The Use of Serious Games in Virtual Environments with Preventive Purposes in Child Health

Mariana H. Rodrigues*
Alexandre A. P. Montilha
Susy N. S. R. Amantini
Sileide A. O. Paccola
Maria A. A. M. Machado

University of Sao Paulo, Department of Pediatric Dentistry, Orthodontics and Public Health – Bauru School of Dentistry, Brazil

Abstract

This paper discusses the importance of using serious games as a supplementary material for disease prevention, targeted at a child audience. The verification of the effectiveness of serious games was achieved primarily by the selection of sources available in scientific databases in the health area as well as in the digital systems technology, followed by the criteria of papers focused on childhood and aimed at prevention. As it has been observed, there are lots of papers which mainly report the development of applications without exploring the results obtained and thus not proving whether they met their expected instructional role or not. However, despite the lack of studies reporting the effectiveness of serious games after they have been tested out, we found that not only are these games well accepted by young audiences, they provide great educational power as well. As to the three-dimensional virtual environments, we also found out that they have been widely employed for the development of serious games, from mobile applications to computer games and consoles.

Keywords: serious games, games, children, health prevention

Author's contact:
*mariana.hortolani@gmail.com

1. Introduction

The unprecedented technological development that has accompanied us has led to a revolution and a great renewal of digital media. All these changes have led to the creation of new forms of action, interaction and acquisition of knowledge, which are very useful in the areas of preventive education aimed at children. In cases where distance is a crucial factor, the use of information and communication technologies for the exchange of information on prevention and treatment of diseases and the continuing education of communities tends to provide people the development of new habits related to health. As a consequence, the use of interactive methodologies assumes environments and planned experiences designed to develop, ideally, the knowledge required to obtain these concepts within all age groups.

A vast array of known communication channels can be adopted to disseminate information as long as they are easily accepted by the audience for which they are intended. Among these channels, we can mention games (whether electronic, arming or board games, etc.), paradidactic books, animations and lots of other graphic materials.

As to the games, there is a category called Serious Games, which relies on the expertise of the gaming industry in order to create more attractive and entertaining simulations, while offering activities that help the absorption of concepts and the development of psychomotor skills. However, there is little to none dissemination of those games aimed at children, especially in the context of education and health.

We know that many applications have been developed. However, why almost none of the results of its effectiveness have been disclosed? We intend to answer these and many other questions by systematically reviewing the proposal, which relies on the verification of existing applications, the success in its use, the topics addressed and the acceptance by the public it is intended.

2. Theoretical Foundation

According to Blackman [2005], the term "serious games" refers to those games with a specific purpose, which goes beyond the idea of entertainment and offers other kinds of experiences, as, for example, those related to learning and training. According to Machado et al. [2009], serious games began to be produced in the mid-1980s, with the purpose of providing training to the U.S. military. Currently, they are applied to simulate critical situations which involve some kind of risk, making decisions, or even to develop a specific skill.

In education, it is possible to simulate situations in which the use of knowledge is necessary for the progress in the game. Machado et al. [2009] further states that, in some cases, education and

training can be combined to simulate situations where we learn something to be used in the simulation itself moments later. Serious games can also be applied in human awareness.

Some difficulties of acquiring materials, product validation and training of personnel - and the need for new approaches to rehabilitation and education for healthy habits -, make the games a great ally of education, training and simulation for health, which can either benefit professionals and patients.

Many studies have proved effective learning and transfer of learning to real environments when such applications are used for educational purposes. Similarly, the use of unconventional spaces for interactive experiences proposes, in this context, the inclusion of elements that do not belong to it, as well as the experience in the entertainment field, arouse greater interest and generate greater audience participation, which triggers better comprehension processes and assimilation of certain subjects.

However, there is still a huge amount of barriers encountered by developers and health professionals, such as the alignment of issues and the definition of projects for specific audiences, which prevents the access to these games by a large portion of the population.

The knowledge that the child will develop along its educational path (even if it is for health education) is closely related to the themes discussed throughout childhood. As much as the conceptions and practices of teaching and learning are diverse, finding a form of knowledge adapted to the age of the children implies choosing a methodological approach, being consistent about it and, at the same time, contributing satisfactorily to achieve the goals, either in general or specific education, at the appropriate level.

Nowadays, most people have shown great interest in interactivity, since they have access to several methods of communication and learning, such as computers, tablets, smartphones and gaming consoles. Children, mostly, have great acceptance for new technologies, and therefore can easily deal with them. As a result, the use of interactive and enjoyable applications makes the subject matter more stimulating and attractive, thus facilitating and strengthening the content assimilation.

A motivating factor to be noted is the application of games focused on health. These games aim to develop specific health care, and should offer challenges according to the competence of the players involved. If possible, they should be able to provide the development of skills as well as its use in groups. Moreover, it is mandatory to provide an effective way of training by reproducing real situations.

Considering the growing demand for preventive treatment in infancy, it is necessary to choose the games aimed at prevention backed up by practical, attractive and functional methodologies, further enabling its widespread use and encouraging improvements in quality of life from early childhood.

Games represent a natural bridge between users and information by incorporating its features to the learning process, which leads to improvements in logical abilities, reasoning and other important skills. Although there are a few prominent examples of educational games in Brazil, there is a growing number of organizations and groups that are exploring opportunities to develop specific games.

As a result, when it comes to preventive health, it is of utmost importance a systematic review that proves the effectiveness of these games for improving the quality of life in childhood. The use of serious games has gained prominence for its potential social reach. We found out, however, that despite the multiplying health applications and the growing and extensive research in this area, serious games are still underused, being more common in other fields, such as education or training. As to mobile serious games targeted at prevention in child health, for example, the existence of studies in development is virtually nonexistent.

3. Problem Formulation

To identify advances in the area of serious games aimed at prevention in child health as well as their contributions to the process of teaching and learning, there is the question: *Is there any evidence that serious games with three-dimensional virtual environments can effectively contribute to prevention in child health?*

4. Proposal

The goal of this study is to verify the effectiveness of educational games with preventive purpose (serious games) aimed at children, focused on child health (average age group: 3-12 years), through three-dimensional environments. It is intended to identify whether existing games, whose main objective is to present educational content, actually promoted effective learning and if this contribution can be proven.

According to Zappa [2012], virtual environments are a reality that have already witnessed (although on a small scale). Such environments correspond to spaces where learning, discussing and reviewing occur regardless of the physical presence or the geographical location of those involved. Therefore, this paper aims to prove that, in a three-dimensional interactive environment, it is possible to implement concepts, bringing to children all over the world a way

of integration and learning, by promoting health, prevention and, especially, quality of life issues.

5. Methodology

This section describes the methodology applied to the study.

5.1 Criteria for Selecting Fonts

Sources available on the Web were selected in scientific databases in the areas of health systems and digital technology. For the initial study, we used Google Scholar.

5.2 Methods of Searching for Sources

The keywords, as previously defined, were applied in the search for journal articles and scientific events in the area, as well as dissertations and theses published in the databases available on the web.

The review was conducted from a research in certain databases. The searched databases were the following:

- Scopus
- Science Direct
- Technology Research Database
- IEEE Xplore
- ACM

5.3 Inclusion and Exclusion Criteria

Inclusion	Exclusion
Documents available on the web.	Documents not reporting the use of serious games for health treatment.
Studies showing serious games with three-dimensional environments used for preventive purposes in child health.	Documents describing the use of serious games, without analyzing the effectiveness after use.
Studies providing data about the acquisition of knowledge or skills of the target audience, in their results.	Documents describing the use of serious games, even though not aimed at children, with proven effectiveness.
Documents containing words of the search string in its title or abstract.	Serious games aimed at areas other than health education (prevention).
Documents written in English or Portuguese.	Documents not covered in the inclusion criteria.

Documents available to the University - as a rule (must be acquired by USP or CAPES).	
Documents published between 2005 and 2013.	

Table 1 . Inclusion and exclusion criteria

5.4 Study Selection Process
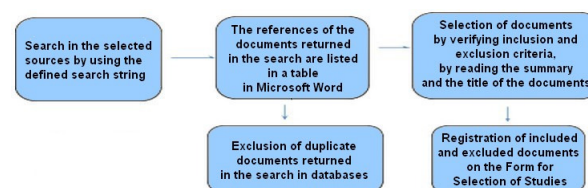
Graphic 1. Study selection process

5.5 Quality Assessment of the Studies

The document was considered relevant when it met all the inclusion criteria, and not relevant when it met one of the exclusion criteria. This evaluation was made by reading the summary and , afterwards, the full text of the document.

5.6 Strategy for Extraction Information

After the process of selection, the following information was extracted from the selected study:

- Source (number of returned documents and duplicate documents)
- Author (s)
- Year of publication
- Title of document
- Relevance of the search result

Thus, we obtained:

- Intervention: methods and evaluation techniques.
- Control: Articles obtained from the searched databases.
- Population: Articles that showed applications using serious games for prevention in child health through three-dimensional environments.
- Results: Proven effective learning for evaluating the use of these applications for health training.
- Application: researchers developing projects in the area of prevention in child health using serious games with three-dimensional environments.

5.7 Terms, Synonyms and Sources to Search

Initial keywords:

|	
Health	*Serious Games*
Virtual Games	*Children*
Prevention	*Health Prevention*

The keywords were combined with the 'OR' and 'AND' conditionals. After refining the search strings, the main strings were obtained, which have proven most successful in the searches:

Serious Games AND Children AND Prevention

Virtual Games AND Children AND Health Prevention

5.8 Preliminary Studies

In the initial study, realized in the Google Scholar base, with the string *Serious games* Children*Prevention**, the following data were obtained:
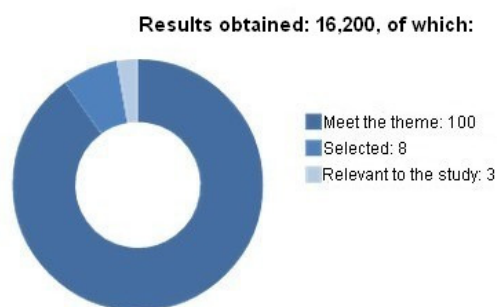
Graphic 2. Results obtained in the preliminary studies
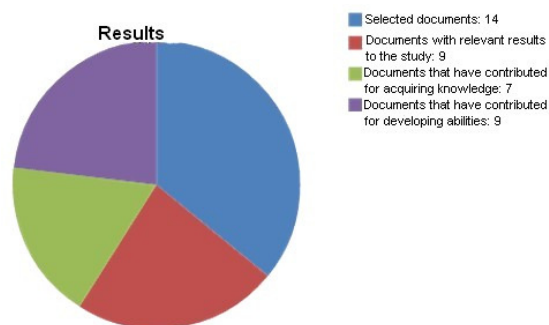
5.9 Secondary Studies

After investigating the defined databases, the following data, showing a huge difference between the obtained and the selected documents, were obtained:
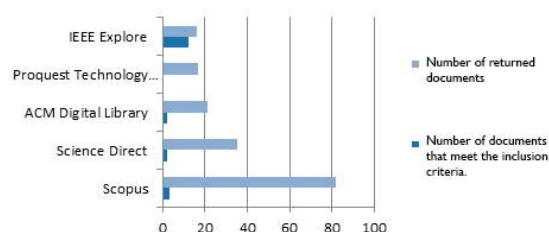
Graphic 3. Results obtained in the secondary studies

6. Results

With the tabulation and analysis of the selected documents, we obtained the following results:

Graphic 4. Results obtained after analyzing the selected documents

7. Related Works and Discussion

Up to this point, we found out the lack of publications concerning the effectiveness of serious games with three-dimensional environments for the sake of prevention in child health. However, it is worth taking note of some considerations.

Much of the material deals with games for the prevention of obesity and diabetes (among other things focused on nutrition), with a significant proportion of the publications also focusing on physical exercise as a way of prevention (games known as exergames). Many report the use of the Wii platform and online games with different content available in every step of the evaluation process as a way of motivating the use of the software and a method of differentiation of the application. Some games also employ more specific equipment, such as haptic gloves, like the report of MACÍAS et. al [2012] in Glooveth: Healthy Living with an Innovative Gameplay.

After analyzing the collected materials, we can ask the following question: is there no research in other areas of health concerning the use of serious games for childhood prevention, or is there little to none dissemination of its results? This question can be a motivating factor for new research projects and innovation in this promising area, as proved by several effective and successful results.

Another point to be considered is the analysis of the results after the application of such materials and the way they give their evaluation. Questionnaires were applied on all studies as evidence of effectiveness. However, we must be wary at this point when it comes to children. Depending on the age and the maturity, the answers can be subjective or not fully consistent with reality. We can still make an addendum: could there be safer methods of analyzing the results, especially for these types of studies involving children?

We also noticed that there are lots of papers which mainly report the development of applications, without exploring the results obtained, and thus not

proving whether they met or not their expected instructional.

The narrative of these games is another compelling factor, which should be outlined. Left in the background in many cases, it represents a crucial element for children to identify with the story of the game, since it makes them feel more immersed. According to Lu et al. [2012], the narrative encourages the public to identify with the characters and the story, which is a key factor in childhood, when dispersion and loss of interest are prone to happen easily.

As to the employment of three-dimensional virtual environments, this systematic review demonstrated its widespread use for the development of serious games. All selected publications have mentioned their use and benefits, since, nowadays, children witness a prevalence of such environments in almost all forms of entertainment available, from mobile applications to computer games and consoles. Anyway, there are positive factors that come with the use of three-dimensional virtual environments, such as: an increased sense of immersion, identification, presence and realism, as well as other factors that contribute positively to the assimilation of concepts covered by the games.

8. Conclusion and Future Challenges

It is worth noting some hindrances encountered along this research, such as the huge number of publications which mainly report the development of applications without exploring the results obtained; the duplication of articles in different databases, approaching the same subject in different ways; the use of games for educational purposes in areas other than the ones researched, and the difficulty of acquiring specific materials through the University, due to restricted time.

Nevertheless, we succeeded in the research regarding the validation of the question initially proposed. We can complete the analysis of the results with more questions: Serious games have proven efficiency. Therefore, why is there so much resistance to its use? Why should we only invest in large-scale entertainment, if we can also simulate activities and situations involving children, in a safe and real way? And finally, why not expand the range of health-related issues to other areas, such as dentistry and psychiatry?

Throughout this study, we observed that there is still too much to be explored - despite all the progress that has been done in this area -, by opening up endless possibilities for innovation for the sake of the society. It is up to researchers and developers exploring the most diverse areas, as well as the development of applications that enhance the quality of human life from the early childhood.

References

ABIRACHED, B. ET AL., 2011. Improving Communication Skills of Children with ASDs through Interaction with Virtual Characters. *Serious Games and Applications for Health (SeGAH), 2011 IEEE 1st International Conference on.*

ADAS, D. ET AL., 2005. The Efficacy of Playing a Virtual Reality Game in Modulating Pain for Children with Acute Burn Injuries: A Randomized Controlled Trial. BCM Pediatrics.

AGNIESZKA, S. ET AL., 2011. The Psychology Serious Game Prototype for Preschool Children. Silesian University of Technology, Institute of Informatics. Gliwice, Poland.

ANETTA, L.A., 2010. The "I's" Have It: A Framework for Serious Educational Game Design. *Review of General Psychology*, Vol.14.

BARANOWSKI, T. ET AL., 2008. Playing for Real: Video Games and Stories for Health-Related Behavior Change. Am J Prev Med, National Institutes of Health.

BARANOWSKI, T. ET AL., 2010. Video Game Play, Child Diet, and Physical Activity Behavior Change: A Randomized Clinical Trial. Am J Prev Med, National Institutes of Health.

BEASLEY, N. ET AL., 2012. The Quest to Lava Mountain: Using Video Games for Dietary Change in Children. *Journal of the Academy of Nutrition and Dietetics.*

BLACKMAN, S., 2005. Serious Games... and Less! *Computer Graphics. In: ACM*, 39(1): 12-16.

BOMARK, P.ET AL., 2012. A Prototype Social Learning Platform for Children with Diabetes Type 1. *MindTrek 2012, October 3-5, 2012.* Tampere, Finland.

BORTOLI, A. AND GAGGI, O., 2011. Play With Eyes: A New Way to Test Children Eyes. *Serious Games and Applications for Health (SeGAH), 2011 IEEE 1st International Conference on.*

BROX, E. ET AL., 2012. User Centric Social Diabetes Game Design for Children. *MindTrek '12 Proceeding of the 16th International Academic MindTrek Conference.*

BUCHANAN, R., 2001. Design Research and the New Learning. *In: Design Issues 17,4 (Boston, Autumn 2001), MIT Press Journal._____.* Education and Professional Practice in Design. *In: Design Issues 14,2 (Boston, Summer 1998), MIT Press Journal.*

BURDEA, G. AND COIFFET, P., 2003. Virtual Reality Technology. 2nd ed., Wiley Interscience.

CAGATAY, M. ET AL., 2012. A Serious Game for Speech Disorder Children Therapy. *Health Informatics and Bioinformatics (HIBIT), 2012 7th International Symposium on.*

CALDWELL, C. ET AL., 2013. The Intersection of Video Games and Patient Empowerment: Case Study of a Real World Application. *IE '13 Proceedings of The 9th*

Australasian Conference on Interactive Entertainment: Matters of Life and Death.

CHATAM, R.E., 2007. Games for Training. *ACM Communications*, 50(7): 36-43.

DALEY, A.J., 2009. Can Exergaming Contribute to Improving Physical Activity Levels and Health Outcomes in Children? *Pediatrics* Vol. 124, N. 2, pp. 763-771.

DAS, D.A., Grimmer, K.A., Sparnon, A.L., Mcrae, S.E. and Thomas, B.H., 2005. The Efficacy of Playing a Virtual Reality Game in Modulating Pain for Children with Acute Burn Injuries: A Randomized Controlled Trial. *BMC Pediatrics*, 5:1 (3 March 2005).

FUCHSLOCHER, A.; Gerling, K.; Masuch, M. and Kramer, N., 2011. Evaluating Social Games for Kids and Teenagers Diagnosed with Cancer. *Serious Games and Applications for Health (SeGAH), 2011 IEEE 1st International Conference on.*

GAGGI, O. ET AL., 2012. A Serious Game for Predicting the Risk of Developmental Dyslexia in Pre-readers Children. *Computer Communications and Networks (ICCCN), 2012 21st International Conference on.*

GESSEL, A.L., 1996. A Criança dos Zero aos Cinco Anos. São Paulo. Editora Martins Fontes.

HENSCHKE, M., HOBBS, D. AND WILKINSON, B., 2012. Developing Serious Games for Children with Cerebral Palsy: Case Study and Pilot Trial. *OZCHI'12, November 26–30, 2012*. Melbourne, Victoria, Australia.

INES, D.L. AND ABDELKADER, G., 2011. Mixed Reality Serious Games: The Therapist Perspective Serious Games and Applications for Health. *(SeGAH), 2011 IEEE 1st International Conference on.*

ISASI, A.R. ET AL., 2013. Helping Children with Intellectual Disability to Understand Healthy Eating Habits with an iPad Based Serious Game. *Computer Games: AI, Animation, Mobile, Interactive Multimedia, Educational & Serious Games (CGAMES), 2013 18th International Conference on.*

KATO, P.M., 2010. Video Games in Health Care: Closing the Gap. *Review of General Psychology*, Vol. 14.

KHAYAT, G.A., MABROUK, T. F. AND ELMAGHRABY, A. S., 2012. Intelligent Serious Games System for Children with Learning Disabilities. *Computer Games (CGAMES), 2012 17th International Conference on.*

KING, S.N. ET AL., 2011. A Model for Treating Voice Disorders in School-Age Children within a Video Gaming Environment. *Journal of Voice*, Vol. 26, N. 5, pp. 656-663.

KIRNER, C., 2013. Desenvolvimento de Aplicações Educacionais Adaptáveis Online com Realidade Aumentada. I*n: Tendências e Técnicas em Realidade Virtual e Aumentada,* may/2013, v. 3, pp. 9-25.

KIRNER, C.AND TORI, R., 2004. Realidade Virtual: Conceitos, Tecnologia e Tendências. São Paulo. Editora SENAC.

LIMA, E.S., 2001. Como a Criança Pequena se Desenvolve. São Paulo. Editora Sobradinho.

LU, A.S. ET AL., 2012. Story Immersion in a Health Videogame for Childhood Obesity Prevention. Games for Health Journal: Research, Development, and Clinical Applications.

MACHADO L.S., MORAES R.M. AND NUNES F.L.S., 2009. Serious Games para Saúde e Treinamento Imersivo. *In: Abordagens Práticas de Realidade Virtual e Aumentada - Livro dos Minicursos*, Porto Alegre: SBC, pp. 31-60.

MACÍAS, E. ET AL., 2012. Glooveth: Healthy Living with an Innovative Gameplay. *UXeLATE '12 Proceedings of the 2012 ACM workshop on User experience in e-learning and augmented technologies in education,* pp. 31-36.

MACVEAN, A.P., 2011. Task-Involved Versus Ego-Involved: Motivating Children to Exercise In a Pervasive Exergame. *Pervasive Computing and Communications Workshops (PERCOM Workshops), 2011 IEEE International Conference on.*

MARTINS, T. ET AL., 2011. Serious Game as a Tool to Intellectual Disabilities Therapy: Total Challenge. *Serious Games and Applications for Health (SeGAH), 2011 IEEE 1st International Conference on.*

MATA, C.D. ET AL., 2009. Low Cost Video Game Technology to Measure and Improve Motor Skills in Children. *IEEE AFRICON'09, 23-25 September 2009*. Nairobi, Kenya.

MICHMIZOS, K.P. AND KREBS, H.I., 2012. Serious Games for the Pediatric Anklebot. *The Fourth IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics.* Rome, Italy. June 24-27.

MILGRAM, P. ET. AL., 1994. Augmented Reality: A Class of Displays on the Reality - Virtuality Continuum. Telemanipulator and Telepresence Technologies. SPIE.

OKINOMOU, A. AND DAY, D., 2012. Using Serious Games to Motivate Children with Cystic Fibrosis to Engage with Mucus Clearance Physiotherapy. *Complex, Intelligent and Software Intensive Systems (CISIS), 2012 Sixth International Conference on.*

POLLACK, J.P. ET AL., 2010. It's Time to Eat! Using Mobile Games to Promote Healthy Eating. *Pervasive Computing, IEEE (Volume:9, Issue:3) July-Sept. 2010,* pp. 21-27.

PRIMACK, B. A. ET AL., 2012. Role of Video Games in Improving Health-Related Outcomes: A Systematic Review. *Am J Prev Med,* 42(6): 630-638.

RADKOWSKI, R. ET AL., 2011. Serious Games for the Therapy of the Posttraumatic Stress Disorder of Children and Adolescents. *Virtual and Mixed Reality - Systems and Applications Lecture Notes in Computer Science.* Vol. 6774, pp. 44-53.

SCARLE, S. ET AL., 2011. Complete Motion Control of a Serious Game Against Obesity in Children. *Third International Conference on Games and Virtual Worlds for Serious Applications.*

SUHONEN, K. ET AL., 2008. Seriously Fun – Exploring How to Combine Promoting Health Awareness and Engaging Gameplay. *MindTrek'08, October 7-9, 2008.*

SUSI, T., JOHANESSON, M. AND BLACKLUND, P., 2005. Serious Games – An Overview. Technical Report HS.

THOMPSON, D. ET AL., 2010. Serious Video Games for Health How Behavioral Science Guided: the Development of a Serious Video Game. Simul Gaming. August 1, 2010, 41(4): 587-606.

WATTERS, C. ET AL., 2006. Extending the Use of Games in Health Care. *Proceedings of the 39th Hawaii International Conference on System Sciences.*

ZAMBONI, L. ET AL., 2012. Serious Games in Social Intervention: Designing Technologies to promote Safe and Healthy Behaviors. *Proceedings of the 9th ACM SIGCHI Italian Chapter International Conference on Computer-Human Interaction: Facing Complexity.*

ZAPPA, P., 2012. Assessing Cooperation in Open Systems: An Empirical Test in Healthcare.

ZYDA, M., 2005. From Visual Simulation to Virtual Reality to Games. Computer.