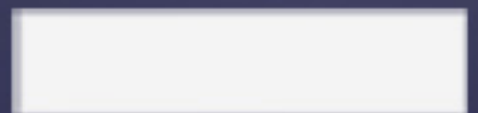
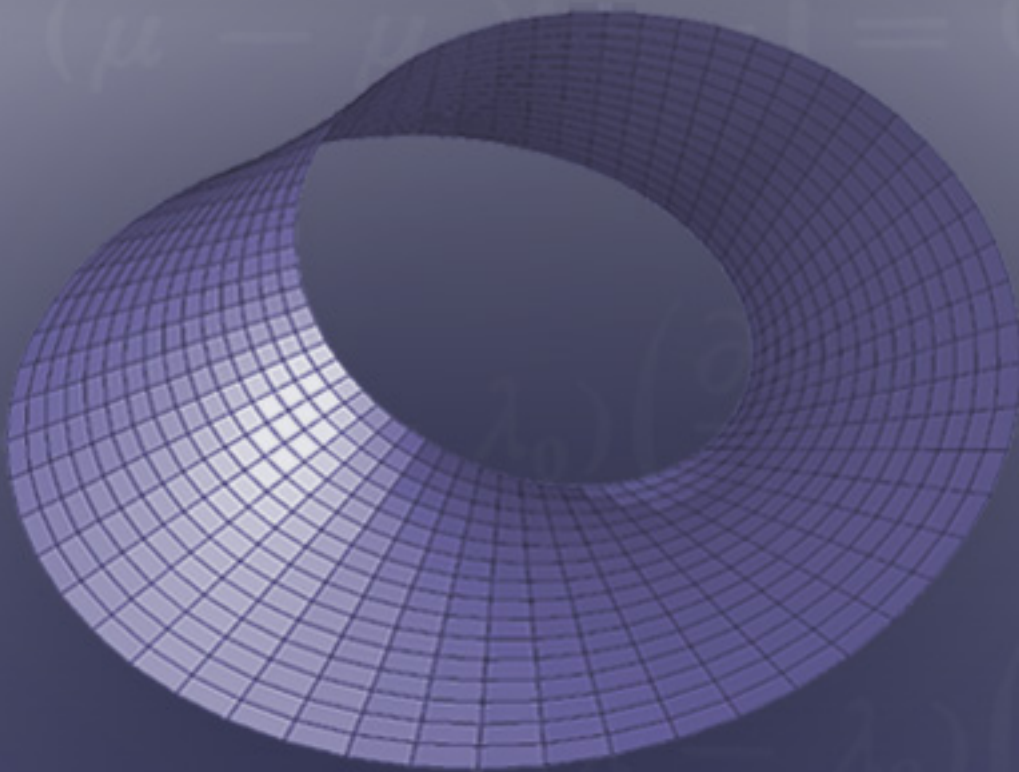




Digital games as a learning tool for children with cognitive disabilities: Literature review and some preliminary methodological and experimental results



Digital Games as a Learning Tool for Children with Cognitive Disabilities: Literature Review and some Preliminary Methodological and Experimental Results

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Abstract

Through the mutual efforts of devoted game researchers and educational practitioners, the value of digital games for learning is starting to augment in formal education, even though considerable opposition persists. Previous studies have shown that an interactive tool tends to educate users better than a pure textual source and it can be argued that in the educational field of perpetual learners such as students with mental retardation, game is a basic form of pedagogy. However, despite the theoretical connection of existing digital game design with accepted general pedagogy methodologies and practices, the important sector of Special Education has not yet been the objective of considerable research.

This paper outlines various theories of Special Educational Needs (SEN) pedagogy with a special interest in mental retardation, in order to demonstrate how educational and commercial games are able to embody the fundamental elements of SEN educational methodologies. More precisely, the paper examines how commercial and educational games support various SEN methodologies and theories regarding mental retardation pedagogy such as those described by Christakis (2002), Kalantzis (1985) and Soulis (2002).

The theoretical discussion of the paper is further substantiated by some preliminary experimental observations in order to highlight actual correlations between digital game play and learning outcomes. Based on the above theoretical correlations and early findings from pilot observations it can be postulated that serious games constitute an important medium of educational pedagogy for children with learning disabilities due to mental retardation.

Keywords: games-based learning, special education, mental retardation, learning theory, pedagogy

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1 Introduction

Modern and classical theories of play have acknowledged many ways in which computer games may progress the learning progress as well as the social and emotional growth of children. Computer game-based learning has taken its place into homes and national curriculums in the form of educational and edutainment software, while Game Studies have addressed their interest into the learning implication of commercial popular titles. Furthermore, game researchers such as Katrin Becker and Irina Verenikina, have connected existing game design with scholarly and widely accepted pedagogy (Becker, 2005b; Verenikina et al, 2003).

The importance of play in the cognitive development of children with mental disabilities has been thoroughly documented in the educational literature. Whilst there has been an ongoing academic interest regarding digital gaming and its learning implications to children, in the formal educational setting, new media are still under-represented. Moreover, the correlation between computer game usage and special education has not yet been the subject of a collective research.

According to studies, despite the educational implications of game usage, education hasn't yet been able to apply with confidence this exciting new medium into its assets, especially regarding individuals with mental disabilities. Media and Game Studies reveal the potentials of game-based learning and studies have already associated learning theories with digital game design and content. In this study we will try to observe whether commercial and educational games support methodologies and theories regarding mental retardation such as those described by Christakis (2002), Kalantzis (1985) and Soulis (2002).

Additionally early findings from case studies will be presented and discussed in order to examine the use of digital games by children with mental disabilities when used as a support to a SEN educator or as a stand alone application.

The focus of the research which this paper reports is application of classical and modern theories of learning for children and young people with mental disabilities to the development of a research base that will support SEN educators as they consider the use of computer games in classroom context.

2 Digital Games as learning tools for Special Education: A literature review

2.1 Learning models embodied in Digital Games

Multimedia usage, intriguing storyline, state of the art graphic environment and creative agents, offer an essential motive to the user to keep on playing, use different strategies and learn through trial and error, maximizing the educational achievement (Klawe, 1999).

According to Facer (2002), digital games and learning process are connected through the new digital environments, supporting new cognitive frameworks of learning. New models of learning, based on personalization and adaptability on student's needs and abilities can merge digital games into their learning framework. Moreover, one of the most important assets of Digital Games is their ability to adapt on user's abilities and timeframe thus avoid feelings of anxiety, inadequacy, boredom and stress (Sedighian, 1997).

Becker has demonstrated how games, even purely commercial ones, already embody the fundamental elements of learning and instructional theories. Learning models such as Gagné's five Categories of Learning and Nine Events of Instruction as well as Gardner's Theory of Multiple Intelligences coincides with game design (Becker, 2005b), while various learning styles can be incorporated, and thus utilized for learning purposes, while designing a popular or educational game and in this way actively support learners of all learning style preferences (Becker, 2005a).

Gagné's theory demands that there are several different types or levels of learning, while each type also requires a different approach to instruction. According to Becker, each of Gagné's five categories of learning is well supported in most games.

- "Verbal information" is provided both verbally and textually,
- "Intellectual skills", such as the use of concepts and rules to solve problems are the basis of most strategy games,
- "Cognitive strategies" are essential in order to accomplish our game tasks.
- "Attitudes" are of cardinal importance to role-playing games.
- while most games require the use of some sort of controller or keypad, thereby helping to develop "fine motor skills".(Becker, 2005b)

All these five categories of learning come to life in Gagné's Nine Events of Instruction, a theory that provides the essential conditions for effective learning. Becker has demonstrated those games, and as she emphasizes "good games", meet virtually all the criteria. Gagné's Nine Events of Instruction applied to games (Becker, 2005b):

1. *Gaining attention (reception) - In games this is referred to as "attract mode"; it is what one sees when a game appears to be playing by itself – it shows elements of the game play and is intended to entice players to play.*
2. *Informing learners of the objective (expectancy) – This is typically part of the back-story and description of the conditions in order to win the game*
3. *Stimulating recall of prior learning (retrieval) – Again, the back-story associated with the introduction to a game provides the frame of reference;*
4. *Presenting the stimulus (selective perception) – This aspect is controlled with-in the game and is designed to provide encouragement as well as challenge.*
5. *Providing learning guidance (semantic encoding) - Games can be self-contained and learning how to play is accomplished within the game itself. In effect, games act as the tutor sometimes with the aid of tutorials and agents.*
6. *Eliciting performance (responding) – This is, of course, an essential component of interactivity – without this, there really is no game.*
7. *Providing feedback (reinforcement) – Without timely and appropriate feedback, the player has no way of knowing whether or not they are progressing towards their goal.*
8. *Assessing performance (retrieval) –Assessment is an integral part of the game.*
9. *Enhancing retention and transfer (generalization) – Moving through levels within a single game requires players to remember skills, knowledge and strategies learned in the previous level (Becker, 2005b).*

2.2 Digital Games and Special Education

Mental Retardation represents a widespread and heterogeneous condition, characterized principally by cognitive deficits in relation to the normal population (Zeaman & House, 1963; Ellis, 1963). Mental retardation is a term used when a person has certain limitations in mental development and in skills such as communicating, taking care of him or herself, and social skills. These limitations will cause a child to learn and develop more slowly than a typical child, while children with mental retardation may take longer to learn to speak, walk, and take care of their personal needs such as dressing or eating.

Student's with mental retardation are often described as "slow learners" and cannot easily integrate to the normal curriculum. With an IQ<70 and possible additional multiple handicaps, the need for special education adapted to their needs and capacities is essential.

Aim of special education is to design and implement an alternative learning framework, in order to overcome the learning difficulties of the student. Proprietary goal of special education is the social integration of the student, in order to achieve the highest possible level of autonomy and self determination.

At this point it would be more than useful to refer to the Vygotskian concept of mediation in learning (Vygotsky, 1981, page 165). According to Vygotsky the young learner uses the object or the person as a medium to understand reality. Play has been described by Vygotsky as the fundamental medium of cultural development (Vygotsky, 1997, page 202). The young learner uses the object or the person

as a medium to understand reality and play is the main medium of children's cultural development. Especially regarding learners with mental retardation and cognitive disabilities, where childhood is extended or even never surpassed, the educational usage of play is immense both according to Piaget and Vygotsky.

Early studies of Malone and Lapper (1987) proposed the usage of digital games as an educational medium, and proved that digital games enhance motivation and learning since the user is more than willing to test his/her knowledge, apply them while gaming and learn and assimilate new information while playing and having fun (Malone, 1980).

Students with cognitive disabilities could use educational software and open source online games in order to experience everyday situation and curriculum learning subjects such as mathematics, reading and vocabulary, promote problem solving skills and prepare themselves virtually for social integration, vocational training and safety (Fitros, 2005). Attention is being supported and students are able to prove their skills and knowledge (Detheridge, 1996).

What is more, software and digital games provide the most important aspect of learning in the context of special education: the possibility to adapt to users needs and divide information into small deliverable packets, able to be integrated by the user accordingly (Detheridge, 1996). By doing one step at a time and completing each task before proceeding to the next one, the user is able to understand each section of information and adapt it to its general sphere of knowledge.

Moreover by using programs and computer games as a team they develop social bonding with their co-students and with family members. By using learning digital games as pairs, discussing issues and storyline, and playing together relationship bonds are encouraged and supported. Cooperation and therefore social integration can be promoted through the usage of special software and digital games (Detheridge, 1996).

It should be mentioned that an added value of computer games is the private engagement. The gamer can test his/her abilities and make mistakes in a much friendlier environment without judgmental remarks, feelings of inadequacy or incapacity (Brooks, 1997). Especially regarding the special education classroom environment where the value of a judgmental free platform which solely increases users' self-confidence and intellectual interest, is more than valuable to the educator. Researches on autism and multimedia games revealed increased interest and sense of personal accomplishment and moreover revealed very positive results at educational objectives such as reading and concept learning (Williamms et al, 2002).

Most children with severe or mild mental retardation will not try a new task since the lack of experience and self esteem will cause anxiety, stress and will end in absence of motivation. These restrains seem to vanish when the individual is in a gaming private framework and it is frequently argued that computer games are valuable tools in enhancing learning. They are seen as an approach of encouraging learners who may lack interest or self motivation (Klawe, 1994).

2.3 Issues and Problematics of Digital Games as new learning media

As it was discussed, digital games have all the potentials to embed not only general educational taxonomies, but can embody the educational content and the educational methodologies designed for students with mental disabilities. However, not all commercial titles are adaptable to special needs' users especially regarding classroom usage. According to researchers and game designers, most commercial titles cannot adapt to a learning scenario, unless the educator adapts the game properly or choose a partial section of the game (Game Accessibility, 2006). Moreover the majority of the commercial titles cannot adapt at all to the extra design and content needs of users with cognitive disabilities, raising an issue of game accessibility.

Additionally, a large amount of learning games have poor graphic quality, simplified and dull storyline or even no storyline at all, since they are based on unlinked tasks with some animation involved. Games often are too difficult, too childish or require too many controls (Bierre et al, 2005). Especially regarding the educational sector for people with cognitive disabilities, there are as yet a small number of games that have a clear contribution to make to the educational agenda (Williamson and Facer, 2004, Balanskat, 2006).

3 Digital Games and Learning Methodologies for Learners with Mental Retardation: Some preliminary results

3.1 Investigating the correspondence between SEN learning methodologies and digital game design

In order to achieve an efficient instructive process, the maintenance of rules and principles is essential. Some of those principles have common application regardless special educative needs, whilst others specialize in children with mild or severe difficulties, such as children and young persons with mental retardation. For example, instructional principles that are based on terms such as “self-action” and “discovery” are not recommended within the SEN framework (Christakis, 2002).

On the following section we will correlate learning methodologies for student with mental disabilities with the use of digital games as an educative medium. Instructional Principles by Christaki, Kalantzi and Soulis will be discussed. Initially, it should be mentioned that the analytic curriculum designed for children with mental retardation in Greece, includes five central fields of knowledge: academic knowledge, social-communicative skills, personal safety and hygiene, physical and psychological health and vocational training (Soulis, 2000, p. 40). All five fields of instructive content can be embedded in digital games.

Literacy and Numeracy skills (writing and verbal skills, arithmetic skills, logic, counting, significance of time and date etc)	Educational and edutainment games have already embedded various levels of academic content. For example, in the All About Numbers ¹ , students visualize math concepts with colorful pictures and animations. Alphabet Track ² allows students to move through 8 fun activities at their own pace. By learning to recognize and locate letters of the alphabet quickly and consistently, students of all levels will acquire more spelling independence and be on track for developing vocabulary skills and other vital literacy skills
Social-Communicative skills	Toward Independence ³ is a well-rounded collection of five life-skill programs that covers functional vocabulary and community outings, money skills, shopping and social behavior , shown step-by-step
Personal Safety and Hygiene	Bodywise ⁴ is able to enliven health and life science curriculums via animations and graphic and allow students to investigate body systems, health education topics, and frequently asked questions about the human body. Out and About ⁵ , includes activities such as cooking, shopping, Use-by dates, spelling, information gathering, sequencing and word processing
Physical and Psychological Health	Dominic Interactive ⁶ is a computer game that helps children reveal their anxiety – depression tendencies and strengths. Smart Alex ⁷ is a cartoon character that can do over a hundred faces, expressing different emotions. At a higher level, users can hold a simple conversation with Alex and talk about their likes and dislikes.

¹All about Numbers: <http://www.turningpointtechnology.com/Software/TF/AllAboutNumberAtLevel1.htm>

²Alphabet Track: <http://www.turningpointtechnology.com/Software/TF/AlphabetTrackSoftware.htm>

³Toward Independence: <http://www.turningpointtechnology.com/Software/AC/TowardIndependenceCD.htm>

⁴Bodywise: <http://www.turningpointtechnology.com/Software/TF/Bodywise.htm>

⁵Out and About: <http://www.turningpointtechnology.com/Software/TF/OutAndAbout2.htm>

⁶Dominic Interactive: <http://www.dominicinteractive.com/page1.html>

⁷Smart Alex: <http://www.turningpointtechnology.com/Software/TF/SmartAlex.htm>

Vocational Training	Through My Town ⁸ student will increase awareness of the descriptions of everyday professions, while through The Sims - Open for Business ⁹ , students realize the meaning of responsibility, punctuality and duty.
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However even though content can be assimilated and adapted at a digital game platform, it would be more than interesting to examine whether instructional methodologies for students with mental retardation can be applied to digital games. According to Christakis, some of the basic Principles of Instruction for persons with learning difficulties are the following:

- Monitoring Principle. Individuals with moderate or severe mental retardation have difficulties in the understanding of meanings, ideas and objects that are not situated in “here and now” experience. Therefore monitoring and immediacy are essential.
- Child-centered/ Individual Adaptation Principle. Vital condition in the design of a successful instructional plan is the adaptation to the abilities and educational needs of each child in combination with the instructive goal and the individual objectives of each instructor.
- Proximity to Real Life situations. Every single teaching unit should have application to this principle. Educative material should satisfy current and future needs of the student. On the opposite situation both the student and the educator spent precious time and potentials without benefits.
- Entrenchment and practice. Repetition and constant practice are indispensable for the development and of knowledge, experience and skills that will have application in every day situations. (Christakis, p.21)

All these instructional principles for children with mental retardation can be, and in some cases have been, embodied in digital games.

Monitoring Principle	Digital Games offer agents that not only monitor and log users behavior while playing, but are able to offer help in case of a difficult situation, lead to the solution and highlight the next step. Therefore the user can be constantly under monitoring and aid throughout his/her gameplay. The game itself is the patient and omnipresent tutor.
Child-centered/Individual Adaptation Principle	A digital game could cover one or more educative needs and could be specialized according to the mental and physical age of the player while reflecting the interests and necessities of each student. By adjusting the level of difficulty and the pattern of navigation, both content and design can be adapted accordingly. Digital games offer the possibility of repetition and practice, offering to the student the potential to practice and learn within his/her own cognitive capabilities and timeframe (Rooms, 2000).
Proximity to Real Life situations	Through the vast amount of game content two categories can be presented. The first category of digital content simulates real life situations and the student can easily assimilate patterns and solutions (e.g. The Sims, Roller Coaster Tycoon, simulation games regarding money/shopping, dressing up etc). However the second category of digital game content that can be characterized as fictional can have equal proximity to real life situations since through the dramatization and the engagement, the user not only identifies to the game hero, but is able to make connections between fantasy world and real world. While using a fictional character (such as a cartoon hero or a fictional creature, e.g. a dragon), children are able to equal fantasy to real life emotions and situations and find practical usefulness to a complete fictional scenario.
Entrenchment and practice	The majority of educative digital games as well as many popular titles use repetition during the game scenario. The user has to repeat steps and acquired skills and knowledge in order to proceed to the next step. Games such as Dora the Explorer, The Sims, are based on trial and error and the repetition of steps in order for the user to accumulate the essential skills (or educative goals) and continue the game. New tasks integrate with the repetitive process of acquired skills and form a full educative goal. For example in a popular educative title the

⁸ My Town: <http://www.turningpointtechnology.com/Software/LL/LADLMyTown.htm>

⁹ The Sims – Open for Business Expansion: http://thesims2.co.uk/products.view.asp?id=37&page=1&movies_nav_page=2

	user has to pick letters throughout his/her journey in various cities and form words and sentences. Acquired letter are used frequently and the process itself has to be repeated in order for the user to travel to a next city. Another value of software and digital games learning is that they motivate users to focus, test their skills, use trial and error and learn while having fun (Brooks, 1997)
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According to Kosta Kalantzi three more essential educational principles complete the base for the efficient design and accomplishment of an educative plan for children with mental retardation, the principle of adaptive curriculum, the principle of localization of the educational program to the direct natural and cultural environment of the student as well as the principle of therapeutic intervention and assistance (Kalantzis, 1985). On the following table we will see the correlation between those principles and digital games.

Principle of Adaptive Curriculum	Curriculums and educational scenarios should be designed according to the mental capacities of the students as well as the educational goal. Adaptivity and personalization is one characteristic that many digital games share and therefore can be modified and used accordingly by the educator, meeting his/her educational goal adapted to each student's particularities.
The Principle of localization of the curriculum in the direct natural and cultural environment.	The ultimate goal of Special Education is to prepare the student for adult life and accomplish the higher possible state of autonomy. Digital games though its immersive logic and cinema-narrative can be used as an effective medium of teaching attitudes and social behavior according to the cultural environment of the student. A virtual example could be Second's Life, Brigadoon. Brigadoon is a small virtual island within the massively multiplayer online game, Second Life created for individuals with autism and Asperger's syndrome in order for them to explore the social interactions that are so hard for them in the real world (Lester, 2006).
The Principle of therapeutic intervention and assistance	This principle ensures that the coexistence of student's skills along with background demands will be harmonious and able to lead to positive interaction. Educational games are able to have a therapeutic result in cases of anxiety, racism, violence, and raise awareness. E.g. Dominic Interactive ¹⁰ is a computer game that helps children reveal their anxiety – depression tendencies and strengths. Additionally digital games with popular animated heroes can have a therapeutic value in issues of self esteem or loneliness.

3.2 SEN learning outcomes through digital game play: Some early experimental results

Using the digital game as an educational tool but also as communication medium, the educator can promote the usage of a common code amongst students, while acquiring an important ally in order to counterbalance diversities in the educational process. The process of digital game imposes the need for cooperation and communication between students. This was also observed in a series of ongoing pilot observations conducted by researchers of the New Technologies Laboratory in Communication, Education and the Mass Media of the University of Athens (UoA NTLab, <http://www.media.uoa.gr/ntlab>) in collaboration with a Rehabilitation and Education Center for children with learning difficulties.

During this series of observations, 12 individuals with mental retardation (ages between 10-17 years old) collaborated harmoniously for the duration of three months as players of educational digital

¹⁰ Dominic Interactive: <http://www.dominicinteractive.com/page1.html>

applications and games. The students used Open Source Digital Games and Educational Software, with both academic as well as social content in sessions of 40 minutes per pair of students.

We used specific games and edutainment software which embed all five fields of instructive contents as described by Soulis (academic knowledge, social-communicative skills, personal safety and hygiene, physical and psychological health and vocational training). Moreover, we observed the presence of the basic principles of instruction for persons with learning difficulties within the gaming experience (Christakis, 2002; Kalantzis, 1985) such as Monitoring Principle, Child-centered/Individual Adaptation Principle, Proximity to Real Life situations, The Principle of localization of the curriculum in the direct natural and cultural environment and The Principle of therapeutic intervention and assistance.

Findings indicated that students' familiarity with computers and keyboard usage augmented radically. 7 out of 12 students were already familiar with basic computer usage and at the end of the gaming sessions demonstrated full understanding of the hardware and basic software applications. The same results were shown with the 5 students that had no past experience. Through their gaming experience, they were able to identify keyboard symbols, refine mouse usage and finger movement sensitivity and realize the meaning of saving information.

It should be mentioned that during game play several students demonstrated an improvement on the understanding of letters and their typing speed. In one specific case, for instance the player managed to augment her typing speed by 40% during sessions of a letter identification game.

Moreover, several students exhibited greater comprehension of numerical and logical skills. By using educational games such as Sebran ABC¹¹ and Dora the Explorer several children started counting without pointing at the items. At first they used the cursor as an extension of their finger and later on they did not have to use the cursor at all.

Indicatively we report that through the use of traditional games in digital form such as "Hangman", and the identification of picture-word, intense interest of attendance from children with difficulties in verbal communication was observed. Moreover in a case of a 16 years old boy without verbal communication skills, the speed of reaction was augmented, and everyday skills such as shopping and giving directions to his co-students could be practiced virtually.

There were two occasions of children that did not seem to improve on any academic skills apart from computer usage and pure enjoyment. It is assumed that due to their cognitive condition further sessions were required as well as a possible adjustment on the gaming software.

What was most important is that, all students were extremely motivated to use the software and understand its logic and goal. Cooperation between students was augmented and even though they had to practice their numerical and academic skills they did it with great enjoyment. It should be mentioned as well that students were not hesitant to proceed on a step during gameplay or repeat it, without the fear of failure, or negative remarks. Moreover it was observed that in several cases students correlated in-game situations with personal situations, being able to express anxieties and fears (Principle of therapeutic intervention and assistance, Proximity to Real Life situations).

With a first observation we could say that the design of digital multiplayer games, promotes the collaboration, decreases learning tension between students, while augments interest and self involvement at the learning process. At the same time even a single-player game, can have the same benefits under the guidance of an instructor.

¹¹ <http://www.wartoft.nu/software/sebran/>

4 Some early conclusions and directions of future work

In accordance with the close correspondence between SEN educational principles and digital gaming, it can be claimed that Digital Games constitute learning environments able to support the above mentioned basic principles of learning for children with cognitive disabilities (Christakis, 2002; Kalantzis, 1985 and Soulis, 2002) as well as to provide a highly enjoyable virtual world that enables interactivity and promotes learning initiative.

As it was presented on this study, educational methodologies for children with cognitive disabilities find application both in the game design and the content of this powerful medium, while our preliminary research revealed that students embrace the new medium and are more than able to benefit from its educational effects.

Even though, Education, Media and Game Studies reveal the potentials of game-based learning, the practical realities of the classrooms differ. Despite the educational implications of game usage, education hasn't yet been able to apply digital games into special education, where personalization and adaptivity to student's capabilities and needs is essential. As it was mentioned in this paper, whilst there has been an ongoing academic interest regarding inclusive computing and its learning implications for people with cognitive difficulties, the correlation between computer game usage and special education has not been yet the subject of extensive research or practical development.

Therefore, in view of the literature review and our current findings, it is of cardinal importance to realize the power of digital games at the service of SEN sector and capitalize on the advantages of the cooperation between play, storytelling and technology. Moreover, further examination of the usage of digital games by people with mental disabilities both regarding learning and social implications is requisite.

Thus, we view the work described in this paper as only the beginning of a large project. Although the given results of the small scale study are promising, further research in a larger scale is required. The correspondence between gaming and all learning principles and methodologies will be tested with various types of commercial games and educational software.

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