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The impact of Universal Desing for Learning in the academic performance of ADHD e-learning students: an experimental scenario

El impacto del Diseño Universal para el Aprendizaje en el rendimiento académico de los estudiantes de TDAH e-learning: un escenario experimental

Laura Mancera[1], Silvia Baldiris[2], Ramón Fabregat[3], Brezhnev Joya[4]

[1] *ESIT, UNIR, Bogotá, Colombia*
Laura.mancera@unir.net
[2] *ESIT, UNIR, Madrid, Spain*
Silvia.baldiris@unir.net
[3] *BCDS, UDG, Girona, Spain*
ramon.fabregat@udg.edu.co
[4] *GDI, ECOPETROL, Bogotá, Colombia*
bjoyam@gmail.com

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Abstract: Universal Design for Learning (UDL) guidelines provide a set of flexible options and scaffolds to ensure access for all learners. In this paper, the results of an experiment done to measuring the impact of using UDL in the academic performance of students suffering ADHD are presented. Results show the positive impact of using UDL for both students with ADHD and students without this disorder.

Keywords e-learning; Attention Deficit Hyperactivity Disorder (ADHD); Universal Design for Learning (UDL).

Resumen: Las pautas de Diseño universal para el aprendizaje (UDL) proporcionan un conjunto de pasos y opciones flexibles para garantizar el acceso de todos los alumnos. En este documento, se presentan los resultados de un experimento realizado para medir el impacto del uso de UDL en el rendimiento académico de los estudiantes que padecen TDAH. Los resultados muestran el impacto positivo del uso de UDL tanto para estudiantes con TDAH como para estudiantes sin este trastorno.

Palabras claves e-learning; trastorno por déficit de atención e hiperactividad (TDAH); diseño universal para el aprendizaje (UDL).

1 Introduction

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. Additionally, nowadays governments, institutions, teachers and researchers are more committed to moving from a homogenizing approach to one that considers diversity as a value that improves the teaching-learning processes. In this way, it is essential to know and adopt methodologies, guides and frameworks that allow an orderly and planned sequence in the change of teaching-learning processes. Such is the case of the Universal Design for Learning framework, which has the essence of designing learning experiences based on the characteristics of each student to respond to all equally [1].

Among the diversity of students, there are those with ADHD, a lifetime neurobiological and neuropsychological heterogeneous disorder, characterized by inattention, hyperactivity and impulsivity symptoms. Students suffering from ADHD have some particular characteristics: they cannot stay for a long time doing the same activity, usually have great difficulty concentrating in class, they tend to fail academic courses, among others. Based on the foregoing, it raises a research question: how the UDL influence the academic outcome of those students suffering from ADHD who have found in e-Learning a means to carry out their academic process? In this paper, an experiment that intends to offer insights to this question is described.

The paper is structured in four sections as follows: section I, presents the introduction; section II exposes the theoretical framework that support this work; section III described the experiment realized; and finally, Section V presents some concluding remarks and proposals for future work.

2 Teorethical foundations

2.1 Universal Design for Learning (UDL)

UDL 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, D & Meyer, A, 2002).

The basis on brain research in which UDL support their framework is that there are three networks essential to learning: 1) recognition (The "what" of learning), 2) strategic (The "how" of learning), and 3) 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.

Consequently, the UDL framework consist of three principles: 1) to provide multiple means of representation; 2) to provide multiple means of action and expression; and 3) to provide multiple means of engagement which means to stimulate interest and motivation for learning, to support affective learning (Meyer, A., Rose, D. H., & Gordon, D., 2014).

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, which helps teachers to identify learners 'strengths, weakness, and preferences.

2) The curriculum barriers template, which helps teachers to identify the potential barriers inherent in the planned curriculum materials and methods.

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

4) The creating systemic change template, which 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). Template 4 is not addressed in this paper.

2.2 Attention Deficit Hyperactivity Disorder (Adhd)

According to the National Institute of Mental Health (NIMH), ADHD is a neuro-biologically and neuropsychological heterogeneous disorder most common in children and adolescents, with a persistence of about 50% into adulthood. The condition entails impairment of executive functions of the brain, influencing an individual's ability to manage and organize her/his thought processes.

Individuals diagnosed with ADHD typically exhibit long-term and pervasive: 1) distractibility (low degree of sustained focus) and 2) impulsivity (poor control over impulses and low tolerance for delayed gratification).

Two-thirds of those diagnosed with ADHD also demonstrate 3) hyperactivity (high degree of restlessness or continuous activity).

Based on ADHD characteristics, several studies have demonstrated that individuals with this disorder have difficulties and letdowns, such as school and job failures, and 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, 2010).

This paper presents an experiment done with university students involved in e-Learning processes in whose courses the UDL was used as a strategy to influence their learning outcomes.

3 Method

The study was carried out through a quantitative research approach considering the academic performance of the student in terms of the final grade obtained in the course. The experiment was done with a virtual course called Research methodology I in the Virtual Unit of the Manuela Beltrán University.

3.1 Participants

The sample consisted of 14 students. With this sample, we proceed to form an experimental group and a control group. The experimental group consisted of 7 students (2 students suffering from ADHD and 5 students who do not suffer from this disorder); the control group was made up of 7 students (2 students suffering from ADHD and 5 students who do not suffer from this disorder). The unit's welfare department referred all the students.

3.2 Procedures

One professor at the UMB together with the author project conducted the experiment. 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. The student's performance rating was given on a scale of 1 to 5, where a grade above 3 resulted in the passing of the course.

Once the course started, with the experimental group we proceeded to fill out the first UDL template, the Class Learning Profile Template, which was filled 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 the forum as the first activity of the study and took three days to be completed. The students with 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 of people with ADHD in terms of learning processes.

The resulted Class Learning Profile Template for the experimental group is presented in Table 1.

Table 1. 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 the readings.	
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. He usually does not finish his tasks. **Student 4:** Difficulty working in 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.

Considering the Class Learning Profile Template, the Curriculum Barriers Template was completed. The resulted template is presented in Table 2.

Table 2. The research methodology I curriculum barriers template

Materials and Methods		Students Qualities	Potential Barriers/Missed Opportunities
Intro	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 7qualities.
	Activity: Independent reading.	**Student 1**: Loses focus, distracted. **Student 5:** Distracted and bored with routines. **Student 3:** He is not a good reader. **Student 3 and 7:** Collaboration skills.	Difficulty working alone. May take more time than necessary to check and read the material. May not be able to abstract the important contents. Reading 40 pages can be a rutinary activity, it may cause that stundent do not finisth the work or late a lot doing it. Does not tap into Student´s 3 reading difficulty. Does not tap into Student´s 3 and 7 collaboration skills.
	Assessment activity 1: evaluation (preguntas de selección multiple con única respuesta-20 preguntas). (25%)	**Student 1 y 5:** Good using constructive feeback. **Student 2, 3 and 7:** Collaboration skills.	Al finalizar la evauación sólo se da la nota al estudiante. Esto no permite potenciar las habilidades de estos estudiantes. 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. **Student 5:** Distracted and bored with routines.	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 3: He is not a good reader. **Student 3 and 7:** Collaboration skills.	Reading 40 pages can be a rutinary activity, it may cause that student do not finish the work or late a lot doing it. Does not tap into Student´s 3 reading difficulty. 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. **Student 3:** Like playing the guitar. **Student 5:** good at doing exercise. **Student 1 and 7:** Pooor organitization skills.	The activity does not tap into Student´s 1, 2, 3, 5 and 7 talents and preference. Difficulty organizing her ideas effectively.
Module 3	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.
	Independent reading 3	**Student 1**: Loses focus, distracted. **Student 5:** Distracted and bored with routines. **Student 3:** He is not a good reader. **Student 3 and 7:** Collaboration skills.	Difficulty working alone. May take more time than necessary to check and read the material. May not be able to abstract the important contents. Reading 40 pages can be a rutinary activity, it may cause that stundent do not finisth the work or late a lot doing it. Does not tap into Student´s 3 reading difficulty. 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; **Student 2:** Leader **Student 2 and 3:** Collaboratio skills. **Student 1, 2**: Poor writing mechanics. **Student 1, 7:** Organizational problems. **Student 2:** Talented at drawing, **Student 3, 6:** Good at oral presentation. **Student 3:** play the guitar **Student 6:** Loves music	May have trouble keeping track of what they are learning and doing. Context won´t draw on his leadership and collaboration skills. Context won´t draw on their collaboration skills. Difficulty expressing their ideas effectively. Difficulty organizing the Project proposal effectively. Does not tap into Student´s 2 drawing skill. Does not tap into Student´s 6 oral skills. Does not tap into Student´s 3 and 6 oral skills. Does not tap into Student´s 3 and 6 musical love.
	Assessment activity 4: Independent proposal Project - second delivery (25%)		

Finally, the UDL Solutions Template was completed. The resulted template is presented in Table 3.

Table 3. The research methodology I solution template

Materials and Methods		Potential Barriers/Missed Opportunities	UDL solutions
	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 read the material. May not be able to abstract the important contents.	Recommend the time for each reading. Propose question to solve during reading. Suggest having the study environment clean, organized and avoid distracters. Purpose a forum 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 (preguntas de selección multiple con única respuesta-20 preguntas). (25%)	The grades to the student is given at the end of the evaluation. This does not allow enhancing the abilities of students 1 and 5. Does not tap into Student´s 2, 3 and 7 collaboration skills.	In addition to the quantitative note 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. Esta actividad puede sumar un 5% del 25% en la nota del módulo 1 si hay participación, de lo contrario sólo se considera la evaluación.
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. Music	Assist students to comprehend and organize what are they going to say. Suggest recording students' speech in order to listen themselves. Motive to text, graphic or music according students' preferences. It is important to recommend software to work with graphic, voice, video and presentations.
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 student's 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 recommends 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.	

The grades obtained for each student according to each group are presented in Tables 4 and 5.

Table 4. Grades of the experimental group

Varianza	Diferencia de medias	Diferencia de error estándar	t	gl	p-valor	Intervalo de confianza	
						Inferior	Superior
No se asumen varianzas iguales	1,00179	0,34565	2,898	9,745	0,016	0,22888	1,77469
Prueba Levene de calidad de varianzas: F=5,344; Sig. =0,039							

Table 5. Grades of the control group

Group	Student	Activity 1	Activity 2	Activity 3	Activity 4	Average
ADHD	(1)	3,5	4,75	3,5	3,75	3,875
	(5)	2,5	4,9	3,25	4	3,6625
HYS	(2)	4,5	4,9	3,75	4	4,2875
	(3)	3,5	4,9	3,35	3,85	3,9
	(4)	5	4,9	4,75	5	4,9125
	(6)	5	4,75	4,5	4,75	4,75
	(7)	3,5	4,75	4	4,35	4,15

3.3 Data analysis and results

The objective of the experiment was to know if the UDL strategy entailed a better academic outcome for both, ADHD and HYS students. 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 (1) comparison of results of the experimental and control group was performed. This comparison was made based on the final grade. Table 6 shows the statistical data of the control and experimental groups.

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 less than 0.05, difference variances are assumed. Thus, the corresponding T-Student test results are presented in Table 7.

Table 6. Statistical data from the average grades

Group	Student	Activity 1	Activity 2	Activity 3	Activity 4	Average
ADHD	(8)	2	3	2	3	2,5
	(9)	2	2	3,2	3,5	2,675
HYS	(10)	4	4	4,5	5	4,375
	(11)	3	3	2	3,7	2,925
	(12)	2	2	2	3,5	2,375
	(13)	4	4	3,5	4	3,875
	(14)	4	3	4	4,2	3,8

Table 7. Result Of The T- Student Test

Group	Sample size	Mean	Standart desviation	Standard error average
Average grade_Experimental group	7	4,2196	0,46586	0,17608

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 UD strategy leads to a more effective academic outcome.

4 Conclusions and future work

The study presented in this paper evidenced the possibility of support the e-Learning process of students suffering from ADHD adapting UDL as a strategy to respond to diversity in classroom. However, the most important of our findings is to see how this impact is equally positive for students who suffer from ADHD as well as for those who do not suffer from this disorder. Future work is addressed to develop learning resources and to design teaching strategies to offer a better learning experience to university students suffering from ADHD and a rewarding teaching experience to teachers of these students.

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