TECHNOLOGY-BASED PROCESS FOR SUPPORTING UNIVERSITY STUDENTS WITH ADHD

Laura Mancera Valetts

Universitat de Girona

DOCTORAL THESIS

Technology-based process for supporting university students with ADHD

Laura Mancera Valetts

2018

DOCTORAL THESIS

Technology-based process for supporting university students with ADHD

Author:

Laura Patricia Mancera Valetts

2018

Doctor of the University of Girona

Addressed by:

Ph.D. Ramon Fabregat Gesa

Ph.D. Silvia Baldiris Navarro

Tutor:

Ph.D. Ramon Fabregat Gesa

Presented in partial fulfilment of the requirements for a doctoral degree from the University of Girona

The research reported in this thesis was carried out as part of the following projects:

- Augmented Reality in Adaptive Learning Management Systems for All (ARrELS project). Funded by the Spanish Science and Education Ministry (TIN2011-23930).
- Inclusive Learning - Supporting Teacher Training for an Inclusive Vocational Education. A transfer of innovation project funded by the European Commission (2012-1-ES1-LEOO5-49449).
- The Open Co-creation Project funded by the Spanish Ministry of Economy and Competitiveness (TIN2014-53082-R).
- The "Comunicacions i Sistemes Distribuïts" project funded by theUniversity of Girona 2016-2018 (MPCUdG2016).

The research reported in this thesis was partially sponsored by:

- The research scholarship program of the University of Girona, reference BR2011/35

The research work done in this thesis was carried out in the BCDS research group (ref. GRCT40) which is part of the DURSI consolidated research group Smart IT Enginnering and Services (SITES) (ref 2017-SGR-1551).

I dedicate this work to Valerie, Isaac, Brez, Mom and Dad,
in grateful recognition for their gift of inspiration
and sense of being better every day.

Acknoledgements

I would first like to thank God for being always with me, thank you for giving me the determination I needed to finish this educational goal I stared some years ago.

I would second like to thank my thesis advisor PhD Silvia Baldiris who was always open whenever I ran into a trouble spot or had a question about my research or writing. She always trusted in my work and my ideas and found the way to transforms them in really.

I would third like to thank my thesis advisor PhD Ramon Fabregat who always with his calls of attention kept me awake in this long process. He steered me in the right the direction whenever he thought I needed it.

I would also like to thank the ADHD experts, PhD Ferran Viñas and PhD Beatriz Caparros, who offered me their knowledge and time to help me raise the research proposal that is now consolidated and presented through this document.

I would also like to thank the experts who were involved in the validation survey for this research project: Mgr. Laura Garavito, Mgr. Viviana Calle, Mgr. Viviana Betancur, Mgr. Yiny Cardenas without their passionate participation and input, the validation survey could not have been successfully conducted.

I would also like to acknowledge PhD Magle Sanchez of the Universidad del estado Zulia, as the second reader of this thesis and I am gratefully indebted to her for her very valuable comments on this thesis.

I would also like to acknowledge Mgr. Fabian Reyes and Mgr. Carolina Ramirez, mathematics teachers of the Virtual Unit of the University Manuela Beltrán, for the guidelines offered me to analysis the quantitative data involved in this thesis.

I also want to express my deepest gratitude to the Virtual Unit of the Manuela Beltrán University for offering me the space, time, resources both pedagogical and technological, as well as its constant voice of encouragement to culminate this process. Without it, this work was not possible.

I also wish to express my heartfelt thanks to the participants of the study cases, without them, definitely nothing of what was done in this work would make sense. Thank you for allowing me to know more about each of you and to teach me what it means to suffer from ADHD, you definitely teach me more than I could have learned from books and articles.

I would also like to express my gratitude to my advisers on final-year projects, Luisa Galviz, Cristian Muñoz, Nathaly Segura and Diana Barragan, who in a reciprocal process provided me with the initial software of the ADHD user modeling.

I would also like to thank the Broadband Communications and Distributed Systems research group for the opportunity to be part of them. To Jose Luis who is instrument in acquirement the financial support I need during my first postgraduate years as student and whom I always remember with a friendly smile. To my colleagues at the group: Sergio, Carolina, Nico, German, Lluis, Antonio, and in special to Jorge, Ceci, David, Xavi for their support in the development of software applications involved in the ADHD user modeling.

I would also like to express my gratitude to the Universitat de Girona, for the financial support during the first two years of my doctorate and for allowing me to finish this process even with all the difficulties that came along over time.

I must also express my very profound gratitude to my husband for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. In this moment, I also to express my thanks to my children, Valerie and Isaac, who behaved well than ever during the writing of the thesis.

Last but not the least, I would like to thank my family: my parents and to my sisters and brothers for supporting me spiritually throughout writing this thesis and my life in general.

Thank you.

List of publications

Journals papers

- **Mancera**, **L.**, Baldiris, L., Fabregat, R., Sanchez, M., & Viñas, F (2017). A domain-independent ADHD Student Model for Computer-Based Educational Systems. Data analysis in higher education. *Journal of Ambient Intelligence and Smart Environments*. Vol. 9, issue 5, pp 625-639. doi: 10.3233/AIS-170455. Impact Factor 2017: 0.809. Quartile 3.
- **Mancera**, **L.**, Baldiris, S., Fabregata, R., & Sánchez, M. (2016). Universal Design for e-Learning: an experience in the Manuela Beltran University to support a learner with ADHD. *Revista Ingeniería e Innovación*. Vol. *4, issue* 1. Retrived from: http://revistas.unicordoba.edu.co/index.php/rii/article/view/969
- **Mancera**, **L.**, Baldiris, S., & Betancur, V. (2015). Indicators of ADHD symptoms in Virtual Learning Context using Machine Learning technics. *Revista EAN, 7)*, pp. 22–37. Retrieved from http://journal.ean.edu.co/index.php/Revista/article/download/1265/1226
- **Mancera**, **L.**, Baldiris, L., & Fabregat, R. (2011). Soporte al Proceso de Formación E-learning de Personas Adultas con Trastorno por Déficit de Atención e Hiperactividad". Revista Internacional Magisterio Educación y Pedagogía. ISSN: 1692-4053 pp 88 - 93 v.52

Conference and Workshops papers

- **Mancera**, L., Baldiris, S., Fabregat, R., Joya, B., & Guerrero, D. "Measuring the effects of UDL in e-Learning students suffering from ADHD," 2018 IEEE 17th International Conference on Advanced Learning Technologies (ICALT), Timisoara, 2018.
- **Mancera**, L., Baldiris, S., Fabregat, R., Gomez, S., & Mejia, C, "aTenDerAH: A Videogame to Support e-Learning Students with ADHD," 2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT), Timisoara, 2017, pp. 438-440. doi: 10.1109/ICALT.2017.157.
- Mejia, C., Gomez, S., **Mancera**, L., & Taveneau, S, "Inclusive Learner Model for Adaptive Recommendations in Virtual Education," 2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT), Timisoara, 2017, pp. 79-80. doi: 10.1109/ICALT.2017.101.
- **Mancera**, L., Baldiris, S., Fabregat, R., & Sanchez, M. Universal Desing for e-Learning: an experience in the Manuela Beltran University. VIII Congreso Internacional de Ambientes Virtuales de Aprendizaje Adaptativos y Accesibles. Cartagena, Colombia. (2016).
- **Mancera**, L., Baldiris, S., Fabregat, R. aTenDerAH: A serious videogame to Entertain and Teach Skills in Adults with ADHD. VI International Conference of Adaptive and Accessible Virtual Learning Environment. Promoting an Inclusive Learning Culture. Montería, Colombia. (2014).
- **Mancera**, L., Baldiris, S., & Fabregat, R. (2012). SARE: Sistema Automático de Reconocimiento de Emociones para soportar el modelado de usuarios con TDAH en Plataformas de elearning. In IV Congreso Internacional de Ambientes Virtuales de Aprendizaje Adaptativos y Accesibles (CAVA). 2012. Cartagena de Indias, Colombia.
- **Mancera**, L., Baldiris, S., & Fabregat, R. (2011). Adapting suitable spaces in Learning Management Systems to support distance learning in adults with ADHD. In Proceedings of the The 11th IEEE International Conference on Advanced Learning Technologies (ICALT) (pp. 105 – 109). Athens, Giorgia, USA: IEEE. http://doi.org/10.1109/ICALT.2011.37

- Baldiris, S., Fabregat, R., **Mancera**, L., Avila, C., Bacca, J., Hernández, J., … Guevara, J. (2011). Atendiendo la diversidad en contextos virtuales de aprendizaje. In M. Llamas, I. Plaza, & C. Vaz de Carvalho (Eds.), Actas Workshop New Trends in Engineering Education at the VII International Conference on Engineering and Computer Education ICECE'2011 (pp. 32–38). Guimarães. Retrieved from http://remo.det.uvigo.es/guimaraes2011/Articulos/A6.html
- **Mancera**, L., Ramírez, D., Segura, N., Guevara, J., Baldiris, S., & Fabregat, R. (2010). Modeling cognitive performance in Virtual Learning Environments in order to personalize learning processes. In II Congreso Internacional de Ambientes Virtuales de Aprenizaje Adaptativos y Accesibles (CAVA 2010). Cartagena, Colombia: CAVA.
- **Mancera**, L., Muñoz, C., Galviz, L., Guevara, J., Baldiris, S., & Fabregat, R. (2010). Modeling emotions in virtual learning environments. In Congreso Internacional de Ambientes Virtuales de Aprenizaje Adaptativos y Accesibles (CAVA 2010). Cartagena, Colombia: CAVA.
- **Mancera**, L., Baldiris, S., & Fabregat, R. (2010). Modeling a game-based adaptive unit of learning to support adults with ADHD in virtual learning environments. In Software Development for Enhancing Accessibility and Fighting Info-exclusion (DSAI 2010). Oxford, OX4 4FY Oxford, United Kingdom: DSAI. Retrieved from http://dsai2010.utad.pt/sessions_and_panel/session1.html

Final thesis reports

Co-director of the bachelor's degree project:

- "Sistema distribuido que soporta el reconocimiento de emociones para la personalización de recursos educativos en la plataforma de e-Learning DOTLRN". Cristian Muñoz and Luisa Galviz. This Project was part of a collaborative work with between University of Girona (Spain) and Universidad Distrital Francisco José de Caldas (Colombia). 2013.
- "Sistema distribuido que soporta la entrega de Recursos de Aprendizajes adaptados de acuerdo al rendimiento cognitivo de cada estudiante en entornos virtuales de aprendizaje". Diana Ramirez Barragan and Nathaly Segura Sanchéz. This Project was part of a collaborative work with between University of Girona (Spain) and Universidad Distrital Francisco José de Caldas (Colombia). 2013.

Projects

- The Open Co-creation Project funded by the Spanish Ministry of Economy and Competitiveness (TIN2014-53082-R). Duration, since 2015 until 2018
- ALTERNATIVE e-ACCESS (Supporting Teachers Training for an Inclusive Vocational Education), Organismo Autónomo Programas Educativos Europeos – Leonardo da Vici –. Duration, since 2012 until 2014.
- ARreLS (Augmented Reality in Adaptive Learning Management Systems for ALL), Ministerio de Economia y Competitividad (TIN2011-23930). Duration, since 2011 until 2013.
- ALTER-NATIVA (Referentes curriculares con incorporación tecnológica para facultades de educación en las áreas de lenguaje, matemáticas y ciencias, para atender poblaciones en contextos de diversidad), European Commission, ALFA III Programme. Duration, since 2011 until 2013.
- A2UN@ (Accessibility and Adaptation for ALL in Higher Education), Ministerio de Educación y Ciencia ([TIN2008-06862-C04-02/TSI]). Duration, since 2009 until 2011.

- AdaptaPlan (Adaptación basada en aprendizaje, modelado y planificación para tareas complejas orientadas al usuario), Ministerio de Educación y Ciencia (MEC). Duration, since 2005 until 2008.

List of acronyms

AAP – American Academy of Pediatrics

ACESAD – Asociación Colombiana de Instituciones de Educación Superior con Programas a distancia

ADHD – Attention Deficit Hyperactivity Disorder

AHS – Adaptive Hypermedia Systems

AMA – American Medical Association

APA – American Psychological Association

ASRS – Adult ADHD Self-Report Scale

AT – Assistive Technologies

ATC – Department of Architecture and Technology in Computers

BCDS – Broadband Communication and Distributed System Research Group

CAST – Center for Applied Special Technology

CPT – Continuous Performance Test

CRPD – Convention on the Rights of Persons with Disabilities

CST – Concept Shifting Test

DDD – Domain Dependent Data

DI – Differentiated Instruction

DID – Domain Independent Data

DSM-V – Version five of the Diagnostic and Statistical Manual of Mental Disorders

DUA – Diseño Universal para el Aprendizaje

EC – European Commission

ECLAC – Economic Commission for Latin America and the Caribbean

EF – Executive Functions

EFA – Education For All

GBL – Gamed-Based Learning

HYS – Healthy Young Students

ICD-10 – 10th revision of the International Classification of Diseases IDRC Inclusive Design Research Centre

ICT – Information and Communications Technology

LD – Learning Disabilities

LMS – Learning Management System

LOE – Organic Law of Education

MDA – Mechanics, Dynamics and Aesthetics

MIT – Massachusetts Institute of Technology

MOOC – Massive Open Online Course

Moodle – Modular Object-Oriented Dynamic Learning Environment

NCES – National Center for Education Statistics

NICE – National Institute of Clinical Excellence

NIH – National Institutes of Health

OIA – Organization of Ibero-American States

OpenACS – Open Architecture Community System

PAL – Planning for All Learners

RAVLT – Rey's Auditory Verbal Learning Test

SA – Sustained Attention

SHA– Sistemas Hipermedia Adaptativos

SM – Student Model

TDAH – Trastorno por Déficit de Atención e Hiperactividad

TEL – Technology-Enhanced Learning

UA – Universal Access

UbD – Understanding by Desing

UD – Universal Design

UDL – Universal Design for Learning

UML – Unified Modelling Language

UN – United Nations

UNESCO – United Nations Educational, Scientific and Cultural Organization

UUID – Universally Unique Identifier

VL – Verbal Learning

VLE – Virtual Learning Environments

WB – World Bank

WCAG – Web Content Accessibility Guidelines

WHO – World Health Organization

WM – Working Memory

List of figures

List of tables

Contents

Abstract

Education promotes personal and social development to achieve the ideals of peace, freedom and justice and thus helps reduce poverty, exclusion, ignorance and war. However, the question is whether education is contributing to the development of more inclusive societies, or, conversely, is playing social exclusion and generating different forms of discrimination within education systems. This is because education systems have been oriented towards the development of homogeneous and uniform practices that respond only to the educational and learning needs of a majority student population considered standard. Based on this, it can be said that education systems have a historical debt to society, specifically to those people who do not fit into that standard label. In this context, international and national organizations and policies seek to move from a homogeneous to a diversity-based approach.

Information and Communication Technologies (ICT) offer the opportunity to respond to the multifaceted individual differences because they have the potential to create highly versatile and flexible educational and training environments. It can provide students with equal access to knowledge, regardless of their preferences, diverse learning needs, gender, geographic location, socio-economic or ethnic background, illness or disability, or any other circumstance that would normally hinder the provision of high-quality education. In this context, e-Learning has become an essential tool for teaching large numbers of diverse students because it provides and integrates a wide range of teaching resources and materials (e.g. video, audio, text, subtitles or sign language, multiple languages, and easily understandable expressions), that can be adapted to suit a variety of learning needs and preferences.

In traditional learning, teachers can easily have an understanding of how their students work and learn. However, in e-Learning it is more difficult for teachers to monitor how their students behave and learn in the system. As well as identify if students have any specific awkwardness in their educational process. The Adaptive Hypermedia Systems (AHS) applied to education emerged as a strategy to offer e-Learning training processes tailored to the characteristics and needs of students, but the truth is that most of the research focused on continuing to offer more and more sophisticated tools for a regular population, leaving aside those who from history have not been considered.

In this thesis, the AHS is used to generate e-Learning processes that consider the characteristics of university students who suffer from Attention Deficit Hyperactivity Disorder (ADHD). Overall, it was proposed a solution that ranges from symptoms detection to academic intervention. Specifically, it was developed a student model based on personal, demographic, academic, behavioral conduct, background and cognitive performance information to create personal student profiles, which indicate if an e-Learning student could have ADHD symptoms. After that, considering preferences and strengths of people suffering from ADHD, two didactic strategies were integrated in academic processes, one based on video games and the other one based on gamification. Additionally, a third strategy based on the implementation of the Universal Design for Learning (UDL) was integrated given the advantages of this framework to help reduce barriers that do not allow quality-training processes for all.

The results showed firstly, that it is possible to identify symptoms of ADHD in e-Learning enviroments; and secondly, the positive impact of video games, gamification and UDL not only on the academic performance but also on the learning experience of all the students, students suffering from ADHD included.

Consequently, on the whole, this thesis contributes to the knowledge in the field of Technology Enhanced Learning (TEL) in the following aspects:

1) Identification of information that allows inferring whether an e-Learning student could have symptoms of ADHD.

2) Evidence about the positive effect of video games, gamification and implementation of UDL in academic performance and e-Learning experience of students suffering from ADHD.
3) The definition and development of a integral technological solution that groups several Web tools and which ranges from the symptoms detection to academic support considering the strengths, preferences and weaknesses of students suffering from ADHD in e-Learning contexts.
4) Evidence of being able to use e-Learning as a means for students with ADHD to carry out their training processes in an inclusive manner.

KEY WORDS: Attention Deficit Hyperactivity Disorder (ADHD), e-Learning, Adaptive Hypermedia Systems (AHS), Videogames, Gamification, Inclusive education, Universal Design for Learning (UDL).

Resumen

El objetivo de la educación es promover el desarrollo personal y social para alcanzar los ideales de paz, libertad y justicia y así ayudar a reducir la pobreza, la exclusión, la ignorancia y la guerra. Sin embargo, la cuestión es si la educación está contribuyendo al desarrollo de sociedades más inclusivas o, por el contrario, está llevando a la exclusión social y generando diferentes formas de discriminación, dado que, a lo largo de la historia, el sistema educativo se ha orientado hacia el desarrollo de prácticas educativas homogéneas y uniformes que responden únicamente a las necesidades educativas y de aprendizaje de una población estudiantil mayoritaria considerada "regular". De esto se puede decir que el sistema educativo tiene una deuda histórica con la sociedad, específicamente con aquellas personas que no encajan en esa etiqueta regular. En este contexto, organizaciones y políticas internacionales y nacionales tratan de que todas las naciones pasen de un enfoque de educación homogéneo a un enfoque basado en la diversidad.

Las Tecnologías de la Información y la Comunicación (TIC) ofrecen la oportunidad de responder a las diferencias individuales de los estudiantes, ya que tienen el potencial de crear entornos educativos y de formación altamente versátiles que pueden proporcionar a los estudiantes igual acceso al conocimiento, independientemente de sus preferencias, necesidades de aprendizaje, género, ubicación, origen socioeconómico o étnico, enfermedad o discapacidad, o cualquier otra circunstancia que normalmente obstaculizaría la provisión de una educación de alta calidad. En este contexto, el e-Learning se ha convertido en una herramienta esencial para la enseñanza de un gran número de estudiantes, ya que proporciona e integra una amplia gama de recursos y materiales didácticos (por ejemplo, vídeo, audio, texto, subtítulos o lenguaje de señas), que pueden adaptarse para responder a una variedad de necesidades y preferencias de aprendizaje.

En los procesos de formación presencial, los profesores pueden fácilmente comprender cómo sus estudiantes trabajan y aprenden. Sin embargo, en e-Learning es difícil para los profesores monitorear cómo sus estudiantes se comportan y aprenden. Así como identificar si tienen alguna dificultad específica en su proceso educativo. Los Sistemas Hipermedia Adaptativos (SHA) aplicados a la educación surgieron como una estrategia para ofrecer procesos de formación e-Learning adaptados a las características y necesidades de los estudiantes, pero lo cierto es que la mayoría de las investigaciones se enfocaron en seguir ofreciendo más y más sofisticadas herramientas para la población regular, dejando de lado a los que a lo largo de la historia no fueron considerados.

En esta tesis, los SHA son usado para generar procesos de formación e-Learning que consideran las características de los estudiantes universitarios que sufren del Trastorno por Déficit de Atención e Hiperactividad (TDAH). De manera general, se desarrolló un proceso que va desde la detección de síntomas hasta al apoyo académico. Específicamente, se desarrolló un modelo del estudiante que considera información personal, demográfica, académica, comportamentales, histórica y cognitiva para identificar si un estudiante e-Learning puede tener síntomas del TDAH. Después de ello, considerando preferencias y fortalezas de persona con TDAH, se integraron dos estrategias didácticas en el proceso académico, una basada en videojuegos y otra en gamificación. Adicionalmente, se desarrolló una tercera estrategia basada en la implementación del Diseño Universal para el Aprendizaje (DUA) considerando su filosofía de contribuir a disminuir las barreras que no permiten procesos de formación de calidad para todos.

Los resultados obtenidos mostraron, en primer lugar, que es posible identificar los síntomas del TDAH en ambientes e-Learning; y, en segundo lugar, el impacto positivo de los videojuegos, la gamificación y el UDL no solo en el rendimiento académico, sino también en la experiencia de aprendizaje de todos los estudiantes, incluidos los que padecen TDAH.

En consecuencia, en general, esta tesis contribuye al conocimiento en el campo del Aprendizaje mejorado con tecnología en los siguientes aspectos:

1) Identificación de información que permiten inferir si un estudiante e-Learning podría tener sintomas del TDAH.

2) Evidencia sobre el efecto positivo de los videojuegos, la gamificación y la implementación de UDL en el rendimiento académico y la experiencia de aprendizaje de los estudiantes que padecen TDAH.

3) La definición y el desarrollo de una solución tecnológica integral que agrupa varias herramientas Web y que va desde la detección de síntomas hasta el apoyo didáctico educativo, considerando las fortalezas, preferencias y debilidades de los estudiantes que sufren de TDAH en ambientes e-Learning.

4) Evidencia de poder utilizar el e-Learning como un medio para que los estudiantes con TDAH lleven a cabo sus procesos de formación de manera inclusiva.

PALABRAS CLAVES: Trastorno por Déficit de Atención e Hiperactividad (TDAH), e-Learning, Sistemas Hipermedia Adaptativos (SHA), Videojuegos, Gamificación, Educación inclusiva, Diseño Universal para el Aprendizaje (DUA).

Resum

L'objectiu de l'educació és promoure el desenvolupament personal i social per assolir els ideals de pau, llibertat i justícia i així ajudar a reduir la pobresa, l'exclusió, la ignorància i la guerra. No obstant això, la qüestió és si l'educació està contribuint al desenvolupament de societats més inclusives o, per contra, està portant a l'exclusió social i generant diferents formes de discriminació, donat que al llarg de la història, el sistema educatiu s'ha orientat cap al desenvolupament de pràctiques educatives homogènies i uniformes que responen únicament a les necessitats educatives i d'aprenentatge d'una població estudiantil majoritària considerada & 'regular'. D'això es pot dir que el sistema educatiu té un deute històric amb la societat, específicament amb aquelles persones que no encaixen en aquesta etiqueta regular. En aquest context, organitzacions i polítiques internacionals i nacionals intenten que totes les nacions passin d'un enfocament d'educació homogeni a un enfocament basat en la diversitat.

Les Tecnologies de la Informació i la Comunicació ofereixen l'oportunitat de respondre a les diferències individuals dels estudiants, ja que tenen el potencial de crear entorns educatius i de formació altament versàtils que poden proporcionar als estudiants igual accés al coneixement, independentment de les seves preferències , necessitats d'aprenentatge, gènere, ubicació, origen socioeconòmic o ètnic, malaltia o discapacitat, o qualsevol altra circumstància que normalment obstaculitzaria la provisió d'una educació d'alta qualitat. En aquest context, l'e-Learning s'ha convertit en una eina essencial per a l'ensenyament d'un gran nombre d'estudiants, ja que proporciona i integra una àmplia gamma de recursos i materials didàctics (per exemple, vídeo, àudio, text, subtítols o llenguatge de senyals), que poden adaptar-se per respondre a una varietat de necessitats i preferències d'aprenentatge.

En els processos de formació presencial, els professors poden fàcilment comprendre com els seus estudiants treballen i aprenen. No obstant això, en e-Learning és més difícil per als professors monitoritzar com els seus estudiants es comporten i aprenen. Així com identificar si tenen alguna dificultat específica en el seu procés educatiu. Els Sistemes Hipermèdia Adaptatius (SHA) aplicats a l'educació van sorgir com una estratègia per oferir processos de formació e-Learning adaptats a les característiques i necessitats dels estudiants, però la veritat és que la majoria de les investigacions es van enfocar en seguir oferint més i més sofisticades eines per a la població regular, deixant de banda els que al llarg de la història no van ser considerats.

En aquesta tesi, els SHA són usats per generar processos de formació e-Learning que consideren les característiques dels estudiants universitaris que sofreixen del Trastorn per Dèficit d'Atenció i Hiperactivitat (TDAH). De manera general, es va desenvolupar un procés que va des de la detecció de símptomes fins a a el suport acadèmic. Específicament, es va desenvolupar un model de l'estudiant que considera informació personal, demogràfica, acadèmica, comportamentales, històrica i cognitiva per identificar si un estudiant e-Learning pot tenir símptomes del TDAH. Després d'això, considerant preferències i fortaleses de les persones amb TDAH, es van integrar dues estratègies didàctiques en el procés acadèmic, una basada en videojocs i una altra en gamificación. Addicionalment, es va desenvolupar una tercera estratègia basada en la implementació del Disseny Universal per a l'Aprenentatge (UDL) considerant la seva filosofia de contribuir a disminuir les barreres que no permeten processos de formació de qualitat per a tots.

Els resultats obtinguts van mostrar, en primer lloc, que és possible identificar els símptomes del TDAH en ambients e-Learning; i, en segon lloc, l'impacte positiu dels videojocs, la gamificación i l'UDL no solament en el rendiment acadèmic, sinó també en l'experiència d'aprenentatge de tots els estudiants, inclosos els que pateixen TDAH.

En conseqüència, en general, aquesta tesi contribueix al coneixement en el camp de l'Aprenentatge millorat amb tecnologia en els següents aspectes:

1) Identificació d'informació que permeten inferir si un estudiant e-Learning podria tenir sintomas del TDAH.

2) Evidència sobre l'efecte positiu dels videojocs, la gamificación i la implementació d'UDL en el rendiment acadèmic i l'experiència d'aprenentatge dels estudiants que pateixen TDAH.
3) La definició i el desenvolupament d'una solució tecnològica integral que agrupa diverses eines Web i que va des de la detecció de símptomes fins al suport didàctic educatiu, considerant les fortaleses, preferències i febleses dels estudiants que sofreixen de TDAH en ambients e-Learning.
4) Evidència de poder utilitzar l'e-Learning com un mitjà perquè els estudiants amb TDAH duguin a terme els seus processos de formació de manera inclusiva.

PARAULES CLAUS: Trastorn per Deficit d'Atenció i Hiperactivitat (TDAH), e-Learning, Sistemes Hipermèdia Adaptatius (SHA), Videojocs, Gamificació, Educació inclusiva, Disseny Universal per a l'Aprenentatge (DUA).

PART 1
THEORETICAL WORK

CHAPTER 1
INTRODUCTION

1.1 PROBLEM STATEMENT

Individuals differ from one to another for many reasons: social, cultural, geographic, economic, ethnic, religious, sexual, intellectual, motor or sensory. This diversity throughout history has led to the exclusion of positive participation in the economic, social, politics and culture context of the society. "Such a society is neither efficient nor safe nor fair" (UNESCO, 2003, p.3).

Education seeks to promote personal and social development to achieve the ideals of peace, freedom and justice and thus helps reduce poverty, exclusion, ignorance and war. However, the question is whether education is contributing to the development of more inclusive societies, or, conversely, is playing social exclusion and generating different forms of discrimination within education systems.

In this context, many international and national policies, conventions, declarations, and statements have been arise to promote the provision of education for all people, without discrimination. The Education For All policy framework geared by the UNESCO Salamanca Statement (UNESCO, 1994) stipulates that education is a right for everyone regardless of physical and psychological characteristics, ethnicity, social class, cultural background, economic status, gender, race, religion, or ability (UNESCO, 2009).

Attention to diversity has raised the need for an inclusive education. UNESCO (2005) defines inclusive education as a process intended to respond to students' diversity by increasing their participation and reducing exclusion within and from education. The challenge posed by greater diversity is to enable students with divergent needs, skills, and interests to attain the same high academic standard.

ICT offer the opportunity to respond to the multifaceted individual differences because have the potential to create highly versatile education and training environments that can provide equal access to learners regardless of gender, geographic location, socio-economic or ethnic background, illness or disability, or any other circumstance that would normally hinder the provision of high-quality education. In this context, UNESCO (2016) expresses that ICT are a bridge to the universal entry of education, equality, quality learning and improving personal and professional development. Against this background, it is worth mention that the European Commission (EC), the Organization of Ibero-American States (OIA), the Economic Commission for Latin America and the Caribbean (ECLAC), among others, have launched many projects and programs such us ALTER-NATIVA project (ALTER-NATIVA, 2013), EU4ALL project (EU4ALL, 2006), MICOLE project (MICOLE, 2004), and @LIS2 project (@LIS2, 2009), which focus upon the use of ICT to support the learning of all students in inclusive settings.

E-Learning is defined as learning facilitated and supported through the use of ICT (Moore, Dickson-Deane and Galyen, 2011). It has become an essential tool for the teaching of large numbers of diverse students and support face-to-face teaching. This is because e-Learning enables to provide and integrate a wide range of teaching resources and materials (e.g. using video, audio, text, closed caption, subtitles or sign language, multiple languages, and easily understandable expressions), that can be adapted to suit a variety of learners' weaknesses, strengths and preferences.

In traditional learning, teachers can easily get an understanding into how their students work and learn. However, in e-Learning, it is more difficult for teachers to monitor how individual students behave and learn in the system and more difficult yet identify if a specific student may have a special educational need (Graf, Kinshuk and Liu, 2009). Addressing a special educational need in the context of e-Learning implies to detect the students' special need and also their preferences.

Adaptive Hypermedia Systems (AHS) support personalized learning, an alternative to the traditional "one-size-fits-all" approach. AHS build a user model of the goals, preferences and knowledge of each individual user, and use this model in order to adapt to the needs of that user in a system (Brusilovsky, 1996). AHS can be useful in any application area where users of a Hypermedia System have essentially different goals and knowledge and where the hyperspace is reasonably large. AHS for e-Learning was one of the first application areas for AHS. In educational context, the user model is usually called student model.

Student modelling supports the recognition and monitoring of special needs through building up and updating a student model. To be able to address a learner' need in an appropriate way a reliable student models is necessary, however getting enough information about a learner to create the model is quite challenging.

In this regard, it is worth mentioning some researches developed in the Broadband Communications and Distributed Systems (BCDS) research group, in which attention to educational needs were attended. In this context, Gelvez, Baldiris and Fabregat (2011) focused a master research in students suffering from hearing deficits in Virtual Learning Environments, specifically, the implementation of a student model that permits to indicate if students suffering from hearing impairments are influenced by augmented reality technology. Bacca, Baldiris, Fabregat, Guevara and Calderon (2012) developed an authoring tool for the creation of accessible Web content to teach Spanish as a second language in indigenous population. Avila, Baldiris, Fabregat and Guevara (2012) proposed a Web content accessibility evaluation process for learning objects in e-Learning environments. Further, Mejía (2013) focused her PhD thesis in developing a framework for detection, assessment and assistance of University Students with Dyslexia and/or Reading Difficulties in which Learning analytics were used. These and much other research throughout the world have been developed.

Nonetheless, much remains to be done considering the amount of people for whom there are many barriers to study, who have found in e-Learning an option to carry out their learning process. According to the National Center for Education Statistics (NCES), during the 2007–2008 academic year, 26 percent of the students who enrolled in a distance education course reported having mobility disabilities, 21 percent reported having sensory disabilities, while another 20 percent indicated that they were affected by other long-lasting conditions, such as cognitive disabilities (Radford, 2012). These statistics, together with the data given by the World Health Organization (WHO) and the World Bank in the global report on disability (2011), in which they indicate that more than a billion people live around the world with some form of disability, demonstrate the need to work in this address. In this context, several countries are targeting virtual education as an important resource to promote inclusion and social mobility (Cabero and Córdoba, 2009; Rama, 2013) given its foundation of autonomous learning, using various methodologies and available strategies that can be accessed by a student without taking into account geographic, temporal, age, gender, race, political, social and cultural barriers. This is the case of Colombia where the Ministry of Education encouraged to increase the virtual education in order to expand coverage and guarantee the quality of education, specifically technicians and technologists programs linked to the productive sector and the competitiveness of companies (Noriega and Torres, 2011). In this context, The Asociación Colombiana de Instituciones de Educación Superior con Programas a distancia (ACESAD) and Virtual EDUCA visualize virtual education as a tool to reduce educational exclusion and help the right to education to be fulfilled, thus generating greater inclusion social, providing quality education and strengthening education as an economic, cultural, social and political development of society (ACESAD & Virtual EDUCA, 2013).

ADHD is a neuro-biologically and neuro-psychologically heterogeneous disorder characterized by inattention, hyperactivity and impulsivity, with an approximate prevalence of 5.9-7.1% in children and adolescents and 5% in young adults, indicating a high persistence into adulthood (Rodillo, 2015). This research work is centered on young-adults people suffering from ADHD, especially those in a university context, who are included in a long life e-Learning process.

Some of the reasons for focusing this thesis on this group of people are described by Nugent and Smart (2014):

a) Many students identified with significant levels of ADHD symptoms in the university have not been previously diagnosed.

b) Students with ADHD have significantly lower university grade point averages, both at the beginning of their studies and throughout college.

c) Affected individuals are significantly more likely to withdraw from a course than students without ADHD.

d) Increasing numbers of individuals diagnosed with ADHD are pursuing postsecondary education and therefore face the transition into adulthood in the challenging environment of college or university.

e) Due to the impact that ADHD generates across several domains, including academic, occupational, social, and psychological, for those with ADHD, the transition between adolescence and adulthood can be a particularly difficult time of life.

Other reasons are:

f) During the last few years, the number of people diagnosed with ADHD has been increasing (Pastor et al. 2015);

g) Several studies have reported that most students with deficits such as those that compose the ADHD, who take online courses, drop them in few days because they find the courses hard to follow (Grabinger, 2009).

h) Contrary to what happened before the research conducted on ADHD was mostly focused on children and adolescents, forgetting young-adult and adult population (Kroes et al., 2001), (DuPaul, et all, 2009); Recently, college students with ADHD have begun to receive more attention, largely due to the increase in numbers of high school students with ADHD pursuing higher education, as well as reports of prescription stimulant misuse on college campuses (Weyandt and DuPaul, 2012).

In an attempt to understand the academic problems associated with ADHD university students, it is important to consider that the ability to wait to gain long-term reward in lieu of a short-term reinforcement is a common impairment for individuals with ADHD (Bitsakou, Psychogiou, Thompson, and Sonuga-Barke, 2009; Plichta et al., 2009; Solanto et al., 2001). In addition, several of the intermediate steps required to achieve satisfactory grades, such as, organization, planning, avoiding distractions, and taking class notes, are common problems experienced by young-adults with ADHD (Goodman, 2009; Weyandt and DuPaul, 2008). Procrastination is also a common detriment to academic performance (Rabin, Fogel, and Nutter-Upham, 2011), and research suggests that procrastinating schoolwork has more detrimental outcomes for individuals with ADHD than other college students (Advokat and Vinci, 2012). Therefore, despite the fact that long-term reinforcement of a desired grade is sufficient for many typically developing university students, individuals suffering from ADHD may require interventions specifically targeting the intermediate steps required for academic success. Additionally, university life requires self-directed learning, consolidates academic skills and group adaptation strategies. In view of the foregoing, it could be concluded that it is necessary to redesign university didactic educational strategies to include ADHD students. This is how several researchs have proposed different school-based interventions for meeting the needs of students with ADHD, such as positive reinforcement, response cost, peer tutoring, home-school notes, allowing alternative response modes, using special organizational systems, modifying tests and using prompt cards). These strategies have been developed, as well, to train teachers to handle ADHD students in classroom environments (Kutcher et al., 2004). In the process of getting more significant learning for ADHD, multiple tools and strategies that integrate ICT have been developed to favor the educational inclusion and educational development of students with ADHD (Chousa, Martínez-Figueira and Raposo-Rivas, 2017).

To address all the above mentioned, the main aim of this dissertation is focused on offers university students suffering from ADHD who have founded in e-Learning the opportunity to develop their learning processs, strategies that considerer their weakness but above all their strengths and preferences. Based on this, the following Main Research Question (**MRQ**) is posed:

MRQ: Which are the components that should be considered for design an inclusive e-Learning intervention that enhances the academic performance of university students suffering from ADHD?

This main research question raises three main issues:

RI1: How to detect ADHD symtopms in e-Learning students?

RI2: How to achieve that e-Learning students who suffer from ADHD obtain a better academic performance?

RI3: How to achieve an e-Learning experience that includes students with ADHD?

1.2 JUSTIFICATION

One of the most pressing challenges of education systems nowadays is to enable equitable and quality education for all, which prioritizes the values of inclusion in a framework of common action. However, the adoption of inclusive education is not an easy issue due to several concerns, including that many times teachers are not prepared to respond to diversity in the classroom, many learning resources are not designed to respond to the variety of preferences and strengths of all students, in many cases it represents an additional investment cost or increased workload for teachers. It is therefore necessary to be aware of the diversity existing in the classrooms, derived from individual differences within the framework of an inclusive educational model.

ADHD is a disorder that affects several aspects of a person's life, including the educational one. However, although all major medical groups - including the American Academy of Pediatrics (AAP), American Medical Association (AMA), American Psychiatric Association (APA), and National Institutes of Health (NIH) - recognize ADHD as a valid condition that should be treated and addressed in classrooms, many teachers and health professionals do not value it as such. This implies that many people who are suffering from it are considered lazy and problematic although there are evidences that there is a link between poor academic performance and ADHD (Wu and Gau, 2013; Daley and Birchwood, 2010; Loe and Feldman, 2007; Nugent and Smart, 2014).

Inclusive e-Learning has opened the possibility for all students, including those for whom there are many barriers to carry out their learning processes in face-to-face training process. One of the reasons is that it provides multiple means of information representation as well as multiple means of actions, making it easier for all people to access education. In an attempt to address these concerns, this thesis was proposed to take advantage of ICT to provide training processes for students with ADHD who have found in e-Learning the possibility of carrying out their education processes. This process was conceived from the outset to take into account the strengths and preferences of students with ADHD through the use of technology.

In view of the foregoing, it is appropriate to conduct this research because diversity is here to stay and students with ADHD are one part of the challenge. Better educational practice will provide in both virtual and face-to-face contexts as long as there are more resources and training strategies that consider the strengths and preferences of all students. People who work in the line of TEL must find the way that these really become a means that facilitates the education for all and not only for those who in fact already have the possibility to access to an amount of educational resources.

This is how this strategy contributes to society in general since it provides an inclusive strategy, which takes into account the characteristics of students with ADHD, but it contributes in a particular way to the entire e-Learning community, including students, teachers, families, relatives and other people that are related in some way to ADHD.

1.3 OBJECTIVES

The problem statement and justification of this work (described in sections 1.1 and 1.2) allowed the author to define the following General Objective (**GO**):

1.3.1 General Objetive

To design an inclusive e-Learning training strategy that considers the characteristics of university students suffering from ADHD to provide them a quality and equitable learning process.

This general objective was supported by the following Specific Objectives (**SO**):

1.3.2 Specific Objectives

- **SO1**: To identify research and evidence-based literature of the existing barriers for a healthy participation of students suffering from ADHD, as well as their strengths, preferences and weaknesses in order to identify a teaching strategy focused on obtaining a better academic performance.
- **S02**: To design and implement a computer-assisted evaluation protocol to identify students with possible symptoms of ADHD applying student-modeling techniques in e-Learning context.
- **SO3**: To design and implement a computer-assisted academic intervention to improve the academic performance of ADHD students who have found in e-Learning an opportunity to carry out their university education.

However, in accordance with the aim of the educational system and the actual dynamics of e-Learning about creating inclusive educational practices to attain a more equitable educational system to attended the Universal Declaration of Human Rights, this research formulates a four objective:

- **SO4**: To design and implement an intervention supported by technology and good practices in attention to diversity to provide an e-Learning a training process that includes university students with ADHD.

1.4 SCOPE AND LIMITATIONS

This project aims to generates e-Learning processes that consider the characteristics of university students who suffer from ADHD. Overall, it was proposed a solution that ranges from symptoms detection to academic intervention. Specifically, it was developed a student model based on personal, demographic, academic, behavioural conduct, background and cognitive performance information to create student profiles which indicate if an e-Learning student could have ADHD symptoms. After that, it is proposed to use teaching strategies focused on the preferences, strengths and weaknesses of university students suffering from ADHD to offer them quality and equitable training processes. It becomes very important to mention that this work is oriented for academic purposes and therefore should not be considered as a tool for clinical purposes.

Regarding limitations, the two most important aspects were:

1. The first one, the difficulty of obtaining a sample of the population under study to carry out the validation scenarios. It was necessary the intervention of the university welfare to capture and achieve the commitment of the students for the participation in the research.
2. The second one, the lack of free access and open source ADHD symptoms evaluation tools which incurredin time and programming costs. At this point, it should be mentioned that there are very refined tools that collect more precise information related to the operformance of users. Our tools collect the just enough information.

1.5 OUTLINE OF THE THESIS

This work was divided into two main parts, the theoretical and the empirical one. In turn, each part is divided into chapters, which correspond to the steps taken to achieve the objectives proposed in this research. In total there are 7 chapters, four of them are part of the theoretical part: introduction, background and literature review, research methodology, and the theoretical solution.

The three remaining chapters, which are part of the empirical part, describes the development of the two modules that make up the framework of the solution, these are: the ADHD Student Model Module and the ADHD Academic Intervention Module, which includes the videogame, the gamification and the UDL strategies. Finally, the chapter of contributions and future work complete the second part of the document.

CHAPTER 1 presents the statement problem including research questions, justification, hypotheses, objectives and the structure of the document.

In CHAPTER 2, the theoretical framework that supports this work is presented. It includes a background of inclusive education as a philosophical basis that leverages the all research; e-Learning as modality of learning process that offers a tool range to develop inclusive education; Adaptive Hypermedia Systems in education as the way to personalize e-Learning environments; ADHD since it is the target group of this research, emphasizing in the implication of this disorder in academic performance and works made in e-Learning context for this population. Finally, it addresses the concepts of game-based learning, serious games and gamification as teaching strategies that use playful as part of the training process to support students with ADHD who have found in e-Learning the possibility of completing their university processes.

In CHAPTER 3, the research methodology drawn up to carry out this thesis is presented, including the approach, the scope, the design, the setting, the participants, the method and instruments for data collection, the type of data and analysis, the reliability and validity of what was done and the ethical considerations.

In CHAPTER 4, last chapter of the teorethical work, the general and conceptual solution proposed to answer research question and aim objectives is presented. Specifically, this chapter engages all the proposed components to respond to the characteristics of students with ADHD and thereby achieve inclusive educational interventions.

In CHAPTER 5, the ADHD Student Model Component is thoroughly described. It means that the whole student modeling approach developed, from the technological development until the implementation of a concrete study case, for identifying students suffering from ADHD symptoms in e-Learning contexts is explained.

In CHAPTER 6, the ADHD Academic Intervention Component, which are the teaching strategies designed and implemented to provide a training process that considers the characteristics of e-Learning students suffering from ADHD is described. On the one hand, the first teaching mediation proposed to support e-Learning students who suffer from AHD consists of using AtenDerAH, a serious game developed to train affected cognitive and behavioral areas in people with ADHD. This part ranges from the development of the necessary resources to carry out the mediation to the study case by means of which the proposed teaching mediation was implemented. On the other hand, this chapter presents the second teaching mediation designed to support the processes of students suffering from ADHD, which consists of using gamification, this part ranges from the development of the necessary resources to carry out the mediation to the study case through which the proposed didactic mediation was validated and implemented. Moreover, this chapter includes the third strategy designed, which consists of using UDL to design the e-Learning experience responding to the preferences, strengths and weakness of student suffereing from ADHD but also the e-Learning experience of students without this disorser.

Finally, in CHAPTER 7, closing discussions are carried out. It includes the conclusions obtained in relation to the objectives previously set, the specific contributions achieved in the field of TEL and the projections for future research.

In addition, this document contains three appendices: Appendix A presents the validation by expert judgment for the ADHD Student Model Component, Appendix B presents the validation by expert judgment for the ADHD Academic Intervention Component, and Appendix C presents the consent and briefing letter used to ask student consent to participate in this research.

CHAPTER 2
BACKGROUND AND LITERATURE REVIEW

2.1 OVERVIEW

Aligned with the problem statement and justification presented in CHAPTER 1 and to address the first specific objective defined for this thesis: "**SO1**: To identify research and evidence-based literature of the existing barriers for a healthy participation of university students suffering from ADHD, as well as their strengths, preferences and weaknesses en academic context, in order to propose an academic intervention focused on obtaining a better academic performance and learning experience", in this chapter author presented the main theoretical bases supporting this research, in educational, technological and study population context.

To begin, the concept of inclusive education as the philosophical basis that leverages this research is outlined in section 2.2. As a subsection of this part, the Universal Design for Learning (UDL) is presented as a teaching proposal that arises to address diversity in the classroom. Subsequently, the sense of TEL as the main research line to which this research contributes is briefly defined in section 2.3. This section includes an explanation of e-Learning and inclusive e-Learning, as a means that facilitates education for all; and also, it includes the concepts of Game-Based Learning, Serious Games and Gamificaton as teaching strategies used in e-Learning contexts. Following, the concept and elements of Adaptive Hypermedia Systems as an alternative to the traditional "one-size-fits-all" approach in the development of e-Learning platforms are explained in sections 2.4. Among the AHS elements, the student model is widely explained. Afterwards, a background of ADHD, target group of this research, is explained and particular reference is made to the implication for academic performance in Section 2.5. Finally, the conclusion of this part of the research is presented in section 2.6.

2.2 INCLUSIVE EDUCATION

Education is one of the most powerful, if not the most powerful, tools for moving towards more inclusive and democratic societies. However, history shows that the education system is not managing to compensate for the inequalities of the students or to be a lever of social advance.

Exclusion in education is a phenomenon of great magnitude that not only affects those who are out of school, because they have never acceded or left early, but also those who are being schooled are segregated or discriminated by their ethnicity, gender or origin social, by their abilities or life situations, or to those who do not achieve satisfactory learning outcomes because they receive an education of lower quality (Blanco, 2008). There is now a broad consensus that the right to education goes beyond mere access or schooling, but constitutes the right to an education of equal quality for all, which should promote the maximum development and learning of each person, and the right to be educated in regular classrooms, that is, on equal terms. From this, it can be said that the education system has a historical debt to society, specifically to those people who do not fit into the regular label. In this context, international and national organizations and policies seek to move from a homogeneous to a diversity-based approach. This diversity-based approach is refered to an inclusive education.

Some of the key international instruments that have been raised to promote the provision of education for all people, without discrimination are:

- The Education For All movement, which was launched at the World Conference on Education for All in Jomtien, Thailand, declared the rights of all children, young people and adults to education (UNESCO, 1990).
- The United Nations Standard Rules on the Equalization of Opportunities for Persons with Disabilities, which represent the firm moral and political commitment of

governments to the adoption of measures aimed at achieving equal opportunities for persons with disabilities (UN, 1993).

- The UNESCO's Salamanca Statement on Principles, Policies and Practice in Special Needs Education was adopted and asserts that education for all must encompass the inclusion of all types of learners in a single learning environment (UNESCO, 1994).
- The commitments generated at the World Education Forum, which established the Dakar Framework for Action Education For All, where flagship initiatives on education and disability were implemented (UNESCO, 2000).
- The Convention on the Rights of Persons with Disabilities (CRPD), which adopts a broad categorization of persons with disabilities and establishes the recognition of the rights and responsibilities of persons with disabilities who, in the field of education, favor the approach of inclusive education (UN, 2007).

In response to these calls, at the regional level, many nations have created laws and action plans to move towards a fair and inclusive education system. It is the case of the Action Plan of inclusive Education (2008/2015) in Catalonia (Departament d'Educació, 2014) which prohibits discrimination in education and supports inclusive education, plan that was reaffirmed and reinforced with the decree 150/2017 (Decree 150/2017, 2017); or the Colombian 1816 Statutory law of 2013 (Statutory law 1816, 2013), which established rules to ensure the full exercise of the rights of people with educational needs in diversity and more recently decree 1421 of 2017 (Decree 1421, 2017) by which educational attention to the population with disabilities is regulated in the framework of inclusive education.

Several definitions have been given about what inclusive education is, however the author is based on the following for its simplicity and clarity. Inclusive education is "a process intended to respond to students' diversity by increasing their participation and reducing exclusion within and from education. Inclusive education is no only refers to people with disabilities but it is about support diversity in the classroom" (UNESCO, 2005).

The challenge posed by greater diversity is to enable students with divergent needs, skills, and interests to attain the same high academic standard. In this sense, Blanco (2014) argues that:

> Moving towards greater inclusion is a complex task because it implies a systemic change that affects the different levels and components of education systems - because the same system that excludes it cannot include - and a cultural change that implies the whole of society (p. 27).

Thereby, in education, accommodating learners who are marginalized by traditional education delivery has and continues to expand the boundaries of the domain and inspire new policies, strategies and practices that benefit all learners. According to Marchesi (2014), responding to the challenge of inclusive education requires:

> To work in the sensibilisation of all the actors of the system, to oppose an inclusive school that is attractive to the majority of the citizens for its educational offer, the teaching style of the teachers, its concern for the diversity of the students and their search for new approaches and means of participation and connection with society (p. 38).

Additionally, several authors affirm that ICT is a key element to achieve an inclusive education because it allows responding to the diverse abilities of the students, including those with ADHD (Chousa, Martínez and Raposo, 2017; Trigueros, Sánchez and Vera, 2012; Estévez and León, 2014; Rojas, Gómez and García, 2013).

On the basis of the above, it is possible to say that overcoming exclusion into education requires to continue working on a wide range of areas including, political, psychological, pedagogical and tecnological with the help of several actors, the students themselves, the professors, the administrative staff, the researchers, the government, among others. Current strategies, programs and policies are an important base, however, additional efforts are needed to achieve a

more just and educated society. Along this path, various pedagogical theories have emerged to facilitate the design of inclusive learning experiences.

2.2.1 Universal Desing for Learning (UDL)

Several pedagogical theories have been proposed, such as the Universal Design for Learning (UDL), the Differentiated Instruction (DI) and the Understanding by Desing (UbD), which have as their essence to design teaching experiences based on the characteristics of each student to respond to all (Rapp, 2014). The UDL is the most widely used framework for providing inclusive educational practices. It is a framework that stated the challenge posed by diversity in the classroom can be supported through the advances on neuroscience on individual learning differences and the power and versatility of technological tools (Rose and Meyer, 2002). According to Rose and Meyer (2002) "the task for educators is to understand how students learn and use technology available in this digital age to provide selected supports where they are needed and position the challenge appropriately for each learner" (p. 8).

The basis on brain research in which the UDL supports their framework is that there are three networks of the brain, which have been identified to be essential for learning:

- Recognition (The "what" of learning)
- Strategic (The "how" of learning)
- Affective (The "why" of learning)

The recognition network enables the identification and understanding of information, ideas and concepts. The strategic network allows planning, executing and monitoring actions and skills. And the affective network enables the engagement with task, learning and the world around. According to Rose and Meyer, although these three neural networks work together to coordinate learning, individual brains differ substantially in the way they perceive and comprehend information, the way they can navigate a learning environment and express what they know and the influence sources that affect individuals to learning.

The UDL framework defines three principles:

- To provide multiple means of representation.
- To provide multiple means of action and expression.
- To provide multiple means of engagement.

The UDL states that address these principles support an affective learning (Meyer, Rose and Gordon, 2014). In conclusion, the UDL principles suggest that to accommodate a broad spectrum of learners, universally designed curricula require a range of options for accessing, using, and engaging with learning materials and states that new digital media and assistive technology offer the opportunity to do it considering their qualities, versatility and transformability (Rose & Meyer, 2002). In this context, curriculum is referred to the definition of the set of core competencies, objectives, contents, methodology, evaluation and feedback that guide the route the students must transit in certain level of education.

In order to help and guide teachers in this process of curriculum design, the UDL framework suggests four templates:

1) The class learning profile template, Table 1, helps teachers to identify learners'strengths, weakness, and preferences. The idea is to highlight the particular student talents, weaknesses, or interests that could facilitate or hinder the effectiveness of the teaching process. For each student is analized the particularities which may affect their ability to make use of the curriculum as originally planned.

Table 1. *The Class Learning Profile Template*

Grade:	**Teacher:**	**Subject:**	**Goal:**	**Date:**
Network	Students Strengths	Students Weaknesses	Student Preferences	
Recognition				
Strategy				
Affect				

2) The curriculum barriers template, Table 2, helps teachers to identify the potential barriers inherent in the planned curriculum materials and methods. In the left column must be listed each method or material that is used in the teaching process and this is aligned with the student qualities defined in the class learning profile. Thus, this template permits to highlights barriers created by the interaction between materials, methods, and student qualities and points out missed opportunities created in the intersection between materials, methods, and student strengths or interests.

Table 2. *The Curriculum Barriers Template*

Grade:	**Teacher:**	**Subject:**	**Goal:**	**Date:**
Materials and Methods		**Students Qualities**		**Potential Barriers/Missed Opportunities**

3) The UDL solutions template, Table 3, helps teachers to consider the barriers previously identified to select, assemble or create flexible learning materials and methods including tools, digital content and Web-based materials to minimize barriers for students:

Table 3. *The UDL Solutions Template*

Materials and Methods	**Potential Barriers/Missed Opportunities**	**UDL solutions**

4) The creating systemic change template, Table 4, helps teachers apply the relevant parts of the concord model to the school o district to build new instructional approaches for reaching every learner (Rose et al, 2002).

Table 4. *The Creating Systemic Change Template*

Concord Model Component	**Implementation examples**
1. Technology infrastructure 2. Administrative support	

As mentioned, Information and Communication Technologies (ICT) play an important role to favor inclusion since they offer the opportunity to respond to the multifaceted individual differences, because they have the potential to create highly versatile educational and training environments that can provide students with equal access to knowledge, regardless of their preferences, diverse learning needs, gender, geographic location, socio-economic or ethnic background, illness or disability, or any other circumstance that would normally hinder the provision of high-quality education.

Next section presents the concepts of TEL, carrying out more in-depth concepts of adaptations and personalization in e-Learning.

2.3 TECHNOLOGY ENHANCED LEARNING (TEL)

In the present globalized world, technology has a great impact on all the fundamental aspects of life, including Education. TEL is the field where technology plays a significant supportive role in making learning more effective, efficient or enjoyable. Related concepts and terminologies that reflect applications and developments in ICT applied to teaching and learning include:

- Learning Management System (LMS): programs through which it is managed and carries out teaching-learning processes using its different tools, such as: forums, messaging, announcements, course content, assessment.
- Immersive learning environments: models (typically 3D) where participants can explore and learn in a simulated environment or virtual world.
- Open learning: sharing of learning resources through open licensing and agreements, e.g Massive Open Online Course (MOOC).
- Collaborative technologies: Web 2.0 offers community and user involvement that maps well onto many learning activities.

With these types of technologies and applications, e-Learning training processes are carried out. Next section presents a more detailed description of the e-Learning concept emphasizing in technologies that are trending in e-Learning and the aplication that allow to manage the necessary actions to carry out the e-Learning training process, i.e. the Learning Management Learning (LMS).

2.3.1 E-Learning

E-Learning is learning utilizing electronic technologies to access educational curriculum outside of a traditional classroom. However, it is important to understand that e-Learning is not just about technology or about adding technology to existing ways of doing things. It is about integrating technology and using it to enhance and transform teaching and learning, it means moving from architecture of presentation to architecture of participation in which technology is used to help learners manage and direct their own learning. There are severeal types of e-Learning, including the represented in Figure 1.

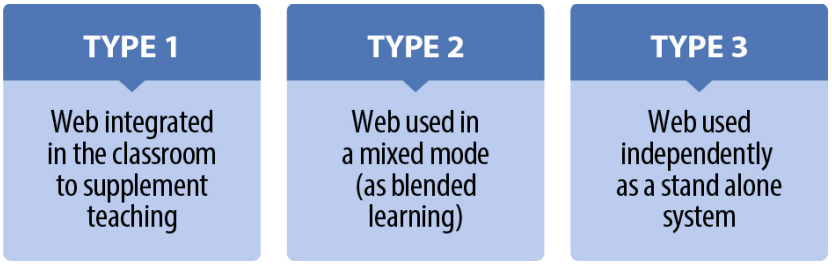


Figure 1. *Different forms of e-Learning. Source: Author*

In e-Learning, some teaching and learning approaches have managed to achieve greater student motivation, promote learning, improve problem-solving skills, promote greater student interaction, improve performance academic, among others, contrasting some aspects such as the lack of personal contact and dropout rate. Some of these trending approaches are:

- Personalised learning: tailoring the learning experience to an individual student's needs and desires. This has the potential to match the mode, learning style, preferences, among others to students. It is a key feature of flexible pedagogies.
- Games in educational context: which includes gamification, serious game and gamed-based learning.
- Mobile learning: "A form of learning delivered through mobile devices, such as basic phones, PDA, smartphones, tablets and similar devices combined with e-Learning content " (Park, Baek and Gibson, 2008).
- Virtual reality: Two different kinds of VR can be identified: non-immersive and immersive. The former is a computer-based environment that can simulate places in the real or imagined worlds; the latter takes the idea even further by giving the perception of being physically present in the non-physical world (Freina and Ott, 2015).
- Augmented reality: is a technology that allows computer-generated virtual imagery information to be overlaid onto a live direct or indirect real-world environment inreal time (Zhou, Duh and Billinghurst, 2008).

Next section addresses the concepts of games in educational context since were the strategies used in this research to support the teaching-learning processes of university students with ADHD.

Games in educational context: Game-Based Learning, Serious Games and Gamificaton

Before moving on to a description of Game-Based Learning, Serious Games and Gamificaton, it is important to remember that ICT should be supported by a pedagogical approach that describes the appropriate teaching methods and practices according to the profile of the student and the context of formation to achieve an effective academic mediation as discussed in Section 2.4.

In this context, pedagogy is the science in charge of studying the aims of learning and how humans being learn. This is relate to education: it is the process of socializing knowledge between individuals, which involves not only specific knowledge such as mathematics or reading, but also influences cultural behaviors and behaviors. Education, for example, can occur in diverse contexts such as home or work, while pedagogy has a direct relationship with teaching. On the other hand, teaching is a branch of pedagogy that is in charge of looking for methods, techniques and strategies to improve learning. It uses knowledge that already exists in pedagogy but concretizes it through teaching resources and also seeks to monitor the success or failure of such strategies.

In this sense, in the educational field, Game-Based Learning, Serious Games and Gamificaton have been proved to have positive effects, in addition to their entertainment value, when they are integrated in teaching-learning processes (Griffiths, 2002). Thus, as today, games have become an important teaching resource, which has the capacity to maintain the student's attitude and challenge them constantly (Kapp, 2012); motivate, teach, and shape the student's behavior (Teng and Baker, 2014).

The terms Game-Based Learning, Serious Games and Gamificaton are often used without any distinction, but they are different teaching strategies.

- Game-Based Learning is the use of games as a means of instruction. This is usually presented as learning through games in an educational context designed by teachers. Generally they are games that already exist, whose mechanics are already established, and are adapted so that there is a balance between the subject of study, the game and the ability of the player to retain and apply what has been learned in the real world (EdTechReview, 2013).

- Serious Games are technological games designed with a purpose beyond mere entertainment, that is, thought and created for educational and informative purposes, for example, simulators or games to create awareness (Dicheva, Dichev, Agre and Angelova, 2015). This type of games places the player or apprentice in a very particular context with the aim of developing a specific knowledge or skill. For this reason, it is difficult to incorporate a Serious Game into a different learning situation for which it was created. A Serious Game can be described as a purposeful game; seeks to influence the resolution of real problems in fabricated environments that simulate real life. Although they can be fun, this is not the intention for which they are created. Social change, skills development, emotional health, etc. are usually sought (Wouters, van Nimwegen, van Oostendorp and van der Spek, 2013).
- Gamification in education incorporates elements of game design to take advantage of them in the educational context. This means that it is not a matter of using games in themselves, but rather taking some of their principles or mechanics such as points or incentives, narrative, immediate feedback, recognition, freedom to make mistakes, etc., to enrich the learning experience (Deterding, Dixon, Khaled, and Nacke, 2011; Kim, 2015). Gamification works as a motivational didactic strategy in the teaching-learning process to provoke specific behaviors in the student within an environment that is attractive to him, that generates a commitment to the activity in which he participates and that supports the achievement of positive experiences to achieve meaningful learning.

Researchers recognize the value of games in educational context because they deliver authentic learning experiences that can model or simulate real life tasks (commonly known as next generation learning environments (Kirkley and Kirkley, 2005)). Years before, Gros had described this same phenomenon in (Gros, 2007), "... in all cases, a key factor of videogames is that they provide a rich environment of experimentation. The player interacts with a created and simulated real context, makes decisions and immediately perceives the consequences".

Moreover, several researches have studied and remarked the positive effects videogames have on specific disciplines, as well as demonstrated their use as a tool for some kind of help or support (i.e. scaffolding, motivating, training, therapy, among others) (Dondlinger, 2007). Thus, there has been recognized a significant impact when games are designed to address a specific problem or to teach a certain skill (Griffiths, 2002).

According to related literature, some skills developed by games in educational context are: facilitate establishing friendship relations with others, motivate people towards achieving goals and how they improve the ability to take risks, solve problems and make decisions (Greitemeyer and Osswald, 2010).

Specifically, in education, videogames have proven to be able to capture students' attention more effectively than other digital content, keeping them in the zone of optimal flow for knowledge creation. Some of these features could be especially advantageous for students with cognitive disabilities, which is a significant drawback for learning (Savidis, Grammenos and Stephanidis, 2006).

Nevertheless, it is also important to state that there are opposing studies on the benefit of video games in the potential to either cause or exacerbate attention problems. On the one hand, Swing, Gentile, Anderson, and Walsh (2010) found that the longer the exposure to video games is, the greater the attention problems. Similarly, Gentile, Swing, Lim, and Khoo (2012) reported attention problems in relation to video game use. On the other hand, Bavelier, Green, Han, Renshaw, Merzenich and Gentile (2011); Durkin (2010); Granic, Lobel and Engels (2014) highlight that video games are likely to have the potential to improve behavioral and cognitive outcomes for population with developmental disabilities, as well as positively impact some executive functions with implications for real-world behavior, like university setting (Buelow, Okdie and Cooper, 2015).

But many authors agree that it is importance additional researches to clarify the effects of Videogames. In this context, several authors point out that this area is important to study

because of mediated interventions, such as those with video games, hold promise for ADHD youth (Barkley, 2014; DuPaul and Stoner, 2014).

As additional values of using videogames to support the learning processes of university students with ADHD are the ones exposed by Strahler, Herrera, Uehara and Amodeo (2015):

> Initial studies, investigating a single administration of video game in children and adolescents with ADHD, report that video game use promotes a state of great cognitive performance (by promoting cognitive feedback), increasing the activation state and excitement of participants (promoting enhanced motivational performance) , increasing attention (14-16), and inhibitory responses (11, 17). The use of Video Game Training in rehabilitation process employs video game elements (mechanisms, dynamics, and esthetics), which empower the learning and motivational process (…).(p.1)

On the other hand, playing video games has turned into one of the most time-consuming leisure time activities of children and adolescents, which in this research, instead of taking it as a disadvantage, is taken as an advantage.

In order to guide the creation and design of video games there are several formal frameworks, one of them is the Mechanics, Dynamics and Aesthetics (MDA) (Hunicke, LeBlanc and Zubek, 2004) , which is widely used. The elements of the MDA framework are described below.

MDA Framework for videogame design

The MDA Framework is known as a formal approach to describe, analyze and understand games through their MDA. These three elements guide the creative process of the videogame design and help ensure a quality product for all the individuals that are part of the game: designers, programmers and gamers. Figure 2 shows a representation of each element and its relationship with the individuals that are part of it, either in its creation or consumption.

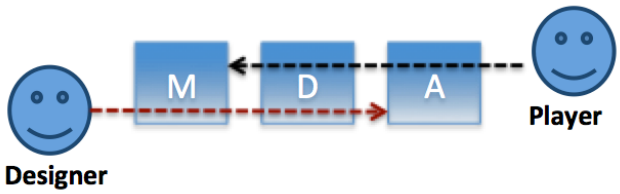


Figure 2. *Designer and player perspectives in MDA Framework. Source: Hunicke et al., (2004).*

The game Mechanics are the lowest level of abstraction of a game. This level is where algorithms and data representation are described, also called rules (Hunicke et al., 2004). In accordance with Zichermann & Cunningham (2011), the primary mechanics are points, levels, leaderboards, badges and challenges/quests and if these are designed and used correctly, it could lead promising responses from the players in terms of aesthetics (i.e. fun, emotions, desires satisfaction). Bunchball, Inc (2014) suggests that the common desires of different users include rewards, status, achievement, self-expression, competitions and altruism. Figure 3 illustrates the interaction between basic human desires and game play. The red XX signifies the primary desire a particular game mechanic fulfills, and the blue X shows the additional areas that it affects.

	Human Desires					
Game Mechanics	Reward	Status	Achievement	Self Expression	Competition	Altruism
Points	XX	X	X		X	X
Levels		XX	X		X	
Challenges	X	X	XX	X	X	X

Virtual Goods	X	X	X	XX	X	
Leaderboards		X	X		XX	X
Gifting & Charity		X	X		X	XX
	X	Suitablemechanic				
	XX	Most suitable mechanic				

Figure 3. *Human desires X game mechanics. Source: Bunchball, Inc (2016).*

The game Dynamics are the run-time behavior of the game Mechanics, meaning when the player interacts with Mechanics (Hunicke et al., 2004). For instance, backing to Figure 3, points are usually just a numeric value, but this number increase when the player performs a desired action and the "number" becomes meaningful for the player, this time as a reward. If the player accumulates a certain predefined amount of points, the player levels up. Similarly, to points, levels are commonly a numeric value, but this time represents a new status on game, that if is compared with another players' level, would represent a better (or worst) status that can be represented using another mechanic such as a leaderboard. Even though the game Mechanics from the previous example (points, levels and leaderboards) are basically numbers, they have different behavior and meaning, but all of them depend of player's actions.

Lastly, game Aesthetics are those that influence the emotions of players when they interact with the system (Hunicke et al. 2004). A good example of aesthetics is that excitement of a soccer player after scoring a goal, or the frustration of a chess player when a bad move was performed. Hunicke et al. (2004) proposes a set of terms to go beyond the words "fun" and "gameplay" to describe the aesthetics, which are sensation (game as sense-pleasure), fantasy (game as make-believe), narrative (game as drama), challenge (game as obstacle course), fellowship (game as social framework), discovery (game as uncharted territory), expression (game as self-discovery) and submission (game as pastime).

Learning Management System

In the field of e-Learning it is necessary to define and describe the LMS, also known as e-Learning platform, which is an hypermedia system that automates the management processes of teaching and learning (i.e., an educational software system).

Nowadays, there are many different e-Learning platforms, which typically share common purpose as:

- To manage and administer a curriculum to a large and sometimes scattered workforce,
- To create structured lessons,
- To publish tests or surveys,
- To share educational multimedia resources and documents, among others
- To enable educational resources, tools and services to support the learning process.

However, the individual features of each of these platforms can vary widely and in many cases, these features permit to choose one or the other. In the field of education research, the open source LMSs are usually used since the source code is open which permits to modified it to be highly customizable according to each study. In this context, Graf (2007) stated that the possibility of incorporating new features in order to provide adaptively and personalization of the work environment considering individual aspects of students is one of the more decisive characteristic for researchers to work with a specific LMS.

Based on a comparison among several LMSs conducted by Vilches (2007) and reforced by Velez (2009) and Mejía (2013), ATutor, dotLRN and Moodle are the most capable LMSs to support

customization, adaptability and accessibility aspects. A brief description of these three LMS is presented below.

- ATutor (2016) is considered one of the most accessible LMS available with an open source license. From its beginnings, this LMS was conceived under a user-centered design approach, favoring the attention to the users' needs and preferences. ATutor adopts the Web Content Accessibility Guidelines (WCAG) for crossing the barriers associated to web content development. In addition, it implements the ISO/IEC 24751-1:2008 standard, which offers the possibility to adjust the system to predefined users' needs and preferences. It permits to extend its functionality with feature modules and develop custom templates to give ATutor a new look. It can be installed on any web server with a PHP interpreter and support MySQL databases mangers. It is also important to mention that ATutor is cited in numerous technical reviews and academic articles.
- dotLRN (2006), also known as .LRN, was initially developed by the Massachusetts Institute of Technology (MIT). dotLRN is supported by a global consortium of educational institutions, nonprofit organizations, companies and open source developers. dotLRN is appropiated for learning and research communities, since it has course management, online communities, content management and learning management capabilities. Consortium member institutions work together to support the progress of each member and to accelerate and expand the adoption and development of dotLRN. The consortium ensures software quality certifying components through software development plans coordinated and maintaining ties with Open Architecture Community System (OpenACS).
- Moodle (2018) is an acronym that stands for Modular Object-Oriented Dynamic Learning Environment. It has been designed to support an educational framework based on the social constructivist philosophy. This LMS maintain educational contents centralized in a database and provides theses contents to students through a web-oriented interfaced. Moodle can be installed on any web server with a PHP interpreter and is has a complete support for the use of MySQL and PostgreSQL databases managers. Additionally, it has a broad development community and it is used for a large community of users around the world. Offer technological flexibility and usability.

On the other hand, according to Benktzon (1993) the different types of students who can access e-Learning are presented in Figure 4. As can be seen, at the end of the pyramid appear the ordinary learners who are individuals without physical and/or mental impariments and for whom typical learning strategies and resources do not represent a barrier. Subsequently, appear the students with special needs who are individuals with some kind of difficulties but who have not recognized physical or mental impairment as such, among them are, Learning Disabilities (e.g., dyslexia), ADHD, or elderly people with minor disabilities such as reduced strength, impaired hearing, etc. Benktzon states that for this type of students, learning strategies needs to be adapted. At the top of the pyramid appear the students with impairments (or disabled) who are individuals who require assistive devices due to severe mobility problems and reduced body functions, among them are deafness, blindness, mobility-impaired, cerebral palsy, etc; this group of students requiered accesible and usable learning resources and strategies in order to eliminate the barriers to access to learning content.

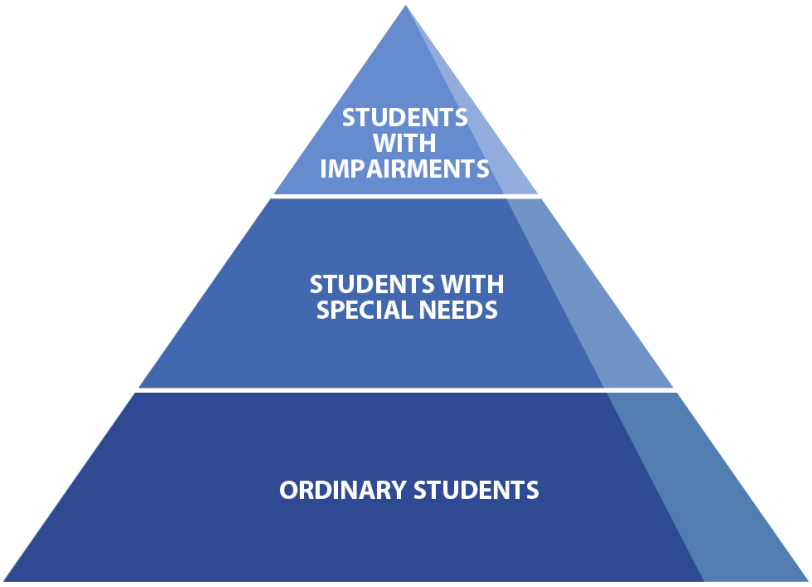


Figure 4. *The students pyramid to achieve a universal design. Source: Benktzon (1993).*

This is how, over the last years, training experiences have been developed for students with divergent needs using e-Learning.

This thesis focuses on e-Learning as a strategy that offers new opportunities for all students, including those with ADHD, but above all as a medium for teaching large numbers of diverse students because it provides and integrates a wide range of teaching resources and materials (e.g. video, audio, text, subtitles or sign language, multiple languages, and easily understandable expressions), that can be adapted to suit a variety of learning needs and preferences.

Based on this, several concepts and tools have emerged to provide e-Learning training processes that cover all that variety of students who may be immersed in the training environment. This serie of concepts are defined below.

2.3.2 Inclusive e-Learning

Inside the inclusive e-Learning context, it is worth mentioning the terms "Universal Access" (UA), "Universal Design" (UD), and "e-Learning for All" insomuch as these are the starting points for an inclusive education system in virtual context.

UA addresses equitable access and active participation of potentially all citizens in the information society. This is in line with the policy recommendation by the Council of Europe who states, "all who are able and willing to participate successfully in higher education should have fair and equal opportunities to do so" (Council of Europe, 1998). To make these opportunities viable, design decisions have to be made to assure that a course or a learning environment is accessible for all. This process is called "UD", which according to Story, Mueller and Mace (1998) is "the design of products and environments to be usable by all people". UD puts high value on both diversity and inclusiveness. Specifically, UD in education is applying in many educational products as computers, websites, software, textbooks, and lab equipment and environments, as classrooms, student union buildings, libraries and distance learning courses.

On the other hand, "e-Learning for All" means ensuring that all students, not only the most privileged, acquire knowledge and skills supported by using a computer-based educational system. Thus, individual differences must be considered by ensuring the maximum range and variety of learning opportunities. In this context, a variety of research has been conducted (Bjork et al., 2008; Donnelly and Mcsweeney, 2008; Moreno, 2008).

Based on the foregoing and the need and call for an equitable education, arises the "e-Inclusion" term, which refer to all activities that are related to the achievements of inclusive ICT, as well as the usage of ICT for inclusion. The major aim of e-Inclusion is to reduce the gap between those who have both the access and the capability to use modern information and communication tools and those who do not, including people in situation of disadvantage due to disabilities or/and those who live in remote regions.

Consequently, "Inclusive e-Learning", as an area of e-Inclusion, tries to produce inclusive spaces in e-Learning, to consider the best possible special/individual needs and preferences when designing the curriculum (learning purposes, methods and materials, assessment and feedback), but also, when designing the e-Learning applications to support learning. According to the aforementioned factors, "the real value of e-Learning is making training available to people who find it difficult to participate in classroom training, or who choose not to" (Grober, Weicht and Berg, 2010).

In traditional learning, teachers can easily get an understanding into how their students work and learn. However, in e-Learning, it is more difficult for teachers to monitor how individual students behave and learn in the system and more difficult yet identify if a specific student may have a special educational need. In this context, many efforts have been conducted to address the individual user's needs to provide adaptive learning processes. To accomplish this purpose, the integration of AHS - an alternative to the traditional "one-size-fits-all" approach in the development of hypermedia systems - with LMS, was proposed (Tiarnaigh, 2005; Colan, Wade, Gargan and Hockemeyer, 2002). In the following section, is presented a description of this concept and the elements surrounding it.

2.4 ADAPTIVE HYPERMEDIA SYSTEMS (AHS)

The Adaptive Hypermedia is the area of Information Technology that study the development of systems, methods and techniques capable of promoting adaptation in response to the expectations, needs, preferences and desires of its users (Brusilovsky, 1996). An AHS is based on an adaptive hypermedia model, which consists of three components: data collection, user modeling and adaptation, which are represented in Figure 5.

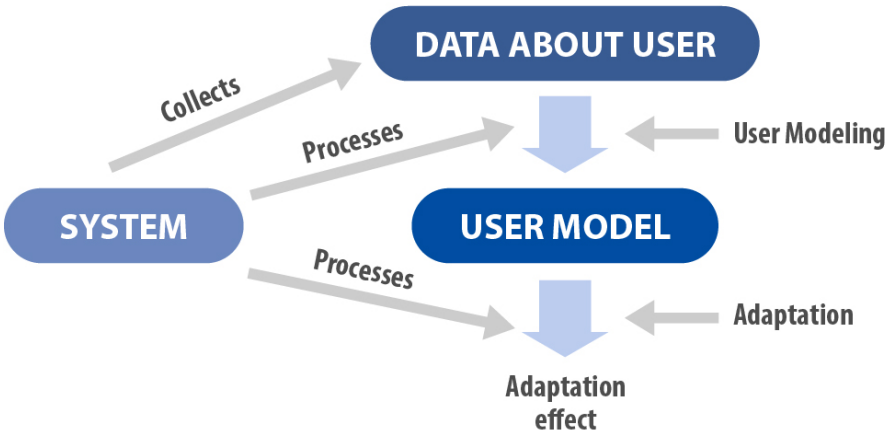


Figure 5. *Classic loop of the AHS. Source: Brusilosvky (2001).*

During data collection, the user, application, or hypermedia system collects data on the user. The user may explicitly tell the AHS that he/she is a particular type of user or the application or system may implicitly collect data on actual user performance to provide a basis for adaptation. During user modelling the user model is built or updated. The user model is the Adaptive System's representation of the user. The data collected about the user is compared against the

user model and the user is classified as a certain type of user. During Adaptation, the user model is processed to provide the hypermedia adaptation resulting in the result of the system, which according to Brusilovsky (2001) could take two forms:

- Levels of content or presentation.
- Levels of links or navigation help.

AHS can be useful in any application area where users of a Hypermedia System have essentially different goals and knowledge and where the hyperspace is reasonably large. AHS for e-Learning was one of the first application areas for AHS. In this context, the User Model (UM) is usually called Student Model (SM).

2.4.1 Student Modelling

In order to offer inclusive learning applications, learning content or learning paths, which could respond exactly to students' educational needs and preferences, it is desirable to have information about the student.

Brusilovsky and Millán (2007) explain that the SM keeps all information about the student. Mainly, this model represents knowledge, interests, preferences, goals, background, and individual traits of the students during their learning process, allowing personalized learning and adaptation to their current needs.

Medina-Medina, García-Cabrera, Rodríguez-Fortiz & Parets-Llorca (2002) explain that one of the forms of user interaction with adaptation is through the creation and updating of the UM. If the user intervenes directly by expressing their preferences or providing their profile through a form, this is, more than an adaptive system, an adaptable system. Along these same lines, De Bra (1998) states that most SHA are both adaptive and adaptable, since they require a way to initialize the User Model or allow users to explicitly adjust the model.

Current a SM includes a range of information about the learners such as sociodemographic information, knowledge, interest, goals, background and collaborative interaction (Baldiris, 2012; Florian, 2013; Laroussi, 2001; Peña, 2004; Mancera, Baldiris and Fabregat, 2008). Additionally, there are some studies that model the cognitive styles (Graf, 2007; Graf, Lin, & Kinshuk, 2005), learning styles (Baldiris, 2012; Carmona, Castillo and Millan, 2007; Graf, 2007; Mejia, 2009; Ortigosa, Paredes and Rodriguez, 2010; Peña, 2004), emotion and affective states (Baldiris et al., 2011; Conati and Maclaren, 2005; Mancera et al., 2011; Picard, 1997), personality (García, Amandi, Schiaffinoa and Campoa, 2006), metacognitive skills (Conati, Larkin and VanLehn, 1997), and attitudes and perceptions (Arroyo and Woolf, 2005). While, other studies are focusing on physical and cognitive disabilities as visual and hearing impairment (Gelvez et al., 2011) and learning disabilities (Mejia, Fabregat and Marzo, 2010), as well as cultural diversity as multiliguism (Bacca, Baldiris, Fabregat and Avila, 2013; Bacca, Baldiris, Fabregat, Guevara and Calderon, 2012), among others. Althoug previous research has considering characteristics of the student that can be useful for identifying ADHD symptoms, as the cognitive performance, these have not been associated for this aim.

To be able to address a student' need in an appropriate way, a reliable student model is necessary. However, getting enough information about an e-Learning student to create the model is quite challenging. It implies to adopt an appropiated SM categorization. Different categorizations exist for SM. In (Martins, Faria, Carvalho and Carrapatoso, 2008), the SM data is divided into two big groups. Figure 6 represents this categorization. Each of the domains presented in Figure 6 refer to the following:

- The Domain Dependent Data (DDD), referring to the specific knowledge information that the system considers that the user possesses on a particular domain.
- The Domain Independent Data (DID), which is composed of two elements: the Generic Model and the Psychological Model of the SM, with an explicit representation.

The data of the Generic Model is related to the student´s interests, common knowledge and background. The data of the Psychological Model is related with the cognitive and affective aspects of the student. Some of these characteristics are relevant for a determined type of SM and not for others (Martins et al., 2008). Therefore, for each AHS, it will be necessary to define which are the characteristics and relevant parameters of the user to be kept.

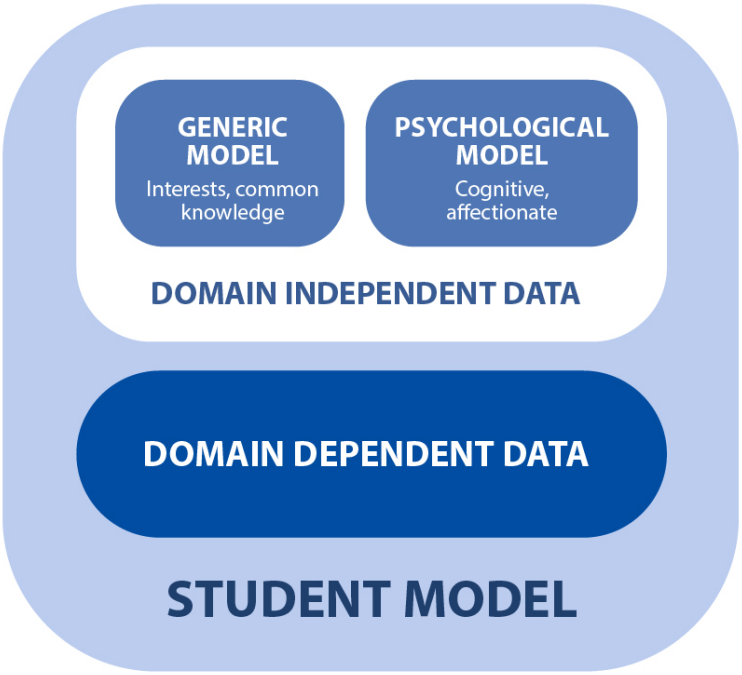


Figure 6. *Architecture to build a Student Model. Source: Author.*

Table 5 shown an overview of the more common characteristics used in SM created in (Martins et all, 2008).

Table 5. *Common characteristics used in SM*

Data	Model	Characteristic	Description/Examples
Domain Dependent Data	Generic Model	Personal information	Name, email, password, etc.
		Demographic data	Age, etc.
		Academic background	Technological studies versus economics etc.
		Qualification Knowledge (background knowledge)	Possibility of a qualitative, quantitative or probabilistic indication of concepts and knowledge acquired for the user
		Deficiencies: visual or others	Sees well, uses eyeglasses, etc.
		Domain of application	Localization of the user etc.
		Inheritance of the characteristics	Creation of stereotypes that allow to classify the user
	Psychological profile	Learning style	Definition of the learning style: visual, verbal, active, sensitive

		Cognitive capacities	
		Traces of the personality	Psychological profile (introverted, extrovert, active, etc.)
		Inheritance of characteristics	Creation of stereotypes that allow to classify the user
Domain Dependent Data		Objectives	Objectives Questionnaires that allow to determine with objectives the user intends to use the system
		Planning / Plan	
		Complete description of the navigation	Kept register of each page accessed
		Knowledge acquired	A collection of knowledge translated in concepts. Possibility of a qualitative, quantitative or probabilistic indication of concepts and knowledge acquired for the user
		Results of assessment	Data of all the tests, exercises, etc.
		Context model	Data related with the environment of the user (resolution of the monitor, etc.)
		Aptitude	Definition of aptitude and the capacity to use the system
		Interests	Definition of the interests of the individual with the objective to adapt the navigation and contents
		Deadline extend	Long, short or normal stated period

Up to this point, the bases of the educational and technological context concerning this thesis have been addressed. The next section focuses on the population under study of this research.

2.5 ATTENTION DEFICITS HYPERACTIVE DISORDER (ADHD)

ADHD is recognized as a life time disorder with a psychiatric, genetic, neuro-biologic, and neurochemical basis (NICE, 2009). It is characterized by a persistent pattern of inattention and/or hyperactivity-impulsivity, which is more frequent and severe than that usually observed in subjects of a similar level of development (American Psychiatric Association-APA-, 2014). The relatively prevalence of the disorder is high, in the school population between 3% and 7% (Caballero and Celorrio, 2014; Xunta de Galicia, 2014), being one of the most common childhood disorders.

As reported in Kwon, Kim and Kwak (2018), the prevalence of ADHD in young people and adults was approximately 3.4% and was signifcantly higher in higher-income than in lower-income countries (4.2% vs. 1.9%, respectively) and, approximately 2–8% of university students have clinically signifcant ADHD symptoms.

Symptoms of ADHD include:

1) Inattention refers to the difficulty in sustaining concentration, especially, in circumstances that offer low stimulation.
2) Hyperactivity-Impulsivity refers to the lack of inhibition or cognitive control over impulses, frequently associated with motor restlessness.

2.5.1 Types of ADHD

On the one hand, the five version of the Manual of Classification of Mental Disorders (DSM-V) performed by the American Psychiatric Association (APA), the ADHD is find in the attention deficit disorders and disruptive behavior category. This manual reflects the existence of three subtypes of ADHD according to the presentation of the predominant symptoms:

- Inattentive predominantly subtype (inattentive symptoms are manifested but not hyperactive/impulsive symptoms).
- Hyperactive/impulsive predominant subtype (symptoms of hyperactivity/impulsivity are met but not those of inattention).
- Combined subtype (inattention symptoms as well as hyperactivity/impulsivity symptoms are satisfied).

International Statistical Classification of Diseases and Related Health Problems published by the World Health Organization (WHO), through the ICD-10 (a classification system for mental disorders with variable diagnostic axes, including the V axis - Psychosocial situations), where the disorders of behavior and emotions of habitual onset in childhood and adolescence, are contemplated the so-called "hyperkinetic disorders". According to the literature (Swanson, Wigal, and Lakes, 2009; Tripp, Luk, Schaughency and Singh, 1999), it can be said that hyperkinetic disorders are in the ICD-10 what ADHD in the DSM-V. Hyperkinetic disorders include:

- Disorder of activity and attention.
- Dissociative hyperkinetic disorder.
- Other hyperkinetic disorders.
- Hyperkinetic disorder without specification.

2.5.2 Diagnostic Criteria

ADHD subtypes that can be diagnosed under the DSM-V approaches differ substantially from the ICD-10 International Classification System since the DMS-V allows a subtype focused on Inattention, Hyperctivity or Impulsivity, whereas ICD-10 requires the presence of the three essential symptoms (inattention, hyperactivity and impulsivity) to obtain the diagnosis of one of the hyperkinetic disorders.

These differences in classification imply different prevalence of the disorder according to the use of one or the other. This is because ICD-10 hyperkinetic disorder corresponds only to the combined subtype of DSM-V.

The criteria for the diagnosis of ADHD according to DSM-V are shown in Table 6.

Table 6. *Criterias for the diagnosis of ADHD according to DSM-V*

A. Exist 1 or 2
1. Six (or more) of the following symptoms of inattention have persisted for at least 6 months with an intensity that is incoherent in relation to the level of development:
Attention deficit: (a) Often does not pay enough attention to details or mistakes due to carelessness in school work, at work or in other activities (b) Often has difficulty maintaining attention on tasks or playful activities (c) Often seems not to listen when spoken directly (d) Often does not follow instructions and does not complete school assignments, assignments, or obligations in the workplace (not due to negativistic behavior or inability to understand instructions) (e) Often has difficulties in organizing tasks and activities

(f) Often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as school or homework) (g) Often mislaid objects necessary for tasks or activities (eg toys, school exercises, pencils, books or tools) (h) Is often easily distracted by irrelevant stimuli (i) Is often neglected in daily activities
2. Six (or more) of the following symptoms of hyperactivity-impulsivity have persisted for at least 6 months with an intensity that is incoherent in relation to the level of development:
Hyperactivity: (a) Often moves excessively hands or feet, or removes in his seat (b) He often leaves his seat in class or in other situations where he is expected to remain seated (c) Often runs or jumps excessively in situations in which it is inappropriate to do so (in adolescents or adults it can be limited to subjective feelings of concern) (d) Often has difficulty playing or leisurely engaging in leisure activities (e) Often "is running" or usually acts as if it has an engine (f) He often talks in excess **Impulsiveness:** (g) Often precipitate answers before the questions have been completed (h) He often has difficulty keeping his turn. (i) Often interrupts or intrudes on the activities of others (eg, intrudes into conversations or games).
B. Some symptoms of hyperactivity-impulsivity or inattention that caused alterations were present before 7 years of age. **C. Some alterations caused by symptoms occur in two or more environments (eg, at school [or at work] and at home).** **D. There must be clear evidence of a clinically significant impairment of social, academic or employment activity.** **E. Symptoms do not appear exclusively in the course of a generalized developmental disorder, schizophrenia or other psychotic disorder, and are not better explained by the presence of another mental disorder (eg, mood disorder, anxiety disorder). , dissociative disorder or a personality disorder).**

To state that the patient may have symptoms consistent with ADHD must meet 6 or more of the symptoms presented in Table 6:

- Symptoms must have been present for more than 6 months.
- The symptoms cause maladaptation and are inconsistent in relation to the level of development.
- Some symptoms present before 7 years.
- Symptoms present in two or more contexts (educational, work, family, social).
- Clear evidence of social, academic or occupational involvement.
- Prior exclusion from other developmental disorders that may be justifying the symptomatology.
- The set of signs may appear separately or in combination.

The criteria for the diagnosis by ADHD according to ICD-10 are shown in Table 7.

Table 7. *Criterias for the diagnosis of ADHD according to ICD-10*

G1. Attention deficit: **At least 6 of the following symptoms of attention deficit persist for at least 6 months, in a setting that is maladaptive and inappropriate to the child's developmental level:**
(1) Frequent inability to pay attention to details, together with careless mistakes in school work and other activities.

(2) Frequent inability to maintain attention in tasks or in the game.
(3) He often seems not to hear what is being said.
(4) Persistent impossibility to complete the assigned school tasks or other assignments that have been assigned to him/her at work (not originated by a deliberate opposition behavior or by a difficulty to understand the instructions).
(5) Decreased ability to organize tasks and activities.
(6) He often avoids or feels markedly uncomfortable with tasks such as homework that require sustained mental effort.
(7) He often loses objects necessary for tasks or activities, such as school supplies, books, pencils, toys or tools.
(8) Easily distracted by external stimuli.
(9) Often forgetful in the course of daily activities.
G2. Hyperactivity:
At least three of the following symptoms of hyperactivity persist for at least six months, to a degree that is poorly adaptive and inappropriate to the child's developmental level.
(1) Frequently shows restlessness with movements of hands or feet or stirring in the seat.
(2) Abandons in class or in other situations where you are expected to remain seated.
(3) He often runs or climbs excessively in inappropriate situations (in adolescents or adults he can only manifest by feelings of restlessness).
(4) He is, in general, inadequately noisy in the game or has difficulty quietly entertaining himself in ludic activities.
(5) Persistently exhibits a pattern of excessive motor activity that is not substantially modifiable by the requirements of the social environment.
G3. Impulsiveness:
At least one of the following symptoms of impulsivity persists for at least six months, to a degree that is poorly adaptive and inappropriate to the child's developmental level.
(1) He often exclaims or responds before the full questions are asked.
(2) He is often unable to keep a turn in queues or in other group situations.
(3) Often interrupts or meddles in the affairs of others (for example, bursts into conversations or the games of others).
(4) Frequently there was too much without being restrained by social considerations.
G4 The onset of the disorder is not later than seven years of age.
G5 Generalized character. The criteria must be met for more than one situation, that is, the combination of attention deficit and hyperactivity should be present both at home and at school, or at school and in other environments where the child can be observed, such as it could be the medical consultation (the evidence of this generalization requires, in general, the information provided by several sources.The information of the parents about the behavior in the school of the child is not usually sufficient).
G6 The symptoms of G1 to G3 cause a cynically significant discomfort or an alteration in social, academic or work performance.
G7 The disorder does not meet the criteria for Pervasive Developmental Disorder (F84), Manic Episode (F30), Depressive Episode (F32) or Anxiety Disorder (F41).

ICD-10 requires the patient to present at least 6 symptoms of attention deficit, 3 of hyperactivity and 1 of impulsivity (6 + 3 + 1) that cause dysfunction in at least two environments. Therefore, it is a more severe and less frequent syndrome than defined by DSM-V (It is more difficult to meet ICD-10 criteria than DSM-V).

In Europe, the DSM-V concept of ADHD has finally been accepted, and hyperkinetic disorder is understood as a more severe form of ADHD. In short, currently, following the evolution of the concept of ADHD and independently of the controversies arising from the conceptualization of this disorder, the most comprehensive aspect of the syndrome is defined by a deficit in the inhibitory control of behavior.

2.5.3 Evolution of ADHD through life

As stated in the diagnostic classifications, ADHD is a persistent pattern of:

- Attention deficit (low degree of sustained focus)
- Hyperactivity (high degree of restlessness or continuous activity)
- Impulsivity (poor control over impulses and low tolerance for delayed gratification)

By persistent it is understood that it will remain more or less stable throughout the evolutionary cycle of the individual. However, this stability does not imply that symptoms manifest themselves in the same way at all stages of the individual's life. Next, it is exposed as depending on the ages these symptoms change in their manifestations (Barkley, 1981):

- Childhood: children with ADHD are characterized by being overly restless, with disobedient and challenging behaviors, tantrums and by focusing less attention on tasks. The game is more immature and they do not accept the rules. In addition, they present / display symptoms of nervousness.
- School stage: in this stage, the symptomatology is detected because they show difficulties to remain seated, follow instructions and pay attention. Additionally, they exhibit impulsive behaviors and problems to interact adequately with their peers.
- Adolescence: at this stage, they are more likely to manifest low academic performance, school maladjustment, social isolation, depression and low self-esteem. It also increases the association with behavioral disorders (associated with use and abuse of alcohol, tobacco and drugs).
- Adult life: at this stage, hyperactive and impulsive behaviors are attenuated but the feeling of restlessness persists, the manifestation of behaviors lacking premeditation, attention problems, disorganization and the difficulty to maintain routines at work and at home. Likewise, they are people who distribute and spend their money worse, organize poorly the domestic tasks, have less ability as parents to educate their children, have less capacity to develop independent work, suffer more traffic accidents and have more difficulties in social and couple of relationships.

2.5.4 Explanatory theories of ADHD

In the explanatory theory of ADHD there are two types of models: cognitive models, which emphasize failure in information processing; and neurobiological models, which focus on genetic influences, on structural and neurobiochemical failures. There are also psychosocial factors that, although they do not explain the etiology of ADHD, serve to understand more comprehensively the development and prognosis of this disorder.

According to Artiagas and Narbona (2011), ADHD is characterized by alterations or delay in the development of functions linked to the maturation of the central nervous system, which begin in childhood and follow a stable evolutionary course. These alterations in the maturative areas of the brain result in alterations in the cognitive areas causing the own symptomatology of ADHD. Hence, a variety of cognitive models that attempt to respond to the cause and origin of the behavioral and cognitive alterations and manifestations of the disorder have emerged. Some cognitive models to explain ADHD are:

- Dual model of Sonuga-Barke (Sonuga-Barke, 2002): It is a multiple deficit model that proposes that the difficulties shown in ADHD are presented in two levels. On the one hand, there are failures at the cognitive level and, on the other hand, failures at the motivational level. With respect to the cognitive level, the main difficulties are placed in the deficits of the executive functioning. With respect to the motivational level, they are based on evidence that there are difficulties in expecting desirable results and working effectively over long period of time.
- Model of Attention Deficit Disorder developed by Brown (Brown, 2008): according to this model, ADHD is due to failures in the functioning of six executive functions:

  - Activation (organizing tasks and materials, estimating time, prioritizing tasks and initiating activity);
  - Focus (focus, keep attention, stay focused on tasks);
  - Effort: regulate alertness, maintain effort and process speed;
  - Emotion (handling frustration and controlling emotions);
  - Memory (use the functional memory and have access to the memory)
  - Action (monitoring and controlling the action itself.
- Model of self-regulation or deficit in inhibitory control (Barkley, 1997): the most elaborate model of ADHD at present is the one proposed by the North American author Rusell Barkley. In his proposal, Barkley relies on the analysis of the interrelationships between behavioral inhibition, executive functions and self-regulation. Barkley postulates that the deficit in the inhibition of the behavior implies a delay or deterioration in the development of four neuropsychological functions. These neuropsychological functions, or executive functions, are non-verbal work memory; the interiorization of language (verbal working memory); self-regulation of affect/motivation/activation/reconstitution. All of them depend on the behavioral inhibition for their effective execution and in turn influence the motor control system.

Although each of the models presented considers certain particular aspects, it has in common the flaws in the Executive Functions (EF). EF have to do with the brain functions that set in motion, organize, integrate and handle other functions. They make people able to measure the short- and long-term consequences of their actions and to plan the results. They allow people to be able both to evaluate their actions at the time of carrying them out and to make the necessary adjustments in cases in which the actions are not giving the desired result. They include planning, inhibition of overbearing responses, flexibility, organized search and working memory (Pennington and Ozonoff, 1996).

2.5.5 Altered cognitive processes in young adults with ADHD

Throughout the studies developed on ADHD have been detected deteriorations or alterations in diverse cognitive functions of the human being. However, there is currently no precise pattern about the specific cognitive functions that need to be explored for an ADHD diagnosis. On the other hand, studies have shown that altered or deteriorated cognitive areas may vary from across the lifespan (Seidman, 2006).

According to several research (Marcheta, 2007; Du Paul et all, 2001; Du Paul et all, 2009; Rogers, Hwang, Toplak, Weiss and Tannock, 2011), some of the cognitive and EF areas deficient in young-adults and adults suffering from ADHD are:

- Sustained Attention (SA), which refers to the ability to maintain a stable performance level over a period of time.
- Working Memory (WM), which is the capacity to store, monitor and manage information.
- Verbal Learning (VL), which refers to the capacity to obtain, hold and remind words.

2.5.6 Implications of ADHD in life

Although people suffering from ADHD appear normal at first glance, reality is that individuals suffering from this disorder have a lower quality of life than those without ADHD (Biederman and Faraone, 2005; Kwon, Kim and Kwak, 2018).

Attention deficit is showed, among other contexts, not fulfilling commitments, being disorganized in working and study environments (lose material, for instance), avoid activities that require organization, concentration or mental effort, change the subject abruptly in talks for not providing attention, are easily distracted by irrelevant aspects and tend not to persist in tasks until their end.

Hyperactivity is shown talking excessively, manipulating objects restlessly, and balance arms and/or legs. They have to be always busy, often doing several activities at the same time. They have difficulty relaxing, or sleeping.

Impulsiveness is showed through impatience, difficulty in waiting, difficulty in expressing oneself, tendency to not follow rules or norms. Individuals with this characteristic usually engage in dangerous activities and accidents (frequently tear down and break objects) and have some kind of compulsion. They are considered inconsistent, respond rashly, often make inopportune comments, interrupt others and intrude on other people's affairs, and may provoke embarrassing and offensive situations. They show hypersensitivity to provocations, criticism or rejection, which causes low tolerance to frustration. They suffer abrupt and sudden oscillations of humor. Their plans and goals may change unexpectedly.

ADHD and adverse academic outcomes

In the educational setting, some studies have demonstrated that there is a close relationship between ADHD symptoms and academic underachievement (Barry, Lyman and Grofer, 2002; Rogers, Hwang, Toplak, Weiss and Tannock, 2011; Birchwood and Daley, 2012). Besides, longitudinal studies show that the academic underachievement and poor educational outcomes associated with ADHD are persistent especially when there is no adequate and timely accompaniment. In this field, several studies demonstrated that subjects with ADHD followed into adolescence fail more grades, achieve lower ratings on all school subjects, have lower class rankings, perform more poorly on standardized academic achievement tests, take more years to complete high school, have lower rates of college attendance, and have lower rates of college graduation (Loe and Feldman, 2007; Zambrano, 2013). In this context, college students with ADHD have a lower quality of life than do students without ADHD (Pinho, Manz, DuPaul, Anastopoulos and Weyandt, 2017; DuPaul, Weyandt, O'Dell and Varejao, 2009).

Some common symptoms of university students with ADHD, grouped into categories and their implication in academic context are described in Table 8.

Table 8. *ADHD common symptoms in academic setting*

Categories	Description and Implications in Academic Context
Trouble concentrating and staying focus	It difficulty listening in class; spaces out and misses lecture content or homework assignments; lack of attention to detail, makes careless mistakes in work, doesn't notice errors in grammar, punctuation, capitalization, spelling, or changes in signs (+,-) in math; difficulty staying on task and finishing school work; distractible, moves from one uncompleted task to another; lack of awareness of time and grades, may not know if passing or failing class.
Hyperfocus	A tendency to become absorbed in tasks that are stimulating and rewarding. Hyperfocus on a certain subject can cause sidetracking away from assigned or important tasks.
Disorganization and forgetfulness	Poor organizational skills; trouble starting and finishing projects (difficulty getting started on tasks); frequently forgetting appointments, commitments, and deadlines; constantly losing or misplacing things (homework, keys, wallet, phone, documents, bills); difficulty knowing what steps should be taken first; difficulty organizing thoughts, sequencing ideas, writing essays, and planning ahead.
Impulsivity	Frequently interrupt others or talk over them; have poor self-control; blurt out thoughts that are rude or inappropriate without thinking; have addictive tendencies; act recklessly or spontaneously without regard for consequences; have trouble behaving in socially appropriate ways (such as sitting still during a long meeting). Rushes through work; does not double check work; doesn't read directions; takes short cuts in written work especially math (does it in his head); difficulty delaying gratification, hates waiting.

Emotional difficulties	Sense of underachievement; doesn't deal well with frustration; easily flustered and stressed out; irritability or mood swings; trouble staying motivated; hypersensitivity to criticism; short, often explosive, temper; low self-esteem and sense of insecurity. Those with ADHD find it difficult to activate or arouse themselves to initiate work that must be done, often complain of being unable to stay alert or even awake in boring situations, and frequently seem to be daydreamy or "in a fog" when they shoud be more alert, focused, and actively engaged in a task.
Hyperactivity or restlessness	Feelings of inner restlessness, agitation; tendency to take risks; getting bored easily; racing thoughts; trouble sitting still; constant fidgeting; craving for excitement; talking excessively; doing a million things at once. They display excessive movement not required to complete a task.

Based on the educational implications showed in Table 8, several authors emphasize the importance of attending university ADHD students considering that it is a particularly challenging period because of the adjustment to the new, unstructured environment that students must make and because this period impact the overall futurelife (Fleming & McMahon, 2012; Lee, 2015). It situation displays the great need for ADHD interventions that support this vulnerable student cohort.

In this direction, this research consideration is given to hyperconcentration in certain subjects and activities that arouse interest or passion for people who suffer from ADHD as a positive aspect for academic performance: "as is the case of children and young people with electronic games or adults with sports, computers ... "(Silva, 2003, p.22).

2.5.7 Disorders associated with ADHD

According to Szatmari, Boyle and Offord (1989), 44% of children with ADHD suffer from at least one other psychiatric disorder, 32% have two disorders and 11% have at least three associated disorders. The most frequent neuropsychiatric disorders coexist with ADHD in both comorbid and secondary forms are showed in Figure 7 (ADHD institute, 2017).

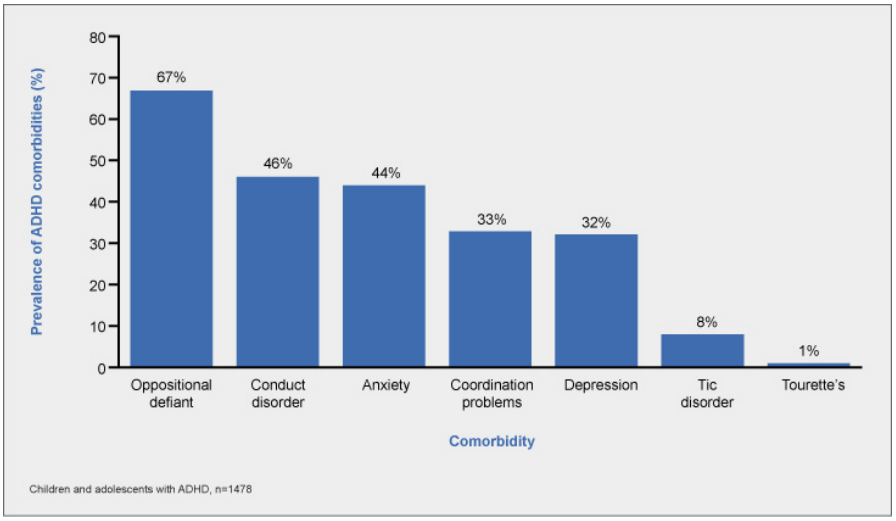


Figure 7. *Co-existing psychiatric disorders associated with ADHD in children and adolescents. Source: ADHD institute (2017).*

2.5.8 Assessment of ADHD in young adults

The assessment of ADHD in young-adults has a number of particular characteristics that may difficult the diagnosis: first, ADHD symptoms may also manifest as a normal variant in the general population; second, other psychiatric disorders may have symptoms similar to ADHD; and three, the need to obtain retrospective information on childhood symptoms (Murphy and Adler 2004). However, it has been observed that young adults with ADHD are reliable informants (Murphy, Barkley and Bush, 2002). Therefore, it is necessary to mention that diagnosis a person with ADHD is a complex task that involves considering a variety of factors and valuing them integrally.

Evaluation instruments

In general, to asses a person for ADHD requires: a review of the medical and behavioral history to determine if a patient had symptoms since childhood; a examination of behavior, to determine if the patient has current compatible symptoms of ADHD; a neuropsychological examination, which is inescapable for clarifying cognitive performance; and additionally, an evaluation of psychopathological comorbidity to discard other illnesses or disorders. Some of these elements are described below.

- General clinical history: collects sociodemographic data, family and personal history, as well as a psychopathological examination oriented to the differential diagnosis of ADHD. It is important to pick up aspects that are frequently present in young people with ADHD, such as traffic accidents, driving fines, legal problems, academic or work performance difficulties.
- Evaluation scales for young and adults: there are different scales and interviews for the evaluation of the symptoms that have proved be useful in clinical practice. Some of the instruments for which a Spanish translation is available are showed and described in Table 9.

Table 9. *ADHD evaluation scales of current simptoms*

Name	Description	Reference
Conners Adult ADHD Diagnostic Interview	The second part of this semi-structured interview includes the diagnostic criteria for ADHD according to DSM-IV. The interview allows the evaluation of criteria in childhood and in adulthood. A clinician administers it.	Epstein and Kollins 2006)
Interview for ADHD of Barkley	Semi-structured interview that includes numerous signs and symptoms of ADHD. Clinical areas not only include the DSM-IV criteria for ADHD, but also different symptoms of inattention, hyperactivity and impulsivity that may influence the severity of the disorder.	(Barkley et al. 1998)
ADHD Rating Scale-IV	Questionnaire that includes 18 items referring to the DSM-IV criteria. Each item is scored from 0 to 3 and is used to determine the presence of each of the symptoms in an individual. This questionnaire can be administered by a clinician expert or be self-administered to both the patient and a direct relative. Initially it was made for use in children, but has been adapted for adult subjects. It scale has a spanish validated version (Bosh et al., 2009).	(DuPaul et al. 1998)
ADHD Symptom Rating Scale	List of 18 symptoms that define the diagnosis of ADHD in the DSM-IV. Each of the symptoms is assessed from "never or almost never" (0) to "very frequent" (3). The intensity in which the present symptoms interfere with the subject's ability to function in different areas (eg work, family life or money management) is also evaluated, and finally it consists of 8 items that assess the	(Barkley et al. 1998)

	behavior of the patient in the last six months (eg discussions or loss of control). This questionnaire consists of two versions, one for the patient and one for a direct relative. There is only one translation into Spanish but it is not validated.	
Conners Adult ADHDD Rating Scale (CAARS)	It consists of six scales, three of them self-administered and three valued by an observer. Each of the scales consists of a series of items that have to be scored from 0 to 3. The number of items in each of the scales depends on the version: long (66 items), short (26 items) and screening (30 items). There is also a version of the researcher for the scale of self-registration, showing good reliability and validity with the self-administered version (Adler et al., 2008a). The long self-administered version of the CAARS has been validated in Spanish, with good psychometric properties and a solid factorial structure of four factors, with good internal consistency (Bosh et al., 2008).	(Conners et al. 1999; Conners et al. 2003).

- Retrospective evaluation of ADHD symptoms in childhood: there are different scales and semi-structured interviews in Spanish for the retrospective evaluation of ADHD symptoms in young and adults patients, which are described in Table 10.

Table 10. *ADHD scales for restrospective evaluation*

Name	Description	Reference
Wender Utah Rating Scale (WURS)	Self-administered questionnaire with two different versions, one for the patient and one for the parents. This instrument retrospectively assesses the presence of ADHD symptoms in childhood. The version for the patient consists of 61 items, with a score ranging from 0 to 4, of which 25 items have been selected for their ability to discriminate ADHD from other disorders. The version of the parents is smaller, 10 items, and is scored from 0 to 3. There is a validated version in Spanish.	(Ward et al. 1993)
ADHD Symptom Rating Scale	It is a questionnaire with the 18 symptoms of the diagnosis of ADHD of the DSM-IV, with the peculiarity that it is asked, retrospectively, if the symptoms were present between 5 and 12 years. Each of the symptoms is evaluated from "never or almost never" (0) to "very frequent" (3). As for the current symptomatology, the extent to which the present symptoms interfered with the subject's ability to function in different areas (eg school, family life or in play) and the patient's behavior among the 5 and 12 years (eg arguments or loss of control). Finally, it incorporates 15 items of dichotomous response (YES / NO) referring to the criteria of the dissocial disorder. This questionnaire consists of two versions, a self-report and a version to be answered by a direct relative. There is a translation into Spanish, but it is not validated.	(Barkley et al. 1998)
ASRS v1.1	The scale of the WHO adult Self-Report Scale (ASRS) version 1.1 is a self-administered questionnaire consisting of two presentations, one of 18 items and another of 6 items. WHO and Kessler et al. developed it jointly with the objective of evaluating ADHD in adults in the framework of the CIDI interview. The international study on mental health promoted by WHO (WHO World Mental Health Survey Initiative) uses this interview as an assessment tool. ASRS V1.1 is based on the 18 symptoms specified in criterion A of the DMS-IV-TR, with five response options per item, which are: never (0), rarely (1), sometimes (2) , often (3) and very often (4). The initial version of 18 questions was considered excessively long as a screening instrument, so the number of items that best predicted the diagnosis of ADHD was studied through a step-by-step logistic regression process.	(Kessler et al. 2005)

	Thus, the reduced version of 6 items was obtained, in which the first four evaluated symptoms of inattention and the last two, symptoms of hyperactivity. The score originally proposed by the authors of the questionnaire is done in a dichotomous way, considering a positive result for ADHD, when the subject marks four or more boxes.	

2.5.9 Interventions for supporting people with ADHD

In most cases, pharmacological treatment is the first choice when it comes to treating ADHD but it is also widely used, psychotherapy and psychoeducational interventions (Murphy, 2005). The stimulant medication treatments are highly effective in the reduction of the core symptoms for most children with ADHD according with the Subcommittee on Attention-Deficit/Hyperactivity Disorder & Management (2011). However, this treatment category is out of the aim of this research project.

Even though the non-pharmacologic interventions such as the behavioral modifications, have less pronounced effects than medications, have shown to be effective in a short-term span a short-term efficacy (Kutcher et al., 2004). The common goal of this behavioral intervention is to modify the physical and social environment to alter or change their behavior (Subcommittee on Attention-Deficit/Hyperactivity Disorder & Management, 2011).

The most common behavior therapy is the behavioral parent training which includes strategies such as systematic approach, goal/target setting, rewards and daily report cards, among others. These strategies have been developed, as well, to train teachers to handle ADHD students in classroom environments (Kutcher et al., 2004) and according with the Subcommittee on Attention-Deficit/Hyperactivity Disorder & Management (2011), the typical outcomes include improvements in attention during instruction, disruptive behavior decrease, work productivity improvement and better compliance with classroom rules. In addition, that behavioral therapy does not require a specific diagnosis.

The gamification and videogames approaches could be suited as tools that can contribute into the field of non- pharmacological interventions since both shares some common strategies used into the behavioral parent training approach such as goal/target settings and rewards.

Academic intervention strategies for ADHD

In a study developed by Rubio, Pérez and Martínez (2017), a serie of measures that are contemplated in the classrooms are gathered to support different aspects of students with ADHD:

> Cooperative learning methods; Learning by tasks; Learning by projects; Autonomous Learning; Learning by discovery based on problems; Teaching contracts; Multilevel teaching; Organization of contents by centers of interest; Work for corners; Graduation of materials and activities; Reinforcement and curricular support, especially in content of the instrumental subjects; Support in the ordinary group; Peer tutoring; Shared teaching of two teachers in the ordinary classroom; Flexible groupings; Splitting the group and including ICT in the daily work (Trad. p. 372).

Regarding to the latter measures, Raposo-Rivas and Salgado-Rodríguez (2017) comment, "at present there is little research that links the use of ICT with ADHD" (p. 126). However, the intervention of ICT to support the training processes of students with ADHD has been increasing in recent years and the results of its application are positive. This is supported by research such as that of Chousa, Martínez and Raposo (2017) in which a bibliometric study was carried out at primary level, bounded between 2001 and 2016. Of the 30 works identified, only 9 were located within the period of time between 2001 and 2010, which means that works in this area have been increasing.

On the other hand, Chousa, Martínez and Raposo indentified the following benefits of using ICT in academic intervention of students with ADHD:

- Favor an individualized teaching.
- Promote autonomous and cooperative learning.
- Encourage the reinforcement of behavior.
- Facilitate the assessment of the dimensions related to ADHD.
- Improve aspects such as attention, impulse control, literacy, and mathematics.
- Improve social and emotional skills.

Instead, González and Oliver (2002), Martínez-Segura (2007), Salgado and Raposo (2012) recommend the following characteristics for an ICT resource that supports the process of training students with ADHD:

- It must be contextualized in a motivating play activity.
- It must not contain excessive animations.
- It should avoid frustration with the error.
- It must have an affordable level of difficulty to their learning.
- It must allow planning that considers a progress screen.
- It must include activities that favor tranquility accompanied by guided verbalizations.

In this context, one of the resources that has received great acceptance, by students with ADHD, teachers and researchers is the video game (González and Oliver, 2002; Cervera and Ygual, 2006). As such, a variety of them have been raised and developed. Table 11 shows a list research that link ADHD, young adults and videogames.

Table 11. *Interventions based on video games in the context of ADHD*

Videogame Citation	***Characterization***			
	Particpantes	**Type**	**Context**	**Focus**
MeMotiva Senior (De Marco, 2010).	Young adults adults	Arcade	Education	Aimed at improving reading speed, reasoning, concentration, attention and working memory
Play Attention (Szafir & Mutlu, 2012)	Children Young adults	Arcade	Education	Designed to improve concentration and overcome attention problems
The virtual Office (Rizzo et al, 2002)	Young adults	Strategy	Education	Assesment and rehabiliation of cognitive/functional processes
Supermarket Game (De Andrade et al, 2006)	Young adults	Strategy	Social	Assesmen of cognitive/functional processes

The majority of video games presented a Table 11 correspond to video games type exercises (Arcade or Strategy), do not tell a story as such and none of the videogames was integrating or addressed to support e-Learning processes of students with ADHD. At this point it is important to mention that a larger list of video games for children population exist, among them: **MeMotiva Junior** (Accesibilidad Rehasoft, 2011), **The Virtual Classrrom** (Rizzo, Bowerly, Buckwalter, Schultheis, Matheis, Shahabi, Neumann, Kim and Sharifzadeh, 2002); **PlayMancer project** (Jiménez-Murcia, Fernández-Aranda, Kalapanidas, Konstantas, Ganchev, Kocsis, Lam, Santamaría, Raguin, Breiteneder, et al, 2009); **Co-StiCap** (De la Guía E., D. Lozano M. and R. Penichet V, 2013).

Indeed, specifically looking for studies combining the three main aspects of this thesis, i.e Games in educational context (Game-Based Learning, Serious Games and Gamificaton), e-Learning and ADHD three related work were found (Ibrahim, Prasad, Alsadoon, et al., 2016; Sitra, Katsigiannakis, Karagiannidis, et al., 2017; Hernández , 2017). Some details of these studies are explaining in the next paragraphs.

Ibrahim, Prasad, Alsadoon, & Pham, (2016) proposed a virtual classroom architecture as an LMS enhancement with synchronous learning (through audio/video conference system), virtual collaborative environment, assessment tools and test to identify the symptoms of the ADHD students, components. This work, although closely related to this thesis, lacks of validation results that not allow us to make comparison of results.

Sitra, Katsigiannakis, Karagiannidis, et al. (2017) implemented gamification strategies in virtual learning environments to impact the students' engagement, specifically they used badges as gamification element. The results of the research showed positive effects on students' engagement and on their overall attitude towards the educational process in general. However, this work does not address the impact on academic performance and the validation scenarie was performed with a very small sample (i.e., five students and just one of them diagnosed with ADHD).

Hernández (2017) address the design and development of a gamified layer into a Course Management System Environment, Google Classroom. The prototype includes game elements such as points, badges, and progress bars. After using the prototype during three weeks, the students showed an easy familiarization with the gamified layer of Google Classroom and an active participation and persistence during their course activities. This research neither addresses the impact of the strategy on the academic performance.

On the other hand, several studies that support e-Learning processes for students suffering from ADHD or other disorders characterized by cognitive, emotional and/or behavioral deficits have been identified. These works are briefly described below given the usefulness they represented for the development of this thesis.

Grabinger, Aplin and Ponnappa-Brenner (2008) propose a construct that guides the development of flexible teaching-learning methodologies aimed at students with cognitive alterations who carry out on-line training processes using Universal Design for Learning (UDL). UDL is an approach that seeks to eliminate the barriers to learning for all students no matters what challenges they bring with them to school (Center for Applied Special Technology –CAST-, 2008). Specifically, they recommend certain resources and tools according to each of the templates provided by the UDL to carry out inclusive educational practices.

Tsianos, Germanakos, Lekkas, Mourlas and Samaras (2010) implemented a framework with which they demonstrated the benefits of applying segmentation and structuring methods to the educational content that is presented to students with low working memory capacity. Likewise, they demonstrated that the application of psychometric techniques, also known as psychological tests, are appropriate in hypermedia learning contexts to evaluate and classify students according to their working memory capacity.

Another work that marked an important reference for this thesis since it integrates the context e-Learning and the evaluation of cognitive aspects is the one developed by Mejía (2013) which is a doctoral research in which a framework for e-Learning context that included several tools to detect Learning Disabilities (LD) and provide assistance to students who present LD, using learning style, recommendations and learning analytics, was developed. The research results obtained in the research demonstrated the efficiency and usefulness of the implemented framework, which gives evidence of the possibility of supporting students with functional diversity in the e-Learning modality.

Klemesa, Epsteina, Zukera, Grinberga and Ilovitcha (2006) developed a voice software to include a different resource to text in e-Learning environments to support students with LD. In addition, they accompany this process with recommendations on computerized tools that support learning. The results of the study suggest that the assistive technology tested in this study is highly beneficial to students with LD who are studying from a distance.

On the other hand, it is important to mention several works in which inclusive educational approach are considered.

Meo (2008) proposes practical techniques that guide teachers of high school social studies in planning and implementing curriculums (goals, methods, material and assessments) by bringing together principles of Universal Design for Learning (UDL), the Planning for All Learners (PAL) procedures, and research-based Reading comprehension strategies, to ensure that all students have genuine opportunities to learn in standards-based settings.

Spooner, Baker, Harris, Ahlgrim-Delzell and Browder (2007) investigated the effects of training in Universal Design for Learning (UDL) on lesson plan development of special and general educators in a college classroom environment. The obtained results suggest that a simple introduction to UDL can help teachers to design a lesson plan accessible for all students.

Courey, Tappe, Siker,and LePage (2012) demostrated that UDL improved multiplicity of options in lesson planning however teachers need more experience in actually implementing the UDL principles in their classrooms.

The concepts seen throughout the theoretical framework reflect the essence that underlies this doctoral work. On the one hand, the technological component as a means to reach more students considering the versatility of the formats and the multiple platforms for it, on the other hand, the pedagogical component based on inclusive education as the way to reach a more dignified learning and in equal conditions for all. Thus, this section allowed us to identify two important issues that are addressed in this thesis:

- Video games and gamification as teaching strategies could be an appropriate tool to support the training processes of students with ADHD.
- UDL as a teaching strategy could be useful to respond to diversity in classrooms.

2.6 CONCLUSIONS OF THE CHAPTER

From the theoretical review carried out and the related works identified on the topics concern on study object of this thesis, the following conclusions were obtained:

- There is a need to continue working towards an education that allows and encourages the participation of all students on equal terms and together, in an environment of respect, recognition and acceptance, welcoming diversity as a value and not as a disadvantage. Strategies, programs, laws, recommendations and projects cited throughout the chapter are an important basis, however, additional efforts are needed to achieve a more just and educated society. It requires working on a wide range of areas including, tecnnological, pedagogical and didactic practices (Marchesi, 2014).

- ICT can be considered as a fundamental instrument to comply with the principle of educational equity and reduce the barriers to knowledge because they have the potential to create highly versatile educational and training environments that can provide students with equal access to knowledge, including student suffering from ADHD (Chousa, Martínez and Raposo, 2017; Trigueros, Sánchez and Vera, 2012; Estévez and León, 2014; Rojas, Gómez and García, 2013; Rose and Meyer, 2002). In this context, it is important to highlight the value of e-Learning as a means to reach many people, especially those who find it difficult to participate in classroom training, or who choose not to (Grober, Weicht and Berg, 2010).

- The UDL is a framework with great potential to achieve the challenge posed by diversity in the classroom, which believes in the power and versatility of technological tools and on individual learning differences (Rose and Meyer, 2002). However, there are few identified studies that support the teaching-learing processes under the e-Learning modality with this type of frameworks.

About ADHD the following aspects are concluded:

- There is no consensus on their symptoms, but depending on, more specifically, the country; they adopt different criteria for their diagnosis and several scales and tests for

their evaluation. In addition, throughout the life the symptoms of the disorder vary and there is currently no need for a diagnosis of the ADHD diagnosis. Based on the above, to diagnosis a person with ADHD is a complex task that involves a variety of factors. In this respect, it is important to point out that in this work, we are not intending to present a method for detecting ADHD in a medical context but to create a student modeling process for identification characteristics of each student.

- Assessing symptoms of ADHD in young people requires considering at least the following dimensions: personal, demographic and academic; background in clinical, academic and social context; behavioral conduct; and cognitive performance. On the evaluation, it was highlighted the usefulness of self-report questionnaires for the evaluation of young people given that they are good informants of the symptoms.
- To assess the cognitive performance of young people with ADHD, it is necessary to evaluate the executive functions related to Sustained Attention, Working Memory and Verbal Learning.
- It is a disorder that negatively impacts the educational context of the people who suffer it, having an impact on low academic performance and bad learning experiences.
- It is a polemic disorder considering that many docents do not recognize it as such, however, the reality is that students who suffer from ADHD struggle constantly with its implications.
- Studies on academic interventions based on ICT, which have positively impacted the training processes of those suffering from ADHD, have focused more on children. Therefore, it is required more research, recommendations, resources, among others focused on young and adults population.
- Video games as an academic intervention for students with ADHD is a field that has many potentialities. This is because the use of videogames elements plus the technology have demostred to empower the learning and motivational processes of students with ADHD. Likewise, there is evidence of the need for more research and development in this area, specifically focused on young and adults population.

Finally, the review of the state of the art shows that there are very few studies that have taken advantage of e-Learning and video games as an educational intervention for university students with ADHD.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 OVERVIEW

As indicated in the title, this chapter includes the research methodology that guided the development of this dissertation. In more details, in this part the author outlines the research approach established to obtain and analyze the information, section 3.2; the research scope to delimit the investigation, section 3.3; the research design to establish the phases that allow obtaining the necessary information, section 3.4; Setting and Participants concers to the population of study and selection of the sample, section 3.5; Data Collection Method and Tools refers to the instruments used to collect information in section 3.6, the type of data analysis in section 3.7; the Validity and Reliability in section 3.8; and ethical considerations taken into account for developing and implementing this research in section 3.9.

3.2 RESEARCH APPROACH

The main reseach question of this research is:

MRQ: Which are the components that should be considered for design an inclusive e-Learning intervention that enhances the academic performance and learning experience of university students suffering from ADHD?

This main research question raises three main issues:

- **RI1**: How to detect ADHD symtopms in e-Learning students?
- **RI2**: How to achieve that e-Learning students who suffer from ADHD obtain a better academic performance and Learning experience?
- **RI3**: How to achieve an e-Learning experience that includes students with ADHD?

To answer these questions, the research approach followed for the objectives of this research was the mixed one. Johnson and Onwuegbuzie (2004) define the mixed approach as "(…) the type of study in which the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts and language in a single study" (p. 17). On the one hand, quantitative research is directly based on the explanatory paradigm. This paradigm preferably uses quantifiable information to describe or try to explain the phenomena it studies (Trad. Sampieri, Collado, and Lucio, 2012). On the other hand, qualitative research is humanistic, in the sense that researcher access the personal, the ways people perceive, feel, think and act. All perspectives of the people studied have value, from their own frames of reference and not from a preconceived theoretical framework. That is why qualitative research studies people and their environment in an integral way (Trad. Durán, 2000).

Thus, in order to answer the **RI1** and to achieve the **SO2** a quantitative approach was used given that usually the diagnosis of a patient with ADHD is based on the performance of the individual on psicometric tests. It is important to emphasize that this evaluation is often accompanied by a series of techniques such as observation (qualitative technique), an aspect that is lacking in virtual learning scenaries.

To answer **RI2** and R**I3** and to achieve **SO3** and **SO4** respectivelly, a mixed approach with quantitative predominance was used. Specifically, the learning process is analyzed in terms of students' academic performace and perception about the academic intervention used. In this sense, the quantitative analysis is based on the grades of the activities and evaluations proposed in the course for each student, in order to establish the possible influence of the didactic strategies used on the academic performance. The qualitative analysis was based on a survey that collects information about the perception of students regarding the didactic intervention used in each validation scenario.

3.3 RESEARCH SCOPE

The research has a descriptive scope according to the study and issues arise from the research question.

According to Sampieri, Collado, and Lucio (2012), "Descriptive studies seek to specify the properties, characteristics and profiles of people, groups, communities, processes, objects or any other phenomenon that is subject to analysis." (trad. p.80)

Based on this definition, with the **RI1** and **SO2** author intended to specify characteristics of young students in order to idenfy or describe a profile related to ADHD symptoms in e-Learning contexts. In the same way, with **RI2** and **RI3**, **SO3** and **SO4** author intended to describe the academic performance and perception of the student against the strategies that were designed and implemented to positively influence these variables.

3.4 RESEACH DESIGN

The design refers to the strategy designed to obtain the necessary information to answer the research questions and achieve the objectives set. In the same line as previous sections, each issue was carried out with a particular design.

For **RI1**, a transactional non-experimental (also know as transversal) design was proposed. Kerlinger (1979, p. 116) cited in Sampieri, Collado, and Lucio (2012, p. 245) "Non-experimental research is one that is carried out without deliberately manipulating variables. In fact, there are no conditions or stimuli to which the subjects of the study are exposed" (trad.). Such is the case of the research carried out with **SO2**, the applications of a series of tests to identify an ADHD profile but a certain stimulus is not applied for it. The dependent variable of the scenari is the inferred profile with respect to symptoms of ADHD and the independent variables were the characteristics and data collected that allow generating the ADHD profile for each student.

For **RI2** and **RI3**, an experimental design of two grades (absence - presence) was carried out. According to Sampieri, Collado, and Lucio (2012):

> In an experiment the researcher deliberately constructs a situation to which several individuals are exposed. This condition consists in receiving a treatment, condition or stimulus under certain circumstances, to then analyze the effects of the exposure or application of the treatment or condition (trad. p. 245).

In this research, the stimuli are the strategies (didactic mediation) designed and implemented to obtain a better academic performance. The dependent variable of the experiment corresponds to the academic performance and perception of students and the independent variable is the absence or presence of the designed strategies (the video games, the gamification and the UDL implementation).

On the other hand, research desing also must indicate the steps to follow to obtain the responses to research qüestions and issues and achieve the proposed objectives, it thus, in this dissertation the methodology proposed by Richards (1993) was follow:

- Phase 1: Information. To identify the existing characteristics of the problem domain and to clearly state the subject under research. In this phase state of the art and theoretical fundations were constructuted. Chapter 1 and 2 are the deliveries of this phase.
- Phase 2: Definition. To define the proposal and approaches of implementation in order to find and produce a solution that ovecomes the limitations presented in the existing alternatives. Chapters 3 and 4 are related to this phase.
- Phase 3. Implementation. To evaluate its pratical feasibility and allows the Deployment of case studies oriented towards the validation of the proposed methods and tools. Chapter 5 and 6 are the deliveries of this phase.
- Phase 4. Validation. To define and deploy experiments that evaluate the validity of the proposal in order to show and document how the proposed solution overcomes the

limtations identified in the information phase. Chapter 5, 6 and 7 are the deliveries of this phase.

3.5 SETTING AND PARTICIPANTS

The implementation of the validation scenaries was carried out at Manuela Beltrán University Virtual Unit, students were referred for the university welfare. Each of the validation scenaries included the participation of students organized as follow.

On one hand, for **RI1** and **SO2**:

- ADHD +, students suffering from ADHD (5 students).
- ADHD-, students with ADHD symptoms but not diagnosed as such (5 students).
- HYS, students without ADHD symptoms (20 students).

On the other hand, for **RI2**, **SO3** and **RI3, SO4**:

- ADHD, students identify in **SO2** as students with possible ADHD symptoms (16 students).
- HYS, students identify in **SO2** as students without possible ADHD symptoms (15 students).

3.6 DATA COLLECTION METHOD AND TOOLS

Given the issues arise from research question; the instruments used were the following:

For **RI1**:

- LMS database with which the demographic and academic data of students is obtained.
- Neuropsychological evaluation battery with which the cognitive performance of the executive functions data is collected.
- Classification rules with which data previously collected were related to infer a profile according to symptoms of ADHD.

For issues **RI2**, and **RI3**:

- LMS database, which keeps the grades obtained by students in each of the activities used to know their academic performance quantitatively.
- Open questions surveys through which information about students' perception of the proposed strategies to improve their academic performance and training experience is obtained. The surveys are presented in detail in CHAPTER 6.

3.7 DATA ANALYSIS

On one hand, the analysis of quantitative data was done with descriptive and inferential statistics through measures of central tendency (arithmetic mean), for issue **RI1**; and hypothesis testing, specifically the t-student test, for **RI2** and **RI3**.

On the other hand, for qualitative analysis, a priori categories were defined, that is, built before the information compilation process, and emerging categories, which arose from the survey of significant referentials from the inquiry itself (Flores, Gómez, Jiménez and Cabrera, 1999). The apriori categories were defined through a general semantic network, that is, the three didactic strategies designed in the same network were included. However, in the analysis of each validation scenario, only the one that corresponded was included. In CHAPTER 6, sections 6.2, 6.3 and 6.4, the analysis developed are described in detail.

3.8 VALIDITY AND RELIABILITY

In order to achieve the control and internal validity of the research, equivalences were established between the experimental and control groups with respect to: age, academic level and evaluation environment. In addition, for **RI1**, before administering the cognitive tests to each student, a brief interview was conducted to avoid sources of invalidation and to ensure that the individuals are willing to present the evaluation. The questions of the interview are:

- How many hours did you sleep?
- Do you have any concern that does not allow you to be aware of what is happening around you? Are you hungry?
- Do you have something pending to do in about two hours?
- With a word, you define your state of mind?

On the other hand, in order to achieve external validity, a content validation process was carried out through judgments of experts in ADHD and psychopedagogues with respect to the tests, UDL strategy and videogame, through a questionnaire of open and closed questions. A detailed form of the judgments of experts is presented in Appendix A and B.

3.9 ETHICAL CONSIDERATIONS

The current study was subject to certain ethical issues. As it was mentioned earlier, all participants reported their written acceptance regarding their participation in the research, through a signed Consent and Briefing Letter (Appendix C). At the same time, sample members were asked to sign a Debriefing and Withdrawal Letter. The aim of both letters was to reassure participants that their participation in the research is voluntary and that they were free to withdraw from it at any point and for any reason. Next to this, participants were fully informed regarding the objectives of the study, while they were reassured that their answers were treated as confidential and used only for academic purposes and only for the purposes of the particular research. Except from the above, participants were not harmed or abused, both physically and psychologically, during the conduction of the research. In contrast, the researcher attempted to create and maintain a climate of comfort.

3.10 CONCLUSIONS OF THE CHAPTER

It can be clearly identified from this chapter that this thesis has two independent fronts, the identification of ADHD symtomps in e-Learning students and the academic support to ADHD students, for this reason a specific methodology was drawn up for each of these fronts. This is how this experience shows that the specific nature of the research problem and the researcher's objectives visualize a clear path to carry out the study. The definition of this methodology sought a greater understanding of the object of study and achieve good results.

CHAPTER 4
THEORETICAL SOLUTION

4.1 OVERVIEW

In CHAPTER 2 author studied some dimensions that need to be considered to evaluate ADHD in young-adults, recognized educational implications for suffering from ADHD and identified some preferences, strenghs and weakness of ADHD young-adults in educational context, **SO1**. In this chapter is presented the general solution designed to support the training processes of university students with ADHD using e-Learning. The solution connects four aspects mainly: technology, academic intervention, ADHD characterization and inclusive education.

The definition of the integral solution is the first step to achieve **SO2**, **SO3** and **SO4** therefore achieve the general objective of this thesis; "**GO:** To design an adaptive and inclusive e-Learning training strategy that considers the characteristics of university students suffering from ADHD to provide them a quality and equitable learning process". Moreover, this solution provided insights for answering the **RI1**, **RI2** and **RI3** and therefore answer the main research question raised with this thesis: "**MRQ**: Which are the components that should be considered for design an inclusive e-Learning intervention that enhances the academic performance and learning experience of university students suffering from ADHD?".

The integral solution was conceived as a framework composed of two modules, one focused on the process of identifying ADHD symptoms in e-Learning students, and the other one, focused on the process of providing academic support based on teaching-learning strategies which considered strengths, preferences and weaknesses of university students suffering from ADHD.

The chapter is structured as follows: Section 4.2 explains the integral solution proposed, including the architecture used for its development. Section 4.2.1 explains the ADHD Student Model Component, which refers to the process stablished to identify if an e-Learnig student may has ADHD symptoms. Section 4.2.2 presents the ADHD Academic Support Component refers to the teaching-learning strategies implemented as academic interventions. Section 4.3 summarizes the chapter.

4.2 INTEGRAL SOLUTION

The aim of this dessertation is to provide e-Learning processes that are meaningful and inclusive with students suffering from ADHD, thereby achieving a better academic performance and learning experience. Considering that e-Learning context is an environment in which it is more difficult to identify if the training process generates barriers for a given student, an integral solution that ranges from symptoms detection of ADHD (**SO2**) (first module) to didactic support considering strengths, preferences and weaknesses of students suffering from ADHD (**SO3**, **SO4**) (second module).

For the first module, the author proposed a SM that considers personal, demographic, academic, behavioral, background and cognitive dimensions to identify if a specific student may have ADHD symptoms. The information capture for these dimensions, coupled into an e-Learning platform make up what was termed ADHD Student Model Component.

For the second module, considering preferences and strengths of people suffering from ADHD (findings found on CHAPTER 2), two didactic strategies were integrated in academic processes, one based on video games and the other based on gamification. Additionally, a third strategy based on the implementation of the Universal Design for Learning (UDL) was integrated given the advantages of this framework to help reduce barriers that do not allow quality-training processes for all.

Figure 8 shows the general architecture of the integral solution, which has been organized into a framework, which comprises the two components. In turn, each component, is composed of two parts:

- The Web applications (Web applications for ADHD Evaluation and Web application for ADHD Academic Intervention).
- The ATutor modules (ADHD Student Model Module and ADHD Academic Interention Module), which become additional functionalities of the Atutor e-Learning platform.

As can be seen, both the Web applicatios that provide the functionality to capture some of the information to create the user model (Web applications for ADHD evaluation) and the video game and the Reusable Learning Object (RLO) with gamification (Web application for ADHD Academic Intervention), were designed as external elements to the e-Learning platform. These elements were considered as external so in this way these applications can be connected with a variety of e-Learning platforms or used for different purpose.

For the development of the ATutor modules, the following elements were taken into account:

- Pack the modules according to the structure and programing language supported by ATutor.
- The use of inline frame as a method to embed the Web applications into ATutor.
- The use of php5-uuid and php5-curl functions to generate a standard identifier also known as Universally Unique Identifier (UUID) to enable Web applications and ATutor to uniquely identify information without significant central coordination.

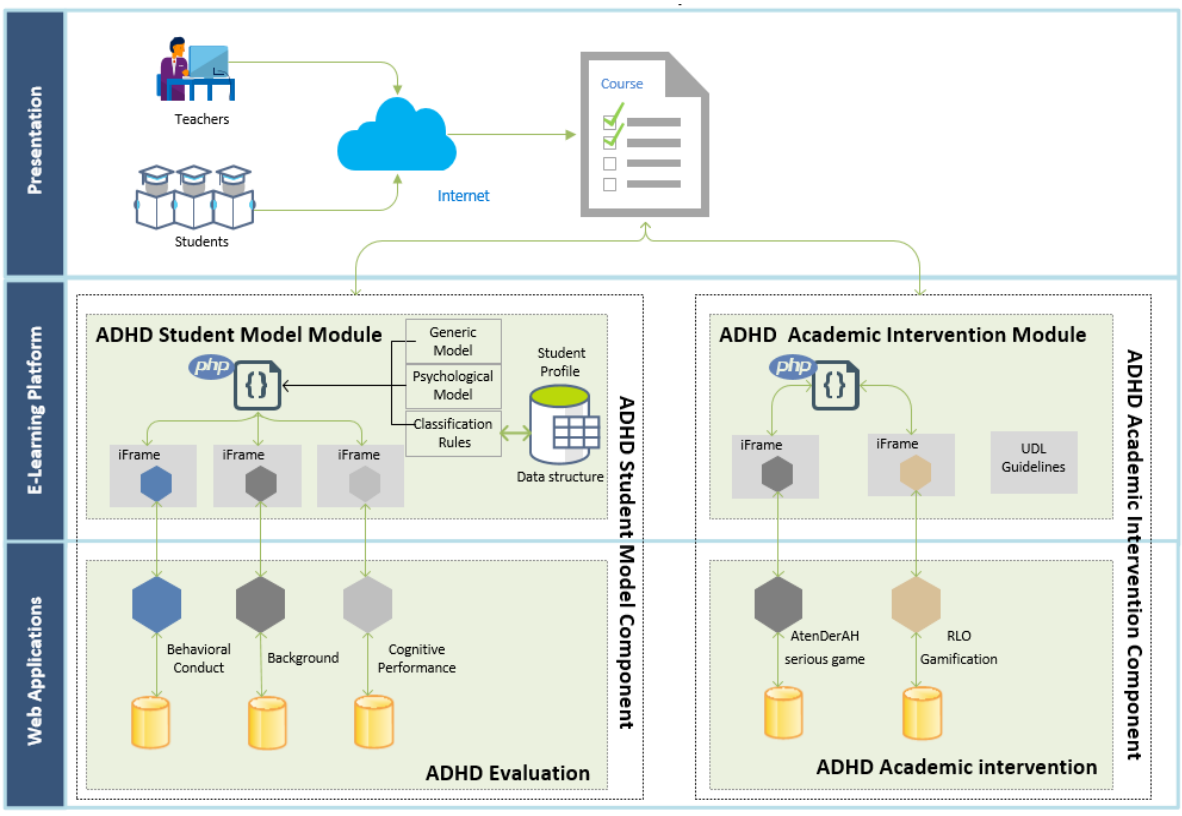


Figure 8. *General architecture of the proposal*

In the case of the ADHD Student Model Module, the following elements were also considered:

- The creation of a data structure, where the information related to the profile is stored.
- The development of the classification rules from which the user 'profile is built.

To complete the process and proceed to use the ADHD Student Model Module and the ADHD Academic Intervention Module, the teacher in a specific course must activate it. In the case of the RLO, a control activity must be defined in the e-Learning platform to be able to put a rating within the platform.

In this thesis, ATutor was the selected e-Learning platform to carry out the development and implementation scenarios due to its accessibility scope and because it was the platform used in several BCDS projects focused on inclusive education.

4.2.1 ADHD Student Model Component

An effective Student Model (SM) for this study must be able to identify if an e-Learning student may have ADHD symptoms. Thus, the research question to be answered in this part of this thesis is **RI1**: how to detect ADHD symtopms in e-Learning students? Based on the theoretical fundamentals presented in CHAPTER 2, it is hypothesized that it requires at least considering information of the following dimensions: personal, demographic and academic; background in clinical, academic and social context; behavioral conduct; and cognitive performance. As can be noted, generic and psychological information are considered, which accoring to Martins et al, (2008) corresponds to a Domain Independent Data (DID) student model. Table 12 shows all elements we proposed to gather up from the student for creating the DID SM, and a detailed description of the data associated to each characteristic dimension is presented.

Table 12. *Student Model based on ADHD symptoms*

SM data Model	Elements	Characteristic Dimension	Data	Values	Description
Domain Independent Data	Generic Model	Personal information	First name	Student's first name	Data which permit to identify a person
			Last name	Student's family name	
			Email	Student's e-mail address	
			User (Id)	Short name required to log on in the e-Learning platform.	
			Password	Encrypted word required to log on in the e-Learning platform.	
		Demographic information	Birthdate	Student's date of birth (Day/Month/Year)	Data which permit to know more about a specific user in terms of location, time, birth
			Gender	• Female • Male	
			Nationality	Student's country of birth	
			City	Student's city of birth	
		Academic information	Semester	1st, 2nd, 3rd, 4th, 5th…	Data referred to academic level
			Level	• Associate´ degree • Bachelor´s degree • Technical´ degree • Education Specialist´ degrees	
			Program	Engineering, Musician, Biology Architecture, Medicine, etc.	Referred to the academic program in which the student is enrolled in
	Psychological Model	Behavioural Conduct information	ADHD behaviours	• Positive • Negative	Referred to the results of apply an ADHD behaviour test

		Background information	Clinical history	Successful outcome along lifetime (Yes or Not)	Referred to the results of apply a history questionnaire
			Schools history	Good relationships with close family member (Yes or Not)	
			Familiar and social history	Good relationships with friends	
		Cognitive Performance information	Sustained Attention (SA)	• Very high • High • Medium • Low • Very low	Referred to the performance of the student when presenting tasks which measure cognitive areas
			Working Memory (WM)		
			Verbal Learning (VL)		
		Inheritance of characteristics	Presence or Absence of ADHD symptoms (Diagnostics process)	• Profile 1: without ADHD symptoms • Profile 2: without ADHD symptoms but impairment in executive functions • Profile 3: with behavioural symptoms of ADHD • Profile 4: with behavioural and cognitive symptoms of ADHD	Set of classification rules for determining the presence of ADHD symptoms (see Figure 1)

Under the proposed model the "*Inheritance of characteristics*" dimension indicates the presence or absence of ADHD symptoms. The inheritance of characteristics works based on a set of classification rules, which are represented in Figure 9. Clasification rules were defined with help of teacher's psychologists from the Universitat de Girona with extensive experience working with ADHD individuals.

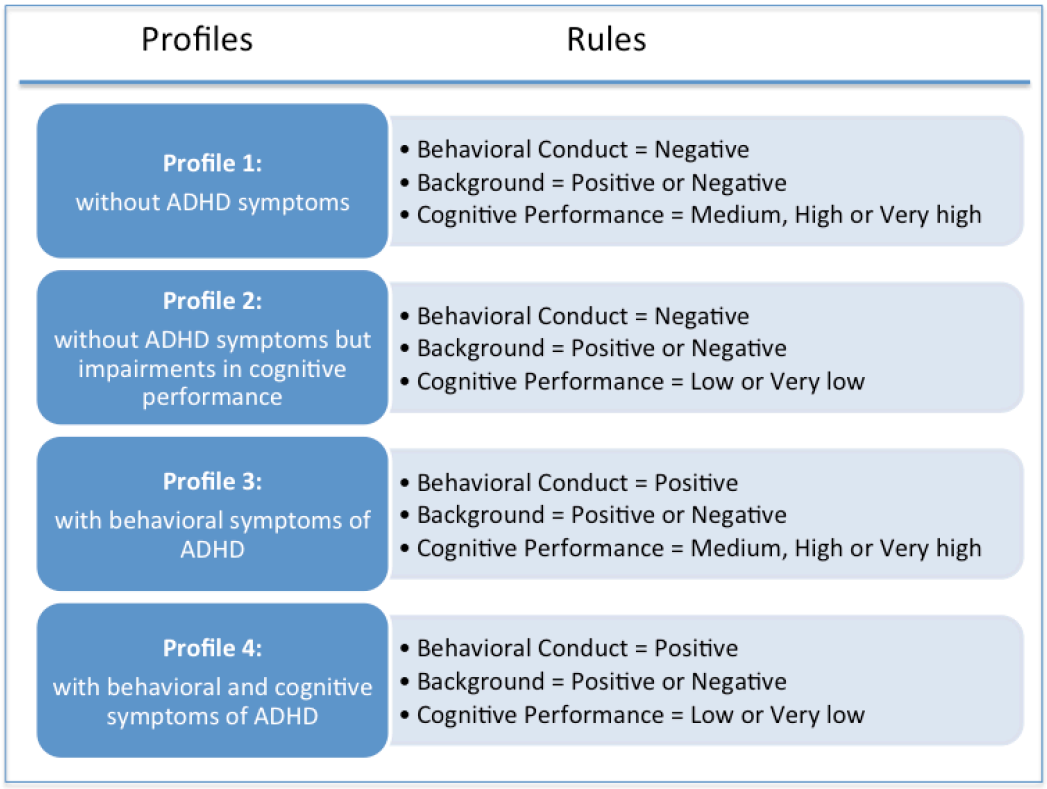


Figure 9. *ADHD Classificatiion rules*

In order to define the classification rules, the psychologists in this work suggested that: Behavioral Conduct information should present higher significance than Background and Cognitive Performance information.

Based on this, the presence or absence of ADHD symptoms may have one of the following values:

- Profile 1 means "without ADHD symptoms of ADHD".
- Profile 2 means "without ADHD symptoms but impairment in cognitive peformance".
- Profile 3 means "with behavioral symptoms of ADHD".
- Profile 4 means "with behavioral and cognitive symptoms of ADHD".

Before ending the SM explanation, it is important to highlight that the data of the Generic Model is used in the measures and calculating results of the values of the Psychological Model. In CHAPTER 5, the implemented system, which includes the used tools to obtain the information from the students for each of the variables of the SM, is presented. Next, the ADHD Academic Intervention Component is described.

4.2.2 ADHD Academic Intervention Component

The ADHD Academic Intervention Component brings together the proposed teaching interventions to support ADHD university students. This component permits to response the **RI2**: "How to achieve that e-Learning students who suffer from ADHD obtain a better academic performance?". Moreover, the definition of the framework addressed the **SO3**: "To design and implement a computer-assisted intervention to support the academic performance of university students suffering from ADHD".

Based on the theoretical fundamentals presented in CHAPTER 2, specifically section 2.4, where scientic references suggest that:

a) Students with attention problems can easily play video games for long periods of time;
b) Games applied to educational settings are a good medium to motivate all students and therefore improve the learning outcomes of all students.
c) Inclusive pedagogical practices as UDL are an efective strategy to respond to diversity in the classroom.

The following strategies were proposed and developed:

a) AtenDerAH: a serious videogame that aim to train cognitive areas related to learning, specifically, those affected by the ADHD. Teacher has to recommend playing AtenDerAH during the formation process.
b) Unit of Learning based on gamification: in this strategy, the learning context must be dynamic and interactive and include elements of games. It is proposed a framework to use this strategy in any topic; it means a Reusable Learning Object (RLO).
c) The templates and principles of the UDL to consider the weaknesses, strengths, and preferences of all students, including those with ADHD symptoms and to eliminate curriculum barriers. The preparation of the template solutions to curriculum barriers take into account the following recommendations:
    - To use the schedule tool provided by the e-Learning platforms, considering that some of the most relevant difficulties of the student with ADHD are the organization and planning capacity.
    - To fragment long assignments given that students with ADHD have trouble maintaining attention for long periods of time.
    - Togive clear instructions, immediate reinforcement and profit mechanisms.
    - To repeat on several occasions the tasks to be performed and deliverable.
    - To promote teamwork.
    - To recommend students review their work after being delivered for correcting errors.

- To use adapted assessments, for example, oral exams, shorter exams, concretion of questions, among others.

4.3 SUMMARY

This chapter summarizes the process designed to offer an inclusive e-Learning experience that include university students suffering from ADHD. This seeks to contribute to a better academic performance and learning experience of the students. The process goes from the identification of symptoms to the academic support in e-Learning environments.

For the symptoms identification it was proposed the ADHD Student Model Component, a technological module that works on the basis of a defined user model that allows identifying if the student may or may not suffering from ADHD symptoms. Based on the literature review (CHAPTER 2), the student's model considers, on the one hand, generic information: Personal, Demographic and Academic information; on the other hand, Psychological information: Behavioral Conduct, Background and Cognitive Performance information. All of this information is related according to some classification rules to categorize the student in one of the following profiles: Profile 1 "without ADHD symptoms of ADHD"; Profile 2 "without ADHD symptoms but impairment in executive functions"; Profile 3 "with behavioral symptoms of ADHD"; and Profile 4 "with behavioral and cognitive symptoms of ADHD".

For academic support the ADHD Academic Intervention Component was proposed, which is a technological module that integrates three teaching-learning didactic strategies: 1) a videogame designed to train cognitive areas that intervene in the learning process, 2) an RLO based on gamification and 3) a learning unit based on the implementation of the Universal Design for Learning (UDL) in order to help reduce barriers that do not allow quality-training processes for all.

The proposed architecture is based on the use of Web applications for the components that can work independently and embed them in e-Learning platforms using inline frames and php5-uuid and php5-curl functions to generate a standard identifier to enable Web applications and e-Learning platforms to uniquely identify information without significant central coordination in order to achieve a portable solution that can work with a variety of e-Learning platforms.

4.4 PUBLICATIONS

Mancera, **L.**, Baldiris, S., & Betancur, V. (2015). Indicators of ADHD symptoms in Virtual Learning Context using Machine Learning technics. Revista EAN, 7), pp. 22–37. Retrieved from http://journal.ean.edu.co/index.php/Revista/article/download/1265/1226

Mancera, **L.**, Baldiris, S., & Fabregat, R. (2012). SARE: Sistema Automático de Reconocimiento de Emociones para soportar el modelado de usuarios con TDAH en Plataformas de elearning. In IV Congreso Internacional de Ambientes Virtuales de Aprendizaje Adaptativos y Accesibles (CAVA 2012). Cartagena de Indias, Colombia: CAVA.

Mancera, **L.**, Baldiris, S., & Fabregat, R. (2011). Adapting suitable spaces in Learning Management Systems to support distance learning in adults with ADHD. In Proceedings of the The 11th IEEE International Conference on Advanced Learning Technologies (ICALT) (pp. 105 – 109). Athens, Giorgia, USA: IEEE. http://doi.org/10.1109/ICALT.2011.37

Mancera, **L.**, Baldiris, L., & Fabregat, R. (2011). Soporte al Proceso de Formación E-learning de Personas Adultas con Trastorno por Déficit de Atención e Hiperactividad". Revista Internacional Magisterio Educación y Pedagogía. ISSN: 1692-4053 pp 88 - 93 v.52.

Mancera, **L.**, Ramírez, D., Segura, N., Guevara, J., Baldiris, S., & Fabregat, R. (2010). Modeling cognitive performance in Virtual Learning Environments in order to personalize learning processes. In II Congreso Internacional de Ambientes Virtuales de Aprenizaje Adaptativos y Accesibles (CAVA 2010). Cartagena, Colombia: CAVA.

Mancera, **L.**, Muñoz, C., Galviz, L., Guevara, J., Baldiris, S., & Fabregat, R. (2010). Modeling emotions in virtual learning environments. In Congreso Internacional de Ambientes Virtuales de Aprenizaje Adaptativos y Accesibles (CAVA 2010). Cartagena, Colombia: CAVA.

Mancera, **L.**, Baldiris, S., & Fabregat, R. (2010). Modeling a game-based adaptive unit of learning to support adults with ADHD in virtual learning environments. In Software Development for Enhancing Accessibility and Fighting Info-exclusion (DSAI 2010). Oxford, OX4 4FY Oxford, United Kingdom: DSAI. Retrieved from http://dsai2010.utad.pt/sessions_and_panel/session1.html

PART 2
IMPLEMENTATION

CHAPTER 5
ADHD STUDENT MODEL COMPONENT

5.1 OVERVIEW

In CHAPTER 4 it was designed the SM and the conceptual architecture to develop in order to identify if a specif university student presents ADHD symptoms, being it the first step to achieve the second specific objective (**SO2**) of this thesis: "**To design** and implement a computer-assisted evaluation protocol to identify students with possible symptoms of ADHD applying student-modeling techniques in e-Learning context". This chapter presents the implementation of this architecture and the validation carried out to accomplish with the proposed layout. The implementation collected information using the registration data on an e-Learning platform and the results of three computer-based neuropsychological tests designed as web application tools that have been developed and integrated into the e-Learning platform.

The implementation of the ADHD Student Model Component is the complement of the work done defining the SM and therefore corresponds to the integral scope of the **SO2** of this thesis: "To design and **to implement** a computer-assisted evaluation protocol to identify students with possible symptoms of ADHD applying student-modeling techniques in e-Learning context". Moreover, this chapter addressed the first research issue that arose from the main research question: "**RI1**: How to detect ADHD symtopms in e-Learning students?".

This chapter is organized as follows: section 5.2 presents the SM architecture, section 5.2.1 describes the process to obtain demographic and academic data, section 5.2.2 the process to obtain behavioral conduct data, section 5.2.3 the process to obtain background data and section 5.2.4 the process to obtain cognitive performance data. Section 5.3 describes the validation scenario carried out that demonstrates the conformity of what has been done and finally, section 5.4 presents some conclusions of this part of the research.

5.2 CONCEPTUAL ARCHITECTURE OF THE ADHD STUDENT MODEL COMPONENT

In CHAPTER 4, the considered student's characteristics and the classification rules proposed to create the ADHD profile were described. In this section, the instruments and process used to obtain the information of each characteristic from the student and the materialization of the conceptual architecture that was designed is presented. Starting from Figure 8, Figure 10 is an extraction of the part concerning the ADHD Student Model Component with additional information regarding the specific information and instruments that are used to obtain it.

On one hand, information related to the Generic Model, i.e., Personal, Demographic and Academic information, is collected through the registration of students in e-Learning platforms since most of them provide this service.

On the other hand, information related to the Psychological Model, i.e., Behavioral Conduct, Background and Cognitive Performance information is collected through three external tools that are connected to the LMS.

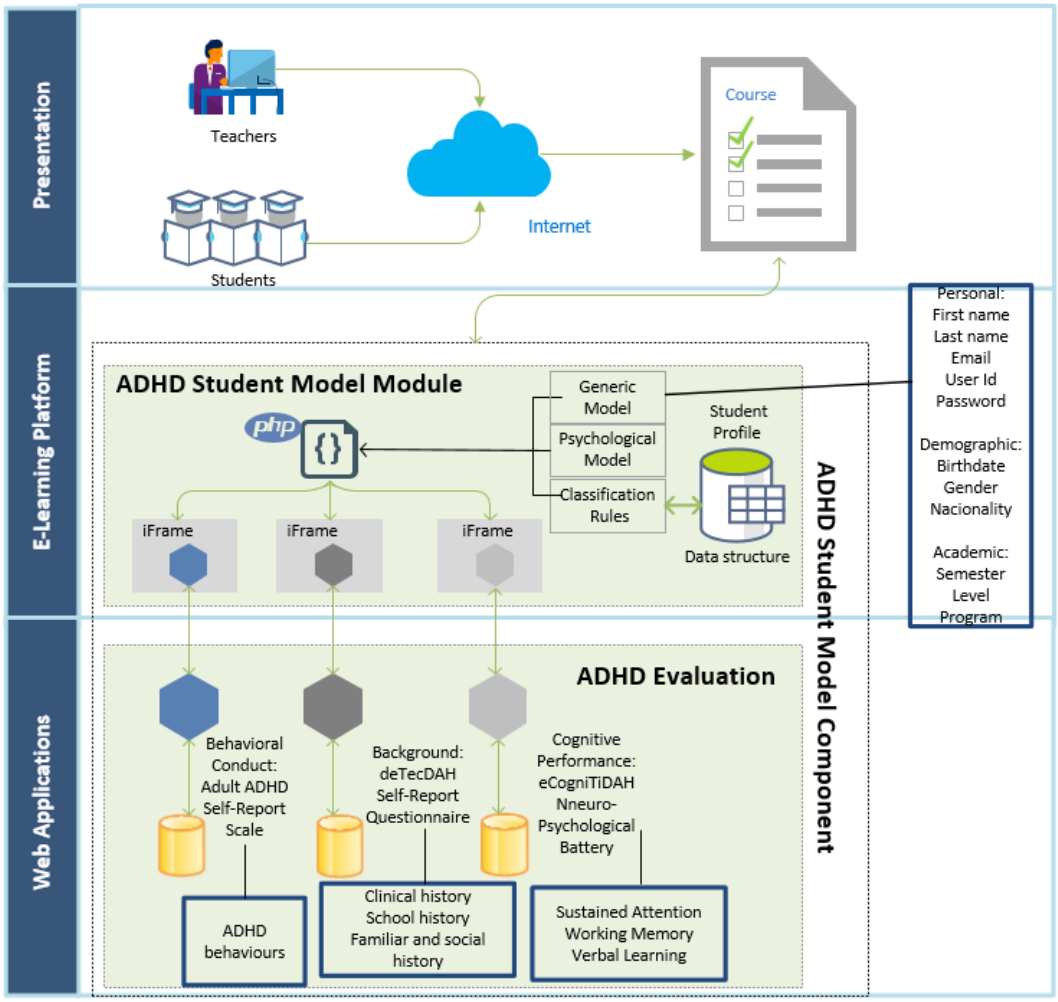


Figure 10. *General framework of the SM architecture*

The following sections describe in detail the way in which the information of each dimension was obtained and present screen shots of the tools of the e-Learning platform or Web applications, according to the case, used for each model and dimensions.

5.2.1 Personal, Demographic and Academic Information

As previously mentioned, the Personal, Demographic and Academic information corresponds to the Generic Model is collected with the registration information on the ATutor platform. In Figure 10 the information of these dimensions was included and Figure 11 shows the graphic user interface of ATutor form for obtaining this information.

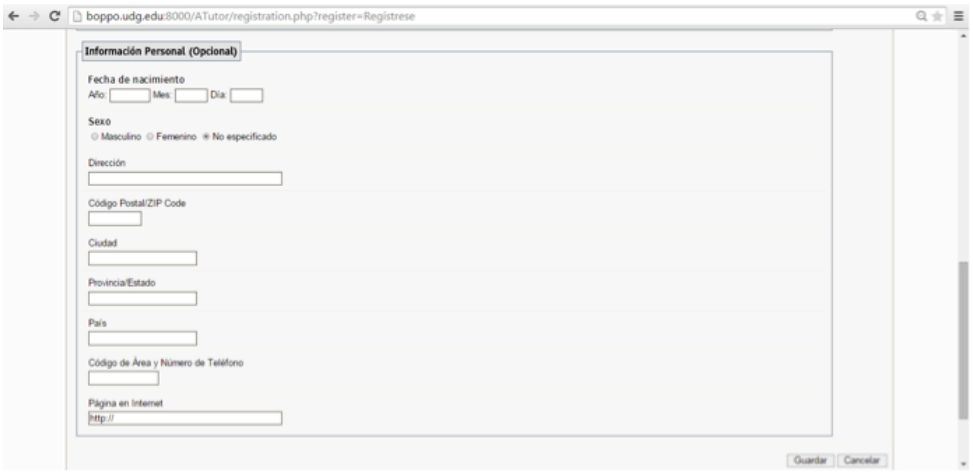


Figure 11. *ATutor GUI for registration*

5.2.2 Behavioral Conduct Information

In order to characterize and to quantify user behaviors that may be relevant to ADHD symptoms, the short version of the Adult ADHD Self-Report Scale (ASRS v2.1) is used (Daigre et al, 2009). This test consists of six items and each item has five possible answers according with the following Liker scale: never, rarely, sometimes, often and very often. In some questions the responses sometimes, often and often are considered a positive answer, and in others only the options often and very often are considered a positive answer. Four or more positive answers suggest the presence of symptoms consistent with ADHD in adults. The result of the evaluation for the behavior conduct is either positive or negative. However, experts in this disorder have stated that even though this scale provides good convergent validity, sensitivity, specificity, and diagnostic capability, there is a high probability of obtaining false-positives. Some of these false-positives are the result of some people with bipolar disorders or schizophrenia, having four or more positive answers. Figure 12 shows the interface of the developed Web form deployed into Atutor e-Learning platform.

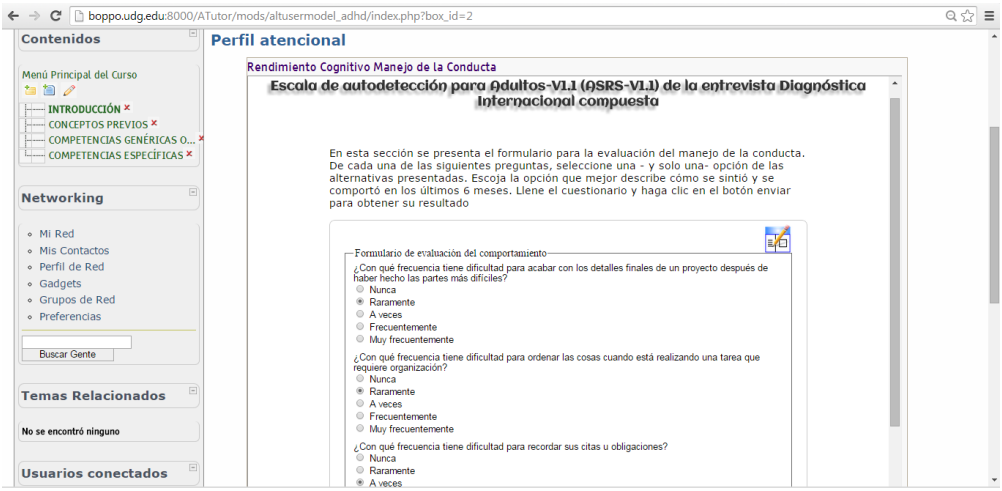


Figure 12. *ASRS Web form into ATutor*

5.2.3 Background Information

In order to complement the characterizing process done by the ASRS questionnaire and thereby reduce the presence of false-positives cases of ADHD, the deTecDAH auto-self report questionnaire has been proposed, developed and included in the evaluation process. It consists of 17 dichotomous (yes/no) questions related to situations that may occur due to the presence of ADHD. These questions have been organized into three sections: clinical (9 questions), scholar (5 questions) and family/social (3 questions). Some key questions (5, 2 and 3 respectively) were used as indicators of the presence of ADHD symptoms in each section. Based on this, about half of key questions answered "yes" indicate the presence of ADHD symptoms (positive); otherwise the result indicates the absence of ADHD symptoms (negative). Figure 13 shows the interface of the developed web form deployed into Atutor e-Learning platform.

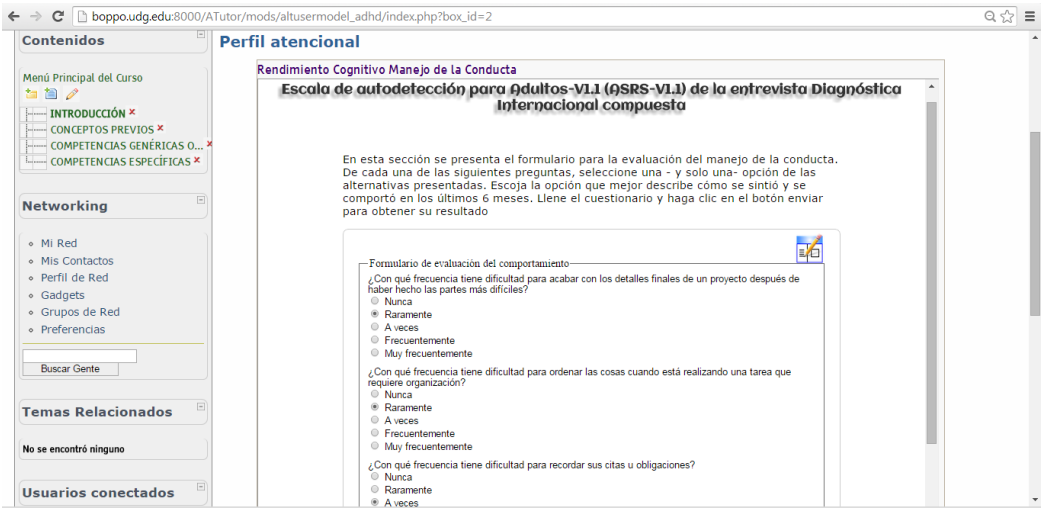


Figure 13. *deTecDAH auto-self report questionnaire into ATutor*

5.2.4 Cognitive Performance Information

Computer-based neuropsychological tests/tasks are frequently used to evaluate the user cognitive performance. We developed a computer-based version of the Sustained Attention Task (SAT) (Van der Elst, Van Boxtel, Van Breukelen and Jolles, 2006) to evaluate the Sustained Attention area; the Rey's Auditory Verbal Learning Test (RAVLT) (Rey, 1958) to evaluate the Working Memory (WM) and Verbal Learning (VL); and the Concept Shifting Test (CST) to evaluate concept shifting. These tests have been comprised into a neuro-psychological battery named eCogniTiDAH. Here, it is important to mention that these tools were developed for research and educative purposes. Next, the software design process followed for the development of eCogniTiDAH is presented.

Domain model

In software engineering, it is a conceptual model of all the issues related to a specific problem. This conceptual model for eCogniTiDAH is showed in Figure 14.

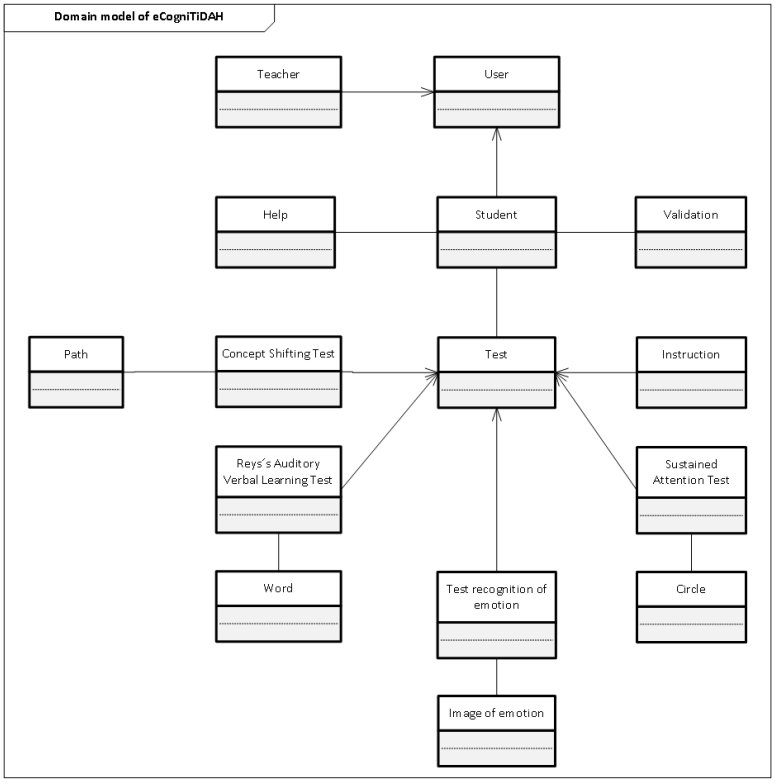


Figure 14. *Domain model of eCogniTiDAH*

Use cases

In order to specify and detail the behavior of eCogniTiDAH, some use cases for the Web application was defined. They have been organized into different functional groups for better interpretation, as shown in the use case diagram in Figure 15.

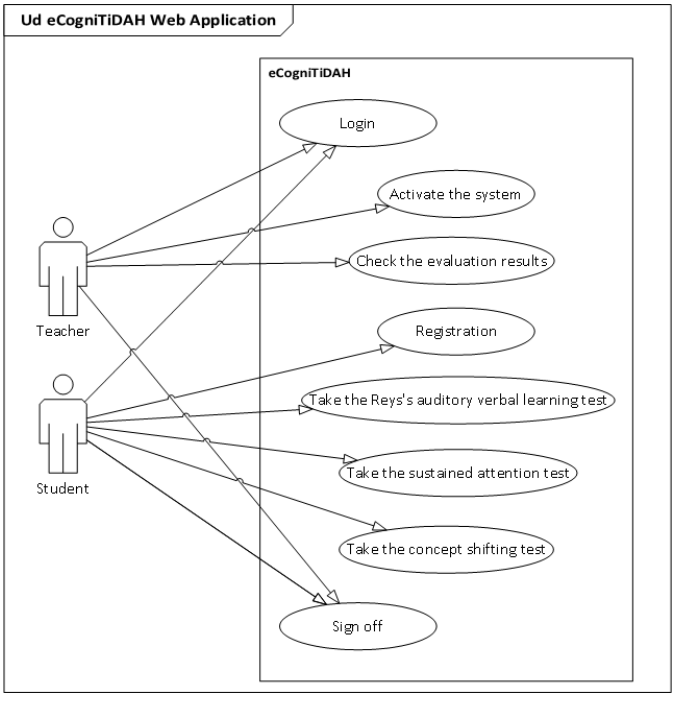


Figure 15. *Use case diagram of eCogniTiDAH*

Figures 16 and 17 show snapshots of the Web application eCogniTiDAH embebed into Atutor platform.

Figure 16. *eCogniTiDAH main interface into ATutor*

Figure 16 corresponds to the interface that appears just after the user must register. Since it was embedded in the ATutor platform, it does not request to register in the application. Once clicking on the "Star evaluation" button, it goes to the interface of Figure 17.

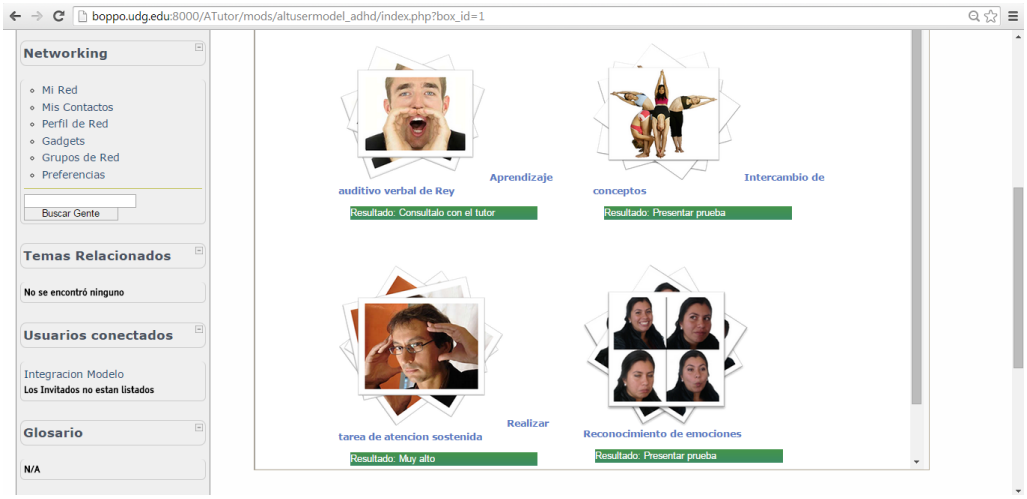


Figure 17. *eCogniTiDAH selection interface into ATutor*

Next, a detailed explanation of each of the tests that make up eCogniTiDAH is explained and presented.

The Sustained Attention Task (SAT)

The SAT is considered a type of Continuous Performance Test (CPT). It consists of a square with three, four or five dots continuously depicted on the screen. The participant is required to press a button if four dots (target) are presented and not to press the button whenever three or five dots (non-targets) are presented. The performance on this test is measured based on the hits, reaction time and errors, specifically omission and commission errors (Börger, 1999; Marchetta, 2007). Hits indicate the number of times a patient was able to detect the stimulus; omission

errors indicate the number of times a patient does not press the button when the stimulus appears; commission errors indicate the times that a patient does not react to the stimulus' presence; and the reaction time indicates the time to respond to a stimulus. Figures 18 and 19 show the interfaces to the SAT.

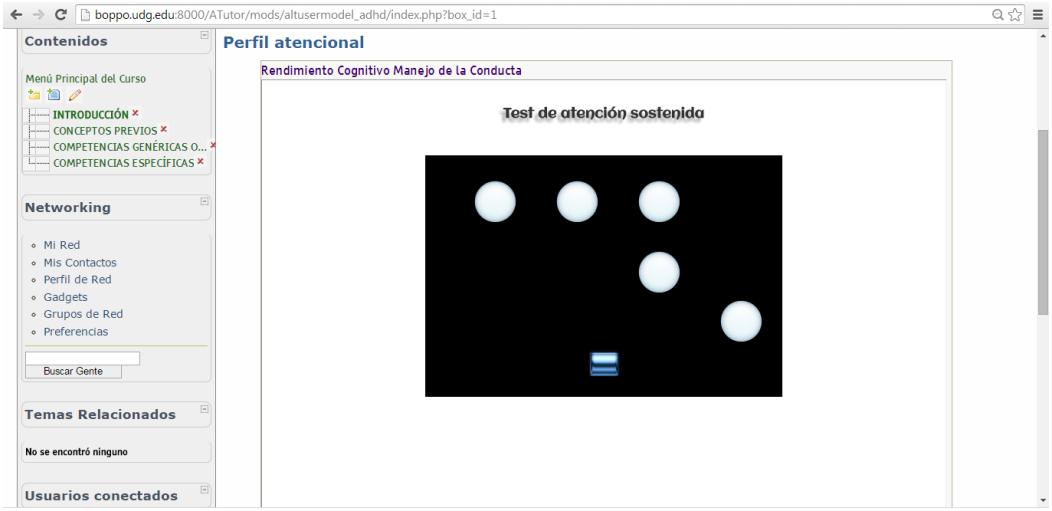


Figure 18. *The SAT with five dots in eCogniTiDAH into ATutor*

Figure 19. *The SAT with three dots in eCogniTiDAH into ATutor*

The Rey's Auditory Verbal Learning Test (RAVLT)

RAVLT test (Rey, 1958) consists of a first list of fifteen words (A1) that are read slowly to the test-taker. Then, the test-taker is required to repeat the words after the reading, independently from the order they were said (Trial 1). The same procedure is repeated in steps Trial 2, Trial 3, Trial 4 and Trial A5, pointing out that the test-taker must always remember all the words, including those said previously. Then, a second list of words (B1) is read as a distractor, and the subject must recall only these new words. After that, the test-taker is asked for the words of the first list (Trial 6). Twenty-five minutes later, the test-taker must able to recall the words of the first list (Trial 7) in order to assess the delayed recall of episodic memory. Word production on the first trial was included as a measure of short-term memory or working memory; word

production on trials 2, 3, 4, 5 and 6 as an index of the learning curve, delayed recall and retention score. Figures 20 and 21 show the interfaces to the RAVLT.

Figure 20. *The instructios of RAVLT in eCogniTiDAH into ATutor*

Figure 21. *The word introduction RAVLT in eCogniTiDAH into ATutor*

The Concept Shifting Test (CST)

It is a Trail Making Type test that measures concept shifting and executive functioning. Both parts of the Trail Making Test consist of 25 circles distributed over a sheet of paper. In Part A, the circles are numbered 1 – 25, and the patient should draw lines to connect the numbers in ascending order. In part B, the circles are labeled with letters (A-Q) and the patient should draw lines to connect the numbers in ascending order. In Part C, the circles include both numbers (1 – 13) and letters (A – L); as in Part A, the patient draws lines to connect the circles in an ascending pattern, but with the added task of alternating between the numbers and letters (i.e., 1-A-2-B-3-C, etc.). The patient should be instructed to connect the circles as quickly as possible, without lifting the pen or pencil from the paper. Time the patient as he or she connects the "trail." If the patient makes an error, point it out immediately and allow the patient to correct it. Errors affect the patient's score only in that the correction of errors is included in the completion time for the task. Figure 22, 23 and 24 show the interfaces of our implementation for this task integrated into ATutor.

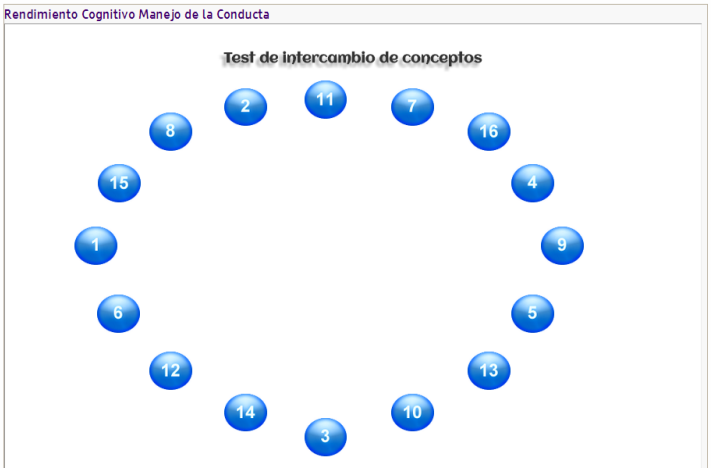


Figure 22. *Part A of the CST in eCogniTiDAH into ATutor*

Figure 23. *Part B of the CST in eCogniTiDAH into ATutor*

Figure 24. *Part C of the CST in eCogniTiDAH into ATutor*

5.3 VALIDATION

The study case was carried out through a quantitative research approach with a descriptive scope. This scope of research pursues to specify important properties of individuals, groups, communities or any other phenomenon that is subjected to analysis (Cid, Méndez and Sandoval, 2011) and it is precisely the goal of this study, to describe the variables of the participant associated to ADHD symptoms inferred using the SM, and compare the results with normalized data.

5.3.1 Procedures

Two professors at the UMB together with the project staff conducted the study case. Professors were previously trained in the use of the system, including the Adult ADHD Self-Report Scale, deTecDAH, and eCogniTiDAH tools.

Students received the guidelines to participate in the study and were trained by the teachers to fill out the questionnaires and cognitive tasks. In line with ethical principles for research, each student provided informed consent for participation in the study in written form.

With the students enrollment on Atutor, the personal, demographic and academic information required for the Generic Model was obtained. Once enrolled, the students were able to access the Psychological Model. In order not to exhaust or bore the participants, the test was divided in two sections. In the first one, the short version of the Adult ADHD Self-Report Scale (ASRS v1.1) and the deTecDAH auto-self report questionnaire were administered. In the second one, the eCogniTiDAH neuropsychological battery was complete. The break time between sections was two hours. The students were individually tested in a noise-isolated room.

5.3.2 Data analysis and results

The results presented below describe the student variables in the SM inferred by the system. The analysis was performed by groups (ADHD+, ADHD- and HYS) to finally draw conclusions. Regarding the Generic Model, the information is represented in Table 13.

Table 13. *Participants characteristics*

Characteristic		**ADHD +**	**ADHD-**	**HYS**
Media Age		21.4	20.6	19,75
Gender	Women	1	2	13
	Men	4	3	7
Medication		3	0	0
Academic level	I	2	3	10
	II	3	2	8
	III	0	0	2
Academic program				
- Psychology		3	2	2
- Criminology		2	1	2
- Sports science			2	7
- Physiotherapy				5
- Nursing				2
- Law				2

In relation to the results shown in Table 13, the average age at ADHD+ and ADHD- group is higher compared to the average of the other two groups and the academic level of the three groups is mostly I and II. This result is consistent with the theoretical foundations that state that students with ADHD tend to repeat school years (Loe & Feldman, 2007; Zambrano, 2013), which means that the student will apply to the university with a higher age than students without ADHD do. On the other hand, the 80% of students in the ADHD+ group were men; this is recurrent with several studies, indicating that men suffer more from the disorder than women (Biederman, Faraone, Braten, Doyle, Spencer et al, 2002).

Regarding the Psychological Model, the first dimension evaluated was the Behavior Conduct using the Adult ADHD Self-Report Scale (ASRS v1.1). Tables 14, 15 and 16 present the obtained results for ADHD+, ADHD- and HYS groups respectively.

Table 14. *Behavior Conduct results for ADHD+ Group*

Student	ASRS Result
1	Positive
2	Positive
3	Positive
4	Positive
5	Positive

Table 15. *Behavior Conduct results For ADHD- Group*

Student	ASRS Result
6	Positive
7	Positive
8	Positive
9	Positive
10	Positive

Table 16. *Behavior Conduct results for HYS Group*

Student	ASRS Result
11	Positive
12	Negative
13	Negative
14	Negative
15	Positive
16	Positive
17	Negative
18	Negative
19	Negative
20	Positive
21	Negative
22	Positive
23	Negative
24	Negative
25	Negative
26	Negative
27	Positive
28	Negative
29	Negative
30	Negative

According to the results shown in Table 14, the ASRS is in line with the previous diagnosis of the students included in the ADHD+ group. Additionally, it is important to highlight that all students who have not been previously diagnosed with ADHD (see Table 15 and 16) have obtained a positive result, which may show the necessity of complementing the assessment with other instruments. It may also indicate an under diagnosis of ADHD.

The other dimension considered in the Psychological Model was the Background Information of the student in clinical, educational and familiar-social contexts using the deTecDAH auto-self report questionnaire. Results of this evaluation are presented in Tables 17, 18 and 19 according to the number of affirmative responses to the key questions (5, 2 and 3 respectively). A positive result in the Background Information is obtained when the value of the sum of the affirmative responses in clinical, scholar and familiar-social context is 5 or greater.

Table 17. *Background Information results for ADHD+ Group*

Student	Clinical (5)	Scholar (2)	Familiar-Social (3)	Total (10)	Background Result
1	5	1	3	9	Positive
2	5	2	2	9	Positive
3	5	2	1	8	Positive
4	5	2	1	8	Positive
5	5	2	2	9	Positive

Table 18*. Background Information results for ADHD- Group*

Student	Clinical (5)	Scholar (2)	Familiar-Social (3)	Total (10)	Background Result
6	3	1	1	5	Positive
7	3	1	2	6	Positive
8	2	2	1	5	Positive
9	4	2	1	7	Positive
10	3	2	1	6	Positive

Table 19. *Background Information results for HYS Group*

Student	Clinical (5)	Scholar (2)	Familiar-Social (3)	Total (10)	Background Result
11	0	1	0	1	Negative
12	0	1	0	1	Negative
13	0	2	0	2	Negative
14	0	2	0	2	Negative
15	1	2	1	4	Negative
16	0	1	0	1	Negative
17	0	1	0	1	Negative
18	0	2	0	2	Negative
19	0	2	0	2	Negative
20	0	2	0	2	Negative
21	1	1	0	2	Negative
22	0	1	0	1	Negative
23	1	2	1	4	Negative
24	0	2	0	2	Negative
25	0	2	0	2	Negative
26	1	1	0	2	Negative
27	0	1	0	1	Negative
28	0	2	1	3	Negative
29	2	2	1	5	Positive
30	0	2	0	2	Negative

By comparing Background Information results with the ASRS, it can be noted that the students of the ADHD+ and ADHD- groups maintained their positive outcome, while the number of student that obtained a positive outcome in the HYS decreased (only one student in Background Information obtained a positive result while in Behavior Conduct six students obtained a positive result). This difference can be explained by the fact that deTecDAH have several questions related to the clinical context.

Concerning the Cognitive Performance informatio using eCogniTiDAH, it is important to describe that, generally, statistics are used to define the performance of a patient in these kind of tests. We compare student's results with the normalized data, according to age and education level, of people without cognitive problems on each of the three tests (Van der Elst et al, 2006; Rey, 1958). Considering that we have different evaluation scales for each test, we compare the patient results on each of them with the mean (μ) of its normalized data in terms of its standard deviation (α). Table 20 gives the parameters that classify the students' results. Those parameters are based on experienced psychologist in ADHD field.

Table 20. *Statistics to compare students' results in cognitive performace per each test*

Statistic	Student Result	Assigned Value
Below μ-2 σ	Very Low	1
Between μ -2 σ and $\mu - \sigma$	Low	2
Between μ - σ and $\mu + \sigma$	Medium	3
Between $\mu + \sigma$ and $\mu + 2\sigma$	High	4
Above $\mu + 2\sigma$	Very High	5

Furthermore, as a variety of characteristics of the cognition it has been considered to extract information about the cognitive performance of a student, it might be said that the cognitive trait dimension comprises a student model itself; thus, for the final cognitive performance result, a number from 1 to 5 is assigned for the possible results on each of the three tools. The final SA result is obtained by adding the values found in these tests. The scale for the classification of the final Cognitive Performance is shown in Table 21.

Table 21. *Range for final cognitive performance classification*

Ranges	Classification
{3, 4}	Very Low
{5, 6, 7}	Low
{8, 9, 10}	Medium
{11, 12, 13}	High
{14, 15}	Very High

As sown in Table 21, the possible results of the Cognitive Capacities are: Very Low, Low, Medium, High and Very High. The ranges for the final classification are obtained considering the limits of the possible results, for example, two very low results (2 x 1) and one low (2) should produce a final very low one (4), but two low results (2 x 2) and one very low (1) should produce a final low result (5). The rest of the ranges are constructed in the same way.

Having explained this, the results of the assessment of each area considered in the cognitive dimension are presented. The first area evaluated was Sustained Attention (SA) using the SAT. Tables 22, 23 and 24 show results for each student.

Table 22. *Sustained Attention results for ADHD+ Group*

Student	Hit	Omission Errors	Error Commission	Reaction Time	Final SA Result
1	Low	Low	Medium	Medium	Low
2	Low	Low	Low	Low	Low
3	Medium	Medium	Medium	Low	Medium
4	Medium	Medium	Medium	Low	Medium
5	Medium	Medium	Medium	Low	Medium

Table 23. *Sustained Attention results for ADHD- Group*

Student	Hit	Omission Errors	Error Commission	Reaction Time	Final SA Result
6	Low	Low	Medium	Low	Low
7	Low	Medium	Medium	Low	Medium
8	Medium	Medium	Medium	Medium	Medium
9	Medium	Medium	Medium	Medium	Medium
10	Medium	Medium	Medium	Medium	Medium

Table 24*. Sustained Attention results for HYS Group*

Student	Hit	Omission Errors	Error Commission	Reaction Time	Final SA Result
11	Very high	High	High	High	High
12	Medium	Medium	Medium	High	Medium
13	High	High	High	High	High
14	Medium	Medium	Medium	High	Medium
15	Low	Low	Medium	Medium	Low
16	High	High	High	High	High
17	High	High	High	High	High
18	Very low	Low	Medium	Low	Low
19	High	High	High	High	High
20	Medium	Medium	Medium	Medium	Medium
21	High	High	High	High	High
22	Medium	Medium	Medium	Medium	Medium
23	Low	Medium	Low	Low	Low
24	Medium	Medium	Medium	Medium	Medium
25	Medium	Medium	High	High	Medium
26	Medium	Medium	Medium	High	Medium
27	Medium	Medium	Medium	High	Medium
28	High	High	High	High	High
29	Very low	Medium	Low	Low	Low
30	Medium	Medium	High	High	Medium

To simplify the SA results, these have been grouped into the number of times that a certain result was obtained. Table 25 shows SA global results.

Table 25. *Sustained Attention global results*

Group	Hits	Omission Error	Error Commission	Reaction Time	Final SA Result
ADHD +					
Low	2	2	1	4	2
Medium	3	3	4	1	3
ADHD -					
Low	2	1	0	2	2
Medium	3	4	5	3	3
HYS					
Very low	2	0	0	0	0
Low	2	2	2	3	4
Medium	9	11	9	4	9
High	6	7	9	13	7
Very High	1	0	0	0	0

According to R and M Scandar (nd) the Hits and the Omission Errors provide information about the attention quality, but the last one is a more meaningful measure. Based on Table 25, it is important to note that in the Hits performance of the ADHD+ and ADHD- groups only Low and Medium results are obtained, while there is a High predominance in the HYS group.

On the other hand, the results of the Omission Errors in the ADHD+ and ADHD- groups have the same predominance (Medium), while the performance in the HYS group improved: Low performance decreased and the Medium and High increased. Referring to these findings, it could be inferred that attentional quality in the HYS group is greater.

According to the Error Commission, R and M Scandar (nd), state that these indicate poor inhibitory control, process that is deficient in people with ADHD. As it can be seen in Table 25, the Error Commission performance of the ADHD+ and ADHD- groups, tends to Medium, while in the HYS there is the same percentage of Medium and High but there is a small percentage of Low.

About the Reaction Time it is important to note that the lower performance of the ADHD+ and ADHD- groups was obtained in this measure. Additionally, the Reaction Time yielded the most marked difference by comparing the results of the three groups, which means that it could be a decisive measure for inferring ADHD symptoms.

As regard to the final SA Result field, which is calculated by averaging the Hit, the Omission Error, the Commission Error and the Reaction Time results, given greater weight to the Omission Error in case of ties, the behavior of the results is congruent with those obtained in the other measures. Omission errors have more weigh in this thesis since is considered a measure of inattention.

Regarding Working Memory (WM) and Verbal Learning (VL), the values considered for the analysis was the number of word production using the RAVLT. As mentioned in section 5.2.4, results on the Trial 1 (first round of the test) are included as a measure of WM. These results are presented in Table 26, 27 and 28.

Table 26. *Working Memory results for: ADHD+ Group*

Student	(Trial 1) WM Result
1	Low
2	Low
3	Very Low
4	Low
5	Very Low

Table 27. *Working Memory results for ADHD- Group*

Student	(Trial 1) WM Result
6	Very Low
7	Low
8	Medium
9	Medium
10	Low

Table 28. *Working Memory results for HYS Group*

Student	(Trial 1) WM Result
11	Very Low
12	Medium
13	Medium
14	Medium
15	Low
16	Medium
17	Medium
18	Medium
19	Medium
20	Low
21	Medium
22	Medium
23	High
24	Medium
25	Medium
26	Medium
27	Medium
28	Medium
29	Low
30	Medium

To simplify the WM results, these have been grouped into the number of times that a certain result was obtained. Table 29 shows WM global results.

Table 29. *Working Memory global results*

Group	Result
ADHD +	
Very low	2
Low	3
ADHD -	
Very low	1
Low	2
Medium	2
HYS	
Very low	1
Low	3
Medium	15
High	1

As it can be seen in Table 29, the Low performance is the tendency in the ADHD+ group. These results are in line with the ones on the prior evaluation. On the other hand, there is not a marked tendency in the ADHD- group, although the results include Low and Very Low performances, which corresponds to the expected result, given that the university welfare department refereed the students in this group as students with potential ADHD problems. The results of the HYS group show a clear tendency to Medium performance, even though High, Low and Very low were obtained. These can be looked as good results, given that the population included in this group was considered with no ADHD, but anyone could suffer from it.

In Table 30, 31 and 32 the results of the Trial 2, 3, 4, 5 and 6 are presented as an index of Verbal Learning (VL).

Table 30. *Verbal Learning results for ADHD+ Group*

Student	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Final VL
1	Low	Low	Low	Low	Low	Low
2	Low	Low	Low	Low	Low	Low
3	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
4	Low	Low	Low	Low	Low	Low
5	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low

Table 31. *Verbal Learning results for ADHD- Group*

Student	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Final VL
6	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
7	Low	Low	Low	Low	Low	Low
8	Medium	Medium	Low	Low	Low	Low
9	Low	Medium	Medium	Low	Low	Low
10	Low	Low	Low	Low	Low	Low

Table 32. *Verbal Learning results for HYS Group*

Student	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Final VL
11	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
12	Medium	Medium	Medium	Medium	Medium	Medium
13	Medium	Medium	Medium	Medium	Medium	Medium
14	Medium	Medium	Medium	Medium	Medium	Medium
15	Low	Low	Low	Low	Low	Low
16	Medium	Medium	Medium	Medium	Medium	Medium
17	Medium	Medium	Medium	Medium	Medium	Medium
18	Medium	Medium	Medium	Medium	Medium	Medium
19	Medium	Medium	Medium	Medium	Medium	Medium
20	Low	Low	Low	Low	Low	Low
21	Medium	Medium	Medium	Medium	Medium	Medium
22	Medium	Medium	Medium	Medium	Medium	Medium
23	High	High	High	High	High	High
24	Medium	Medium	High	High	High	High
25	Medium	Medium	Medium	Medium	Medium	Medium
26	Medium	Medium	Medium	Medium	Medium	Medium
27	Medium	Medium	Medium	Medium	Medium	Medium
28	Medium	Medium	Medium	Medium	Medium	Medium
29	Low	Low	Low	Low	Low	Low
30	Medium	Medium	Medium	Medium	Medium	Medium

To simplify the VL results, these have been grouped into the number of times that a certain result was obtained. Table 33 shows VL global results.

Table 33. *Verbal Learning global results*

Group	Final result VL
ADHD +	
Very low	2
Low	3
ADHD -	
Very low	1
Low	4
HYS	
Very low	1
Low	3
Medium	14
High	2

Table 33 shows a Low and Very low performance as a tendency in the ADHD+ group, while in the ADHD- group there is room for Medium performances. On the other hand, there is a clear tendency in the HYS group to the Medium performance, even though High, Low and Very low performances were obtained.

Because of the complexity of the cognitive dimension, a final cognitive performance was inferred relating the SA, the WM and the VL performance. These results are obtained adding the values found and applying a classification explained in Table 7. These final results are presented in Tables 34, 35 and 36.

Table 34. *Final Cognitive results for ADHD+ Group*

Student	Sustained Attention	Working Memory	Verbal Learning	Final Result
1	Low	Low	Low	Low
2	Low	Low	Low	Low
3	Medium	Very low	Very low	Low
4	Medium	Low	Low	Low
5	Medium	Very low	Very low	Low

Table 35. *Final Cognitive results for ADHD- Group*

Student	Sustained Attention	Working Memory	Verbal Learning	Final Result
6	Low	Very low	Very Low	Very low
7	Low	Low	Low	Low
8	Medium	Medium	Low	Medium
9	Medium	Medium	Low	Medium
10	Medium	Low	Low	Low

Table 36. *Final Cognitive results for HYS Group*

Student	Sustained Attention	Working Memory	Verbal Learning	Final Result
11	High	Very low	Very low	Low
12	Medium	Medium	Medium	Medium
13	High	Medium	Medium	Medium
14	Medium	Medium	Medium	Medium
15	Low	Low	Low	Low
16	High	Medium	Medium	Medium
17	High	Medium	Medium	Medium
18	Low	Medium	Medium	Medium
19	High	Medium	Medium	Medium
20	Medium	Low	Low	Low
21	High	Medium	Medium	Medium
22	Medium	Medium	Medium	Medium
23	Low	High	High	Medium
24	Medium	Medium	High	Medium
25	Medium	Medium	Medium	Medium
26	Medium	Medium	Medium	Medium
27	Medium	Medium	Medium	Medium
28	High	Medium	Medium	Medium
29	Low	Low	Low	Low
30	Medium	Medium	Medium	Medium

As it can be seen in Tables 32, 33 and 34 the final result is similar to the performance obtained by the students in each cognitive area. Conversely, Tables 35, 36 and 37 show the results of the profile of each student according to ADHD when applying the classification rules that were proposed.

Table 37 shows that all the five students in the ADHD+ group were classified in profile 4, which mean "behavioral and cognitive symptoms of ADHD".

Table 37. *ADHD+ student profile*

Student	Results			Profile
1	Positive	Positive	Low	4
2	Positive	Positive	Low	4
3	Positive	Positive	Low	4
4	Positive	Positive	Low	4
5	Positive	Positive	Low	4

Table 38 shows that three students of the ADHD- were classified in the profile 4 and two students in the profile 3, this last profile means "behavioral symptoms of ADHD".

Table 38. *ADHD- student profile*

Student	Results			Profile
6	Positive	Positive	Very Low	4
7	Positive	Positive	Low	4
8	Positive	Positive	Medium	3
9	Positive	Positive	Medium	3
10	Positive	Positive	Low	4

Finally, Table 39 shows that thirteen students of the HYS were classified in the profile 1, which means "without ADHD symptoms of ADHD"; one student in the profile 2, which means "without ADHD symptoms but impairment in executive functions"; three in the profile 3; and three in profile 4.

Table 39. *HYS student profile*

Student	Results			Profile
11	Positive	Negative	Low	4
12	Negative	Negative	Medium	1
13	Negative	Negative	Medium	1
14	Negative	Negative	Medium	1
15	Positive	Positive	Low	4
16	Positive	Negative	Low	4
17	Negative	Negative	Medium	1
18	Negative	Negative	Medium	1
19	Negative	Negative	Medium	1
20	Positive	Negative	Low	4
21	Negative	Negative	Medium	1
22	Positive	Negative	Medium	3
23	Negative	Negative	Medium	1
24	Negative	Negative	Medium	1
25	Negative	Negative	Medium	1
26	Negative	Negative	Medium	1
27	Positive	Negative	Medium	3
28	Negative	Negative	Medium	1
29	Negative	Positive	Low	2
30	Negative	Negative	Medium	1

This classification shows that it was possible to infer an ADHD profile to each student, based on the student results in each dimension considered in the SM proposed. These results are important because they give evidences supporting the validity of the system for detecting ADHD symptoms in e-Learning scenarios.

5.4 CONCLUSIONS OF THE CHAPTER

Results of the validation proves that the system is able to make a profile of the students with symptoms of ADHD, based on the characteristics included in the SM, thus reaching **SO2** and responding to **RI1**.

In addition, it is concluded that to identify in e-Learning context students with possible symptoms of ADHD require considering at least the following dimensions: personal and demographic information; background in clinical, academic and social context; behavioral conduct; and cognitive performance.

However, it is important to highlight the effectiveness of the self-applied tests as useful tools to identify diagnostic criteria for ADHD, In addition to being validated, the results that were obtained compared with all the follow-up of the protocol established in the user model, were accurate.

The study is not intending to present a method for detecting ADHD in a medical context, but can support teachers and trainers in an educational context, giving them insights about possible symptoms of ADHD in their students that can be corroborated by psychologists.

In summary, the research has found that it is possible to identify if an e-Learning student could have related ADHD symptoms.

5.5 PUBLICATION

Mancera, **L**., Baldiris, L., Fabregat, R., Sanchez, M., & Viñas, F (2017). A domain-independent ADHD Student Model for Computer-Based Educational Systems. Data analysis in higher education. Journal of Ambient Intelligence and Smart Environments. Vol. 9, issue 5, pp 625-639. doi: 10.3233/AIS-170455. Impact Factor 2017: 0.809. Quartile 3.

CHAPTER 6
ADHD ACADEMIC INTERVENTION COMPONENT

6.1 OVERVIEW

In CHAPTER 2 it was identified some preferences, strengths and weaknesses of young and adults suffering from ADHD in academic context. Against this background, in CHAPTER 4 it was designed the ADHD Academic Intervention Component that brings together three strategies based on these preferences, strengths and weaknesses to support ADHD students who have found in e-Learning an opportunity to carry out their university education. With the design of this component and the conceptual definition of the architecture that abstracts how the system that contains the component would be, the first part of **SO3** and **SO4** was achieved. Therefore, in CHAPTER 4 it was addressed the **RI2**: "How to achieve that e-Learning students who suffer from ADHD obtain a better academic performance?" and **RI3**: "How to achieve an e-Learning experience that includes students with ADHD?".

This chapter presents the implementation of the architecture defined and the validation carried out to accomplish with the proposed layout. By doing so, the **SO3** is accomplished: "**: To design and implement an computer-assisted academic intervention** to improve the academic performance of ADHD students who have found in e-Learning an opportunity to carry out their university education", and **RI2** is answered. The **SO4** is also reached: "**To design and implement** an intervention supported by technology and good practices in attention to diversity to provide an eLearning a training process that includes university students suffering from ADHD", and the RI3 is answered.

The academic intervention brings together three didactic strategies based on the findings of effectiveness of games in the training processes of students suffering from ADHD; on the other hand, based on the broad use of the UDL as a framework that allows teachers to address diversity in the classroom. This chapter is organized as follows: section 6.2 presents aTenDerAH, the first strategy designed, which is a videogame to intervene cognitive areas related to learning to check if these improve the academic performance of ADHD university students. Section 6.3 presents the ROL based on gamification, the second strategy designed, which was designed to offer students a dynamic, interactive and ludic learning. Section 6.4 presents the application of UDL templates and principles to offer an inclusive environment, the third strategy designed. Finally section 6.5 presents the conclusions of the validation sceneries.

6.2 STRATEGY 1: AtenDerAH

aTenDerAH is a serious videogame designed to train cognitive areas related to learning in university students suffering from ADHD symptoms who are involved in e-Learning courses. This part of the thesis corresponds with **SO3**. To describe the videogame, some of the elements of the classification proposed by Werbach and Hunter were taken into account (Werbach & Hunter, 2012).

6.2.1 Mechanics

Points

Each level has a number of points that can be reached depending on the tasks and the order in which they perform them. The order of the tasks corresponds to a planning exercise that the player must do to carry out the activities. Figure 25 shows the point system designed for level 1 and Figure 26 shows the point system designed for level 2.

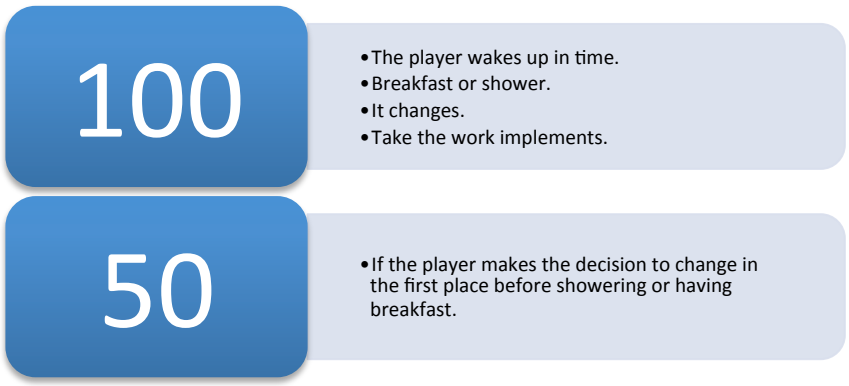


Figure 25. *Point system for level 1 - AtenDerAH*

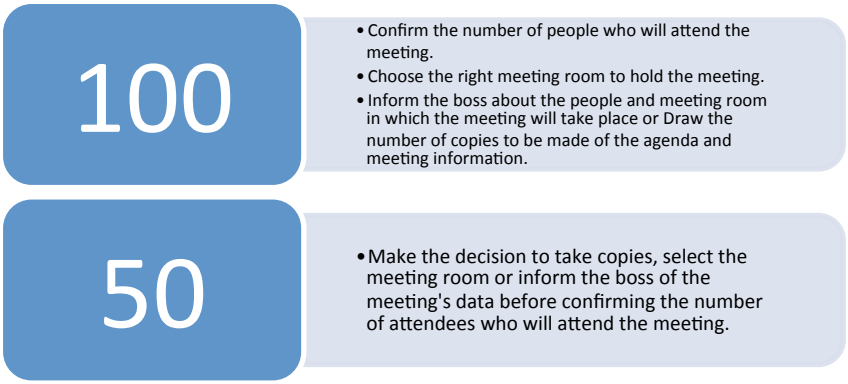


Figure 26. *Point system for level 2 – AtenDerAH*

Levels

ATenDerAH is composed of two levels. The first one has a minor difficulty and the activities to develop correspond to daily activities at home. The second one occurs in an office setting and the activities correspond to specific tasks related to a job position. The names of the levels are: 1) At home, and 2) At the office.

Challenges

Each level in ATenDerAH is composed of a number of activities that the player must do. All the activities need to be completed in order to overcome the level. The challenge is to plan the order in which the player will develop these activities so that time does not run out and reach to perform all activities and thus overcome each level.

Rewards

With respect to the plot of the game, the player must select the best way to develop the activities. If the player chooses the best way, he is rewarded with points that he can change for extra time and clues that indicate the following steps. Figure 27 shows where the rewrds are displayed in the game. In addition, there are extra activities as organize the house and office which are rewarded with extra time and points.

Figure 27. *Display of rewards*

6.2.2 Dynamic

Narrative

The story of the videogame is about a student who has been accepted to an internship in a recognized company and must face the first job day. In ATenDerAH, facing the first day of work means that the player must arrive on time to the office and can carry out the tasks entrusted by the direct manager. The story has two scenarios, the first, the house of the player and the second happens in the company. Thus, AtenDerAH is composed of two levels called as follow: 1) At home, and 2) At the office.

At home level the mission is getting to work at 7.30 o'clock performing some tasks of a daily life: wake up on time, have a shower to be clean, get formal dress to give a good impression at work, have breakfast to have energy and more time to develop activities, take the keys before leaving home and drive to work respecting signs and the traffic code to avoid being penalised and wasting time. Snapshots of each task are shown in Figure 28, Figure 29, Figure 30, Figure 31 and Figure 32. Figure 28 is when the player decides to lay the bed.

Figure 28. *aTenDerAH level 1 – Activity 1*

Figure 29 refers to the selection of the type of clothing that the player considers that he must use for his first day of work.

Figure 29. *aTenDerAH level 1 – Activity 2*

Figure 30 refers to the decision to take a shower according to an estimated order.

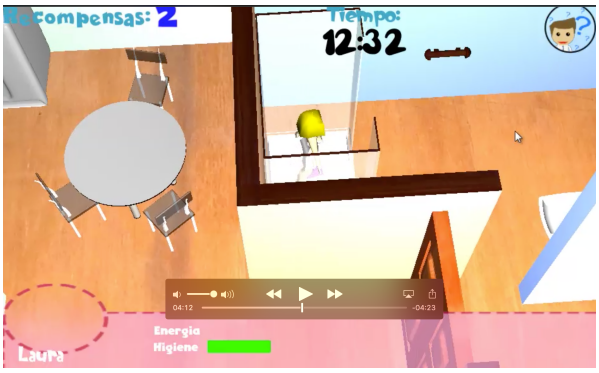


Figure 30. *aTenDerAH level 1 – Activity 3*

Figure 31 refers to the decision to take breakfast or not for your first day of work.

Figure 31. *aTenDerAH 1st level – Activity 4*

Figure 32 refers to the activity of taking the workbag and the keys before leaving for work.

Figure 32. *aTenDerAH 1st level – Activity 5*

At the office level the mission is to organize a meeting for the boss performing the following tasks: contact people to confirm attendance; choose a meeting room; print the meeting material; inform the boss about the meeting details. Snapshots of the each task in the game are showed in

Figure 33, Figure 34, Figure 35 and Figure 36. Specifically, Figure 33 shows the moment when the player arrives at the company and receives instructions to go to the office.

Figure 33. *aTenDerAH 2nd level – Activity 1*

Figure 34 shows the moment when the player has arrived at the office and finds the activities he has to do.

Figure 34. *aTenDerAH 2nd level – Activity 2*

Figure 35 shows the moment in which the player is taking some photocopies, which is one of the tasks that must be performed to comply with the duties assigned on the first day of work.

Figure 35. *aTenDerAH 2nd level – Activity 3*

Figure 36 shows the task to select the meeting room, also one of the duties that has been assigned to successfully complete the first day of work.

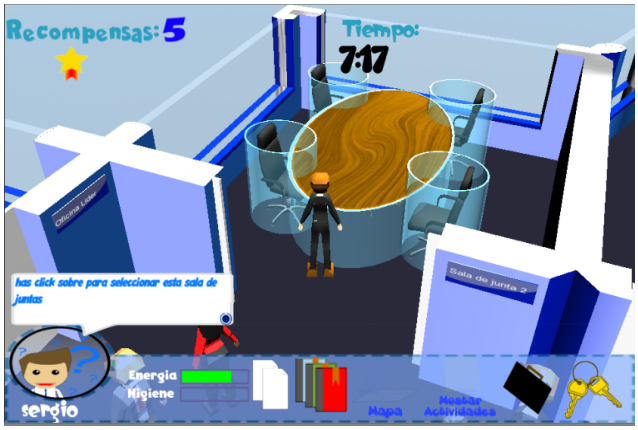


Figure 36. *aTenDerAH 2nd level – Activity 4*

While the player drive to work need to comply with the traffic lights to avoid being penalized with reduction of time. A snapshot of the car scenarie is showed in Figure 37.

Figure 37. *(A) aTenDerAH 1st level – Car scenarie 1*

6.2.3 Aesthetics

The purpose of aTenDerAH is to train, in a fun way, cognitive abilities related to the process of learning in e-Learning students suffering from ADHD. However, the game has been designed so that the student does not perceive the game as an obligation because it is part of the course but to see it as a leisure and entertainment space. According to the exposed, the aesthetic components that create aTenDerAH player experiences are: *Submission* and *Expression.*

On the other hand, the cognitive areas trained in the 1st level are:

- Decision-making since players must decide which clothes are appropriate to bring for work and which breakfast to have in order to obtain energy.
- Attention since the player has to pay attention to the hints and remember to take the keys before leaving home.
- Planning since the player has to think the order to execute tasks.
- Rule abiding since traffic signs should be obeyed.

Mainly, the cognitive areas trained in the 2nd level are: attention since the player has to pay attention to the hints and the number of people who will attend to the meeting, which is randomly selected by the videogame, since based on this number, the player has to choose the size of the meeting room and the number of photocopies to do; on the other hand, organizational and manage time skills are trained with the videogames since the player must complete with the tasks in a fixed time and have the possibility of organizing their house and office in several opportunities.

6.2.4 Technolology

aTenDerAH is a 3D serious videogame developed using different applications:

- Unity for the creation of the 3D game and the interactive content.
- Cinema 4D for the creation of the models and animations in 3D.
- Photoshop for the creation of textures for the 3D models.

Additionally, aTenDerAH was conceived as a Web application to favor the portability of the game. Web environments have several advantages to accomplish this requirement such as the simplicity of implementation, the wide diversity of technology, ecosystems, programming languages, frameworks and libraries both server side, as client side and the possibility to use wherever to browser that runs JavaScript is available.

6.2.5 Validation

The study case was carried out through a mixed research approach with a descriptive scope. The objective of the study was to know the influence of the video game in the academic performance of students (quantitative part) and also their perception about the videogame as academic intervention (qualitative parte).

Participants

The study case was implemented with the same participants involved in the evaluation of the ADHD student model. However, the ADHD group sample was expanded according to the results obtained in the validation scenarie of the student model (Section 5), it means students who profiled 4 and 3, thus allowing not considere the (ADHD-) group. Futhermore, one more student was included in the Healthy Young Students group (HYS). Thus, the sample was formed as follow: 16 young students in the ADHD group (ADHD=16) and 15 Healthy Young Students (HYS=15).

With this sample two groups were formed, the experimental one, which included AtenDerAH as a stimulus in the learning environment, and the control one in which the stimulus was not included. The experimental group consisted of 8 students from the ADHD group and 7 students from the HYS group; and the control group consisted of 8 students from the ADHD group and 8 students from the HYS group.

Procedures

One professor at the UMB together with the researcher author conducted the study case. They were responsible for adapting the "Training by Competencies" course in Atutor. Two instance of the couser were created to support the intervention. In one of them, as a tool of the learning environment, AtenDerAH was integrated. The course lasted 30 days, was composed of two modules, each one with a written activity and an evaluation of 10 multiple choice questions - single answer. The first written activity consisted in describe a scenario of the use of a technical

competence based on knowledge (Knowledge), attitudes (Knowing Be) and skills (Knowing how to Do) elements. The second one consisted in describe a scenario of a transversal competence based on knowledge (Knowledge), attitudes (Knowing Be) and skills (Knowing how to Do) elements.

During course, students were encouraged to use aTenDerAH three times a week for ten minutes. Specifically, the professor sent an email with the indication to use the videogame. The academic grading was on numeral form from 1 to 5 with 1 being the worst and 5 being the best, considering a 3 the lowest passing grade. With the information obtained up so far, the quantitative analysis was performed.

At the end of the course, the students completed a survey through google form, which permit to collect the qualitative data.

Realiability and validity

To achieve internal control and validity of the research, equivalences were established between the experimental group and the control group with respect to: sample, age, level of training and initial indications received. In addition, the expert judgment method was used to verify the reliability of the strategy proposed. The validation was carried out in two contexts, for the video game, with psychologists, as for the instruments of data collection, with teachers. Appendix A and B present the templates format used and the results of the expert judgment.

Quantitative analysis

Data collection

The academic performance data was obtained from the grade of the two written activities and the two evaluations proposed in the teaching process. For evaluations the grade was based on the number of correct answers, 10 correct responses is equivalent to 5, the maximum grade. For the case of the activities, a rubric was defined. Accoring to Wamba et all (2007), rubrics allow guidance and evaluation in educational practice. It describes the criteria to be taken into account in assessing a work or task, and collects a gradient of quality or level of depth for each criterion. Its use allows the student to be evaluated in an objective way, and at the same time allow the teaching staff to previously expose the criteria with which to evaluate a work, presentation or activity (López Salinas, 2002), placing the students in front of the key elements of their learning and evaluation which allowed to establish the grade of each student. The designed rubric is presented in Table 40.

Table 40. *Evaluation Rubric*

	Performance level				
Criterion	**Null level (1)**	**Low level (2)**	**Medium level (3)**	**High level (4)**	**Optimun level (5)**
Content (60%)	The content is not elaborated.	The content does not respond to the request.	Some parts of the content do not correspond to what was requested.	The content responds to what is requested and its own construction but does not reference other works.	The content responds to what was requested and an own construction is visualized and reference other works, proposing a nesting.
Presentation (20%)	The homework was not presented.	The homework does not have a coherent and organized thread that	The work has a coherent and organized thread that allows the understanding of what is written,	The work is organized, it is easy to read the document and understandable in its entirety.	The work is organized, the document is easy to read and understandable in its entirety. APA

		allows the comprehension of what is written. The APA standards are not followed.	but does not follow APA standards.	Some APA standards are followed.	standards are followed.
Timely delivery (20%)	The homework was not presented.	The homework is presented 3 days after the stablished date.	The homework is presented 2 days after the stablished date.	The homework is presented 1 day after the stablished date.	The homework is presented in the stablished date.

Data analysis and results

Based on these instruments, the information obtained for each student according to each group is presented in Table 41 and 42. An average of all the grades obtained was calculated to work with this in the analysis phase.

Table 41. *Academic Performance – Experimental Group –Scenarie 1*

Group	Student	Activity 1	Evaluation 1	Activity 2	Evaluation 2	Average
ADHD	3	3	3,4	3,8	3,5	3,425
	4	3,8	4	3,8	4,5	4,025
	6	3,2	3	3,4	3,5	3,275
	7	2,4	3,5	3,4	4	3,325
	8	3	4,5	3,4	4	3,725
	9	3	3	4	3	3,25
	10	3,6	3,5	3,8	3,5	3,6
	16	3,4	4	3,8	3	3,55
HYS	17	4	4	4,6	4,5	4,275
	18	4,2	4,5	4,8	4,5	4,5
	22	4,2	3,5	4,2	4	3,975
	26	4	4	4	4	4
	27	4,2	5	4,2	5	4,6
	28	2,8	5	2,8	5	3,9
	31	5	4	5	4,5	4,625

Table 42. *Academic performance – Control Group – Scenarie 1*

Group	Student	Activity 1	Evaluation 1	Activity 2	Evaluation 2	Average
ADHD	1	2,8	3	3,8	3	3,15
	2	3,2	2,5	3,2	3	2,975
	5	2,6	3	3,8	3	3,1
	11	2,8	2,5	4	3	3,075
	12	2,6	3,5	3,2	3,5	3,2
	13	3,6	2,5	4	3	3,275

	14	2,8	3	3,8	3,5	3,275
	15	2,8	3	4	3	3,2
HYS	19	3,2	3,5	3,6	3,5	3,45
	20	4,2	4	4,4	4,5	4,275
	21	4,8	3	4,8	3,5	4,025
	23	5	4	5	4,5	4,625
	24	5	4,5	5	5	4,875
	25	4	3,5	4	3,5	3,75
	29	2,8	5	2,8	5	3,9
	30	4,2	3	3,8	3	3,5

The statistical test used to determine if the grade obtained by the two groups, control and experimental groups, differ significantly from each other is the T-Student, which is part of the techniques of inferential analysis based on the theoretical model of distribution (Hernández, Fernández & Baptista, 2003). The "T-Student" test allows a hypothesis contrast for the difference of means, since it evaluates if two groups differ significantly from each other in their experimental settings (Hernández et al., 2003). The hypotheses raised for this experiment were:

- *Ho (hipótesis nula) = AtenDerAH does not lead to a better academic outcome since there is no difference between the experimental and control groups.*
- *Ha (hipótesis alternativa) = AtenDerAH leads to a a better academic outcome since there is a difference between groups.*

The statistical software package IMB SPSS Statistics version 22.0 was used to carry out the T-Student statistical of independent samples using a significance ($\alpha = 0.05$), which means that we worked with a confidence of (95%). One of the values given by the computational statistical application is the p-value, which corresponds to the smallest possible level of significance that can be chosen. Thus, to carry out the contrast of hypothesis the following rules are considered:

- *Si p-valor ≤ α, Ha is accepted (The null hypothesis is rejected)*
- *Si p-valor > α, Ho is accepted (Alternative hypothesis is rejected)*

To analyze the data, three (3) comparisons of results were performed, one for the control and experimental groups, onother for each ADHD group (control and experimental), and another for each HYS group (control and experimental), taking as the analysis value the average of the grades. Next, these comparisons are described.

- Comparison of the final grades of the experimental and control groups. Table 43 presents the statistical data of this comparison.

Table 43. *Final grade statistical data of the control and experimental groups - AtenDerAH*

Group	Size	Average	Standard deviation	Standard error average
Final grade_Experimental_ADHD	15	3,87	0,47408	0,12241
Final grade_Control_ADHD	16	3,6031	0,58351	0,14588

The statistical package generates two "T" tests, one assumes equal variances and the other one different variances. However, since the probability associated with the levene statistic (Sig) is greater than 0.05, we assume equal variances. Thus, the corresponding T-Student test results are presented in Table 44.

Table 44. *T-Student results of the control and experimental groups - AtenDerAH*

Variance	Difference of means	Standard error difference	t	gl	p-value	Confidence interval	
						Lower	Upper
Equal variances are assumed	0,26688	0,19174	1,392	29	1,175	0,14003	0,59122
Levene test of variances quality: F=0,744; Sig. =0,395							

Since p-value 1,175 > 0.05, Ho is accepted for a 95% confidence level. Therefore, we conclude that we do not have found statistically significant evidence that there are differences between the means of the groups represented, the control group and the experimental group. However, a subgroup analysis was conducted to look for a more specific information.

- Comparison of the final grades of the control and experimental ADHD subgroups. Table 45 presents the statistical data of this comparison.

Table 45. *Final grade statistical data of the control and experimental ADHD subgroups - AtenDerAH*

Group	Size	Average	Standar deviation	Standard error average
Final grade_Experimental_ADHD	8	3,5219	0,26303	0,09300
Final grade _Control_ADHD	8	3,1562	0,10329	0,03652

The statistical package generates two "T" tests, one assumes equal variances and the other one different variances. However, since the probability associated with the levene statistic (Sig) is smaller than 0.05, we assume different variances. Thus, the corresponding T-Student test results are presented in Table 46.

Table 46. *T-Student results of the control and experimental ADHD subgroups - AtenDerAH*

Variance	Difference of means	Standard error difference	t	gl	p-value	Confidence interval	
						Lower	Upper
Equal variances are not assumed	0,36563	0,09991	3,660	9,109	0,005	0,14003	0,59122
Levene test of variances quality: F=4,724, Sig. =0,047							

Since p-value is 0.005 ≤ 0.05, Ha is accepted for a 95% confidence level. Therefore, we conclude that we have found statistically significant evidence that there are differences between the means of the groups represented, the control ADHD subgroup and the experimental ADHD subgroup.

Another way to reject the null hypothesis is when between the values of the confidence interval there is 0 (zero), aspect that is fulfilled in this case. In addition, as the mean of the experimental group (Table 45) is greater, it follows that academic performance was more effective in students who used AtenDerAH, that is, the experimental group.

- Comparison of the final grades of the control and experimental HYS subgroups. Table 47 presents the statistical data of the this comparison.

Table 47. *Final grade statistical data of the control and experimental HYS subgroups - AtenDerAH*

Group	Size	Average	Standard deviation	Standard error average
Final grade_Experimental_ADHD	7	4,2679	0,31215	0,11798
Final grade_Control_ADHD	8	4,0500	0,51235	0,18114

The statistical package generates two "T" tests, one assumes equal variances and the other one different variances. However, since the probability associated to the levene statistic (Sig) is greater than 0.05, we assume equal variances. Thus, the corresponding T-Student test results are presented in Table 48.

Table 48. *T-Student results of control and experimental HYS subgroups - AtenDerAH*

Variance	Difference of means	Standard error difference	t	gl	p-value	Confidence interval	
						Lower	Upper
Equal variances are assumed	0,21786	0,22340	0,975	13,000	0,347	-0,26477	0,70048
Levene test of variances quality: F = 1,583, Sig= 0,230							

Since p-value is 0.347 > 0.05, Ho is accepted for a 95% confidence level. Therefore, it is conclude that we do not have found statistically significant evidence that there are differences between the means of the groups represented, the HYS control and HYS experimental subgroups. From this we conclude that AtenDerAH did not allow a better academic performance for students without ADHD symtomps.

As mentioned in the previous comparison, another way of rejecting the null hypothesis is when there is not a zero (0) among the confidence interval values. However, in this case it can be observed the 0 (zero) in the interval, therefore the Ho is accepted. However, it is important to note that the mean of the experimental group (Table 47) is higher than the mean of the control group.

As can be seen from the three comparisons made, AtenDerAH positively influenced the academic performance of students with ADHD but not students of the HYS group. However, it also did not influence negatively. In this context, since the object of study of this research is to provide an inclusive scenario, we proceeded to carry out experiments that will lead us to this end.

Qualitative analysis

Data collection

The survey presented in Table 49 was designed to collect qualitative information that would support the quantitative analysis and thereby achieve a greater understanding of the study object of this dissertation.

Table 49. *Survey for AtenDerAH Perception*

Questions
1. Did you like using AtenDeAH during the course?
2. What did you like the most and least liked of AtenDerAH?
3. Would you use AtenDerAH again?
4. Would you change anything about AtenDerAH?
5. Do you consider AtenDerAH influence your academic performance?
6. Mention other area that you consider was influenced by AtenDerAH

To carry out the analysis of qualitative results, a semantic network (Figure 38) extracted from the research question and proposed objectives was designed. This sematic network allowed the author to carry out a segmentation of the supracategories, categories and subcategories a priori that goes in concordance with the quantitative part of this research and that guided the analysis of the data obtained through the survey. For this validation scenario, the Gamification and UDL categories were not taken into account.

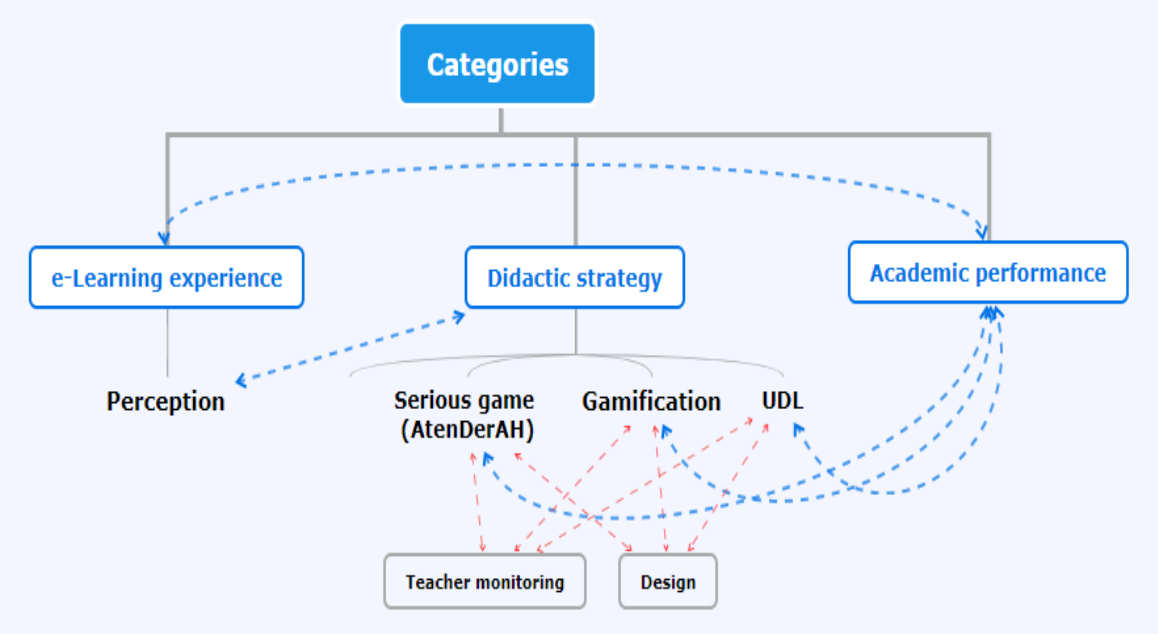


Figure 38. *Semantic network*

Table 50 presents the description of each supracategory, category and subcategories to facilitate the understanding and analysis of the data found.

Table 50. *Categories description*

Category	Description
e-Learning experience	It refers to the personal experience of the student regarding the teaching and learning process as a whole.
Dydactic strategy	Methods o techniques to improve learning. It uses knowledge that already exists in pedagogy but concretizes it through didactic resources and learning secuences.
Academic performace	It refers to the grade obtained through an evaluation process.
Perception	Interpretation and analysis of the different situations to which the student was confronted.
Serious game	It refers to the serious game developed as a didactic resource to train cognitive areas related to attention, AtenDerAH.
Gamification	Gamification is the application of principles and elements of the game in a learning environment with the purpose of influencing behavior, increasing attention, motivation, among others. In this research, it refers to the didactic units designed and implemented with elements of the game to teach a training course.
UDL	It refers to the implementation made of the UDL to design a training course that considers the preferences, strengths and weaknesses of the entire group of students, including those with ADHD.
Design	Refers to the appearance and clarity of the elements that make up the resource or environment. It relates to the organization of the elements.
Teacher monitoring	Actions aimed at offering help and guidance to their students, so that they acquire the capacity to build meaning and attribute meaning to the learning contents.

Data analysis and results

Next, the analysis of results by categories is showed, denoting a reflection and description of what arose through the research.

- For the *<e-Learning experience>* category, the students announce that the training environment was dynamic and improves the training experience, as described below. Student 24 (HYS): "having different and news resources demonstrate the interest of the university for improving our training environment and I think it impacts on a better experience"; Student 2 (ADHD): "Definitely this kind of resources makes the process more dynamic". These were segments extracted from the answers to question1. On the other hand, Student 4 (ADHD): "I believe that this influences motivation and improves the process". This was a segment that was extracted from answers to question 6. Interpreting these results, it could be said that resources like aTenDerAH are useful and valuable for a better e-Learning experience not only for students with ADHD but also for all students.

- In concordance with the above, from *<Didactic strategy>* and *<Serious games (AtenDerAH)>*" categories, it was extracted that students perceived AtenDerAH as a resource that moves motivation and is a good strategy to take advantage of those moments of leisure that occur during the review of learning content. These were some fragments from aswers to questions 1, 2, 3 and 4. Student 8: "I like because it kept me in the platform all the time, I felt that I took advantage of time"; Student 10: "In somehow, I blocked a bit the need to surf on the internet to waste time, that is, I preferred to play it than to see other things outside the platform"; Student 3: "I liked it and I feel that it somehow helped me to maintin the motivation"; Student 27: "I believe that all platforms should have these resources, they are good"; Student 24:"Although the game did not teach us about the subject, it was good to know that the university is researching to provide better strategies, whether to awaken the motivation, because making these virtual courses is a bit complicated".
- For the *<Academic performace>* category, the students state that the game influences the academic performance, although they are aware that it does so because of the variables that move around it. Some fragments about it are: "I believe that it influence de academic performance because I do not waste my time so much"; "I think that it influenced my performance especially because I preferred to play the game instead of concentrating on unnecessary things on the internet and when I got tired of playing I continued with the content of the course", "My grades reflect that it influence positively and I want to highlight the constant of the teacher's emails was fundamental". These results are consistent with the quantitative analysis.
- On the other hand, through the analysis of the information it was found that *<Teaching monitoring>* is an emerging subcategory of the teaching strategy that influences the academic performance and the e-Learning experience. Some fragmets related: "teacher's emails was fundamental"; "I think the support of the professor and the tutor also influenced"; "The teacher was very attentive to our process, this usually does not happen"; "I felt important, the professor and the researcher constantly sent us emails to play, but they also reminded us to do the activities", "I liked that in addition to the game, the professor and the researcher were very aware of us, even by email".
- Regarding the *<Design>* category, it is important to clarify that in this validation scenario the design refers to the design of the game, not the design of the training course. About this the students stated that the game environment is appropriate, the colors and sound pleasant, however, students specified that the game was not very clear at first about how to play it, however the support of the teacher was fundamental so as not to lose motivation. This can be glimpsed in the following fragments: "I liked the plot of the game, I think was interesting"; "I liked the simplicity of the game, aesthetically speaking"; "the game did not easily indicate that keys should be used to play, but it was fun to find out how to make it works"; "it took me a while to understand how to play it, but I could do it"; "I found very good the clues of the game to do the tasks". Analyzing the answers, it is in agreement with the recommendations extracted from the studies of González and Oliver (2002), Martínez Segura (2007), Salgado and Raposo (2012) where indicate that ICT resources for supportting the learning proceses of students with ADHD must not contain excessive animations and must include activities that favor tranquility accompanied by guided verbalizations.

6.2.6 Conclusions of strategy 1

The validation of this part of research allowed getting several conclusions:

- AtenDerAH is favorable to enhance the academic performance nd learning experience of students with ADHD, not because of the tool itself, but because other variables that are sets in motion with the game, such as motivation and novelty. Esto no fue directamente measured, but students' answers expressed it. Also, It is justified by both qualitative and quantitative analysis. And, although the quantitative results do not support this finding for the HYS group, it is important to note that the qualitative analysis provides evidence

of the positive perception of the impact on academic performance for the two subgroups (ADHD and HYS) of the experimental group.

- The integration of resources such as aTenDerAH in the training process energize, motivate and maintain the student's attention in the training environment, preventing them from losing time and dispersing during the learning process. Which is essential for students with ADHD but also for students without this disorder considering that nowadays there is a lot of distraction on the Internet.

- It is relevant the teacher mediation in e-Learning processes since it was a constant in the fragments extracted from the students' answers. Many strategies can be developed to enrich the training experiences and thereby improve the academic performance of the students, however, the role of the teacher to stimulate the students, with ADHD or without ADHD, is fundamental to achieve that the strategy has a positive impact.

The findings of this validation allowed us to answer the second research issue of this thesis **RI2**: "How to achieve that e-Learning students who suffer from ADHD obtain a better academic performance and learning experience?". Moreover, by conducting this validation we achieved the third specific objective **SO3** of this thesis: "To design and implement an computer-assisted academic intervention to improve the academic performance of ADHD students who have found in e-Learning an opportunity to carry out their university education".

6.3 STRATEGY 2: ROL BASED ON GAMMIFICATION

The second strategy implemented to achieve **SO3** consists of using gamification as a didactic strategy. For this purpose, a Reusable Learning Object (RLO) was implemented. The RLO was designed so that it could be customized in different domains of knowledge.

6.3.1 Description of the Web Application

The ROL is a framework designed for a three-unit of learning in the form of an observation race in which the teacher must introduce the learning objectives, the learning content (in pdf format) and the evaluation questions. The dynamic of the units consists consists of reading the pdf content and carrying out a gamified evaluation. Figures 39, 40 and 41 show snapshots of the RLO. Figures 39 shows the welcome interface.

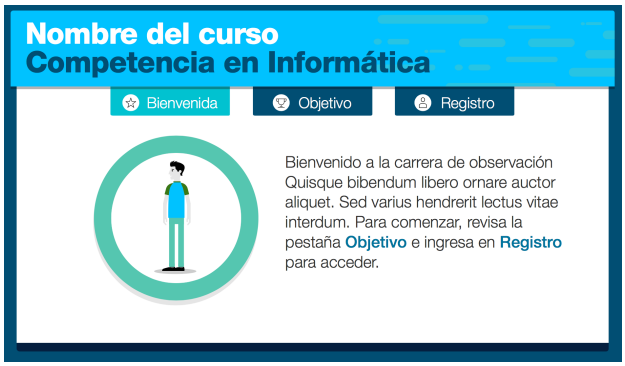


Figure 39. *Reusable Learning Object (RLO) Home*

Figures 40 shows the registration interface.

Figure 40. *Reusable Learning Object (RLO) instructions 1*

Figures 41 shows the instructions of the observation race, it means the instructions of the three units.

Figure 41. *Reusable Learning Object (RLO) instructions 2*

After the instructions, it is displayed the interface that allows student to go to the tematic units (See Figure 42).

Figure 42. *Tematic units RLO*

Figure 43 and 44 show a Learning Unit with the type of false and true evaluation. Figure 43 shows the instructions of a Learning Unit.

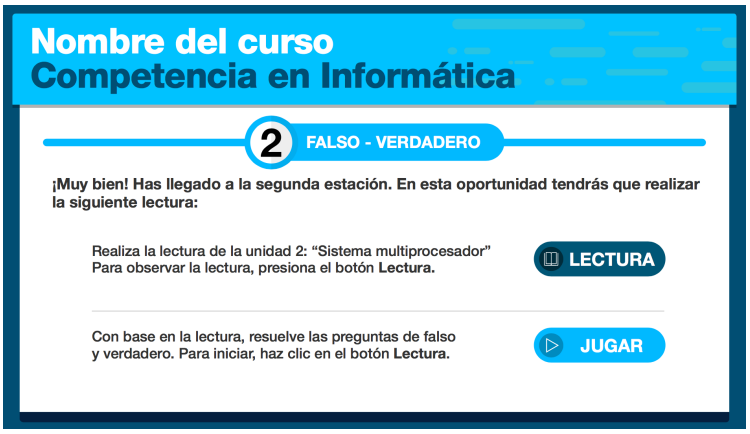


Figure 43. *Instructions of a Learning Unit*

Figure 44 shows the evaluation of the Learning Unit.

Figure 44. *True/False Questions – unit 2 RLO*

When a grong answer is obtained, a feedback is presented in order to offer a short explantion of the topic to the student. In Figure 45 this interface is presented.

Figure 45. *Feedback to wrong answers*

Depending on the correct answers, the student earns a certain number of points and a coin:

- For 1 or 2 questions aptly answers, the student gets 100 points represented in an aluminum coin.

- For 3 or 4 questions aptly answers, the student gets 200 points represented in a bronze coin.
- For 5 or 6 questions aptly answers, the student gets 300 points represented in a silver coin.
- For 7 or 9 questions aptly answers, the student gets 400 points represented in a gold coin.
- For 7 or 9 questions aptly answers, the student gets 500 points represented in a platinum coin.

The number of points is equivalent to the grade obtained in the evaluation by removing the zeros, for example, 500 points is equivalent to a 5. In Figure 46, 47, 48, 49 and 50, the interfaces of points are presented.

Figure 46. *Gammifications 500 points RLO*

Figure 47. *Gammifications 400 points RLO*

Figure 48. *Gamifications 300 points*

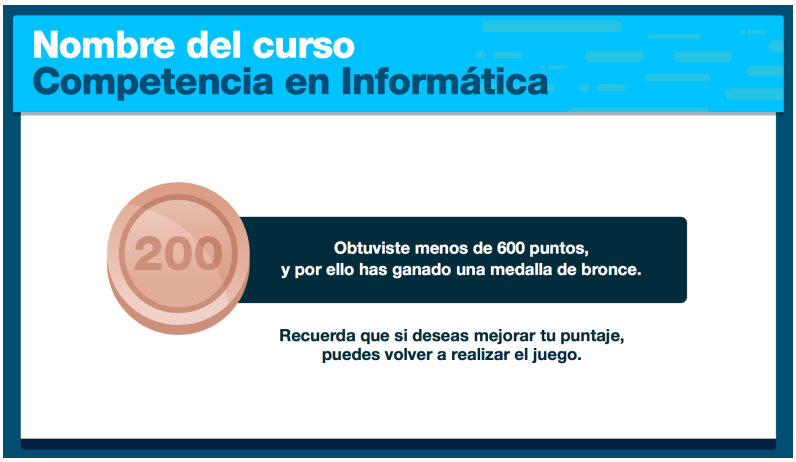


Figure 49. *Gamifications 200 points*

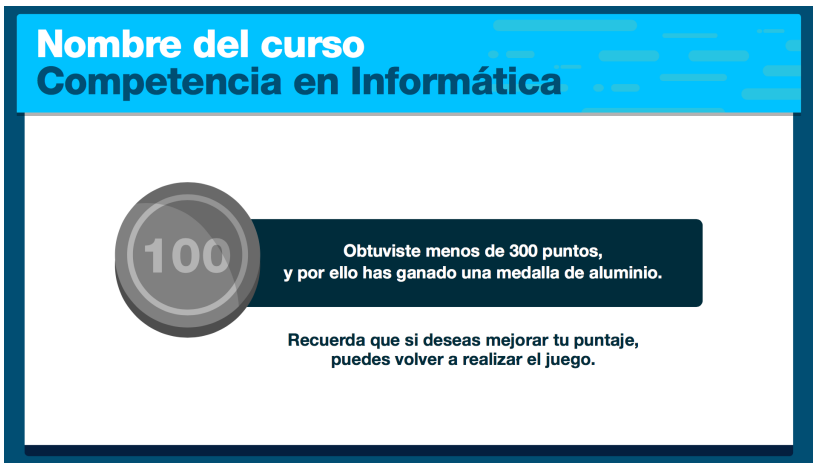


Figure 50. *Gamifications 100 points*

Once the reading and execution of the three thematic units are finished, the student is placed in a ranking depending on the total of points obtained throughout all the units.

The learning resource was evaluated in learning processes in higher education. The analysis was implemented under two perspectives, a quantitative and a qualitative one. The validation is presented below.

6.3.2 Validation

The study case was carried out through a mixed research approach. On the one hand, considering the academic performance of the student in terms of the final grade obtained in the course (quantitative approach), and on the other hand, considering student's perception about the resource as academic intervention. Knowing students' perceptions is an important tool for future improvement actions.

Participants

The study case was implemented with the same participants of the strategy 1 plus a student who joined the experiment. In total, the sample consisted of 31 students. The experimental group consisted of 8 students from the ADHD group and 7 students from the HYS group; and the control group consisted of 8 students from the ADHD group and 8 students from the HYS group.

Procedures

One professor at the UMB together with the author project conducted the study case. They carried out the adaptation and assembly of the virtual courses in Atutor. For the control group they assembly a course with the tipical tools offered by the e-Learning platform (Atutor), these are, content repository and questionarie. For the experimental group the course was adapted and assembled with the gamification strategy. The name of the course was "Basic digital competence". The course lasted 30 days and was composed of three tematic units. At the end of the course, the research team proceded to apply an open questionnaire formed by 10 questions to the experimental group that collected information about the perception of the participants.

Quantitative approach

Data collection

For the quantitative study, the academic performance data was obtained from the three grades obtained by each student in each evaluation. The information obtained for each student according to each group is presented in Table 51 and 52.

Table 51. *Academic Performance – Experimental Group –Scenarie 2*

Group	Student	Evaluation 1	Evaluation 2	Evaluation 3	Final grade
ADHD	3	3	3	3	3,000
	4	4	3	4	3,667
	6	2	4	3	3,000
	7	2	3	4	3,000
	8	3	2	4	3,000
	9	3	4	3	3,333
	10	4	3	3	3,333
	16	3	4	3	3,333
HYS	17	4	4	3	3,667
	18	4	5	4	4,333

	22	4	3	4	3,667
	26	4	3	3	3,333
	27	4	5	4	4,333
	28	3	4	4	3,667
	31	3	4	4	3,667

Table 52. *Academic Performance – Control Group –Scenarie 2*

Group	Student	Evaluation 1	Evaluation 2	Evaluation 3	Final grade
ADHD	1	3	3	4	3,333
	2	3	2	3	2,667
	5	3	3	3	3,000
	11	3	2	3	2,667
	12	2	3	3	2,667
	13	4	2	3	3,000
	14	3	3	3	3,000
	15	3	2	3	2,667
HYS	19	2	4	4	3,333
	20	3	4	4	3,667
	21	5	3	3	3,667
	23	5	4	4	4,333
	24	4	4	5	4,333
	25	5	2	3	3,333
	29	4	5	5	4,667
	30	4	3	3	3,333

Data analysis and results

The objective of the experiment was to know if the gamification strategy entailed a better academic outcome for both, the ADHD group and the HYS group. As described above, in the case study 30 students participated, which were divided into two groups: control group and experimental group and in turn, these groups were divided into two subgroups: ADHD and HYS.

The statistical test used to determine if the two groups, control and experimental groups differ significantly from each other is the T-Student, which is part of the techniques of inferential analysis based on the theoretical model of distribution (Hernández, Fernández & Baptista, 2003).

The "T-Student" test allows a hypothesis contrast for the difference of means, since it evaluates if two groups differ significantly from each other in their experimental settings (Hernández et al., 2003). The hypotheses raised for this experiment were:

- *Ho (null hypothesis) = The gamification strategy does not lead to a better academic outcome since there is no difference between the experimental and control groups.*
- *Ha (alternative hypothesis) = The gamification strategy leads to a a better academic outcome since there is a difference between groups.*

The statistical software package IMB SPSS Statistics version 22.0 to perform the statistical T-Student independent samples using a significance (α = 0.05) which means that was worked with a confidence of (95%) was used. One of the values given by the computational statistical application is the p-value, which corresponds to the smallest possible level of significance that can be chosen. Thus, to carry out the contrast of hypothesis the following rule were considered:

- *If p-value ≤ α, Ha is accepted (Null hypothesis is rejected)*
- *If p-value> α, Ho is accepted (Alternative hypothesis is rejected)*

To analyze the data, three (3) comparisons of results were performed, one for each group (control and experimental), onother one for ADHD subgroups (control and experimental), and another one for HYS subgroup (control and experimental). Next, these comparisons are described.

- Comparison of the final grades of the control and experimental groups. Table 53 presents the statistical data of this comparison.

Table 53. *Final grade statistical data of the control and experimental groups – Gamification*

Group	Size	Average	Standar deviation	Standard error average
Nota definitiva_Experimental_ADHD	15	3,4889	0,43399	0,11206
Nota definitiva_Control_ADHD	16	3,3542	0,63783	0,15946

The statistical package generates two "T" tests, one assumes equal variances and the other one different variances. However, since the probability associated with the levene statistic (Sig) is greater than 0.05, we assume equal variances. Thus, the corresponding T-Student test results are presented in Table 54.

Table 54. *T-Student results of control and experimental groups - Gamification*

Variance	Difference of means	Standard error difference	t	gl	p-value	Confidence interval	
						Lower	Upper
Levene test of variances quality	0,13468	0,19729	0,683	29	0,500	-0,26883	0,53819
Prueba Levene de calidad de varianzas: F=1,451; Sig. =0,238							

Since p-value 1,175 > 0.05, Ho is accepted for a 95% confidence level. Therefore, we conclude that we do not have found statistically significant evidence that there are differences between the means of the groups represented, the control group and the experimental group. However, a subgroup analysis was conducted to look for a more specific information.

- Comparison of final grades of the control and experimental ADHD subgroups. Table 55 shows the statistical data of this comparison.

Table 55. *Final grade statistical data of the control and experimental subgroups - Gamification*

Group	Size	Average	Standard deviation	Standard error average
Final grade_Experimental_ADHD	8	3,2083	0,24802	0,8769
Final grade _Control_ADHD	8	2,8751	0,24776	0,8760

The statistical package generates two T tests, one assuming equal variances and other assuming different variances. However, since the probability associated with the statistic levene (Sig) is greater than 0.05, equal variances are assumed. Thus, the corresponding T-Student test results are presented in Table 56.

Table 56. *T-Student results of the control and experimental ADHD subgroups - Gamification*

Variance	Difference of means	Standard error difference	t	gl	p-value	Confidence interval	
						Lower	Upper
Equal variances are assumed	0,33312	0,12395	2,688	14	0,018	0,6729	0,59896
Levene test of variances quality: F=0, Sig. =0,998							

Since p-value is 0.018 ≤ 0.05, *Ha* is accepted for a 95% confidence level. Therefore, it is concluded that statistically have been found significant differences between the means of the represented groups, the ADHD control subgroup and the ADHD experimental subgroup, which means that the gamification strategy leads to a more effective learning. Additionally, as the mean of the experimental group (Table 53) is higher, it is concluded that learning was more effective in students who used the gamification strategy, that is, the experimental group.

- Comparison of final grades of the control and experimental HYS subgroups. Table 57 shows the statistical data of this comparison.

Table 57. *Final grade statistical data of the control and experimental HYS subgroups*

Group	Size	Average	Standard deviation	Standard error average
Final grade_Experimental_ADHD	7	4,0476	0,22979	0,8685
Final grade _Control_ADHD	8	3,3750	0,41547	0,14689

The statistical package generates two T tests, one assuming equal variances and other assuming different variances. However, since the probability associated with the statistic levene (Sig) is greater than 0.05, equal variances are assumed. Thus, the corresponding T-Student test results are presented in Table 58.

Table 58. *T-Student results of the control and experimental HYS subgroups - Gamification*

Variance	Difference of means	Standard error difference	t	gl	p-value	Confidence interval	
						Lower	Upper
Equal variances are assumed	-0,02368	0,24263	-0,098	13	0,924	-0,54784	0,50048
Levene test of variances quality: F = 2,235; Sig= 0,159							

Since p-value is 0.002 ≤ 0.05, *Ha* is accepted for a 95% confidence level. Therefore, it is concluded that statistically have been found significant differences between the means of the represented groups, the HYS control subgroup and the HYS experimental subgroup, which means that the gamification strategy leads to a more effective learning.

Another way to reject the null hypothesis is when between the values of the confidence interval there is not 0 (zero) as evidenced in this case. Additionally, as the mean of the experimental subgroup (Table 55) is higher, it is concluded that learning was more effective in students who used the gamification strategy, that is, the experimental subgroup.

As can be seen from the three comparisons made, gammification positively influenced the academic performance of students with ADHD and HYS group.

Qualitative approach

Data collection

The survey presented in Table 59 was designed to collect qualitative information that would support the quantitative analysis and thereby achieve a greater understanding of the study object of this dissertation.

Table 59. *Survey for Gamification perception*

Questions
1. If you are agreeing with the training strategy used in this course, explain the reason.
2. If you like using this traning strategy, explain the reason.
3. If you prefer using another learning strategy, indicate which one.
4. Is the teaching methodology used adequate to the characteristics of the group and of the subject of the course?
5. If you consider this learning strategy influence your academic performance, indicate how.
6. Do you think another learning strategy could benefit your academic performance? Indicate which one.
7. The training strategy stimulated you to go as far as possible in your academic interests. Yes, Not. Why?
8. The presentation of the course has facilitated the understanding of the information.
9. Is the presentation of the course content tailored to my needs?
10. In terms of desing, what did you like most about the course?

Data analisys

To carry out the analysis of qualitative results, the semantic network showed in Figure 35 extracted from the research question and proposed objectives was used. For this validation scenario, the Seriuos game and UDL categories were not taken into account. Next, the analysis of results by categories is showed.

- For the *<e-Learning experience>* category it was observed that students considered the ROL attractive and they prefer to use this type of strategies, as expressed by several of them in the following fragmnts: “At times I did not feel the pressure of being in a course, I felt more confident”; “the experience was different, out of the conventional and that was positive, I would like more courses would be like this”; “It has been one of the best courses they have given us”; “I felt more secure, I just lacked in the tool to be able to chat something like that”; “The experience was good, however it lacked more support from the teacher”, “I consider it a kind of useful training for all, I felt comfortable but I know my colleagues too”. Addressing these segments, it is concluded that e-Learning experiences can be generated to be perceived by students, attractive, motivating, and adapted to their characteristics.

- For the *<didactic strategy>* category, specifically the *<gamification>* students consider gamification as a good teaching strategy that impact academic performance, motivation and confident. Several fragments of the students' answers are: “I really liked the methodology of the course, just missing more monitoring from the teachers as in the course of the video game”, “learning in this way makes you not feel like an obligation”, “Yes, I agree with the strategy because it is different, motivating, young people like this”, “Yes, I agree with the strategy, we could also use augmented reality glasses and other new technologies”, “I really liked the ranking and the form of evaluation, I would have prefered a little more of teaching monitoring in order to clear up doubts, But I still liked it”, “Yes, I definitely felt identified with this training strategy, they did it for me”. These fragments were extracted for answers of the ADHD and HYS groups. Thus, it could be said that this strategy addresed classroon diversity.

- Regarding the *<Academic performance>* category, students felt a direct and positive influence with the grade achieved. Some fragments that show it, are: “the strategy motivated me to review all the readings and answer the questions carefully to be well ranked”, “I definitely did well by the type of evaluation”, “the strategy helped me not to feel bored and anxiety and that's why I think I got good grades”. These answers are consistent with the results found in the quantitative part.

- Finally, on the *<Design>* category it was possible to observe that the colors, the simplicity and the clarity of the information play an important role in e-Learning resources. Some fragments that showed this are the following: "many times they put a lot of flat information that does not inspire reading, I liked how they information was organized into the resource", “the design of the tool was perceived clean, I liked that very much, without being that boring content that hang in other courses”, “I was struck by the colors, the sounds, very beautiful”.

- As in the previous case, with this strategy also emerged the category *<Teaching monitoring>* extracted from data units of meaning as: "I really liked the methodology of the course, just missing more company from the teachers as in the course of the video game", "I would have given a little more teacher support to clear up doubts, but I liked it anyway". As in the validation scenario carried out with aTenDerAH as a resource, it is again in line with the recommendations extracted from the studies of González and Oliver (2002), Martínez Segura (2007), Salgado and Raposo (2012) where indicate that ICT resources for supportting the learning proceses of students with ADHD must not contain excessive animations and must be contextualized in a motivating play activity.

6.3.3 Conclusions of strategy 2

After carrying out the validation scenario and analyzing the quantitative and qualitative results, several conclusions were reached:

- In first instance, this research concludes that the implementation of a didactic practice mediated by gamification is favorable for academic performance in particular, but also in

the general training experience of all students, including those suffering from ADHD. This is evidenced both by qualitative and quantitative study.

- On the other hand, the qualitative results show that e-Learning requires strategies such as gamification to counteract the double effort involved in successfully achieving learning processes with this modality. In accordance with this, it is important to take care of the design of educational resources, since it impacts the e-Learning experience.
- Likewise, an important finding that emerges from this validation scenario is the role of teacher given that data units of meaning show the need for the monitoring to influence the e-Learning experience.
- The results supports the findings of Sitra et al., (2017) and Hernández (2017) sobre el positive effects on the students in terms of satisfaction and attitude towards the course.

The findings of this validation also allowed the author to answer the second research issue of this thesis **RI2**: "How to achieve that e-Learning students who suffer from ADHD obtain a better academic performance and learning experience?".

Moreover, by conducting this validation we achieved the third specific objective **SO3** of this thesis: "To design and implement an computer-assisted academic intervention to improve the academic performance of ADHD students who have found in e-Learning an opportunity to carry out their university education".

6.4 STRATEGY 3: UDL

The interest of this strategy is to offer an inclusive course in the sense that it considers the characteristics of all students, including those with ADHD. Specifically, the curriculum of a course named "Research Methodolgy I" was redesigned using the UDL framework. This course was designed as retribution for the participation in the validation scenarios of AtenDterAH and Gamification, considering the difficulty that the subject generates for many students. This part of the thesis corresponds to **SO4.**

6.4.1 Research Methodolgy I Re-design

To redesign the course three of the four UDL framework templates were used: 1) the class learning profile template, 2) the curriculum barriers template and 3) the UDL solutions template, in order to identify if we can make changes in the course methodology that allows us to assist the student to perform better.

The Class Learning Profile Template

The students suffering from ADHD were more unconfident about their strengths and weaknesses so that we assist them with a general template we completed according to usual strengths, weakness and preferences, in terms of learning processes, of people that suffer from this disorder (Table 60).

Table 60. *A General Class Learning Profile Template for ADHD Characterictics*

Grade		Subject	
Goal			
Network	**Students—Strengths**	**Students—Weaknesses**	**Students—Preferences/Interests**
Recognition (Learning "what")	- Good readers	- Inattentive to visual details, and do not notice or remember letters, sequences or visual patterns within words -Low processing speed	
Strategy (Learning "how")	-Creatives -Intuitive -Good memory -Ability to solve problems -Ability with computers -Verbally they can express their ideas and thoughts articulately. - Hyper-focus capacity -Praise is so very important for students with ADD/ADHD	-Easily and highly distracted -They struggle with focusing and paying attention. -Problems with the organization -Too forgetful -Problems to complete tasks and jobs -Problems with prioritization -Quickly abandon their tasks and projects -Difficulty with time management -Problems with planning -Problems with self-monitoring and self-regulation -Struggle with written works -Impatient -Don't think the same thing twice -Being to make many mistakes by carelessness -The mind works faster than they can expect which often makes them forget what they were going to say	
Affect (Learning "why")	-Empathy -Originality -Sense of humor -High power capacity -Enthusiasm -Spontaneous -Ability to take risks -Activity towards the novel -Good use of constructive feedback -Good gross motor skill -Fighters -Love for the animals -Work well in collaboration groups	-Fear to fail -Low self-esteem -Low expectation of success -Problems outside of work -It gives up easily -Problems keeping the energy in an activity to be able to finish it. -Jumping from activity to activity, not because of lack of inspiration, but because you must be pushed to finish the many projects that start -They are easily overwhelmed -Distracted and bored with routines -It's hard to stay seated	-Diversity of interests -Small tasks -Video game -Multimedia -Manual activities, demonstrations, laboratory experiences -Background music -Outdoor activities -Learning material in verbal an written format

The resulted Class Learning Profile template for the experimental group is presented in Table 61.

Table 61. *The Research Methodology I Class Learning Profile*

Grade: First Semester Subject: Research Methodology I			
Network	**Student Strengths**	**Students Weaknesses**	**Students Preferences/Interests**
Recognition (Learning "what")	**Student 4**: Excellent observer, extensive vocabulary **Stundet 6**: Good reader	**Student 3:** is not good with reading	
Strategy (Learning "how")	**Student 1 (ADHD)**: Good at oral presentations **Student 2**: Talented at drawing and good leader **Student 5 (ADHD):** Creative **Student 6:** Good at oral presentations, good writer	**Student 1 (ADHD)**: Loses focus, distracted; Organizational problems; struggle with writing assignments **Student 2**: Poor writing mechanics **Student 7:** Poor organization skills **Student 5 (ADHD):** Poor writting skills	
Affect (Learning "why")	**Student 1 (ADHD):** Good use of constructive feedback. Attraction of novelty **Student 2:** Collaboration skills **Student 3:** Collaboration skills **Student 7**: Good humor sense and good collaboration skills **Student 5 (ADHD)**: Good use of constructive feedback, Spontaneous	**Student 1 (ADHD):** Moves from one uncompleted task to another **Student 5 (ADHD):** Distracted and bored with routines. They usually does not finish his tasks **Student 4:** Difficulty working as a team	**Student 1 (ADHD):** Loves videogames, collaborative work **Student 2:** Like listening to music, works with graphics, videogames **Student 3:** Likes computers; play guitar, prefers oral presentation **Student 4:** Likes reading and writing **Student 5:** Love videogames; doing exercise **Student 6:** Loves nature and listen to music **Student 7:** Loves videogames, computer

The Curriculum Barriers Template

Considering the class learning profile template, the curriculum barriers template was completed. The resulted template is presented in Table 62.

Table 62. *The Research Methodology I curriculum barriers template*

Materials and Methods		**Students Qualities**	**Potential Barriers/Missed Opportunities**
Introduction	Content: Video explaining briefly the curse, how is the classroom organized and presenting the activities the students have to do in order to approve the curse (include value of each activity). Finally, the teacher recommends looking at the schedule of the curse. The video takes 10 minutes	**Student 1:** Loses focus and distracted **Student 5:** Distracted and bored with routines	These qualities may have trouble keeping track of what they are going to learn
Module 1	Content: PDF (20 pages) and multimedia	**Student 1, 3, 5 and 7:** Loves videogames **Student 2, 6:** Likes listening to music	This kind of content does not tap into students 1, 2, 3, 5, 6 and 7 qualities

	Activity: Independent reading	**Student 1**: Loses focus, distracted	Difficulty working alone. May take more time than necessary to check and read the material. May not be able to abstract the important contents
		Student 5: Distracted and bored with routines	Reading 40 pages can be a rutinary activity , it may cause that stundent do not finisth the work or late a lot doing it
		Student 3: He is not a good reader	Does not tap into Student´s 3 reading difficulty
		Student 3 and 7: Collaboration skills	Does not tap into Student´s 3 and 7 collaboration skills
	Assessment activity 1: Evaluation (Multiple-Choice-Test - 20 questions). (25%)	**Student 1 y 5:** Good using constructive feedback	The student's grade is given at the end of the evaluation withou feedback. This does not allow to enhance the abilities of these students.
		Student 2, 3 and 7: Collaboration skills	Does not tap into Student´s 2, 3 and 7 collaboration skills
Module 2	Content: PDF and multimedia.	**Student 1, 3, 5 and 7:** Loves videogames **Student 2, 6:** Likes listening to music	This kind of content does not tap into these interest and skill
	Activity: Independent reading 2	**Student 1**: Loses focus, distracted	Difficulty working alone. May take more time than necessary to check and read the material. May not be able to abstract the important contents
		Student 5: Distracted and bored with routines	Reading 40 pages can be a rutinary activity, it may cause that stundent do not finisth the work or late a lot doing it
		Student 3: He is not a good reader	Does not tap into Student´s 3 reading difficulty
		Student 3 and 7: Collaboration skills	Does not tap into Student´s 3 and 7 collaboration skills
	Assessment activity 2: Oral video report posted in a fórum (25%)	**Student 2:** Talented at drawing and good leader	The activity does not tap into Student´s 1, 2, 3, 5 and 7 talents and preference
		Student 3: Like playing the guitar	
		Student 5: good at doing exercise	
		Student 1 and 7: Pooor organitization skills	Difficulty organizing her ideas effectively
Module 3	Content: PDF and multimedia.	**Student 1, 3, 5 and 7:** Loves videogames	This kind of content does not tap into these interest and skill
		Student 2, 6: Likes listening to music	
	Activity: Independent reading 3	**Student 1**: Loses focus, distracted	Difficulty working alone. May take more time than necessary to check and read the material. May not be able to abstract the important contents
		Student 5: Distracted and bored with routines	Reading 40 pages can be a rutinary activity , it may cause that stundent do not finisth the work or late a lot doing it

		Student 3: He is not a good reader	Does not tap into Student´s 3 reading difficulty
		Student 3 and 7: Collaboration skills	Does not tap into Student´s 3 and 7 collaboration skills
	Assessment activity 3: Independent proposal Project - first delivery (25%)	**Student 1 and 5 (ADHD)**: Loses focus, distracted	May have trouble keeping track of what they are learning and doing
		Student 2: Leader	Context won´t draw on his leadership and collaboration skills
		Student 2 and 3: Collaboration skills	Context won´t draw on their collaboration skills
		Student 1, 2: Poor writing mechanics	Difficulty expressing their ideas effectively.
		Student 1, 7: Organizational problems	Difficulty organizing the Project proposal effectively
		Student 2: Talented at drawing	Does not tap into Student´s 2 drawing skill.
		Student 3, 6: Good at oral presentation	Does not tap into Student´s 3 and 6 oral skills Does not tap into Student´s 3 and 6 musical loves
		Student 3: play the guitar	
		Student 6: Loves music	
	Assessment activity 4: Independent proposal Project - second delivery (25%)		

The Curriculum Solutions Template

Finally, *the UDL solutions template* was completed. The resulted template is presented in Table 63.

Table 63. *The Research Methodology I UDL solutions template*

Materials and Methods		**Potential Barriers/Missed Opportunities**	**UDL solutions**
Introduction	10-minutes video presentation	Distracted from listening; may have trouble keeping track of what their are going to learn	Provide an abstract with the key points of the video in PDF format and suggest students to download and paste it in a visible place (Include the schedule). Related to the schedule, the teacher should send a notification at least a week ago before the expired of each activity.
Module 1	Digital content in PDF and multimedia	Long texts does not tap into these interests and skills	Divide the content into shorter readings into segments of 10-15 minutes. Improve the multimedia navigation avoiding the number of click the student have to press. Include the possibility of active Background music. Integrate the aTenDerAH videogame (Mancera, Baldiris & Fabregat, 2014) as a tool into the e-Learning platform and recommend students 1 and 5 to play it when boring,
	Independent reading	Difficulty working alone. May take more time than necessary to check and	In this case that RLO was recommended to be used, indicating the time for each reading.

		read the material. May not be able to abstract the important contents	Suggest having the study environment clean, organized and avoid distracters. Porpouse a fórum in order to debate about questions responses. The student can debate in the way that he / she considers best adapts to his / her qualifications: written, oral, graphic. Give the possibility of creating new threads and responses of those threads.
	Assessment activity 1: evaluation (multiple choice questions with single answer-20 questions) (25%)	The grade of the evaluation is given to the student at the end. This does not allow to enhance the abilities of **students 1** and **5** Does not tap into **Student´s 2, 3** and **7** collaboration skills	In addition to the quantitative grade that the platform exam tool provides, provide a qualitative feedback that leads the student to a process of reflection and achievement of learning. Provide a forum for questions so students clear up concerns among themselves. This activity can add up to 5% of 25% in the module 1 note if there is participation, otherwise only the evaluation will be considered.
Module 2	Assessment activity 2: Oral video presentation posted in a forum	Difficulty expressing her ideas effectively, Does not tap into **Student´s 2** drawing skill	Suggest recording student´s speech about the report on a digital recorder in order they listen and write what they said. And assist them to edit, comprehend and organize it. The presentation can be presented ad their prefer, with power point with writer, graphic and music ideas. It is important to recomend names of programs to work with grapich, voice, video and presentatiosn.
Module 3	Assessment activity 3: Independent project	Could have difficulty working alone. May have trouble keeping track of what he is learning and doing Context won´t draw on his leadership and collaboration skills	Support student 1 and 5 in the selection of their research idea. Send almost 2 emails to check fthe students progress during the process. Recommend student using a voice recorder to listen what they write. Create a forum in which student 3 could provide support in good writting mechanics. Provide positive and constructive feedback on job review so the second delivery is better. For students with drawing skills recomends to include diver figures in their proposal document.
	Assessment activity 3: Independent project	Could have difficulty working alone. May have trouble keeping track of what he is learning and doing Context won´t draw on his leadership and collaboration skills	

6.4.2 Validation

The study case was carried out through a mixed research approach. On the one hand, considering the academic performance of the student in terms of the average of the grades obtained in the course (quantitative approach), and on the other hand, considering student's

perception of the resource in their academic performance. Knowing students' perceptions is an important tool for future improvement actions.

Participants

The participants were initially the same as those of strategies 1 and 2. However, this scenario was made in an unregulated course of the Virtual Unit of the Manuela Beltran University, as a benefit for their participation in previous case studies. The course was about Research Methdology, a tranversal tematic they see during their formation process in all academic programs, which according to teachers are often difficult for students. Although the course was conceived as a benefit, several of the students withdrew from the case study. In total, the sample consisted of 14 students. With this sample, we proceed to form an experimental group and a control group. The experimental group was made up of 7 students (2 from the ADHD group and 5 from the HYS group), the control group was made up of 7 students (2 with ADHD and 5 from the HYS group).

Procedures

One professor of the Virtual Unit of the Manuela Beltran University together with the author project conducted the study case. They were responsible for adapting two classrooms called "Research Methodology I" according to the didactical and methodoly of how the standard course of the university is carried out. In one of the courses, the UDL strategy was used. The course lasted 20 days, was composed of two modules and three activities. As in the previous scenarios, the academic grading was on numeral form from 1 to 5 with 1 being the worst and 5 being the best, considering a 3 the lowest passing grade..

With the experimental group, it means the course in which the UDL was used, once the course started, the first template of the UDL -the *Class Learning Profile Template*- was filled out with the help of the students. A synchronous meeting was held with each student to guide him or her during the process. This task was proposed through a forum as the first activity of the curse and took three days to be completed.

Quantitative approach

Data collection

For the quantitative study, the academic performance data was obtained by calculating the average of the grade obtained in the four proposed evaluation activities. For activity evaluation 1, refered to the exam of multiple-choice questions - single answer, the grade was based on the number of correct answers, 10 to 8 correct answers corresponds to a 5, ,8 to 6 correct answers corresponds to a 4, 6 to 4 correct answers corresponds to a 3, 4 to 2 correct answers corresponds to a 2, 2 to 0 correct answers corresponds to a 1. For activity evaluation 2, refered to the collaborative oral presentation, a rubric was defined. This rubric is presented in Table 64.

Table 64. *Evaluation Rubric – Activity 2 – UDL*

	Performance level				
Criterion	**Null level (1)**	**Low level (2)**	**Medium level (3)**	**High level (4)**	**Optimun level (5)**
Content (30%)	The content is not elaborated.	The content does not respond to the request.	The content responds to the request but does not build its own.	The content responds to what is requested and its own construction but does not reference other works.	The content responds to what was requested and an own construction is visualized and reference other works, proposing a

					nesting.
Organization (20%)	The homework was not presented.	The work did not include all the elements requested in the presentation: introduction, an outcome and conclusions. And the time available for the presentation was not used properly.	The work did not include all the elements requested in the presentation: introduction, an outcome and conclusions. However, the time available for the presentation was used appropriately.	The work had an introduction, an outcome and ended with conclusions. However, the time available for the presentation was not used properly.	There is a logical sequence between each of the parties making an organized presentation. The time available for the presentation was used appropriately.
Utility and design of the support resources used for the presentation (20%)	The homework was not presented.	The resources used did not support the explanation and its design is not harmonious.	The resources employed moderately supported the explanation and its form was not pleasant.	The resources employed supported the explanation but form was not pleasant.	The resources employed enriched the explanation and its form was pleasant.
Clarity of the explanation (20%)	The presentation is not made.	The concepts are not addressed clearly and there is no evidence of domination of the presentation.	ome concepts were clearly addressed, however, others showed ambiguities.	The concept addressed is presented clearly, however, lack of mastery in certain elements of the presentation is evident.	The concept is presented clearly, without ambiguities, projecting security and mastery of all the elements of the presentation.
Timely delivery (10%)	The homework was not presented.	The homework is presented 3 days after the stablished date.	The homework is presented 2 days after the stablished date.	The homework is presented 1 day after the stablished date.	The homework is presented in the stablished date.

For activities evaluation 3 and 4, refered to the proposal writting project, a rubric also was defined. The rubric is presented in Table 65.

Table 65. *Evaluation Rubric – Activity 3 and 4 – Scenarie 3*

	Performance level				
Criterion	**Null level (1)**	**Low level (2)**	**Medium level (3)**	**High level (4)**	**Optimun level (5)**
Content (40%)	The content is not elaborated.	The content does not respond to the request.	The content responds to the request but does not build its own.	The content responds to what is requested and its own construction but does not reference other works.	The content responds to what was requested and an own construction is visualized and reference other works, proposing a nesting.
Format and structure (25%)	The homework was not presented.	The work is not organized, and the specifications of the APA standards for presentation of works are not	The work is not organized, and the specifications of the APA standards for presentation of works are partially fulfilled.	The work is organized, easy to read and partially meets the specifications of APA standards for submission	The work is organized, easy to read and fully complies with the specifications of the APA standards for submission of papers.

		met.		of papers.	
Conclusions and reflections (25%)	The homework was not presented.	The student does not produce conclusions of the work carried out.	The conclusions and reflections lack depth and do not account for lessons learned.	The conclusions and reflections demonstrate an analysis exercise regarding the work carried out. Make inferences from the experience of what they learned throughout the course.	The conclusions and reflections demonstrate an analysis exercise regarding the work carried out. Make inferences from the experience of what they learned throughout the course. The student decribes the importance of the study object proposed.
Timely delivery (10%)	The homework was not presented.	The homework is presented 3 days after the stablished date.	The homework is presented 2 days after the stablished date.	The homework is presented 1 day after the stablished date.	The homework is presented in the stablished date.

The information obtained for each student according to each group is presented in Tables 66 and 67.

Table 66. *Grades of the experimental group – UDL*

Group	Student	Activity 1	Activity 2	Activity 3	Activity 4	Average
ADHD	4	3,5	4,75	3,5	3,75	3,875
	9	2,5	4,9	3,25	4	3,6625
HYS	17	4,5	4,9	3,75	4	4,2875
	18	3,5	4,9	3,35	3,85	3,9
	22	5	4,9	4,75	5	4,9125
	27	5	4,75	4,5	4,75	4,75
	28	3,5	4,75	4	4,35	4,15

Table 67. *Grades of the control group – UDL*

Group	Student	Activity 1	Activity 2	Activity 3	Activity 4	Average
ADHD	13	2	3	2	3	2,5
	14	2	2	3,2	3,5	2,675
HYS	23	4	4	4,5	5	4,375
	19	3	3	2	3,7	2,925
	25	2	2	2	3,5	2,375
	29	4	4	3,5	4	3,875
	30	4	3	4	4,2	3,8

Data analysis

The objective of the experiment was to know if the UDL strategy entailed a better academic outcome for both, ADHD and HYS students. As described above, 14 students participated in the study case, which were divided into two groups: control group and experimental group. In each group students with ADHD were indentified.

The statistical test used to determine if the two groups, control and experimental groups, differ significantly from each other is the T-Student, which is part of the techniques of inferential analysis based on the theoretical model of distribution (Hernández, Fernández & Baptista, 2003).

The "T-Student" test allows a hypothesis contrast for the difference of means, since it evaluates if two groups differ significantly from each other in their experimental settings (Hernández et al., 2003). The hypotheses raised for this experiment were:

- *Ho (null hypothesis) = The UDL strategy does not lead to a better academic outcome since there is no difference between the experimental and control groups.*
- *Ha (alternative hypothesis) = The UDL strategy leads to a better academic outcome since there is a difference between groups.*

The statistical software package IMB SPSS Statistics version 22.0 to perform the statistical T-Student independent samples using a significance ($\alpha = 0.05$), which means that, was worked with a confidence of (95%). One of the values given by the computational statistical application is the p-value, which corresponds to the smallest possible level of significance that can be chosen. Thus, to carry out the contrast of hypothesis the following rule were considered:

- *If p-value ≤ α, the Ha is accepted (Null hypothesis is rejected)*
- *If p-value> α, Ho is accepted (Alternative hypothesis is rejected)*

To analyze the data, one comparison of results of the experimental and control group was performed. This comparison was made based on the average grade and is presented first below. In this scenarie a comparison between ADHD and HYS experimental and control groups was not realized since the number of the sample was not enough to apply the T-Student.

- Comparison of final grades of experimental and control groups. Table 68 shows the statistical data of this comparison.

Table 68. *Final grade statistical data of control and experimental groups - UDL*

Group	Size	Average	Standard deviation	Standard error average
Final grade_Experimental	7	4,2196	0,46586	0,17608
Final grade_Control	7	3,2179	0,78697	0,29745

The statistical package generates two T tests, one assuming equal variances and another assuming different variances. However, since the probability associated with the statistic levene (Sig) is less than 0.05, difference variances are assumed. Thus, the corresponding T-Student test results are presented in Table 69.

Table 69. *T-Student results of control and experimental groups - UDL*

Variance	Difference of means	Standard error difference	t	gl	p-value	Confidence interval	
						Lower	Upper
Equal variances are not assumed	1,00179	0,34565	2,898	9,745	0,016	0,22888	1,77469
Levene test of variances quality: F=5,344; Sig. =0,039							

Since p-value is 0.016 ≤ 0.05, *Ha* is accepted for a 95% confidence level. Therefore, it is concluded that statistically have been found significant differences between the means of the represented groups, experimental and control groups which means that UDL strategy leads to a more effective academic outcome.

As can be seen from the comparison made, UDL positively influenced the academic performance of students with ADHD and HYS groups.

Qualitative approach

Data collection

In order to evaluate qualitatively the effectiveness of the solutions implemented, a short survey was conducted. The inteview asked about the aspects presented in Table 70.

Table 70. *Survey for UDL perception*

Questions
1. If you are agreeing with the training strategy used in this course, explain the reason.
2. If you like using this traning strategy, explain the reason.
3. If you prefer using another learning strategy, indicate which one.
4. If you consider this learning strategy influence your academic performance, indicate how.
5. Do you think another learning strategy could benefit your academic performance? Indicate which one.
6. The training strategy stimulated me to go as far as possible in my academic interests. Yes, Not. Why?
7. The presentation of the course has facilitated the understanding of the information.
8. Is the presentation of the course content tailored to my needs?
9. Is the teaching methodology used adequate to the characteristics of the group and of the subject of the course?
10. In terms of desing, what did you like most about the course?

Data analysis

To carry out the analysis of qualitative results, the semantic network showed in Figure 35 extracted from the research question and proposed objectives was used. For this validation scenario, the Seriuos game and Gamification categories were not taken into account. Next, the analysis of results by categories is showed.

- For the *<e-Learning experience>* category it was observed that students considered the course offers a good e-Learning experience because the teacher support, the organization of information, the type of activities and explanations of tools that were encouraged to use as the schedule and the games. Some units of meaning extracted from students' aswers are: “I liked the whole course in general, the information was better distributed", "really the course was very good (...) I think that considered the strengths of each one for the activities is a very professional gesture, very novel”, “the explanation of several tools that sometimes we do not usually use seemed very useful”, “the way they

proposed the activities of the course was excellent, there was a bit of everything, very good".

- Although the previous category is directly related to the *<didactic strategy>* category, specifically the *<UDL>* category was perceived very postively because students feel considered from the first moment until the end with the application of the templates and finalization questions of the course. Some units of meaning were extracted from students' aswers: "This process of asking ourselves what we consider our strengths and then considering them in the activities and evaluation seemed incredible", "this course was put in the place of each one of us, really good the strategy of those templates", of the three courses, this was the most liked", "I felt taken into account, each one has a space in the course". These fragments show the preference of these strategies for all students, not only for students suffering from ADHD.
- Regarding the category *<Academic performance>,* the students showed a direct and positive influence with the grade achieved. Some units of meaning that leverage this finding are: "the constant follow-up of the teacher meant that one will not be left behind in the process", "I feel that I learned a lot", "as I felt the activities very mine I think I did them well". This is supported by the results obtained with the quantitative analysis carried out.
- Concerning the *<Design>* category, the students express that there was no change in course design except that the information was better organized. The following units of meaning show it: "although the course was equal to other, the information was better organized", "there were no specific changes in colors only as more orderly", "it does not have the colors of the games but everything was understood very well, I would have liked to see something different in the design of the course".
- As in the previous case, *<Teaching monitoring>* category also emerged. Some data units of meaning as: "I liked the whole course in general (...) and the teacher was very attentive all the time, very good", "The accompaniment of the teacher was one of the things I liked the most".

6.4.3 Conclusions of strategy 3

In this section, it was presented a validation scenario of a e-Learning course designed and assembled following the UDL framework and some recommendations achieved with the development of CHAPTER 2 of this document concerns to academic intervention of students with ADHD. After analyzing the results of the validation, the following conclusions could be established:

- The UDL is a framework that facilitates good results in terms of academic performance and learning experience for all students including those with ADHD.
- The UDL is a framework that addresses diversity in the classroom and students persive it as such. From the application of the first, students feel that they are being treated as people, not as a number behind the computer, this step makes them feel considered and this effectively affects the student learning experience and could impac de academic performance. Additionally, despite not being clear about what their preferences, weaknesses or strengths will be used, they perceive the benefit in the training environment.
- Students suffering from ADHD also take advantage of timelines, constant feeback, short explanations, alerts, in addition to videogames and gamification. From what is concluded that the variety of resources makes learning experiences richer and this impacts academic performance. This is in accordance with the nature of ADHD, in which several authors highlight the need to innovate in classrooms that include students with ADHD.

Based on the above, it is concluded that it is possible to design inclusive e-Learning experiences.

The findings of this validation allowed the author to answer the third research issue of this thesis **RI3**: "How to achieve an e-Learning experience that includes students with ADHD?". Moreover, by conducting this validation we achieved the fourth specific objective **SO4** of this thesis: "To design and implement an intervention supported by technology and good practices in attention to diversity to provide an eLearning a training process that includes university students with ADHD".

6.5 PUBLICATIONS

Mancera, L., Baldiris, S., Sanchez, M., & Fabregat, R. (2016). Universal Design for e-Learning: an experience in the Manuela Beltran University to support a learner with ADHD. Ingeniería e Innovación, 4(1).

Mancera, L., Baldiris, S., Fabregat, R., & Joya, B. "Measuring the effects of UDL in e-Learning students suffering from ADHD," 2018 IEEE 17th International Conference on Advanced Learning Technologies (ICALT), Timisoara, 2018.

Mancera, L., Baldiris, S., Fabregat, R., Gomez, S., & Mejia, C, "aTenDerAH: A Videogame to Support e-Learning Students with ADHD," 2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT), Timisoara, 2017, pp. 438-440. doi: 10.1109/ICALT.2017.157.

PART 3
FINAL REMARKS

CHAPTER 7
CONCLUSIONS, CONTRIBUTIONS AND FUTURE WORK

7.1 OVERVIEW

This chapter has been organized in the following sections: in section 7.2 the conclusions are established according to the objectives of this research and considering the results obtained in the validation scenarios carried out. Section 7.3 specifies the contributions of the results obtained with the development of this research. . Finally, section 7.4 describes some possible lines of research that may be of interest and may follow contributing to the research field of TEL.

7.2 CONCLUSIONS

Information and Communication Technologies (ICT) offer the opportunity to respond to the multifaceted individual differences because they have the potential to create highly versatile and flexible educational and training environments. It can provide students with equal access to knowledge, regardless of their preferences, diverse learning needs, gender, geographic location, socio-economic or ethnic background, illness or disability, or any other circumstance that would normally hinder the provision of high-quality education. In this context, e-Learning has become an essential tool for teaching large numbers of diverse students because it provides and integrates a wide range of teaching resources and materials (e.g. video, audio, text, subtitles or sign language, multiple languages, and easily understandable expressions), that can be adapted to suit a variety of learning needs and preferences.

This dissertation examines the use of e-Learning by integrating teaching didactic strategies that respond to the preferences, strengths and weaknesses of students suffering from ADHD with the aim of exploring how these strategies impact the academic performance and the training experience of these students in a incluive way. To specify this, four objectives were proposed, these objectics guide each of the conclusions reached.

The first specific objective (**SO1**) was: "To identify research and evidence-based literature of the existing barriers for a healthy participation of university students suffering from ADHD, as well as their strengths, preferences and weaknesses en academic context, in order to propose an academic intervention focused on obtaining a better academic performance and learning experience". This led the author to review topics related to ADHD as screening adults for attention-deficit/hyperactivity disorder, evolution of ADHD through life, altered cognitive processes in young adults with ADHD, implications of ADHD in life, ADHD and adverse academic outcomes, supportting to young students with ADHD. From this review developed in CHAPTER 2 of this document, it was identified:

- University students who suffer from this disorder are in a difficult position, because contrary to what happens with the child population where there is a hyperdiagnosis; with the young-adult population there is an underdiagnosis (Valdizán, Izaguerri-Gracia, 2009; Ramos-Quiroga, Bosch-Munsó, Castells-Cervelló, NogueiraMorais, García-Giménez, Casas, 2006; Kessler, Adler, Barkley, Biederman, Conners, Demler, et al, 2006). Thus, they are students who can be considered lazy and without interest when they are really struggling with serious difficulties to carry out their learning processes. This is because cognitive functions affected by the persistence of ADHD, that is, the executive functions which regulate many activities related to the learning as planning, inhibition of overbearing responses, flexibility, organized search and working memory can not be executed properly impacting the effective learning process of students. Consequently, a considerable number of students who access university would suffer from the disorder without knowing it.
- On the other hand, there are no biomedical tests that allow an objective diagnosis of the ADHD, which even complicate the process (Valdizán, Izaguerri-Gracia, 2009; Cohen and

Alfonso, 2003). Additionally, it is a disorder with many stigmas about its existence, for example in Spain, until 2013 through the Organic Law of Improvement of Educational Quality (LOMCE), ADHD has been included within the section aimed at students with specific difficulties of learning. From the foregoing, it coud be concluded that the higher education institutions are in clear need of specific resources to detect students with or without a previous diagnosis of ADHD, and to provide assistance to them.

- In accordance with the above, diagnosing ADHD is a complex process that requires at least evaluating possible symptoms from childhood, the typical signs and symptoms and possible comorbidities, using self-assessment scales as auxiliary instruments of the first order and applying neuropsychological tests (Valdizán and Izaguerri-Gracia, 2009; McCann and Roy-Byrne, 2004; Cohen and Alfonso, 2003).
- Gamification and Serious Games considered as educational didactic strategies can positively impact the learning outcomes, i.e., the academic performance of students with ADHD (De Marco, 2010; Szafir and Mutlu, 2012; Rizzo et al, 2000). Apart from that, using Universal Design for Learning (UDL) permits to ensure that all students have genuine opportunities to learn in standards-based settings (Meo, 2008; Spooner, Baker, Harris, Ahlgrim-Delzell and Browder, 2007; Courey, Tappe, Siker, and LePage, 2012), including those with ADHD. This conclusion guided the scope of the third objective.

The second specific objective (**SO2**) established in this research was: "To design and implement a computer-assisted evaluation protocol to identify students with possible symptoms of ADHD applying student-modeling techniques in e-Learning context". This objective supports the identification of ADHD students in e-Learning context, a difficult and important process ad mentioned on second conclusion presented in Objective 1. Thus, in order to achieve this objective which is described in CHAPTER 5, data from the following dimension were obtained: personal and demographic; background in clinical, academic and social context; behavioral conduct; and cognitive performance. Results of the validation of the user model proposed permit the autor to arrive at the following conclusions:

- The self-applied tests are useful tools to identify diagnostic criteria for ADHD, because in addition to being validated, the results that were obtained compared with all the follow-up of the protocol established in the user model, were accurate.
- It is concluded that it is possible to identify if an e-Learning student could have possible symptoms of ADHD, stating that the study is not intending to present a method for detecting ADHD in a medical context, but support teachers in an educational context,

The third specific objective (**SO3**) outlined in this research was: "To design and implement an computer-assisted academic intervention to improve the academic performance of ADHD students who have found in e-Learning an opportunity to carry out their university education". According to the final conclusion achived with the first objective, two didactic strategies were designed to support learning processes of ADHD university students, one based on a videogame (Chapter 6, section 6.2) and another one based on gamification (Chapter 6, section 6.3). Each strategy was validated through a different scenario although using the same sample. From the results obtained in these scenarios with a control group and an experimental group, each with a group of students suffering from ADHD and another without this disorder, it was possible to conclude that:

- The developed serious videogame, AtenDerAH, had a positive impact on the academic performance and e-Learning experience of students suffering from ADHD due to effects on motivation, time management and platform focus. This is supported both by the quantitative analysis carried out and by the qualitative ones. On the other hand, despite not having been quantitatively significant in the academic performance of students without ADHD, the qualitative analysis showed that the students of this group also perceived the benefits of using AtenDerAH.
- For its part, the gamification strategy showed positive effects on academic performance and training experience for both the ADHD group and the group without ADHD, showing

significant significance with respect to the control group. In this case, the students stressed the importance of the novel compared to what they have found in other e-Learning courses, highlighting the importance resource design (being practical, clean design and friendly to the students).

- An important conclusion drawn from the qualitative analysis of the validation of both strategies was the aspect of the teacher's monitoring. In the scenario of AtenDerAH, where the teachers interacted constantly because they wanted the students to use the video game at least 3 hours a week during the two months of the course in which the video game was integrated, the students expressed their gratitude towards the teacher since he was constantly in contact with them. On the other hand, the gamification strategy was designed as an independent work and in spite of awakening the motivation of the students and achieving a higher performance, the students of the experimental group expressed interest but greater accompaniment from the teacher. This is a finding that reinforces the several studies that highlight the role of the virtual teacher as a mediator of the process to achieve learning that is more meaningful and better training experiences.
- Based on the previous points, it is concluded that it is possible to influence the academic performance of students with ADHD through serious games and gamification, achieving better e-Learning experiences.

The fourth objective (**SO4**) of this research was: "To design and implement an intervention supported by technology and good practices in attention to diversity to provide an eLearning a training process that includes university students with ADHD". This objective implied that the teaching strategies based on the preferences of students with ADHD would impact positively and in the same way all students. From the previous strategies, the gamification showed to be a mediation that offers a useful method for both groups (ADHD and without ADHD), however, the author of this thesis also created a strategy based on the implementation of the Universal Design for Learning (Chapter 6, section 6.4). Based on the results obtained on the validation of this case study, the following conclusions could be established:

- Students suffering from ADHD also take advantage of timelines, constant feeback, short explanations, alerts, in addition to videogames and gamification.
- The UDL stratety applied had a positive impact on the academic performance and e-Learning experience of all students (ADHD and without ADHD),so much so that students, when were asked about the preference among the three courses in which the strategies were validated, they chose the course where the UDL was applied. However, it is important to note that the latter had immersed the two previous strategies.
- Based on the above, it is concluded that it is possible to design training experiences that include students with ADHD in e-Learning training environments influencing academic performance.

As a general conclusion of the study, we can say that AtenDerAH, gamification and the use UDL achieved a positive impact in academic performance and e-Learning experience; however, it requires preparation and planning by the teachers to implement this type of training. The review of literature shows that inclusive education is a task that can not be postponed by educational institutions and teachers must prepare to respond to it and the challenges of being a 21st century teacher.

7.3 CONTRIBUTIONS

The following list summarizes the contributions of this dissertation to the research areas involved (i.e., educational science and information and communication technologies).

In the area of educational science:

- A consolidated literature on ADHD, specifically in aspects related to the impact of this disorder on academic processes.
- Evidence and knowledge obtained about the positive effect of video games, gamification and implementation of UDL in academic performance and e-Learning experience in students suffering from ADHD (Mancera, Baldiris, Fabregat and Joya, 2018; Mancera, Baldiris and Fabregat, 2011).
- Evidence of being able to use e-Learning as a means for students with ADHD to carry out their training processes in an inclusive manner.
- In the area of information and communication technologies:
- The definition of a solution that ranges from the posible symptoms detection to academic support considering the strengths, preferences and weaknesses of students suffering from ADHD in e-Learning contexts. The solution identifies elements, procedures, methods and software tools to support ADHD university students in e-Learning contexts. Specifically, it contributes with the definition of an ADHD user model (Mancera, Baldiris, Fabregat, Viñas and Sanchéz, 2017) and serious games, gamification and UDL implementacion strategies definition.
- An online auto-self report questionnaire named deTecDAH designed to capture information about ADHD symtomps in background and educational context (Appendix D). It consists of 17 dichotomous (yes/no) questions related to situations that may occur due to the presence of ADHD.
- A computer-based version of the Sustained Attention Task (SAT) (Van der Elst, Van Boxtel, Van Breukelen and Jolles, 2006) to evaluate the Sustained Attention area; the Rey's Auditory Verbal Learning Test (RAVLT) (Rey, 1958) to evaluate the Working Memory (WM) and Verbal Learning (VL). These tests have been comprised into a neuro-psychological battery named eCogniTiDAH. It is important to mention that these tools were developed for research and educative purposes (Mancera, Baldiris, Fabregat, Viñas and Sanchez, 2017).
- aTenDerAH, a serious videogame designed to train cognitive areas (executive functions) deficient in university students suffering from ADHD symptoms who are involved in e-Learning courses (Mancera, Baldiris, Fabregat, Gomez and Mejía, 2017).
- A Reusable Learning Object structured with gamification, which can be used in different disciplines and contexts.
- The modules to integrate the functionality of identifying ADHD symptoms and provide academic support to students with ADHD in ATutor platforform.

7.4 FUTURE WORK

In this section, future work lines are proposed to improve the development carried out and extend the research.

Regarding the ADHD User Model Component, several cognitive areas were evaluated through several web applications; however, it is recommended the development of other evalution tools to evaluate other cognitive areas considering that there is not a standard characterization of the cognitive areas affected by ADHD.

Additionally, it is necessary to continue this research study to consider the validity of the cognitive assessment tools as a predictor tool using specific standard tests (eg, performance on a battery of cognitive tasks) as well as to analyze its effectiveness with large samples of university students with ADHD.

On the other hand, ADHD User Model Component was analyzed quantitatively. A qualitative research should also be carried out to collect information, for example, regarding the degree of student satisfaction with respect to the inferred profile.

Regarding to the ADHD Academic Intervention Component, research should be developed using other teaching strategies, with teacher follow-up in order to achieve a whole range of possibilities.

In this research, the e-Learning experience was analyzed; however it is important to deep in the study of motivational aspects, which could be used as criteria to improve the strategies.

It is also proposed to extend the qualitative study through a more extensive data collection instruments expanding the semantic network developed in order to know more about the perception of students.

Moreover, considering that the research was developed within the framework of an inclusive e-Learning, it is proposed as future work the design and development of accessible experiences and resources in order to create scenarios of education for all without exception.

Finally, taking the study from a descriptive to a correlational scope, establishing a relationship for example between the time that each student was exposed to the strategies with respect to academic performance.

REFERENCES

Accesibilidad Rehasoft. (2011). Memotiva. Recuperado de http://www.rehasoft.com/tdah/memotiva/

ACESAD, VIRTUALEDUCA (2013). La educación superior a distancia y virtual en Colombia: Nuevas realidades. Toro, N. A., & Rama, C. (Eds.). Available: http://virtualeduca.org/documentos/observatorio/la_educacion_superior_a_distancia_y_virtual_en_colombia_nuevas_realidades.pdf

ADHD institute, 2017. Psychiatric comorbidities in patients with ADHD. Retrieved from: http://adhd-institute.com/burden-of-adhd/epidemiology/comorbidities/

Advokat, C., and Vinci, C. (2012). Do Stimulant Medications for Attention-Deficit/Hyperactivity Disorder (ADHD) Enhance Cognition?. *In Current directions in ADHD and its treatment*. InTech.

ALTER-NATIVA Project. (2013). ALTER-NATIVA Project. Retrieved 2 September 2016, from http://titanic.udg.edu:8000/www_alternativa/

@LIS2 program (2009). @LIS2 program. Retrived 28 may 2018, from http://cetes.medicina.ufmg.br/revista/index.php/rlat/article/viewFile/73/197

American Psychiatric Association. (1994). Diagnotic and statical manual of mental disorders: (DSM-IV-TR), (4ª Ed). Washington, DC: American Psychiatric Press.

American Psychiatric Association (2014). Manual Diagnóstico y Estadístico de los Trastornos Mentales (DSM-5), 5ª Ed. Madrid: Editoral Médica Panamericana.

Arroyo, I., and Woolf, B. P. (2005). Inferring learning and attitudes from a Bayesian Network of log file data. *In 12th International Conference on Artificial Intelligence in Education - AIED'2005 (pp. 33–40)*. Amsterdam: C.-K. Looi, G. McCalla, B. Bredeweg, & J. Breuker (Eds.).

Artigas, J., and Narbona, J. (2011). Trastornos del neurodesarrollo. [Madrid]: S.E.N.E.P., Sociedad Española de Neurología Pediátrica.

Subcommittee on Attention-Deficit/Hyperactivity Disorder & Management. (2011). ADHD: clinical practice guideline for the diagnosis, evaluation, and treatment of attention-deficit/hyperactivity disorder in children and adolescents. Pediatrics, peds-2011.

ATutor (version 2.2. Released) [Software]. (2016). Inclusive Design Research Centre and OCAD University. Retrieved from: http://www.atutor.ca/

Avila, C., Baldiris, S., Fabregat, R., and Guevara, J. C. (2012, September). A web content accessibility evaluation process for learning objects in the context of a virtual learning environment. *In International Conference on Web-Based Learning (pp. 181-190).* Springer, Berlin, Heidelberg.

Bacca, J., Baldiris, S., Fabregat, R., Guevara, J. C., and Calderon, D. I. (2012). A Case-based Reasoning Approach to Support Teaching of Spanish as a Second Language in Indigenous Communities from *Latin America. 13th Ibero ‐American Conference*. Cartagena, Colombia.

Bacca, J., Baldiris, S., Fabregat, R., and Avila, C. (2013). A Case-based Reasoning Approach to Validate Grammatical Gender and Number Agreement in Spanish language. *International Journal of Interactive Multimedia and Artificial Intelligence*, 2(1), 73–81. doi:10.9781/ijimai.2013.2110

Baldiris, S. (2012). Supporting Competence Development Processes on Open Learning Systems through Personalization (PhD). University of Girona.

Baldiris, S., Fabregat, R., Mancera, L., Ávila, C., Bacca, J., Hernández, J., and Carlos, J. (2011). Atendiendo la Diversidad en Contextos Virtuales de Aprendizaje. New Trends in Engineering Education, *II International Conference on Engineering and Computer Education - ICECE '2011* (pp. 32–38).

Barkley, R.A. (1981). Hyperactive children: A handbook of diagnosis and treatment. New York: Guilford Press.

Barkley, R.A. (1997). Behavioual inhibition, sustained attention, and executive functions: Constructing a unifying theory of AD/HD. Psychological Bulletin, 1221, 65-94.

Barkley, R. A., & Murphy, K. R. (1998). Attention-deficit hyperactivity disorder: A clinical workbook. Guilford Press.

Barkley, R. A. (2014). Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment. Guilford Publications.

Barry, T., Lyman, R., and Grofer, L. (2002). Academic underachievement and Attention-Deficit/Hyperactivity Disorder: The negative impact of symptom severity on school performance, *Journal of School Psychology 40,* 259-283.

Bavelier, D., Green, C. S., Han, D. H., Renshaw, P. F., Merzenich, M. M., and Gentile, D. A. (2011). Brains on video games. Nature Reviews Neuroscience, 12(12),763–768

Benktzon, M. (1993). Designing for our future selves: the Swedish experience. Applied Ergonomics, 24(1), 19–27.

Biederman, J., Mick, E., Faraone, S. V., Braaten, E., Doyle, A., Spencer, T., ... & Johnson, M. A. (2002). Influence of gender on attention deficit hyperactivity disorder in children referred to a psychiatric clinic. American Journal of psychiatry, 159(1), 36-42.

Biederman, J. (2005). Attention-deficit/hyperactivity disorder: a selective overview. Biological psychiatry, 57(11), 1215-1220.

Birchwood, J., and Daley, D. (2012). Brief report: The impact of attention deficit hyperactivity disorder (ADHD) symptoms on academic performance in an adolescent community sample. *Journal of adolescence*, 35(1), 225-231.

Bitsakou, P., Psychogiou, L., Thompson, M., and Sonuga-Barke, E. J. (2009). Delay aversion in attention deficit/hyperactivity disorder: an empirical investigation of the broader phenotype. *Neuropsychologia*, 47(2), 446-456.

Bjork, E., Ottosson, S., and Thorsteinsdottir, S. (2008). E-Learning For All. E-Learning: 21st Century Issues and Challenges (pp. 49–70).

Blanco, R. (2008). Haciendo efectivo el derecho a una educación de calidad sin exclusiones. *Revista Colombiana de Educación*, 54, 14-35.

Blanco, R. (2014). Inclusión educativa en América Latina: caminos recorridos y por recorrer. *In Á. Marchesi, R. Blanco & L. Hernández, Avances y desafíos de la educación inclusiva en Iberoamérica* (pp. 1-173). Madrid: Organización de Estados Iberoamericanos para la Educación, la Ciencia y la Cultura (OEI). Available: http://files.matices-ugc.webnode.es/200000041-a4669a6898/Metas_inclusiva.pdf

Blondis TA, Roizen NJ, Fishkin J, et al. (1995). Motor Control and Perceptual-Motor Deficit Association with ADHD Children. *Arch Pediatr Adolesc Med*; 149: 66-72.

Börger, N., at al. (1999). Heart rate variability and sustained attention in ADHD children, Journal of abnormal Child Psychology 27, 32-33.

Brown, T. (2008). ADD/ADHD and impaired executive function in clinical practice. Current Psychiatry Reports, 10(5), 407-411.

Brusilovsky, P. (1996). Methods and techniques of adaptive hypermedia. User Modeling And User-Adapted Interaction, 6(2-3), 87-129. doi: 10.1007/bf00143964.

Brusilovsky, P. (2001). Adaptive HypermediaUser Modeling and User-Adapted Interaction 11: 87. https://doi.org/10.1023/A:1011143116306

Brusilovsky, P., and Millán E. (2007) User Models for Adaptive Hypermedia and Adaptive Educational Systems. In: Brusilovsky P., Kobsa A., Nejdl W. (eds) The Adaptive Web. Lecture Notes in Computer Science, vol 4321. Springer, Berlin, Heidelberg

Buelow, M. T., Okdie, B. M., and Cooper, A. B. (2015). The influence of video games on executive functions in college students. Computers in Human Behavior, 45, 228-234.

Bunchball Inc. (2014). Bunchball Receives Notice of Allowance for Fundamental "Gamification as a Service" Patent. Redwood City. URL: http://www.bunchball.com/news/bunchball-receives-noticeallowance-fundamental gamification-service-patent

Caballero, R. and Celorrio, R. (2014). Atención a la diversidad: alumnado con trastorno por déficit de atención e hiperac vidad en la etapa de educación primaria (Trabajo Fin de Grado). Universidad de Valladolid, Soria. Recuperado de http://uvadoc.uva.es/handle/ 10324/8403

Cabero, J., and Córdoba, M. (2009). Inclusión educativa: inclusión digital. Revista Educación Inclusiva, 2(1), 61-77

Carmona, C., Castillo, G., and Millán, E. (2007). Discovering Student Preferences in ELearning. International Workshop on Applying Data Mining in e-Learning.

Cervéra-Mérida, J. F., & Ygual-Fernández, A. (2006). Uma propuesta de intervención em trastornos disortográficos atendiendo a la semiologia de los errores. Rev Neurol, 42(2), 117-26.

Chan, P. A., and Rabinowitz, T. "A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents," Annals of General Psychiatry, vol. 5, no. 1, 2006.

Chousa, C., Martínez-Figueira, E., and Raposo-Rivas, M. (2017). ICT for educational intervention in ADHD: a bibliometric research. Perspectiva Educacional. Formación de Profesores. Vol 56(3), pp. 142-161.

Cid, A., Méndez, R., and Sandoval, F. (2011). Investigación Fundamentos y Metodología, ed. Prentice Hall, México.

Cisterna, F. (2005). Categorization and triangulation as processes of validation of knowledge in qualitative investigations. Theoria, (14), 61-71.

Cohen, M. A. A., & Alfonso, C. A. (2003). AIDS psychiatry: psychiatric and palliative care, and pain management. In AIDS and Other Manifestations of HIV Infection (Fourth Edition) (pp. 537-576).

Colan, O., Wade, V., Gargan, M., and Hockemeyer, C. (2002). An architecture for integrating adaptive hypermedia services with open learning environments. Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications. Denver, CO: EDMEDIA.

Conners, C. K., Erhardt, D., Epstein, J. N., Parker, J. D. A., Sitarenios, G., & Sparrow, E. (1999). Self-ratings of ADHD symptoms in adults I: Factor structure and normative data. Journal of Attention Disorders, 3(3), 141-151.

Conners, C. K., Epstein, J. N., Angold, A., & Klaric, J. (2003). Continuous performance test performance in a normative epidemiological sample. Journal of abnormal child psychology, 31(5), 555-562.

Council of Europe. (1998). Recommendation No. R (98) 3 on access to higher education in Europe.

Conati, C., and Maclaren, H. (2005). Data-Driven Refinement of a Probabilistic Model of User Affect. 10th International Conference UM'05. Lecture Notes in Computer Science (Vol. 3538, pp. 40–49). Springer-Verlag.

Conati, C., Larkin, J., and VanLehn, K. (1997). A Computer Framework to Support Self-explanation. , IOS Press (). In B. du Bolay & R. Mizoguchi (Eds.), 8th World Conference on Artificial Intelligence in Education AIED'97, Knowledge and Media in Learning Systems (pp. 279–286).

Courey, S. J., Tappe, P., Siker, J., and LePage, P. (2012). Improved lesson planning with Universal Design for Learning (UDL). Teacher Education and Special Education, 20, 1-21. doi:10.1177/0888406412446178

Daley. D., and Birchwood. J. (2010). ADHD and academic performance: Why does ADHD impact on academic performance and what can be done to support ADHD children in the classroom?. Child: Care, Health and Development 36(4). pp:455-464.

De Andrade, L. C. V., Carvalho, L. A. V., Lima, C., Cruz, A., Mattos, P., Franco, C., ... & Grieco, B. (2006, November). Supermarket Game: an adaptive intelligent computer game for attention deficit/hyperactivity disorder diagnosis. In Artificial Intelligence, 2006. MICAI'06. Fifth Mexican International Conference on (pp. 359-368). IEEE.

De Bra, P. (1998). Adaptive hypermedia on the Web: Methods, technology and applications. En Proceedings of the WebNet 98 Conference (pp. 220-225). Fl., USA: AACE

Decree 150/2017. Departament d'Ensenyament, Catalunya, Barcelona, October 17, 2017.

Decree 1421/2017. Ministerio de Educación Nacional de Colombia, Bogotá, August 29, 2017.

De la Guía E., D. Lozano M., and R. Penichet V. (2013). Co-StiCap: System based on Distributed and Tangible User Interfaces to Improve Skills in Children with ADHD. In Proceedings of the 2nd International Workshop on Interaction Design in Educational Environments, Vol 1: IDEE, (ICEIS 2013), pp. 64-73. DOI: 10.5220/0004602800640073

De Marco, M. (2010). Programas informáticos para trastornos de lectoescritura, Dislexia y/o TDAH. P. Arnaiz; Mª. D. Hurtado y FJ Soto (Coords.), 25.

Departament d'educació. (2007). Aprender juntos para vivir juntos. Plan de acción 2008 - 2015. Retrieved from https://www.fcsd.org/fitxer-89292_89292.pdf

Deterding, S., Dixon, D., Khaled, R., and Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification". En Memorias del 15th International Academic MindTrek Conference: Envisioning Future Media Environments, pp. 9–15. doi: 10.1145/2181037.2181040

Daigre, C. et al., Adult ADHD Self-Report Scale (ASRSv1.1) symptom checklist in patients with substance use disorders, Actas españolas de psiquiatría 37 (2009), 299-305.

Dicheva, D., Dichev C., Agre G., and Angelova, G. (2015). Gamification in Education: A Systematic Mapping Study. Educational Technology & Society, 18 (3), 75–88. Recuperado de: http://www.ifets.info/journals/18_3/6.pdf

Dondlinger, M. J. (2007). Educational video game design: A review of the literature. Journal of applied educational technology, 4(1), 21-31.

Donnelly, R., and Mcsweeney, F. (2008). Applied E-Learning and E-Teaching in Higher Education. (R. Donnelly & F. McSweeney, Eds.) (p. 440). New York, USA: IGI Global. doi:10.4018/978-1- 59904-814-7

dotLRN (s.f) [Software]. MIT. http://www.dotlrn.org

Durán, M. (2000). Diseños e investigación cualitativa. Conferencia escrita sin editar. Universidad Nacional de Colombia. Bogotá.

Durkin, K. (2010). Videogames and young people with developmental disorders. Review of General Psychology, 14(2), 122–140. http://doi.org/10.1037/a0019438

DuPaul, G. J., Anastopoulos, A. D., Power, T. J., Reid, R., Ikeda, M. J., & McGoey, K. E. (1998). Parent ratings of attention-deficit/hyperactivity disorder symptoms: Factor structure and normative data. Journal of Psychopathology and Behavioral Assessment, 20(1), 83-102.

DuPaul, G. J., Weyandt, L. L., O'Dell, S. M., and Varejao, M. (2009). College students with ADHD: Current status and future directions. Journal of attention disorders, 13(3), 234-250.

Du Paul, G., Schaughency, E., Weyandt, L., Tripp, G., Kiesner, J., Ota, K., and Stanish, H. (2001). Self report of ADHD symptoms in university students: Cross-gender and cross-national prevalence. Journal of Learning Disabilities 2001; 34: 370-380.

DuPaul, G. J., and Stoner, G. (2014). ADHD in the Schools, Third Edition: Assessment and Intervention Strategies. Guilford Publications.

Estévez, B. and León, M.J. (2014). Una mirada inclusiva hacia el tdah en las aulas escolares. XI Congreso Internacional y XXXI Jornadas de Universidades y Educación Inclusiva. Quaderns Digitals.net.

EdTechReview (2013). What is GBL (Game-Based Learning)? EdTechReview. Retrieved from: http://edtechreview.in/dictionary. /298-what-is-game-based-learning

Epstein, J. N., & Kollins, S. H. (2006). Psychometric properties of an adult ADHD diagnostic interview. Journal of Attention Disorders, 9(3), 504-514.

Entertainment Software Association (ESA). "2015 Essential Facts About the Computer and Video Game Industry." The Entertainment Software Association. (2015). Available from: http://www.theesa.com/wp-content/uploads/2015/04/ESA-Essential-Facts-2015.pdf

EU4ALL project (2006). EU4ALL project. Retrieved 28 May 2018, from http://www.eu4all-project.eu/

Faraone, S. et al. (2000). Attention-deficit/hyperactivity disorder in adults: an overview. Biological Psychiatry, vol. 48, pp. 9-20.

Fleming, A. P., & McMahon, R. J. (2012). Developmental context and treatment principles for ADHD among college students. Clinical child and family psychology review, 15(4), 303-329.

Flores, J. G., Gómez, G. R., & Jiménez, E. G. (1999). Metodología de la investigación cualitativa. Málaga: Aljibe.

Florian, B. (2013). Technology-enhanced support for lifelong competence development in higher education (PhD). University of Girona.

Freina, L., and Ott, M. (2015, January). A literature review on immersive virtual reality in education: state of the art and perspectives. In The International Scientific Conference eLearning and Software for Education (Vol. 1, p. 133). " Carol I" National Defence University.

García, F., Amandi, A., Schiaffinoa, S., and Campoa, M. (2006). Evaluating Bayesian networks' precision for detecting students' learning styles. Computers & Education.

Gelvez, L., Baldiris, S., and Fabregat, R. (2011). Modelado de Usuario para apoyar el Proceso de Enseñanza y Aprendizaje de Personas con Déficit Auditivo. Congreso Internacional de Ambientes Virtuales de Aprendizaje Adaptativos y Accesibles: Hacia un sistema educativo.

Gentile, D. A., Swing, E. L., Lim, C. G., and Khoo, A. (2012). Video game playing, attention problems, and impulsiveness: Evidence of bidirectional causality. Psychology of Popular Media Culture, 1(1), 62–70. http://doi.org/10.1037/a0026969

González, G., and Oliver, R. (2002). La informática en el déficit de atención con hiperactividad. Comunicación y Pedagogía, no 182, pp. 56-67.

Goodman, D. W. (2009). ADHD in adults: update for clinicians on diagnosis and assessment. Primary Psychiatry, 16(11), 38.

Grabinger, S., Aplin, C. and Ponnappa-Brenner, G. (2008). Supporting Learners with Cognitive impairments in Online Environments. TechTrends, Vol 52, Num 1.

Grabinger, S. (2009). A framework for supporting postsecondary learners with psychiatric disabilities in online environments. In Proceedings of the 8th European Conference on e-Learning: ECEL (p. 236). Academic Conferences Limited.

Graf, S., Lin, T., & Kinshuk. (2005). Improving student modeling: The relationship between learning styles and cognitive traits. In CELDA (pp. 37-44).

Graf, S. (2007). Adaptivity in learning management systems focussing on learning styles.

Graf, S., Kinshuk and Liu, T. C. (2009). Supporting Teachers in Identifying Students' Learning Styles in Learning Management Systems: An Automatic Student Modelling Approach. Journal of Educational Technology & Society, 12(4).

Granic, I., Lobel, A., and Engels, R. C. (2014). The benefits of playing video games. American Psychologist, 69(1), 66-78.

Greitemeyer, T., & Osswald, S. (2010). Effects of prosocial video games on prosocial behavior. Journal of personality and social psychology, 98(2), 211.

Griffiths, M. (2002). The educational benefits of videogames. Education and Health, vol. 20, no. 3. pp. 47-51.

Gros, B. (2007). Digital games in education: The design of games-based learning environments. Journal of research on technology in education, 40(1), 23-38.

Gröber, P., Weicht, M., and Berg, M. (2010). Inclusive eLearning–Special Needs and Special Solutions?. In 3rd Workshop on inclusive eLearning, London (UK) (Vol. 9).

Hernández, L. A. (2017). *Gamified layer for Google Classroom to improve the user experience and engagement of students with ADHD* (Master thesis). University of Skovde.

Hernández, R., Fernández, C., and Baptista, P. (2003). Metodología de la investigación. (3ra Edición). México: Mc Graw-Hill.

Hunicke, R., LeBlanc, M., and Zubek, R. (2004, July). MDA: A formal approach to game design and game research. In Proceedings of the AAAI Workshop on Challenges in Game AI (Vol. 4, No. 1, pp. 1-5). AAAI Press San Jose, CA.

Ibrahim, M., Prasad, P. W. C., Alsadoon, A., and Pham, L. (2016, July). Synchronous virtual classroom for student with ADHD disorder. In Computer Science and Software Engineering (JCSSE), 2016 13th International Joint Conference on (pp. 1-6). IEEE.

International Covenant on Economic, Social and Cultural Rights, art. 13, G.A. Res. 2200A (XXI), U.N. GAOR, Supp. No. 16, U.N. Doc. A/6316 (1966).

Jiménez, J. E., Antón, L., Díaz, A., Díaz, J., Rojas, E., Estévez, A., and Ortiz, M. R. (2007). TRADISLEXIA: un videojuego interactivo para el tratamiento de la dislexia [Software informático]. Universidad de La Laguna: Autores.

Jiménez-Murcia, S., Fernández-Aranda, F., Kalapanidas, E., Konstantas, D., Ganchev, T., Kocsis, O., ... & Kaufmann, H. (2009). Playmancer project: a serious videogame as an additional therapy tool for eating and impulse control disorders.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. Educational researcher, 33(7), 14-26.

Klemes, J., Epstein, A., Zuker, M., Grinberg, N., and Ilovitch, T. (2006). An assistive computerized learning environment for distance learning students with learning disabilities. Open Learning: The Journal of Open, Distance and e-Learning. Vol. 21, No. 1, February 2006, pp. 19–32.

Kessler, R.C,, Chiu, W.T., Demler, O., Merikangas, K.R., and Walters, E.E. (2005). Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. Arch Gen Psychiatry 2005; 62:617-27

Kessler, R. C., Adler, L., Barkley, R., Biederman, J., Conners, C. K., Demler, O., ... & Spencer, T. (2006). The prevalence and correlates of adult ADHD in the United States: results from the National Comorbidity Survey Replication. American Journal of psychiatry, 163(4), 716-723.

Kapp, K. (2012). The Gamification of Learning and Instruction. Game-based methods and Strategies for Training and Education. Pfie¬er.

Kim, B. (2015). Understanding Gamification. Library Technology

Kirkley, S. E., & Kirkley, J. R. (2005). Creating next generation blended learning environments using mixed reality, video games and simulations. TechTrends, 49(3), 42-53.

Kroes, M., Kalff, A. C., Kessels, A. G., Steyaert, J., Feron, F. J., Van Someren, A. J., and Crolla, I. F. (2001). Child psychiatric diagnoses in a population of Dutch schoolchildren aged 6 to 8 years. Journal of the American Academy of Child & Adolescent Psychiatry, 40(12), 1401-1409.

Kutcher, S., Aman, M., Brooks, S. J., Buitelaar, J., van Daalen, E., Fegert, J., and Kusumakar, V. (2004). International consensus statement on attention-deficit/hyperactivity disorder (ADHD) and disruptive behaviour disorders (DBDs): clinical implications and treatment practice suggestions. European Neuropsychopharmacology, 14(1), 11-28.

Kwon, S. J., Kim, Y., & Kwak, Y. (2018). Difficulties faced by university students with self-reported symptoms of attention-deficit hyperactivity disorder: a qualitative study. Child and adolescent psychiatry and mental health, 12(1), 12.

Lee, Y. (2015). Teachers' apitudes, knowledge, and classroom management strategies regarding students with ADHD: A cross-cultural comparison of teachers in South Korea and Germany (Un-published doctoral dissertation). University of Leipzig, Leipzig, Germany. Available from: https://www.researchgate.net/publication/282776028_Knowledge_of_attentiondeficit_hyperactivity_disorder_ADHD_-_a_comparison_of_pre-service_teachers_in_primary_and_special_education_in_Germany

López Salinas, J. L. (2002). Uso de rúbricas generalizadas para evaluar conocimientos en la técnica didáctica Aprendizaje Basado en Problemas. Recuperado el 20 de enero de 2011, de www.mty.itesm.mx/rectoria/dda/rieee/word.../1B-Uso-Rubricas.doc.

Loe. I., and Feldman. H. (2007). Academic and educational outcomes of children with ADHD. Journal of Pediatric Psychology 32(6). pp: 643-654.

Laroussi, M. (2001). Conception et réalisation de système didactique hypermédia adaptatif: CAMELEON (PhD). Manouba University.

Ley N°1618. Congreso de la república de Colombia, Bogotá, Colombia. 27 de febrero de 2013. Disponible en: http://wsp.presidencia.gov.co/Normativa/Leyes/Documents/2013/LEY%201618%20DEL%2027%20DE%20FEBRERO%20DE%202013.pdf

Lin, T., and Kinshuk. (2005). Cognitive Profiling in Life-Long Learning. In C. Howard, J. V. Boettcher, L. Justice, K. Schenk, P. L. Rogers, & G. A. Berg (Eds.), Encyclopedia of International Computer- Based Learning (pp. 245–255). Hershey, PA, USA: Idea Group Inc.

Mancera, L., Baldiris, S., and Fabregat, R. (2008). Modelling Collaborative Competence Level using Machine Learning Techniques. Proceedings of the IADIS International Conference on e-Learning 2008 (pp. 56–60). Amsterdam, The Netherlands: IADIS. Retrieved from http://www.iadisportal.org/e-learning-2008-proceedings.

Mancera, L., Baldiris, S., Fabregat, R., Viñas, F., and Caparros, B. (2011). Adapting Suitable Spaces in Learning Management Systems to Support Distance Learning in Adults with ADHD. 11th IEEE International Conference on Advanced Learning Technologies (pp. 105–109). Athens.

Mancera, L., Baldiris, S., Fabregat, R., Sánchez, M., & Viñas, F. (2017). A domain-independent data ADHD student model for computer-based educational systems. Data analysis in higher education. Journal of Ambient Intelligence and Smart Environments, 9(5), 625-639.

Mancera, L., Baldiris, S., Fabregat, R., Gomez, S., & Mejia, C. (2017, July). aTenDerAH: a videogame to support e-Learning students with ADHD. In Advanced Learning Technologies (ICALT), 2017 IEEE 17th International Conference on (pp. 438-440). IEEE.

Mancera, L., Baldiris, S., Fabregat, R., & Joya, B. (2018, July). Measuring the Effects of UDL in e-Learning Students Suffering from ADHD. In 2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT) (pp. 327-329). IEEE.

Marchesi, Á., Blanco, R., and Hernández, L. (2014). Avances y desafíos de la educación inclusiva en Iberoamérica (pp. 1-173). Madrid: Organización de Estados Iberoamericanos para la Educación, la Ciencia y la Cultura (OEI). Available: http://files.matices-ugc.webnode.es/200000041-a4669a6898/Metas_inclusiva.pdf

Marchesi, A. (2014). Retos y dilemas de la inclusión educativa. In Á. Marchesi, R. Blanco & L. Hernández, Avances y desafíos de la educación inclusiva en Iberoamérica (pp. 1-173). Madrid: Organización de Estados Iberoamericanos para la Educación, la Ciencia y la Cultura (OEI). Available: http://files.matices-ugc.webnode.es/200000041-a4669a6898/Metas_inclusiva.pdf

Marchetta, N.D. (2007). Cognitive Processes in Adults with ADHD, Neuropsych Publishers, Maastricht, ISBN 978-90-75578-35-2.

Martínez-Segura, M.J. (2007). Utilización de las TIC en la respuesta educativa a las dificultades de aprendizaje atencionales. Comunicación & Pedagogía, no 219. pp. 8-14.

Martins, A. C., Faria, L., Vaz de Carvalho, C., and Carrapatoso, E. (2008). User Modeling in Adaptive Hypermedia Educational Systems, Educational Technology & Society 11 (2008), 194-207.

McCann, B. S., & Roy-Byrne, P. (2004). Screening and diagnostic utility of self-report attention deficit hyperactivity disorder scales in adults. Comprehensive psychiatry, 45(3), 175-183.

Medina, N., García, L. and Parets, J. (2002). Taxonomía de sistemas hipermedia adaptativos. En JISBD'2002, Taller de Sistemas Hipermedia Colaborativos y Adaptativos (pp. 1-10).

Medina-Medina, N., García-Cabrera, L., Rodríguez-Fortiz, M. J., & Parets-Llorca, J. (2002, May). Adaptation in an evolutionary hypermedia system: Using semantic and petri nets. In International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems (pp. 284-295). Springer, Berlin, Heidelberg.

Medina, N. García, L., Torres, J., and Parets, J. (2001). Evolution in adaptive hypermedia systems. IWPSE'01. Orlando, Florida.

Mejia, C. (2009). Adaptation Process to Deliver Content based on User Learning Styles (Master Thesis). Universitat de Girona.

Mejia, C., Fabregat, R., and Marzo, J. L. (2010). Including Student's Learning Difficulties in the User Model of a Learning Management System. XXXVI Conferencia Latinoamericana de Informática (CLEI 2010) (pp. 845–858).

Mejia, C. (2013). Framework for detection, assessment and assistance of university students with dyslexia and/or reading difficulties (PhD). Universitat de Girona.

Meo, G. (2008). Curriculum planning for all learners: Applying universal design for learning (UDL) to a high school reading comprehension program. Preventing School Failure, 52(2), 21-30. doi:10.3200/PSFL.52.2.21-30

Meyer, A., Rose, D., and Gordon, D. (2014). The UDL Guidelines: A framework for Implementation. In Universal Design for Learning, theory and practice (1st ed., pp. 109-126). Wakefield: CAST Professional Publishing.

MICOLE project (2004). MICOLE Project. Retrived 28 May, 2018, from http://micole.cs.uta.fi/

Moodle (versión 3.5 Realeased) [Software]. (2018). https://moodle.org/?lang=es

Moore, J.L., Dickson-Deane, C., and Galyen, K. (2011). e-Learning, online learning, and distance learning environments: Are they the same?. Internet and Higher Education 14 (1), PP.129–135. Elsevier.

Moreno, G. (2008). E-Learning For All: adaptación considerando el contexto de acceso (Master Thesis). University of Girona.

Murphy, K.R., and Adler, L.A. (2004). Assessing Attention Deficit Hyperactivity Disorder in Adults: Focus on Rating Scales. The Journal of Clinical Psychiatry, Supplement 3, 65, 12-17.

Murphy, K.R., Barkley, R.A., and Bush, T. (2002). Young Adults with ADHD: Subtype differences in Comorbidity, Educational, and Clinical History. The Journal of Nervous and Mental Disease. Vol. 190, No. 3, 147-157.

Murphy, K.R. (2005). Psychosocial Treatments for ADHD in Teens and Adults: A Practice-Friendly Review. Journal of Clinical Psychology/In Session, Vol.61, (5), 1-13.

Nanny's circle: http://nannyscircle.com/

National Institute of Clinical Excellence –NICE –. (2009). Attention deficit hyperactivity disorder Diagnosis and Management of ADHD in children, young people and adults. London: NICE Clinical Guideline.

Noriega, L., and Torres, E. (2011). Aulas virtuales: ¿Desarrollo pedagógico y didáctico o avance tecnológico? (Tesis de especialización). Universidad Militar Nueva Granada, Bogotá.

Nugent, K., and Smart, W. (2014). Attention-deficit/hyperactivity disorder in postsecondary students. Neuropsychiatric disease and treatment, 10, 1781.

Ortigosa, A., Paredes, P., and Rodriguez, P. (2010). AH-questionnaire!: An adaptive hierarchical questionnaire for learning styles. Computers & Education, 54(4), 999–1005.

Park, H., Baek, Y., and Gibson, D. (2008). Design of an adaptive mobile learning system. In J. Lumsden (Ed.), Handbook of research on user interface design and evaluation for mobile technology (Vol. 1, pp. 286 - 301). Hershey, PA: Information Science Reference.

Pastor, P. N., Reuben, C. A., Duran, C. R., and Hawkins, L. D. (2015). Association between Diagnosed ADHD and Selected Characteristics among Children Aged 4-17 Years: United States, 2011-2013. NCHS Data Brief. Number 201. Centers for Disease Control and Prevention.

Peninington, B.F., and Ozonoff, S. (1996). Executive Functions and Developmental Psychopathology. Journal of Child Psychology and Psychiatry, 37(1), pp. 51-57.

Pennington, B.F., and Ozonoff, S. (1996). Executive functions and developmental psychopathology. Journal of Child Psychology and Allied Disciplines, 37 (1), 51-87.

Peña, C. I. (2004). Intelligent agents to improve adaptivity in a web-based learning environment control adaptivity in a web-based learning (PhD). University of Girona.

Picard, R. W. (1997). Affective Computing. MIT Press, Cambridge, MA.

Pinho, T. D., Manz, P. H., DuPaul, G. J., Anastopoulos, A. D., & Weyandt, L. L. (2017). Predictors and moderators of quality of life among college students with ADHD. Journal of attention disorders, 1087054717734645.

Plichta, M. M., Vasic, N., Wolf, R. C., Lesch, K. P., Brummer, D., Jacob, C., and Grön, G. (2009). Neural hyporesponsiveness and hyperresponsiveness during immediate and delayed reward processing in adult attention-deficit/hyperactivity disorder. Biological psychiatry, 65(1), 7-14.

Rabin, L. A., Fogel, J., and Nutter-Upham, K. E. (2011). Academic procrastination in college students: The role of self-reported executive function. Journal of clinical and experimental neuropsychology, 33(3), 344-357.

Radford, A. (2012). Learning at a Distance: Undergraduate Enrollment in Distance EducationCourses and Degree Programs. Stats in Brief. Nces 2012-154 (pp. 1-22). National Center for Education Statistics.

Rama, C. (2013). La educación virtual como la modalidad educativa para las personas con necesidades especiales: solo en la red no hay personas con discapacidad. Revista Diálogo Educacional, 13(38), 325-345.

Ramos Quiroga, J. A., Bosch Munsó, R., Castells Cervelló, X., Nogueira Morais, M., García Giménez, E., & Casas Brugué, M. (2006). Trastorno por déficit de atención con hiperactividad en adultos: caracterización clínica y terapéutica. Revista de Neurología, 42(10), 600-606.

Rapp, W. (2014). Universal design for learning in action. Baltimore MD: Brooks.

Raposo-Rivas, M., & Rodríguez, A. B. S. (2017). Estudio sobre la intervención con Software educativo en un caso de TDAH. Revista de Educación Inclusiva, 8(2).

Rey, A. (1958). L'examen clinique en psychologie. París: Presse Universitaire de France.

Richards, W. (1993). Research Methodology in Software Engineering. Future directions in software engineering, summary of the Dagstuhl Workshop, 18(1), 36–37.

Rivas, M. R., and Rodríguez, A. B. S. (2015). Estudio sobre la intervención con Software educativo en un caso de TDAH. Revista de Educación Inclusiva,8 (2), 121-138

Rizzo, A. A., Buckwalter, J. G., Bowerly, T., Van Der Zaag, C., Humphrey, L., Neumann, U., and Sisemore, D. (2000). The virtual classroom: a virtual reality environment for the assessment and rehabilitation of attention deficits. CyberPsychology & Behavior, 3(3), 483-499.

Rizzo, A. A., Bowerly, T., Buckwalter, J. G., Schultheis, M., Matheis, R., Shahabi, C., and Sharifzadeh, M. (2002, September). Virtual environments for the assessment of attention and memory processes: the virtual classroom and office. In Proceedings of the Fourth ICDVRAT (pp. 3-12).

Rohde, L. A., Barbosa, G., Tramontina, S., and Polanczyk, G. (2000). Transtorno de déficit de atenção/hiperatividade. Revista Brasileira de Psiquiatria, 22, 07-11.

Rodríguez, G., Flores, J., and García, E. (1996), Metodologia de la investigacion cualitativa. Granada, España, Ediciones Aljibe. experimental group.

Reports, 51(2), 29-35. Recuperado de: https://journals.ala.org/ltr/issue/download/502/252

Rose, D., and Meyer, A. (2002), "Universal Design for learning: The Concept" in Teaching every student in the digital age: Universal design for learning, 1st ed, Alexandria, VA: Association for Supervision and Curriculum Development, 2002, pp. 8.

Rose, D., and Meyer, A. (2002). Teaching every student in the digital age. Alexandria, VA: American Association for Supervision & Curriculum Development.

Rogers, M., Hwang, H., Toplak, M., Weiss, M., and Tannock, R. (2011). Inattention, working memory, and academic achievement in adolescents referred for attention deficit/hyperactivity disorder (ADHD). Child Neuropsychology, 17(5), 444-458.

Rodillo, E. (2015). Attention deficit/hyperactivity disorder in adolescents. Revista Médica Clínica Las Condes Volume 26, Issue 1, p.p 52-59.

Rojas , G., Gómez, M.G. and García, N.J. (2013). El uso de un so ware educa vo para pro- mover el aprecio por la diversidad en alumnos de primaria. Revista Apertura, (5)2, 16-29. Recuperado de http://www.udgvirtual.udg.mx/apertura/index.php/apertura/ article/view/406/331

Rubio, J. A. R., Pérez, E. H., & Martínez, J. P. (2017). Implementación y valoración de medidas educativas ordinarias adoptadas con el alumnado diagnosticado con trastorno por déficit de atención e hiperactividad en la comunidad autónoma de la Región de Murcia. Educación XX1, 20(1).

Salgado, A.B., and Raposo, M. (2012). Software educativo para la intervención en TDAH: una experiencia con LIM y MeMotiva. Cid, X.M., Rodríguez, D., Gonçalves, D. (coords.). III encontro internacional-Fenda Dixital: TIC, Escola e Desenvolvimento local. Oporto (Portugal): ESEPF. Recuperado de: http://www.esepf.pt/index.php?c=a_biblio/outrs/fenda_2012.html

Sampieri, R. H., Collado, C. F., & Lucio, P. B. (2012). Metodología de la Investigación. McGraw-Hill.

Savidis, A., Grammenos, D., and Stephanidis, C. (2006). Developing inclusive e-learning and e-entertainment to effectively accommodate learning difficulties. Universal Access In The Information Society, 5(4), 401-419. doi: 10.1007/s10209-006-0059-3

Scandar, R., and Scandar, M. (n/d), Test de atención sostenida, Software.

Seidman, L. (2006). Neuropsychological functioning in people with ADHD across the lifespan. Clinical Psychology Review Volume 26, Issue 4, Pages 466-485.

Silva, A.B. (2003). Mentes inquietas: entendendo melhor o mundo das pessoas distraídas, impulsivas e hiperativas. São Paulo: Editora Gente.

Sitra, O., Katsigiannakis, V., Karagiannidis, C., and Mavropoulou, S. (2017). The effect of badges on the engagement of students with special educational needs: A case study. Education and Information Technologies, 22(6), 3037-3046.

Solanto, M. V., Abikoff, H., Sonuga-Barke, E., Schachar, R., Logan, G. D., Wigal, T., ... & Turkel, E. (2001). The ecological validity of delay aversion and response inhibition as measures of impulsivity in AD/HD: a supplement to the NIMH multimodal treatment study of AD/HD. Journal of abnormal child psychology, 29(3), 215-228.

Sonuga-Barke, E. J. S. (2002). Psychological heterogeneity in AD/HD—a dual pathway model of behaviour and cognition. Behavioural Brain Research, 130, 29-36.

Spooner, F., Baker, J. N., Harris, A. A., Ahlgrim-Delzell, L., and Browder, D. M. (2007). Effects of training in Universal Design for Learning on lesson plan development. Remedial and Special Education, 28, 108-116. doi:10.1177/07419325070280020101

Statutory law 1618. Congreso de Colombia, Colombia, Bogotá, Febrary 27, 2013.

Story, M. F., Mueller, J. L., and Mace, R. L. (1998). The universal design file: Designing for people of all ages and abilities. Raleigh, North Carolina State University. www.ncsu.edu/ncsu/design/cud/pubs_p/pudfiletoc.html

Strahler Rivero, T., Herrera Nuñez, L. M., Uehara Pires, E., and Amodeo Bueno, O. F. (2015). ADHD rehabilitation through video gaming: a systematic review using PRISMA guidelines of the current findings and the associated risk of bias. Frontiers in psychiatry, 6, 151.

Swanson, J. M., Wigal, T., and Lakes, K. (2009). DSM-V and the future diagnosis of attention-deficit/hyperactivity disorder. Current psychiatry reports, 11(5), 399-406.

Swing, E. L., Gentile, D. a, Anderson, C. a, and Walsh, D. a. (2010). Television and video game exposure and the development of attention problems. Pediatrics,126(2), 214–21. http://doi.org/10.1542/peds.2009-1508

Szatmari, P., Boyle, M. H., and Offord, D. R. (1989). ADDH and conduct disorder: Degree of diagnostic overlap and differences among correlates. Journal of the American Academy of Child and Adolescent Psychiatry, 28, 865–872.

Szafir, D., & Mutlu, B. (2012, May). Pay attention!: designing adaptive agents that monitor and improve user engagement. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 11-20). ACM.

Teng, K., and Baker, C. (2014). What Can Educators Learn from the Gaming Industry?. Edutopia. Recuperado de: http://www.edutopia.org/blog/educators-learn-from-gaming-indu stry-kelly-teng.

Tiarnaigh, M. (2005). Adaptive Moodle. Final Year Project, Trinity College Dublin.

Tsianos, N., Germanakos, P., Lekkas, Z., Mourlas, C., and Samaras, G. (2010, June). Working memory span and e-learning: The effect of personalization techniques on learners' performance. In International Conference on User Modeling, Adaptation, and Personalization (pp. 64-74). Springer, Berlin, Heidelberg.

Torrente, J., Del Blanco, Á., Moreno-Ger, P., and Fernández-Manjón, B. (2012, November). Designing serious games for adult students with cognitive disabilities. In International Conference on Neural Information Processing (pp. 603-610). Springer Berlin Heidelberg.

Tripp, G., Luk, S. L., Schaughency, E. A., and Singh, R. (1999). DSM-IV and ICD-10: a comparison of the correlates of ADHD and hyperkinetic disorder. Journal of the American Academy of Child & Adolescent Psychiatry, 38(2), 156-164.

Trigueros, F.J., Sánchez, R. and Vera, M.I. (2012). El profesorado de Educación Primaria ante las TIC: realidad y retos. REIFOP. Revista electrónica interuniversitaria de formación del profesorado, 15(1), 101-112.

United Nations Educational, Scientific and Cultural Organization - UNESCO. (1990). World Declarationnon Education For All Meeting Basic Learning Needs. Jomtien, Thailand. Retrieved from: http://www.unesco.org/education/wef/en-conf/Jomtien%20Declaration%20eng.shtm

UNESCO. (1994). The Salamanca Statement and Framework for Action on Special Needs Education. In world conference on special needs education: access and quality. Salamanca, Spain. Retrieved from http://www.unesco.org/education/pdf/SALAMA_E.PDF

UNESCO. (2000). Education for All: Meeting our Collective Commitments, Dakar. Retrieved from: http://www.unesco.org/education/efa/ed_for_all/dakfram_eng.shtml

UNESCO. (2003). Overcoming Exclusion through Inclusive Approaches in Education. A Challenge and a Vision. http://lst-iiep.iiep-unesco.org/cgi-bin/wwwi32.exe/[in=epidoc1.in]/?t2000=019295/(100).

UNESCO. (2005). Guidelines for inclusion: Ensuring Access to Education for All (pp. 1-37). Paris. United Nations Educational, Scientific, and Cultural Organization. Available: http://unesco.org/educacion/inclusive.

UNESCO. (2009a). Policy Guidelines on Inclusion in Education. Paris: United Nations Educational Scientific and Cultural Organization.

UNESCO. (2016). Tecnologías digitales al servicio de la calidad educativa: una propuesta de cambio centrada en el aprendizaje para todos. Paris: United Nations Educational Scientific and Cultural Organization. Available: http://unesdoc.unesco.org/images/0024/002451/245115S.pdf

United Nations - UN. (1993). The Standard Rules on the Equalization of Opportunities for Persons with Disabilities. New York, USA.

UN. (2007). General Assembly, Convention on the Rights of Persons with Disabilities : resolution / adopted by the General Assembly, A/RES/61/106, available at: http://www.refworld.org/docid/45f973632.html [accessed 28 May 2018]

Valdizán, J. R., & Izaguerri-Gracia, A. C. (2009). Trastorno por déficit de atención/hiperactividad en adultos. Rev Neurol, 48(Supl 2), S95-9.

Van der Elst, W., Van Boxtel, M. P. J., Van Breukelen., G. J. P., and Jolles, J. (2006). The Concept Shifting Test: Adult Normative Data, Psychological Assessment, the American Psychological Association, 18, 424–432.

Velez, J. (2009). Entorno de aprendizaje virtual adaptativo soportado por un modelo de usuario integral (PhD). Universitat de Girona.

Vilches, E. (2007). Analysis of steps of the platform of virtual learning Microcampus at The University Estatal to Distance of Costa Rica. Revista Electrónica INIE, 1–34.

Wamba, A. M., Ruiz, C., Climent, N. and Ferreras, M. (2007). Las rúbricas de evaluación de los Practicum como instrumento de reflexión para los estudiantes de Educación Primaria. En Cid, A. et al. (coords.), Buenas prácticas en el Practicum (pp. 1251-1261). Santiago de Compostela: Imprenta Universitaria.

Ward, M. F. (1993). The Wender Utah Rating Scale: an aid in the retrospective. Am j psychiatry, 1(50), 885.

Werbach, K., and Hunter, D. (2012). For the Win. How Game Thinking Can Revolutionize Your Business. Philadelphia: Wharton Digital Press.

Weyandt, L. L., and DuPaul, G. J. (2008). ADHD in college students: Developmental findings. Developmental disabilities research reviews, 14(4), 311-319.

Weyandt, L. L., and DuPaul, G. J. (2012). College students with ADHD: Current issues and future directions. Springer Science & Business Media.

Wouters, P., Van Nimwegen, C., van Oostendorp, H., and Van der Spek, E. D. (2013). A Meta-Analysis of the Cognitive and Motivational Efects of Serious Games. Journal of Educational Psychology. Advance online publication. doi: 10.1037/a0031311

World Health Organization. (2011). Resumen Informe Mundial sobre la Discapacidad. Retrieved from http://www.who.int/disabilities/world_report/2011/accessible_es.pdf

Wu S., and Gau S. (2013). Correlates for academic performance and school functioning among youths with and without persistent attention-deficit/hyperactivity disorder. Research in Developmental Disabilities 34(1). pp:505-515.

Xunta de Galicia (2014). Protocolo de consenso sobre TDAH na infancia e na adolescen- cia nos ámbitos educa vo e sanitario. San ago de Compostela, España: Xunta de Ga- licia. Recuperado de http://www.edu.xunta.gal/portal/sites/web/files/protocolo_de_ consenso_sobre_tdah.pdf

Zambrano, Y. (2013). *Rendimiento Académico en Escolares con Déficit de Atención/hiperactividad en una Muestra de colegios de la Ciudad de Bogotá* (Especialitatio thesis). Universidad Nacional de Colombia. Bogotá.

Zhou, F., Duh, H. B. L., and Billinghurst, M. (2008). Trends in augmented reality tracking, interaction and display: A review of ten years of ISMAR. IEEE International Symposium on Mixed and Augmented Reality, 15–18. Cambridge, UK.

Zichermann, G., and Cunningham, C. (2011). Gamification by design: Implementing game mechanics in web and mobile apps. " O'Reilly Media, Inc.".

APPENDIX A
ADHD STUDENT MODEL COMPONENT
EXPERT JUDGMENT VALIDATION TEMPLATE

This appendix presents the template used to validate the deTecDAH and CogniTiDA web applications and the evaluation protocol concers to the ADHD Student Model Component (CHAPTER 5) using the experts judment method. The template is originally in Spanish language.

Dear _____ ,

receive a cordial and respectful greeting.

I am writing to you in order to request your invaluable collaboration as an expert to validate the instruments deTecDAH (complementary scale to detect ADHD symptoms), CogniTiDAH (neuropsychological evaluation Battery for ADHD) and an evaluation protocol that integrates these instruments and others, to identify possible symptoms of ADHD university students in e-Learning context. This validation is part of my doctoral thesis entitled: e-INCLUSION, e-LEARNING AND e-INTERTAIMENT TO SUPPORT UNIVERSITY STUDENTS SUFFERING FROM ADHD.

The validation of this protocol is of great relevance, since it is expected to obtain valid, accurate and useful results for the generation of strategies that help students achieve better learning.

The following is a brief description of the research and the objectives of validation by expert judgment. Fisrt, you will be asked for a brief information about your professional profile, and second you should done the validation.

- **RESEARCH INFORMATION**

Specific objective of the research related to the present validation

(SO2): To design and implement a protocol based on technology aspects to identify in e-Learning context university students with possible symptoms of ADHD applying student-modeling techniques.

To carry out this objective, it was proposed an evaluation protocol composed of:

1) An inspection of personal and demographic information.
2) An inspection of behavioral conduct.
3) An inspection of background in clinical, academic and social context.
4) An inspection of cognitive performance.

To make the inspection of point 2), the Adult ADHD Self-Report Scale is used (https://olacoach.com/wp-content/uploads/2015/10/Cribado-TDA.pdf). On the other hand, to inspect point 3), the deTecDAH questionnaire was proposed and to review point 4) the CogniTiDAH evaluation battery was proposed.

According to the results obtained by the student in each of the mentioned tests and cognitive tasks, it is inferred if the student could present ADHD symptoms.

- **OBJECTIVE OF VALIDATION BY EXPERT JUDGMENT**

1) Determine the content validity of the deTecDAH instrument.
2) Determine the technological validity of the CogniTiDAH instrument.

3) Determine the sufficiency of the evaluation protocol to indicate if an e-learning student could present ADHD symptoms.

- **EXPERT IMFORMATION**

Table 71. *Expert information – First component*

Date	
Full name	
Academic training	
Area of experience	
Years of experience	
Institution	
Sign	

- **deTecDAH VALIDATION**

According to the indicators of table 72, evaluate each of the items in table 73 (using the abbreviation that appears in parentheses). In the column "Comments" you can include those observations that you consider appropriate with respect to the corresponding item.

Instrument:

https://docs.google.com/forms/d/1soXI8-9isByuVT1vBlwYbwZE7nADrwETUe8tiXs7zo0/edit

Table 72. *deTecDAH validation indicators*

Category	Clasification (Abreviation)	Indicator
SUFFICIENCY The items that belong to the same dimension are enough to obtain the measurement of it.	1. Does not meet the criteria	The items are not enough to measure the dimension.
	2. Low Level	The items measure some aspect of the dimension, but do not correspond completely.
	3. Moderate level	Few items must be increased to be able to evaluate the dimension completely.
	4. High level	The items are sufficient to evaluate the dimension completely.
CLARITY The item is easily understood, that is, its syntactic and semantic are adequate.	1. Does not meet the criteria	The item is not clear.
	2. Low Level	The item requires a lot of modifications in the use of the words according to their meaning or the order of them.
	3. Moderate level	A very specific modification of some of the terms of the item is required.
	4. High level	The item is clear, has appropriate semantics and syntax.

COHERENCE The item has a logical relationship with the dimension or indicator that it is measuring.	1. Does not meet the criteria	The item has no logical relation to the dimension.
	2. Low Level	The item has a tangential relationship with the dimension.
	3. Moderate level	The item has a moderate relationship with the dimension it is measuring.
	4. High level	The item is completely related to the dimension it is measuring.
RELEVANCE The item is essential or important, that is, it must be included.	1. Does not meet the criteria	The item can be eliminated without affecting the measurement of the dimension.
	2. Low Level	The item has some relevance, but another item may be including what it measures.
	3. Moderate level	The item is relatively important.
	4. High level	The item is very relevant and should be included.

Table 73. *DetecDAH validation template*

Dimension	Ítem	Sufficiency	Coherence	Relevance	Clarity	Comments
Academic	1. Indicate if you liked to go to school					
	2. Indicate if you attended school regularly					
	3. Indicate if you used to repeat school courses:					
	4. Faced with homework ... used to finish them because he liked them and they seemed important to him?					
	5. Faced with homework ... used to finish them, although it seemed boring?					
	6. Faced with homework ... used to finish them, but with the help of their parents or teachers?					
	7. Do you remember if they constantly called their parents from school to talk about their performance?					
	8. Indicate if you used to present difficulty in the written expression (spelling, grammar, punctuation, organization)					
	9. Indicate if you used to have difficulty reading (fluency, speed and / or comprehension)					
	10. Indicate if you used to present mathematical difficulty (arithmetic operations, mathematical reasoning)					

	11. Indicate if you have changed your university career or have changed from a university degree to a technical					
Clinic	1. Indicate if you have ever come to the clinic for attention problems, impulsivity or hyperactivity					
	2. Indicate if you have ever been evaluated for attention problems, impulsivity and / or hyperactivity					
	4. Indicate if you have been diagnosed with ADHD?					
	5. If you were diagnosed, indicate how much (approximately) the diagnosis was given:					
	6. Indicate if you have ever been diagnosed with any of the following disorders:					
	6. Indicate if you have ever followed treatment for difficulties in the care, specifically for ADHD:					
	7. Indicate what type of treatment was followed					
	8. Indicate if you consider that you currently have ADHD					
	9. If your previous answer was yes, more specifically, consider that you have problems of:					
Familiy	1. Indicate if any member of your family has had difficulties similar to yours					
	2. Indicate if any member of your family has been diagnosed with ADHD:					
	3. Indicate with whom you currently reside:					
	4. Indicate how you consider the relationship you have with the people you live with:					
Social	1. Indicate how you have considered relationships with your friends over time:					
	2. Indicate how you consider the relationship with your friends today:					
	3. Indicate, yes. You have been diagnosed with ADHD or believe you have it, if you consider that your regular or bad relationships with family or friends are directly related to ADHD					
	4. Indicate if you think it is difficult for you to make friends?					

Do you consider there is some dimension that should be part of the instrument that has not been included and therefore has not been evaluated? In case your answer is affirmative, indicate which one.

- **CogniTiDAH VALIDATION**

The cognitive tasks that have been included in the battery are previously validated tests and widely used in the diagnosis of ADHD. The three cognitive tasks are designed to evaluate Young-adults. However, they are licensed tests. In this research, they have been computerized considering the proposed objectives.

Instrument: http://boppo.udg.edu:8000/ATutor/login.php

To access the tests you must enter the following access data, in registered user:

User: test; Password: test123

Then click on Course "*COMPETENCES*". In the following interface click on "*User Model*". Scroll down until you find "*Accessibility profile for interaction and communication technology*" and click on "*Attention profile for ADHD*". In the interface you must enter your data and proceed to perform the cognitive tests.

According to the indicators of table 74, evaluate each of the items in table 75 (using the abbreviation that appears in parentheses). In the column "Comments" you can include those observations that you consider appropriate with respect to the corresponding item.

Table 74. *CogniTiDAH validation indicators*

Category	Classification (Abbreviation)	Indicator
Technological operation The cognitive test works correctly.	1. Does not meet the criteria (NC)	The test does not work correctly.
	2. Low Level (BN)	Although the test works, there are several aspects that must be adjusted.
	3. Moderate level (MN)	Although the test works, there are operating details that must be adjusted.
	4. High level (AN)	The test works properly.
Clarity The test is easily understood, that is, its syntactic and semantics are adequate.	1. Does not meet the criteria (NC)	The test is not clear.
	2. Low Level (BN)	The test requires many modifications or a very large modification in the use of the words according to their meaning or the ordering thereof.
	3. Moderate level (MN)	A very specific modification of some of the terms of the item is required.
	4. High level (AN)	The test is clear, has appropriate semantics and syntax.
Relevance The test is essential or important, that is, it	1. Does not meet the criteria (NC)	The test can be eliminated without affecting the measurement of the category.
	2. Low Level (BN)	The test has some relevance, but another test may be including what it measures.

must be included.	3. Moderate level (MN)	The test is relatively important.
	4. High level (AN)	The test is very relevant and should be included.

Table 75. *CogniTiDAH validation template*

Dimension	Category			
	Technological operation	**Relevance**	**Clarity**	**Comments**
Test de Aprendizaje Auditivo Verbal del Rey				
Tarea de Atención Sostenida				
Test de Intercambio de Conceptos				

Do you consider that the development of the tests is adequate? Please justify your response.

- **VALIDATION OF THE CLASSIFICATION PROTOCOL**

According to the result obtained by each student on the assessment tests, he/she is classified in one of the following established profiles:

- Profile 1 means "without ADHD symptoms of ADHD".
- Profile 2 means "without ADHD symptoms but impairment in cognitive peformance".
- Profile 3 means "with behavioral symptoms of ADHD".
- Profile 4 means "with behavioral and cognitive symptoms of ADHD".

In the following figure (Figure 51) you will find the classification rules that will be used to place the student in one of those four profiles.

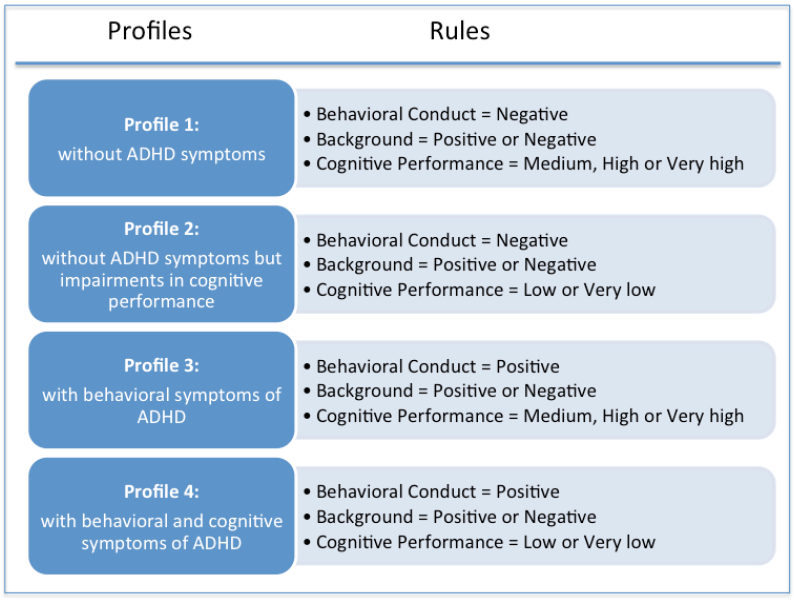


Figure 51. *Attention profiles*

Now, according to the indicators of table 76, proceed to evaluate each of the items in table 77 (using the abbreviation that appears in parentheses). In the column "Comments" you can include those observations that you consider appropriate with respect to the corresponding item.

Table 76. *Profile validation indicators*

CATEGORY	CLASIFICATION	INDICATOR
SUFFICIENCY The evaluation protocol allows to know if a student could present symptoms of ADHD.	1. Does not meet the criteria (NC)	The protocol is not enough.
	2. Moderate level (MC)	The protocol requires other tests and cognitive tasks.
	3. meet the criteria (SC)	The protocol is sufficient.
COHERENCE The classification has consistency with what has been proposed.	1. Does not meet the criteria (NC)	The classification presented is not coherent.
	2. Moderate level (MC)	The classification presents inconsistency and should be adjusted.
	3. meet the criteria (SC)	The classification is coherent.
CLARITY The classification is easily understood, that is, its syntactic and semantics are adequate.	1. Does not meet the criteria (NC)	The classification is not clear.
	2. Moderate level (MC)	Modifications to the classification are required.
	3. meet the criteria (SC)	The classification made is completely clear.
ACCURATE The classification has a logical relationship with what you are really measuring.	1. Does not meet the criteria (NC)	The presented classification, although it responds with the raised thing, does not allow to indicate if a student could have symptoms of the ADHD.
	2. Moderate level (MC)	The classification requires modifications so that it really fulfills the purpose of indicating if a student could present symptoms of ADHD.
	3. meet the criteria (SC)	The classification is appropriate.

Table 77. *Profile validation template*

DIMENSION	Sufficiency	Coherence	Clarity	Accurate
Number of tests				
Classification tree				
Weight of dimensions (cognitive, behavioral, etc).				

Would you include more tests in the assessment protocol of ADHD?

Yes

Do not

Why?

Would you assign other weights to the dimensions and other ways to perform the classification?

Yes

Do not

Why?

Thanks again for your valuable answers.

APPENDIX B
ADHD ACADEMIC INTERVENTION COMPONENT EXPERT JUDGMEN VALIDATION TEMPLATE

This appendix presents the template used to validate the videogame and ROL didactic strategies which are part of the ADHD Academic Intervention Component (CHAPTER 6) using the experts judment method. The template is originally in Spanish language.

Dear _____ ,

receive a cordial and respectful greeting.

I am writing to you in order to request your invaluable collaboration as an expert to validate the academic intervention proposed to support university students in e-Learning context in a inclusive way. This validation is part of my doctoral thesis entitled: e-INCLUSION, e-LEARNING AND e-INTERTAIMENT TO SUPPORT UNIVERSITY STUDENTS SUFFERING FROM ADHD.

The validation of this protocol is of great relevance, since it is expected to obtain valid, accurate and useful results for the generation of strategies that help students achieve better learning.

The following is a brief description of the research and the objectives of validation by expert judgment. Fisrt, you will be asked for a brief information about your professional profile, and second you have to do the validation.

- **RESEARCH INFORMATION**

Specific objectives of the research related to the present validation

(SO3): To design and implement a computer-assisted academic intervention to improve the academic performance of ADHD students who have found in e-Learning an opportunity to carry out their university education.

To carry out this objective, it was proposed an academic intervention base on tow didactic strategies:

1) The use of a videogame called AtenDerAH, designed to train cognitive areas related to learning in university students suffering from ADHD symptoms who are involved in e-Learning courses.
2) The use of a Reusable Learning Object based on gamification, designed to carry out three learning units using this ROL.

- **OBJECTIVE OF VALIDATION BY EXPERT JUDGMENT**

1) Determine the content and technological validity of the AtenDerH videogame.
2) Determine the content and technological validity of the gamified ROL

- **EXPERT IMFORMATION**

Table 78. *Expert information – Second component*

Date	
Full name	
Academic training	
Areas of experience	
Years of experience	
Institution	
Signature	

- **AtenDerAH VALIDATION**

Instrument: http://boppo.udg.edu:8000/ATutor/login.php

To access the tests you must enter the following access data, in registered user:

User: test Password: test123

Then click on Course "*COMPETENCES*". In the following interface click on "**AtenDerAH**" to see the videogame.

According to the indicators of table 79, evaluate each of the items in table 80 (using the abbreviation that appears in parentheses). In the column "Comments" you can include those observations that you consider appropriate with respect to the corresponding item.

Table 79. *AtenDerAH validation indicators*

Category	Classification (Abbreviation)	Indicator
Technological operation The videogame works correctly.	1. Does not meet the criteria (NC)	The videogame does not work correctly.
	2. Low Level (BN)	Although the videogame works, there are several aspects that must be adjusted.
	3. Moderate level (MN)	Although the test videogame, there are operating details that must be adjusted.
	4. High level (AN)	The videogame works properly.
Clarity The videogame is easily understood.	1. Does not meet the criteria (NC)	The videogame is not clear.
	2. Low Level (BN)	The videogame requires many modifications or a very large modification in the use of the words according to their meaning or the ordering thereof.
	3. Moderate level (MN)	A very specific modification of some of the terms of the item is required.
	4. High level (AN)	The videogame is clear, has appropriate semantics and syntax.

Appropiate Refers purpose for which the videogame is intended.	1. Does not meet the criteria (NC)	The videogame is nor relevant.
	2. Low Level (BN)	The videogame has some relevance, however it needs a lot of ajusments.
	3. Moderate level (MN)	The videogame is relevant however it need son ajusments.
	4. High level (AN)	The videogame is convenient for the purpose for which it is intended.
Desing The design of the videogame is appropiate.	1. Does not meet the criteria (NC)	The colors, the environment, the characters, the didactic are not suitable for students with ADHD.
	2. Low Level (BN)	The colors, the environment, the characters, the didactic are not suitable for students with ADHD, however, can be adjusted.
	3. Moderate level (MN)	The colors, the environment, the characters, the didactic are suitable for students with ADHD, however, they requiere a little adjusment.
	4. High level (AN)	The colors, the environment, the characters, the didactic are suitable for students with ADHD.
Story The story of the videogame.	1. Does not meet the criteria (NC)	The story of the videogame is not interesting and appropiate.
	2. Low Level (BN)	The story of the videogame is interesting but inappropriate
	3. Moderate level (MN)	The story of the videogame is interesting and appropiate, however it needs some ajusments.
	4. High level (AN)	The story of the videogame is interesting and appropiate.

Table 80. *AtenDerAH validation template*

Instrument	**Category**				
	Technological operation	Clarity	Appropiate	Desing	Story
AtenderAH					
Comments					

Would you recommend something about the video game? Please justify your response.

- **ROL VALIDATION**

Instrument: http://boppo.udg.edu:8000/ATutor/login.php

To access the tests you must enter the following access data, in registered user:

User: test; Password: test123

Then click on Course "*COMPETENCES*". In the following interface click on "**RLO***"* to see the Resusable Learning Object.

According to the indicators of table 81, evaluate each of the items in table 82 (using the abbreviation that appears in parentheses). In the column "Comments" you can include those observations that you consider appropriate with respect to the corresponding item.

Table 81. *RLO validation indicators*

Category	Classification (Abbreviation)	Indicator
Technological operation The ROL works correctly.	1. Does not meet the criteria (NC)	The test does not work correctly.
	2. Low Level (BN)	Although the test works, there are several aspects that must be adjusted.
	3. Moderate level (MN)	Although the test works, there are operating details that must be adjusted.
	4. High level (AN)	The test works properly.
Clarity The videogame is easily understood.	1. Does not meet the criteria (NC)	The ROL is not clear.
	2. Low Level (BN)	The ROL requires many modifications or a very large modification in the use of the words according to their meaning or the ordering thereof.
	3. Moderate level (MN)	A very specific modification is required.
	4. High level (AN)	The ROL is clear, has appropriate semantics and syntax.
Appropiate The videogame is convenient for the purpose for which it is intended.	1. Does not meet the criteria (NC)	The ROL is nor relevant.
	2. Low Level (BN)	The ROL has some relevance, however it needs a lot of ajusments.
	3. Moderate level (MN)	The ROL is relevant however a very specific ajusment is required.
	4. High level (AN)	The ROL is convenient for the purpose for which it is intended.
Desing The diseño del videojuego es apropiado for the purpose for which it is intended.	1. Does not meet the criteria (NC)	The colors, the environment, the didactic are not suitable for students with ADHD.
	2. Low Level (BN)	The colors, the environment, the didactic are not suitable for students with ADHD, however, can be adjusted.
	3. Moderate level (MN)	The colors, the environment, the didactic are suitable for students with ADHD, however, they requiere a little adjusment.
	4. High level (AN)	The colors, the environment, the didactic are suitable for students with ADHD.

Table 82. *ROL validation template*

Instrument	**Category**			
	Technological operation	Clarity	Appropiate	Desing
ROL				
Comments				

Would you recommend something about the ROL? Please justify your response.

Thanks again for your valuable answers!

APPENDIX C
CONSENT AND BRIEFING LETTER

This appendix presents the template used to ask students consent to participate in the research.

Dear student,

The purpose of this consent form is to provide the participants in this research with a clear explanation of the nature of the same, as well as their role in it as participants.

The present investigation is conducted by the candidate to Doctor in Technology Laura Mancera Valetts, of the University of Girona, Spain. The goal of this study is to contribute to improving the virtual training processes of students with attention problems, specifically ADHD, through inclusive strategies.

If you agree to participate in this study, you will be asked to answer questions in an interview and perform cognitive assessment tasks (or complete a survey, or whatever the case may be). This will take approximately 40 minutes of your time.

Participation is this study is strictly voluntary. The information collected will be confidential and will not be used for any other purpose other than those of this investigation. Your answers to the questionnaire and the interview will be coded using an identification number and therefore, they will be anonymous. Once the interview data is used, it will be eliminated.

If you have any questions about this project, you can ask questions at any time during your participation. Likewise, you can withdraw from the project at any time without it harming you in any way. If any of the questions during the interview seem uncomfortable, you have the right to let the researcher know or not to answer them.

Thank you in advance for your participation.

_____

I agree to participate voluntarily in this investigation, conducted by _____. I have been informed that the goal of this study is _____

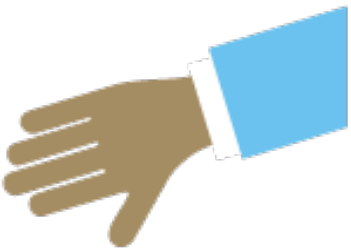
I have also been told that I will have to answer questionnaires and questions in an interview, which will take approximately _____ minutes.

I acknowledge that the information I provide in the course of this investigation is strictly confidential and will not be used for any purpose other than those of this study without my consent. I have been informed that I can ask questions about the project at any time and that I can withdraw from it when I decide, without causing any harm to me. If I have questions about my participation in this study, I can contact _____ to the phone number_____.

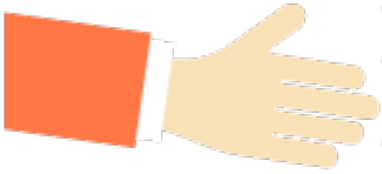
I understand that a copy of this consent form will be given to me, and that I may request information about the results of this study when it has concluded. For this, I can contact _____ to the aforementioned phone.

Participant's name Signature of the Participant Date

Technology-based process for supporting university students with ADHD



In this thesis, the Adaptive Hypermedia System (AHS) is used to generate e-Learning processes that consider the characteristics of university students who suffer from Attention Deficit Hyperactivity Disorder (ADHD). Overall, it was proposed a solution that ranges from symptoms detection to academic intervention. Specifically, it was developed a student model based on personal, demographic, academic, behavioural conduct, background and cognitive performance information to create personal student profiles which indicate if an e-Learning student could have ADHD symptoms. After that, considering preferences and strengths of people suffering from ADHD, three didactic strategies were integrated in academic processes: one based on video games, one on gamification and another one based on the implementation of the Universal Design for Learning (UDL) to help reduce barriers that do not allow quality-training processes for all.



Universitat de Girona