148–151.
Dempsey, J., Lucassen, B., Gilley, W., & Rasmussen, K. (1993–1994). Since Malone's theory of intrinsically motivating instruction: What's the score in the gaming literature? *Journal of Educational Technology Systems, 22*(2), 173–183.
Dempsey, J., Rasmussen, K., & Lucassen, B. (1996). *The instructional gaming literature: Implications and 99 sources*. Technical report no. 96-1. University of South Alabama, College of Education.
DerVanik, R. (2005). The use of PDAs to assess in physical education. *Journal of Physical Education, Recreation and Dance, 76*(6), 50–52.
Dorman, S. (1997). Video and computer games: Effect on children and implications for health education. *Journal of School Health, 67*(4), 133–138.
Dowrick, P. (1999). A review of self-modeling and related interventions. *Applied and Preventive Psychology, 8*, 23–39.
Fery, Y., & Ponserre, S. (2001). Enhancing the control of force in putting by video game training. *Ergonomics, 44*(12), 1025–1037.
Fiorentino-Holland, L., & Gibbone, A. (2005). Using the Virtual Gym for practice and drills. *Teaching Elementary Physical Education, 16*(5), 14–16.
Funk, J., & Buchman, D. (1995). Video game controversies. *Pediatric Annals, 24*(2), 91–94.
Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave Macmillian.
Gentile, D., Lynch, P., Linder, J., & Walsh, D. (2004). The effects of violent video game habits on adolescent hostility, aggressive behaviors, and school performance. *Journal of Adolescence, 27*, 5–22.
Goodman, D., Bradley, N., Paras, B., Williamson, I., & Bizzocchi, J. (2006). Video gaming promotes concussion knowledge acquisition in youth hockey players. *Journal of Adolescence, 29*(3), 351–360.
Harper, J., Kaiser, S., Ebrahimi, K., Lamberton, G., Hadley, H., Ruckle, H., et al. (2007). Prior video game exposure does not enhance robotic surgical performance. *Journal of Endourology, 21*(10), 1207–1210.
Hayes, E., & Silberman, L. (2007). Incorporating video games into physical education. *Journal of Physical Education Recreation and Dance, 78*(3), 18–24.
Hays, R. (2005). *The effectiveness of instructional games: A literature review and discussion*. Technical report 2005-004. Orlando, FL: Naval Air Warfare Center, Training Systems Division.
Hemphill, D. (2005). Cybersport. *Journal of the Philosophy of Sport, 32*, 195–207.
Herz, J. (2001). *Gaming the system: What higher education can learn from multiplayer online worlds* (pp. 169–191). EDUCAUSE Publications from the Internet and the University Forum.
Hewitt, M., Denman, S., Hayes, L., Pearson, J., & Wallbanks, C. (2001). Evaluation of 'Sun-safe': A health education resource for primary schools. *Health Education Research, 16*(5), 623–633.
Hornung, R., Lennon, P., Garrett, J., DeVellis, R., Weinberg, P., & Strecher, V. (2000). Interactive computer technology for skin cancer prevention targeting children. *American Journal of Preventive Medicine, 18*(1), 69–76.
Hrastinski, S. (2008). What is online learner participation? A literature review. *Computers and Education, 51*(4), 1755–1765.
Jenson, J., & De Castell, S. (2008). Get up and play! From simulation to imitation in digital games. *Education Canada, 48*(2), 40–44.
Kahn, E., Ramsey, L., Brownson, R., Heath, G., Howze, E., Powell, K., et al. (2002). The effectiveness of interventions to increase physical activity. A systematic review. *American Journal of Preventive Medicine, 22*(4), 73–108.
Kim, M., & Hyungil, K. (2007). *The theory of planned behavior and the intention to play sport video games*. Paper presented at the North American Society for sport management conference (NASSM 2007). Florida, USA, May–June 2007.
Klawe, M. (1999). Computer games, education and interfaces: The E-GEMS project. In *Proceedings of the graphics interface conference* (pp. 36–39). Ontario, Canada.
Lager, A., & Bremberg, S. (2005). *Health effects of video and computer game playing: A systematic review*. Stockholm: Swedish National Institute of Public Health.
Lieberman, D. (1995). *Three studies of an asthma education video game*. Report to the National Institute of Allergy and Infectious Diseases. Bethesda, MD: National Institutes of Health.
Lieberman, D. (1997). Interactive video games for health promotion: Effects on knowledge, self-efficacy, social support, and health. In R. Street, W. Gold, & T. Manning (Eds.), *Health promotion and interactive technology: Theoretical applications and future directions* (pp. 103–120). Mahwah, NJ: Lawrence Erlbaum Associates.
Lieberman, D. (2001). Management of chronic pediatric diseases with interactive health games: Theory and research findings. *Journal of Ambulatory Care Management, 24*(1), 26–38.
Lieberman, D. (2006). *Dance games and other exergames: what the research says*. <http://www.comm.ucsb.edu/faculty/lieberman/exergames.htm> Accessed 12.11.07.
Lockyer, L., Wright, R., Curtis, S., Curtis, O., & Hodgson, A. (2003). Energy Balance. Design and formative evaluation of a health education multimedia game. In D. Lassner & C. McNaught (Eds.), *Proceedings of world conference on educational multimedia, hypermedia and telecommunications 2003* (pp. 2721–2724). Chesapeake, VA: AACE.
Louise, S., Renaud, L., & Kaufman, D. (2008). Cognitive and affective impacts of online game-based learning about STIs: Formative evaluation by experts. In K. McFerrin et al. (Eds.), *Proceedings of society for information technology and teacher education international conference 2008* (pp. 1739–1743). Chesapeake, VA: AACE.
Luepker, R. (1999). How physically active are American children and what can we do about it? *International Journal of Obesity, 23*(Suppl. 2), S12–S17.
Malone, T. (1980). *What makes things fun to learn? A study of intrinsically motivating computer games*. Technical report no. CIS-7 (SSL-80-11). Xerox Palo Alto Research Center.
Marshall, S., Biddle, S., Gorely, T., Cameron, N., & Murdey, I. (2004). Relationships between media use, body fatness and physical activity among children and youth: A meta-analysis. *International Journal of Obesity, 28*(10), 1238–1246.
Mohnsen, B. (2005). Dance dance revolution: The next big technology device. *Teaching Elementary Physical Education, 16*(2), 36–39.
Mumtaz, S. (2001). Children's enjoyment and perception of computer use in the home and the school. *Computers and Education, 36*(4), 347–362.
Munguba, M., Valdes, M., & da Silva, C. (2008). The application of an occupational therapy nutrition education programme for children who are obese. *Occupational Therapy International, 15*(1), 56–70.
Neuhauser, L., & Kreps, G. (2003). Rethinking communication in the e-health era. *Journal of Health Psychology, 8*(1), 7–23.

Nippold, M., Duthie, J., & Larson, J. (2005). Literacy as a leisure activity: Free-time preferences of older children and young adolescents. *Language, Speech and Hearing Services in Schools, 36*(2), 93–102.
Oblinger, D. (2004). The next generation of educational engagement. *Journal of Interactive Media in Education, 2004*(8), 1–18.
O'Hanlon, C. (2007). Gaming: Eat breakfast, drink milk, play Xbox. *The Journal, 34*(4), 34–39.
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.
Paperny, D., & Starn, J. (1989). Adolescent pregnancy prevention by health education computer games: Computer-assisted instruction of knowledge and attitudes. *Pediatrics, 83*(5), 742–752.
Parizkova, J., & Chin, M. (2003). Obesity prevention and health promotion during early periods of growth and development. *Journal of Exercise Science and Fitness, 1*(1), 1–14.
Partridge, A., Blair, E., & Leidman, M. (2007). Promoting physical activity within the elementary school curriculum through simulations and games. In C. Crawford et al. (Eds.), *Proceedings of society for information technology and teacher education international conference 2007* (pp. 1230–1235). Chesapeake, VA: AACE.
Pollock, M., Gaesser, G., Butcher, J., Després, J., Dishman, R., Franklin, B., et al. (1998). ACSM position stand: The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Medicine and Science in Sports and Exercise, 30*, 975–991.
Prensky, M. (2001). *Digital game-based learning*. New York: McGraw-Hill.
Riviere, D. (2004). Metabolic functions and sport. *Bulletin de l'Académie Nationale de Medicine, 188*(6), 913–922.
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 and Education, 40*(1), 71–94.
Rubin, D., Leventhal, J., Sadock, R., Letovsky, E., Schottland, P., Clemente, I., et al. (1986). Educational intervention by computer in childhood asthma: A randomized clinical trial testing the use of a new teaching intervention in childhood asthma. *Pediatrics, 77*(1), 1–10.
Russell, W. (2007). Physical educators' perceptions and attitudes toward interactive video game technology within the physical education curriculum. *Missouri Journal of Health Physical Education Recreation and Dance, 17*, 76–89.
Schott, G., & Hodgetts, D. (2006). Health and digital gaming: The benefits of a community of practice. *Journal of Health Psychology, 11*(2), 309–316.
Sell, K., Lillie, T., & Taylor, J. (2007). Energy expenditure during physically interactive video game playing in male college students with different playing experience. *Journal of American College Health, 56*(5), 505–511.
Shewokis, P., Krane, V., Snow, J., & Greenleaf, C. (2001). Does trait cognitive anxiety influence the learning of perceptual-motor skills in a contextual interference paradigm? *Journal of Human Movement Studies, 41*(3), 225–245.
Shingo, N., & Takeo, M. (2002). The educational experiments of school health promotion for the youth in Japan: Analysis of the 'sport test' over the past 34 years. *Health Promotion International, 17*(2), 147–160.
Shrimpton, B., & Hurworth, R. (2005). Adventures in evaluation: Reviewing a CD-ROM adventure game designed for young people with psychosis. *Journal of Education Multimedia and Hypermedia, 14*(3), 273–290.
Silk, K., Sherry, J., Winn, B., Keesecker, N., Horodynski, M., & Sayir, A. (2008). Increasing nutrition literacy: Testing the effectiveness of print, website, and game modalities. *Journal of Nutrition Education and Behavior, 40*(1), 3–10.
Sothern, M. (2004). Obesity prevention in children: Physical activity and nutrition. *Nutrition, 20*(7–8), 704–708.
Stidder, G. (2004). The use of information and communication technology in physical education. In S. Capel (Ed.), *Learning to teach physical education in the secondary school: A companion to school experience* (pp. 219–238). London: Routledge.
Streisand, B. (2006). Not just child's play. *US News and World Reports, 141*(6), 48–50.
Tan, B., Aziz, A., Chua, K., & Teh, K. (2002). Aerobic demands of the dance simulation game. *International Journal of Sports Medicine, 23*, 125–129.
Telama, R., Nupponen, H., & Piéron, M. (2005). Physical activity among young people in the context of lifestyle. *European Physical Education Review, 11*(2), 115–137.
Timpka, T., Graspemo, G., Hassling, L., Nordfeldt, S., & Eriksson, H. (2004). Towards integration of computer games in interactive health education environments: Understanding gameplay challenge, narrative and spectacle. *Studies in Health Technology and Informatics, 107*(2), 941–945.
Tingen, M., Grimling, L., Bennett, G., Gibson, E., & Renew, M. (1997). A pilot study of preadolescents to evaluate a video game-based smoking prevention strategy. *Journal of Addictions Nursing, 9*(3), 118–124.
Trout, J., & Christie, B. (2007). Interactive video games in physical education. *Journal of Physical Education Recreation and Dance, 78*(5), 29–45.
Trout, J., & Zamora, K. (2005). Using Dance Dance revolution in physical education. *Teaching Elementary Physical Education, 16*(5), 22–25.
Turnin, M., Tauber, M., Couvaras, O., Jouret, B., Bolzonella, C., Bourgeois, O., et al. (2001). Evaluation of microcomputer nutritional teaching games in 1876 children at school. *Diabetes and Metabolism, 27*, 459–464.
Tuzun, H. (2007). Blending video games with learning: Issues and challenges with classroom implementations in the Turkish context. *British Journal of Educational Technology, 38*(3), 465–477.
Unnithan, V., Houser, W., & Fernhall, B. (2006). Evaluation of the energy cost of playing a dance simulation video game in overweight and non-overweight children and adolescents. *International Journal of Sports Medicine, 27*, 804–809.
Vandewater, E., Shim, M., & Caplovitz, A. (2004). Linking obesity and activity level with children's television and video game use. *Journal of Adolescence, 27*(1), 71–85.
Virvou, M., Katsionis, G., & Manos, K. (2005). Combining software games with education: Evaluation of its educational effectiveness. *Educational Technology and Society, 8*(2), 54–65.
Wang, C., Chia, M., Quek, J., & Liu, W. (2006). Patterns of physical activity, sedentary behaviours and psychological determinants of physical activity among Singaporean school children. *International Journal of Sport and Exercise Psychology, 4*(3), 227–249.
Wang, X., & Perry, A. (2006). Metabolic and physiologic responses to video game play in 7- to 10-year-old boys. *Archives of Pediatrics and Adolescent Medicine, 160*(4), 411–415.
Wilson, N. (2004). Impact of lifestyle choices of New Zealand children. *Journal of Science and Medicine in Sport, 7*(4), 87.
Yawn, B., Algatt-Bergstrom, P., Yawn, R., Wollan, P., Greco, M., Gleason, M., et al. (2000). An in-school CD-ROM asthma education program. *Journal of School Health, 70*(4), 153–159.
Ziegler, S. (2007). The (Mis)education of generation M. Learning. *Media and Technology, 32*(1), 69–81.