A methodological framework for the cognitive-behavioural evaluation of educational e-games

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ABSTRACT

The proposed methodological framework reviews and uses knowledge from the field of cognitive psychology in order to evaluate aspects of educational games. In particular, we concentrate on two components of human cognition that play a central role to learning, namely memory and motivation. After having reviewed theories in the field, we created a questionnaire in order to evaluate educational games. The questionnaire incorporates different experimental findings of cognitive psychology. Especially, we have applied Maslow's motivation theory, Behavioural findings on reinforcement, experimental findings about attention and memory. We present the results obtained from the evaluation of two games, PAC-MAN and Mega Jump. The results confirmed the user ratings of the two games, showing that there seem to be cognitive reasons for the success/failure of different games. Finally, lists of guidelines for developers and instructors are included.

INTRODUCTION

Dealing with issues of educational games and technological applications, the present chapter wishes to provide a methodological framework for the design and evaluation of such applications. The methodology is based on findings from cognitive psychology regarding human memory and motivation. Firstly, definitions and classifications of games are presented, following by an introduction to the concept of edutainment. Then we review a series of relevant theories from cognitive psychology, like cognitive theories of memory and their relevance to games, cognitive and behavioural theories of motivation and the theoretical relation between motivation and memory. Continuing, we examine different evaluation methods used for technological applications and present a new methodology, which uses simple questionnaires for the evaluation process. The questionnaires have been used in two case studies which are briefly presented. Furthermore, the objectives of the following work are: (1) to provide a theoretical methodological framework for the evaluation of digital educational games, (2) to provide an interdisciplinary approach that connects computer technology and cognitive psychology, (3) to offer guidelines for the design and evaluation of such applications, and (4) to recommend a basis for the further expansion of the cognitive evaluation of technological applications.

Background

Is play older than culture? Did humans evolve from Homo Sapiens (*Man the Wise*), to Homo Faber (*Man the Maker*), and to Homo Ludens (*Man the Player*)? Whether one decides to agree or disagree with Johan Huizinga (1955) the immense value of play and games in human societies remains. The attracting and motivating powers of games are nowadays well recognised and different educational systems and educational applications seem to use play and games for their purposes. The terms *Game-Based Learning* and *Digital Game-Based Learning* are well established and used, showing this trend in modern pedagogy and educational technology to incorporate gaming elements and principles (Prensky, 2003).

Definition and Classification of Games

Defining games is not an easy task. Huizinga (1955) described a game as a voluntary activity, specific to time and space with well defined rules that make the participants feel joy and that they do something different. According to Kramer (2000), games have clear components and rules and can provide a common experience, a sense of equality and freedom, while they can also be very engaging and active. From the different available definitions, certain characteristics seem important, like the voluntary nature of games or that they can provide an escape from routine and everyday life. Games are also governed by rules and abstract concepts, since they could also take the form of different representations. Games have an affective aspect as well, since the participants can experience a number of different emotions. Games can provide an opportunity for socialisation and the creation of communities of players (Huizinga, 1955).

In addition, digital games have a number of key features. According to Prensky (2001) games can have different characteristics, such as the existence of rules and goals; they can be interactive, adaptive, and informative; they can allow and facilitate the communication and the creativity of the players; they can also enhance feelings of self fulfillment and achievement, etc.

There are many different ways to categorise games. According to Prensky (2005) there are mini and complex games (based on their complexity). Games could be also classified based on their themes (action games, labyrinth games, strategy games, role games, simulation games, etc.) (Kekes, 2002) or on the technology they use (i.e. local network games, online games, etc.).

Educational games

Another possible categorisation of games is between educational and non-educational ones. When gaming and learning principles are combined, a new field in games is created, known as *serious* or *educational games*. According to Prensky (2001), an educational game designed for learning is a subset of gaming and entertainment. It is a fusion of the principles of learning, education and computer games. In the same way, serious games use the game as an ingredient in order to provide learning and training through a pleasant experience (Blackman, 2005). In line with the pedagogic principles of constructivism and constructionism, in which the learners are actively seeking and constructing meaning, educational games appear appropriate for education (Lepper and Cordova, 2005). Using modern technology in educational games seems a necessity, since the majority of students in western societies use technology and different applications for various aspects in their lives (e.g. socialisation, entertainment, formal and informal learning, etc.). In addition, computer and video games are also highly engaging, they allow for the effective management and renewal of content, while players are expected to process information and take decisions efficiently (Prensky, 2003).

Edutainment

The trend in learning to combine educational and gaming elements is known as *Edutainment*. Different learning institutions, like museums, use Edutainment in order to increase learner participation, motivation and enhance the learning experience (Lepouras and Vassilakis, 2005). Edutainment could be also approached as an attempt to incorporate entertainment and games in a life long learning process (Antoniou and Lepouras, 2008).

COGNITION (GAMES, MEMORY, MOTIVATION)

From the field of cognitive psychology we can draw important information about the brain. Therefore, we can design games to facilitate human perception, information processing, information storage, retrieval, etc. We have concentrated on two fields of cognitive psychology particularly relevant to learning, namely motivation and memory, which we view as a starting point in the endeavour to create a generic methodology for the cognitive-behavioural evaluation of digital educational games. Learning is directly dependent on all aspects of memory for the efficient processing of information. Similarly, motivation is also a key to effective learning. There are two types of motivation: intrinsic and extrinsic. Motivation that occurs as a natural consequence of the learning process is known as intrinsic. Motivation that occurs due to external influences like assessment and deadlines in known as extrinsic. Intrinsic motivation usually triggers efficient learning (Elton, 1996). Well-designed educational games can activate intrinsic motivation processes and can be very beneficial for learning (Cordova and Lepper, 1996; Denis and Jouvelot, 2005; Garris, Ahlers, and Driskell, 2002). Intrinsically motivated learners can also adopt a deep approach to learning. Approaches to learning seem to be different from time to time and from course to course. An individual could have a deep or a surface approach to the learning situation. Students with a deep approach to learning look for meaning, critically examine evidence, relate new and old information, and show an active interest. Students with a surface approach to learning rely on teacher information, focus on the defined syllabus, show lack of confidence, do not easily connect old and new information or look for meaning (Biggs, 1987).

In the following section, a short introduction to some influential cognitive theories of human memory and motivation will be presented, as well as their relation to each other and games.

Memory

According to Atkinson et al. (1993), there are three main stages in human memory: coding, storage and retrieval. During coding, information is transformed into an acceptable form for the human memory and is then stored for future reference. When needed, information is retrieved from memory storage. However, in order to code and store information, attention is required. From the immense number of environmental stimuli available, humans only focus on some, which will be coded and stored, if necessary. Considering educational games in this light, it is important that the games have attention attracting powers. For example, rotating objects, illuminated objects, etc. can attract players' attention. Although, objects that stick out from their environment can easily attract attention, when this is not done carefully, could have a negative effect and lead to users' cognitive overload (Mayer and Moreno, 2003).

Continuing, once attention is captured, the relevant information needs to be coded. Humans use different coding techniques in order to increase memory efficiency and they tend to group information based on different criteria. Coding could be phonetic (e.g. reading out loud the numbers we wish to store), semantic (e.g. try to find relations between objects), or visual (e.g. connecting words to their images). For example, when presented with the following letters 'H E L L O T H E R E', most people would not code these letters individually, but they would rather *see* them as two words HELLO THERE. Thus instead of storing 10 units of information, they would only store 2.

Effective coding techniques, like grouping that was above presented, help humans to solve the problem of limited memory capacity (especially, in some memory systems, like short term and working memory) (Baddeley, 1986). The famous magic number 7±2 (Miller, 1956) described the capacity limitation of human processing systems and explains that humans can effectively deal with no more than 7±2 units of information at a time. Adequate information processing time given to the individual can lead to increased chances for repetition and practice, which can in turn lead to increased chances for successful memory storing. Apart from the possibilities for repetition and practice of information, if information is provided in a particular context, then memory mechanisms can become more efficient. It is also known that properly organised information in meaningful categories is another factor that could lead to efficient storage in memory.

Talking about efficient and effective memory storage implies that information can be accessed in the future when needed. However, retrieval of previously stored information is not always achieved. Most researchers agree that human oblivion is due to two main reasons. The first is that some memory data weaken over time and finally disappear. The second is that old information is replaced by new. Although it is difficult to know whether forgetting is due to storage problems or retrieval problems, we do know that retrieval chances increase when information was coded successfully. A retrieval failure could be due to interferences. Sometimes, usually similar units of information can interfere with the retrieval processes and not allow the individual to access specific units (Baddeley, 1997).

Motivation

Studying human motivation, it is necessary to briefly mention the important motivation theory of Maslow (1954). In his theory, Maslow suggests a hierarchy of needs (Figure 1). When low order needs are satisfied (physiological needs), humans try to satisfy higher order needs (like the need for artistic achievement). Humans are only motivated to strive for higher order needs only after lower order needs are satisfied first. These needs move progressively from physiological needs (i.e. food, water), to safety needs (i.e. comfort, security, freedom from fear), to needs for belongingness and love (i.e. affiliation, acceptance), to needs for esteem (i.e. competence, approval, recognition), to cognitive needs (i.e. knowledge, understanding, novelty), to aesthetic needs (i.e. symmetry, order, beauty), to needs for self-actualisation. The Maslow hierarchy of needs can be used to explain the needs of a player in order to understand how she becomes motivated in a game environment (Siang and Rao, 2003).

Furthermore, behavioural motivation theories are also very influential and should be introduced. Behavioural theories deal with the prediction of behaviour and in this case through a series of reinforcements, players could become more or less motivated to participate in a game. In particular, reinforcement could be positive (reward), negative (avoidance of unpleasant stimuli), extinction (non-reward) and punishment (Skinner, 1969). In addition, there are 5 types of simple schedules that determine the frequency and the predictability of the reinforcement techniques. Schedules are protocols that decide when a behaviour will be reinforced. Thus, there are Fixed ratio schedules (reinforcement after a decided number of responses), Continuous ratio schedules (reinforcement after every response), Fixed interval schedules (reinforcement after a decided time), Variable ratio schedules (reinforcement after a random number of responses), and Variable interval schedules (reinforcement after a random length of time). Different schedules have different outcomes. For example, ratio schedules produce higher rates of responses than interval schedules; variable schedules produce higher rates of responses than fixed schedules, etc. (Ferster and Skinner, 1957). There are more schedules used for predicting response rates, like compound and superimposed schedules, however, their presentation is beyond the scope of the present work, mainly due to space restrictions. The role of reinforcements and schedules will be examined in relation to games at a following section.

Finally, motivation and memory are highly positively correlated, since the more motivated we are the more likely we process and store information efficiently (Brooks and Shell, 2006). In this light, motivation could be also defined as the process during which the individual consciously or subconsciously uses her working memory for processing specific information (Pintrich and Schunk, 1996). The direct link between motivation and memory has been also found experimentally (Szatkowska, 2008).

METHODOLOGICAL FRAMEWORK

The proposed methodology provides a framework for the evaluation of educational games. A methodology for the evaluation of such applications should be able to allow the easy assessment of the range of product’s functionality (Can the user effectively do what she intends to do?), of the impact of the interface (Is the product easy to use?), and of the identification of problems (Dix, 2003). For this reason, we have developed a methodology that combines in a novel manner different evaluation methods. In particular, the proposed methodology is a combination and augmentation of inspection methods and analytic models. According to the classification proposed by Ivory and Hearst (2001), there are different methods that can be used for the evaluation of different applications. Table 1 summarises their findings.

In the past there have been research efforts towards the cognitive evaluation of video games. In particular, Gackenbach and Rosie (2009) asked gamers to cognitively evaluate different games, based on the PASS model which examines different aspects of human cognition (**P**lanning, **A**ttention-arousal, **S**imultaneous and **S**uccessive cognitive processing). The results revealed the importance of the cognitive evaluation of games. However, the methodology used was time consuming, both in terms of data collection and in terms of their statistical analysis, since 233 participants evaluated up to three games. Undoubtedly, such an approach will produce important results based on user perceptions; nevertheless, there are certain occasions when time and resources limitations require methodologies that can produce usable results in a more time-effective manner. To this end, the proposed methodology here, only involves expert evaluation of games based on cognitive principles.

Cognitive Walkthroughs (Inspection Method) and Cognitive Task Analysis (Analytic Model) were combined to create a methodology in which experts use and evaluate educational games. Based on cognitive psychology theories, some of which were briefly presented above, a questionnaire was developed in order to summarise key findings and provide easy visualisation of results. The questionnaire is easy to use and can produce quick qualitative results. A quick view of the results can reveal possible areas for improvement.

The questionnaires

A first restricted version of the questionnaires will be presented, as an example of the proposed method. All questions derive from the cognitive and behavioural theories on human motivation and memory, briefly presented previously. From the findings on human memory, the questionnaire includes the following questions:

- Do the game features attract players' attention to desired points?
- Is there sound coding? (sounds relevant to stimuli)
- Is there semantic coding? (for example, a small sword in a button could symbolise the player's available weapons in the game)
- Is there visual coding? (Is the environment organised in a meaningful manner to the players? For example, all weapons should be placed in the same place on the screen).
- Are there up to 7±2 units of information or groups of objects available to the user? (more units could lead to a cognitive overload)
- Is information retrieved through recognition or recollection? (recognition of information is less demanding than recollection)
- What is the volume of data or information that the user handles?
- Are there interferences? (visual or auditory)
- Can the player practice or repeat the needed information or skills?
- Is there help option and non-player characters? To what extend?

From the findings on human motivation, the questionnaire includes the following questions:

- Are there explicit rules?
- Is it safe? or Does the player perceive it as safe?

- Does the game create a sense of belonging to the players?
- Is there a feeling of appreciation?
- Is it easy to understand and does it provide knowledge to the players?
- What are the aesthetics of the game?
- Does it cover player needs for self esteem?
- Are there positive reinforcements? What kind?
- Are there punishments? What kind?
- Are there balanced proportions of reinforcement? (reinforcement schedule)
- Are there balanced intervals between the reinforcements?

CASE STUDIES

The proposed method was tested with two mini, non-educational games, due to their simplicity and ease of use. PAC-MAN (http://www.thepcmanwebsite.com/media/pacman_flash/) and Mega Jump (http://www.ultimatearcade.com/game/mega-jump) were evaluated. We decided to test the methodology with two simple, non-educational games first, trying to examine the basic functionality of the methodology. Further developments with possible improvements of the existing questions and possible additions from more cognitive theories would enhance the methodology and make it appropriate for use with more complicated and educational games. PAC-MAN was introduced in 1980 and was chosen in our evaluation as a classic and very popular game among users. Mega Jump although much more recent game (introduced in 2007) with better graphics quality, was chosen since users have rated it as one of the worst flash games (http://flashgn.com/worstrated.php). Using the questionnaires, evaluation tables were completed for both games, showing that PAC-MAN scored higher in almost all questions compared to Mega Jump. Table 2 summarises the results of the two evaluations. Symbol "+" indicates that the game supports the criterion stated in the question, while symbol "-" indicates lack of support; symbol "±" indicates that both positive and negative aspects were found.

The following examples show different aspects of the two games and how information was organised and presented to the user. Due to space limitations, the extended evaluation process will not be presented. Only specific, indicative examples will be offered here.

In PAC-MAN players have to *eat* the white dots and the fruits available to them, while at the same time avoiding the ghosts. In the question *Are there up to 5 units of objects?,* the answer was positive since players only need to remember and manage 3 to 4 groups of objects (i.e. pacman itself, dots, ghosts, fruits) (Figure 2).

In PAC-Man there are also explicit simple rules that cover the players' needs. Figure 3 shows the sentence with the rules above the game screen. Therefore, the answer to the relevant question in the questionnaire about the existence of clear rules is also positive.

A motivating factor in PAC-MAN is the fact that there is a screen with different players' score ranking. The higher the score the better place the player gets on the score list. Figure 4 demonstrates how the game fulfills the player's need for self esteem.

Despite the few negative features (e.g. poor graphics), PAC-MAN successfully draws attention, uses different types of coding, makes only a few units of information available to the player at a time, avoids memory retrieval tasks, has limited interferences, covers most of Maslow's needs and uses a number of reinforcements. On the other hand, Mega Jump has been rated by users as one of the worst flash games. Using our methodology, it was observed that Mega Jump scores significantly lower than PAC-MAN. The aim of the game is to place a frog on a catapult and make a giant jump, using the right wind indications. In the following examples, it will be explained why Mega Jump scores low on the questionnaire and this could possibly explain the negative user reviews. Although Mega Jump uses coding techniques, avoids cognitive overload of the players, covers their needs for safety and inclusion, and avoids negative reinforcement, a number of problematic areas remain. Playing the game, one quickly realises the sound interferences and the lack of effective motivational strategies. In particular, the game does not cover the basic motivational needs for the existence of clear rules. The first screen of the game provides the game rules to the player (*tips for long jumps*) (Figure 5). However, once the player follows these rules progressively understands that these rules do not always apply. For example, the rules explain that east winds are best for longer jumps. However, we tried a south wind jump and scored 2913.5 but when we tried an east wind jump we only scored 2770.5. Clearly, in this case the rules were not followed, confusing the player. In addition, the game does not change levels and does not provide a bigger challenge to the players; rather the same scene is repeated again and again, meaning that player motivational needs for knowledge and understanding are not covered. Mega Jump also fails to provide effective reinforcements since scores seem to be random and do not follow a logical sequence. Users have pointed that aspect out. One user mentions: "To top it off, the scores seemed close to random because with no obstacles, it's almost impossible to tell what factors lead to your score" (http://flashgn.com/review/97). Finally, the cover for self esteem is not covered either, since the high scores list of the menu does not work, thus not enabling the user to add her score on the list (Figure 6).

FUTURE RESEARCH DIRECTIONS

The methodological framework is by no means completed, since only specific two areas of human cognition have being used. In future works, we plan to incorporate findings from other cognitive fields, like vision, language, etc.

Furthermore, apart from using research findings from cognitive psychology, an analysis of user cognitive schemas (e.g. prior knowledge and knowledge representations) needs to be considered before the design of an educational game (Lindley and Sennersten, 2008). For example, while designing an educational game for preschool students, one needs to discover what the potential users already know and the ways they have organised specific information. Future research could include the study of students' cognitive schemas in regards to specific topics and provide guidelines for the development of educational games of different levels.

CONCLUSION

Although questionnaires were used here, the technique remains qualitative, providing indications of positive, negative and or neutral characteristics of the games, rather than giving a final mark of the games. In this light, the questionnaires summarise the key characteristics of the games and assist the evaluation process. The tables provide a structured environment for the visualisation of results, thus assisting the reviewer and targeting basic key points that should not miss attention. In addition, tables are easy to use and self-explanatory to understand. Their use is flexible and it can cover a vast spectrum of different games, from educational, to mini or complex, etc. The questions used are based on widely known theories of human cognition. The proposed methodology is also easy to use and can assist game evaluators in targeting different game elements. The two case studies described here, show that our findings agree with users' ratings of the two games, thus validating the methodological approach used, allowing us to conclude that there seem to be cognitive and behavioural reasons for the success/failure of different games. Finally, according to Dix et al. (2003) the evaluation process should be a part of the entire development cycle of products, not simply something done at the end. In this light, the proposed methodology could serve as a development tool (i.e. providing guidelines for developers) as well as a tool for final evaluation.

Guidelines for developers

The different theories reviewed previously for the development of the methodology and its questions, can be also used for the formation of a set of guidelines for educational game developers. Following the guidelines could lead to a cognitive improvement of the game and possibly increase game success rates, either in terms of learning efficiency or in terms of user satisfaction.

According to Miller's findings on human processing capacity, players should not be given more than 7 ± 2 units of information to manage at a time. A unit could have more than one item, as long as they are properly grouped. For example, the numbers 2010 can be grouped as a date, rather than a series of four random numbers. The date 2010 can be one unit of information. When it is necessary to provide more than 9 units of information, the information should be well organised and the players should be given time for practice and rehearsal.

Having Non Player Characters that can provide help is in general a good idea. The players should be given a help function for tips and advices, if needed.

When a game has memory retrieval demands on the players, it increases cognitive load. However, if memory retrieval is necessary, then recognition of information is easier than recollection. Contextual retrieval is also more effective, since when the context that information was coded and stored is provided, players find it easier to remember the information, when asked.

In order to avoid interferences in educational games, it is important to provide the players with the necessary time for mastering different skills, before introducing new. Careful planning of educational activities means that similar learning goals stand out as much as possible, allowing the learner to realise the differences and similarities.

Contextual learning and prior knowledge can be used to enhance the game's learning efficiency. Often (not always) prior knowledge can help people to understand new situations and new knowledge can help people to understand past situations (Pressley et al., 1992). For these reasons, the skills needed in a game should be introduced in a well-planned sequence talking advantage of users' knowledge levels for the mastering of new skills.

Successful retrieval rates are better for items that were presented either first or last on a list of items (Atkinson et al., 2003; Siang and Rao, 2003). Educational games can benefit from this finding. For example, when dialogues are used in games the most important information should be given to the player either at the beginning of the dialogue or at the end.

In complex games, when higher order thinking and information processing is required, information should be presented bit by bit and different tasks should be also presented in an increasing difficulty fashion. For example, in complex strategy games, players could start with simple tasks close to their starting point and progressively move further.

Game rules should be available to the players from the very beginning and should be clear and easy to understand. As previously described in the evaluation of Mega Jump, when rules are either not clear or not always followed, players feel confused and lose their motivation.

Players should also feel that they can save the results of their achievements (e.g. their scores) and that the game provides a safe environment. Players should also feel that they have good chances of winning the game. An impossible or very difficult goal is demoralising. Similarly, tasks should be challenging to the appropriate level, not too easy or too difficult.

An aesthetically carefully designed environment can attract players' attention and function as a motivating factor. Aesthetic needs include the requirements for good graphics, appropriate non intrusive music and sound effects, etc. However, good graphics and effects are not sufficient on their own for a game's success. On the case studies presented above, PAC-MAN had poorer graphics than Mega Jump; nevertheless, PAC-MAN is among the most popular games whereas Mega Jump is among the worst and unpopular ones.

Educational games could consider the different player needs for self esteem, belongingness and self actualisation. It is important that the players feel they achieve a gradual increase in the knowledge and skills they gain from a game, helping them to raise their self esteem. Educational games should be cautiously designed to avoid the social isolation of their users. Being a part of a playing group can be a very important motivating and learning factor.

Finally, a well-planned scheme of reinforcements could be a good motivating factor in games. It is best when punishments are avoided and desired behaviour is reinforced either by providing rewards (e.g. extra power) or by removing unpleasant elements (i.e. lighting up a previously dark area). Reinforcement schedules should be also carefully planned.

Guidelines for instructors

Games can be effectively used for educational purposes, since they are able to promote critical and high order thinking necessary for learning. Gamers/learners can be expected to analyse and synthesise information and apply knowledge to new domains (Dickey, 2006; Franco and de Deus Lopes, 2009). There are numerous advantages from the use of games in the learning processes (de Aguilera and Mendiz, 2003). For example, games apart from the attention attracting and motivating powers they have, can also provide contextual information. For example, in a game designed to teach history, students can learn the historical events in the historical context (i.e. relevant building architecture, costumes used by the characters, music themes, etc.). Moreover, games can target a wide range of cognitive skills. For instance, TagTiles, a tangible electronic board game for educational purposes, was designed to improve different cognitive abilities such as procedural memory, motor skills, executive functions and spatial skills (Verhaegh, Fontijn, and Hoonhout, 2007). Creativity of participants was also increased when video game technology was used as a part of a new pedagogy (Harris et al., 2009).

Educational games are also very beneficial to people with learning disabilities. Paniagua, Colomo, and Garcia-Crespo (2009) designed a software platform for people with disabilities that included educational games. The promising results indicate the effectiveness of games for this specific user group. In addition, both users and educators were satisfied with the use of the software and users' social and cognitive skills improved. Instructors that teach students with learning disabilities could consider including educational games in their teaching schedule, since carefully designed games are found to significantly help people with disabilities in their learning process.

Games are also very useful for the teaching of financially and socially deprived children. Students overall motivation increased when games were introduced. Improvements in cognitive skills and indications for deep learning (interdisciplinary learning, analysis and synthesis of data, application of knowledge in different domains), as well as improvements in technology literacy skills and social skills were also found (Franco and de Deus Lopes, 2009).

Several educational games have been designed for teaching different topics and they are available to interested instructors. There are games aimed to provide knowledge in a specific domain, like the one developed at Purdue University to teach chemistry (Morales et al., 2006) and there are games that aim to improve certain cognitive abilities, like preschoolers' psychomotor skills (Marco et al., 2009). Instructors can consider these applications as a tool for the enhancement of the teaching methods and the learning experience. However, in this process, it is important to remember that games require effective instructional strategies in order to be successful. When games have been employed without further consideration of the instructional framework they did not have the expected learning outcomes (Adcock et al., 2008). Thus, games can be valuable learning tools if designed and used in a way that respects user cognitive and learning needs, as a part of a well planned pedagogical approach.

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Figures and Tables

Figure 1. Hierarchy of Needs (Maslow, 1954)

Inspection Methods	Testing Methods	Research Methods	Analytic Models	Simulation Methods
Cognitive Walkthroughs	Coaching	Field Observation	Model Based Evaluation, GOMS analysis	Information Processing Modeling
Feature Inspection	Co-discovery	Focus Groups	UIDE Analysis	Petri Net Modeling
Heuristic Evaluation	Performance Measurement	Interviews	Cognitive Task Analysis	Genetic Algorithm Modeling
Pluralistic Walkthrough	Question asking Protocol	Logging Actual Use	Task-Environmental Analysis	Information Scent Modeling
Perspective-based Inspection	Remote Testing	Proactive Field Study	Knowledge Analysis	
Guideline Review	Retrospective Testing	Questionnaires	Design Analysis	
Formal Usability Inspection	Shadowing	Meta-evaluations	Programmable User Models	
Consistency Inspection	Teaching	Contextual Inquiry		
Standards Inspection	Thinking Aloud Protocol	Surveys		
Screen Snapshots	Log File Analysis			
User Feedback				

Table 1. Classification of Evaluation Methods (Ivory and Hearst, 2001)

Evaluation Table			
	Questions	Pac-Man	Mega Jump
Memory	**Attention** – Does the game draw attention?	+	±
	Coding – Is there sound coding?	+	±
	Coding – Is there semantic coding?	+	+
	Coding – Is there visual coding?	±	-
	Capacity – Are there up to 5 units of objects?	+	+
	Retrieval – Is recollection or recognition processes avoided?	+	±
	Forgetting – What is the volume of the data?	+	+
	Forgetting – Are there minimum or no interferences?	+	-
	Repetition – Is there a possibility for repetitions and rehearsal of data?	-	±
	Help – Is there available help to the players and to what extent?	-	-
Motivation	**Maslow's Theory** – Are there clear rules?	+	-
	Maslow's Theory – Does the player feel safe?	+	+
	Maslow's Theory – Is there a feeling of inclusion?	+	+
	Maslow's Theory – Is there a feeling of appreciation?	+	-
	Maslow's Theory – Does the player feel she is learning and understanding?	+	-
	Maslow's Theory – Does it cover the player's aesthetic needs?	-	±
	Maslow's Theory – Does it cover the player's needs for self esteem?	+	-
	Behaviorism – Is there positive reinforcement and what kind?	+	-
	Behaviorism – Is negative reinforcement avoided?	+	+
	Behaviorism – Are there balanced proportions of reinforcement?	+	-
	Behaviorism – Are there balanced intervals between the reinforcements?	+	-

Table 2. Evaluation Table for the Case Studies

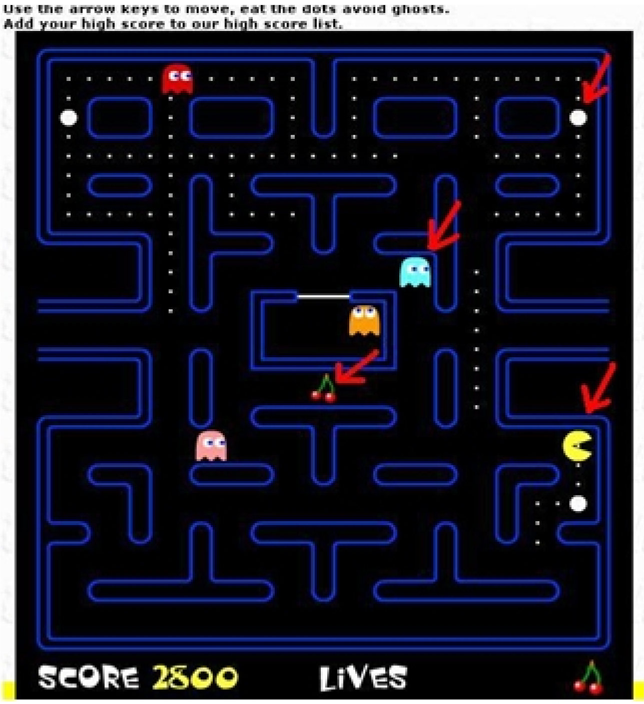

Figure 2. PAC-MAN- units of information

Figure 3. PAC-MAN- clear rules

Figure 4. PAC-MAN-high score list

Figure 5. Mega Jump – rules

Figure 6. Mega Jump – Inactive High Scores List