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The use of mobile technology in the development of cognitive skills of high school students with special educational needs

María Graciela Badilla-Quintana[1]
Centro de Investigación en Educación y Desarrollo (CIEDE-UCSC) y Departamento de Currículum, Evaluación y Tecnologías de la Información, Facultad de Educación, Universidad Católica de la Santísima Concepción, Concepción, Chile
mail: mgbadilla@ucsc.cl
ORCID: https://orcid.org/0000-0002-1317-9228

Gabriela Ramírez Peña
Universidad Santo Tomás, Concepción, Chile
mail: gabriela.ramirez@liceobicentenariocoelemu.cl
ORCID: https://orcid.org/0000-0002-0498-8189

Francisco Javier Sandoval-Henríquez
Universidad Católica de la Santísima Concepción, Concepción, Chile
mail: fjsandoval@ucsc.cl
ORCID: https://orcid.org/0000-0001-5974-6227

Fabiola Sáez-Delgado
Centro de Investigación en Educación y Desarrollo (CIEDE-UCSC) y Departamento Fundamentos de la Pedagogía, Facultad de Educación, Universidad Católica de la Santísima Concepción, Concepción, Chile
mail: fsaez@ucsc.cl
ORCID: https://orcid.org/0000-0002-7993-5356

Ligia Gómez Franco
Ball State University, USA
mail: legomezfranco@bsu.edu
ORCID: https://orcid.org/0000-0003-1633-0963

[1] Corresponding autor: Centro de Investigación en Educación y Desarrollo (CIEDE-UCSC) y Departamento de Currículum, Evaluación y Tecnologías de la Información, Facultad de Educación, Universidad Católica de la Santísima Concepción, Concepción, Chile.
Avenida Alonso de Ribera, 2850, Campus San Andrés, Concepción 4070129, Chile

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ABSTRACT
Mobile technology can help personalize instruction and enhance generic and specific learning skills for students with special educational needs. This study examines the effects of a technology intervention strategy on the attention/concentration and spelling skills. Participants were students with permanent and temporary educational needs attending secondary schools in Chile. A pretest-posttest experimental design with a control group was adopted. 73 students participated, under three conditions: a) control group, with a printed guide-based strategy and without the use of technology, b) an experimental group with a computer-based strategy, and c) an experimental group with an iPad-based strategy. Analysis of variance was used to compare the means of the three groups. The results show that the iPad-based strategy obtained significant differences compared to the other conditions. It is concluded that iPad mobile technology can improve both the generic attention/concentration skills and the specific spelling skills in students with special educational needs.

Keywords: special education, high school, special educational needs, mobile technology.

Uso de tecnología móvil en el desarrollo de habilidades cognitivas de estudiantes de educación secundaria con necesidades educativas especiales

RESUMEN
La tecnología móvil puede ayudar a personalizar la enseñanza y mejorar las habilidades de aprendizaje genéricas y específicas de estudiantes con necesidades educativas especiales. Este estudio examina los efectos de una estrategia de intervención tecnológica en las habilidades de atención/concentración y ortografía. Los participantes fueron estudiantes con necesidades educativas permanentes y transitorias que asisten a escuelas secundarias en Chile. Se adoptó un diseño experimental pretest-postest con grupo control. Participaron 73 estudiantes, bajo tres condiciones: a) grupo de control, con una estrategia basada en guía impresa y sin uso de tecnología, b) grupo experimental, con una estrategia basada en computador, y c) grupo experimental, con una estrategia basada en iPad. Se utilizó un análisis de la varianza para comparar las medias de los tres grupos. Los resultados muestran que la estrategia basada en iPad obtuvo diferencias significativas en comparación con las otras condiciones. Se concluye que la tecnología móvil puede mejorar tanto las habilidades genéricas de atención/concentración como las específicas de ortografía en estudiantes con necesidades educativas especiales.

Palabras clave: educación especial, educación secundaria, necesidades educativas especiales, tecnología móvil.

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1. Introduction

Special education refers to a series of accommodations that include alternative curricula and learning objectives, personalized assistance, teaching methods, and specialized knowledge. The main purpose of these accommodations is for students with Special Educational Needs (hereinafter SEN) to access, participate and advance in their education under the effective right to education and to equal opportunities without exclusions (UNESCO, 2019). Framed in this scenario, students with SEN often have difficulties in generic skills such as attention/concentration (hereinafter A/C) and in specific skills such as visual and regulated spelling.

First, addressing A/C encompasses a fundamental training for all content domains, since a deficiency in this skill can interfere with the learning itself and even cause an academic performance lower than the students' actual potential (Charitaki et al., 2018). Second, literature related to teaching indicates that spelling has turned out to be a complex endeavor, mainly due to methods based on rote learning of spelling rules and the abuse of dictation as an evaluation instrument (Wakui, 2016).

Consequently, emphasis is placed on developing effective instructional strategies to improve cognitive skills which have the potential to improve the learning in students with SEN. In an effort to contribute to this, various researchers have shown that the integration of mobile technology, when consistent with the Constructivist Theory of Learning, can improve teaching and learning contexts in special education (Cheng & Lai, 2019; Cumming & Draper, 2017), enhance the commitment and motivation towards academic tasks (Edel et al., 2019), maximize independence in the classroom (Chang et al., 2020; Sharaf, 2022), improve language skills (Rodríguez & Cumming, 2017) and functional mathematical skills (Chelkowski et al., 2019; Root et al., 2019).

When analyzing these investigations, it has been observed that the use of mobile technology in special education is effective; however, a solid evidence base has not yet been established (Mayer, 2020). Most studies that refer to the use of technology for educational purposes tend to focus on students without SEN (Cumming & Draper, 2017; Ismaili & Ibrahimi, 2017). Consequently, the scientific community encourages teachers to modify their practices towards a quality professional practice by incorporating mobile technology in classrooms. This will provide opportunities to deepen the current knowledge and to theorize its pedagogical advantages in special education (Chukwuemeka & Samaila, 2020; Moreno, 2020).

1.1 Mobile technology and the direct manipulation principle

Mobile technology constitutes a valuable alternative for the organization of the differentiated educational study plan. Its characteristics, such as easy input, wireless connectivity, interactive applications and Tangible User Interface, reduce the mental and spatial demands required to operate and navigate the device and stimulate the user's visual, auditory, tactile, and kinesthetic sensory systems (Clarke & Abbott, 2016; Moreno, 2020; Wood et al., 2016).

Based on Wang et al. (2016), the mobile technology is considered a clear applied example of the direct manipulation principle which usually presents a set of visual representations and a repertoire of manipulations that can be performed on any of the visual representations. That is, the viewing surface is also the surface of input, and all operations on the touch screen involve directly touching the graphical object or icon with which persons are interacting with their fingers.

This direct manipulation interaction resembles actions performed with real objects; for example, when using a mobile device, users can turn the pages of an electronic book by sliding a finger on the screen. Similarly, the device can transform into a drawing pad, a calculator, or a piano keyboard. In this way, the user responds and interacts through natural and intuitive gestures (Stevens, 2011).

Various authors point out that the actions of tapping and swiping, afforded by mobile technology, should increase the attention to the content and promote a greater and more immediate learning, unlike desktop computers that have a Graphical User Interface, where the interaction occurs through peripherals such as the mouse and keyboard (Wang et al., 2016; Wood et al., 2016). However, the empirical background on the subject is scarce, and still is needed to explore its effect on learning and cognitive skills. At the same time, more evidence is required regarding whether the use of mobile technology is more effective when compared to other instructional supports (Chelkowski et al., 2019; Cumming & Draper, 2017).

1.2 Attention-concentration and spelling skills

Mobile technology has been widely used in language arts for the development of literacy, reading fluency, and vocabulary (Görgen et al., 2020; Rodríguez & Cumming, 2017). However, there is limited knowledge about its effect on specific skills, such as spelling. For instance, Rello et al. (2014) developed a pedagogical method based on the use of iPads with the goal of improving the spelling of students with dyslexia. Their findings showed that incorporating game-like and specific exercises integrated into the mobile technology helped students improve their spelling skills. Kagohara et al. (2012) taught students with Autism Spectrum Disorder (ASD) to check the spelling of words using common word-processing programs. The results showed that the intervention, which was carried out using iPads, was effective for the tasks that involved spell checking.

Empirical evidence also turned out to be scarce in regard to the attention/concentration generic skill. For example, Hetzroni & Israel (2019) investigated the impact of iPad use on the identification of graphic symbols. Participants were children and adults with ASD who used mobile technology to learn 15 symbols. The results showed that 50% of the participants in both groups recognized the meaning of a greater number of symbols after the intervention. The authors inferred that the iPad technology enabled stimulus control by reducing communication barriers, thereby increasing the ability to learn more symbols and improving the A/C skills.

1.3 The present study

Consistent with the rationale presented, this study analyzes the effect of an educational intervention strategy incorporating technology, specifically computers and iPads, on the attention/concentration and spelling skills of students with permanent and temporary SEN attending secondary schools in Chile.

In this context, the overarching research question is: What is the effect of an educational intervention strategy with integration of technology on attention/concentration and spelling skills in high school students with SEN?

Based on the insights gained from the literature review, and considering the research question, 5 hypotheses were tested in this research:

(1) Using an iPad based-strategy should be predictive of both improvements in attention/concentration and spelling skills in high school students with SEN.

(2) Using an iPad based-strategy should be predictive of both improvements in attention/concentration and spelling skills in high school students with permanent and temporary SEN.

(3) An iPad based-strategy is more effective to improve attention/concentration and spelling skills in high school students with SEN than the strategies based on computer and on printed guide activities.

(4) Technology (computer and iPad based-strategies) is effective to improve attention/concentration and spelling skills in students regardless of gender.

(5) Attention/concentration and spelling skills results are influenced by the students' educational level.

2. Method

2.1 Research Design

A pretest-posttest experimental design with a control group was adopted. According to Ato et al. (2013), it is possible to extend this design to include more than two experimental groups. The method used was quantitative with an explanatory approach, since its focus was to explain whether the incorporation of technology affects attention/concentration and spelling.

2.2 Participants

A total of 76 students from 4 secondary public schools in Chile participated in this study. The gender distribution included 36 boys and 40 girls, (47% and 53%, respectively). Of these, 30 were 9th graders (39%) and 46 were 10th graders (46%). Importantly, 24 students in the study had permanent SEN needs (32%) and 52 students had temporary SEN needs (68%). It is relevant to note that according to Chilean regulations, educational institutions with School Integration Programs (SIP) are able to include a maximum of two students with permanent educational needs and only five with temporary educational needs per level.

The participants were assigned by simple random sampling to three research conditions. The first group, which was the control group, completed pedagogical activities with traditional instruction based on printed guides, the second group completed pedagogical activities using a computer, and the third group using an iPad. All explanations and instructions were aimed towards the development of attention/concentration and spelling skills.

The number of participants assigned to each of the three groups was even, with 25 students participating in the control group that used a traditional strategy based on the use of learning guides without the use of technologies, 24 students in the experimental group that used a strategy based on computers, and 24 students in the experimental group that adopted an iPad-based strategy. In order for students to participate, parents were provided with information about the study and given an informed consent to sign if they granted their permission, since all the students were younger than 18 years old. The students also gave their verbal assent to participate in the research. All the information was used confidentially, safeguarding the identity of the students and not causing any physical or psychological harm from the use of the technology in this study.

2.3 Description of the Educational Activities

The educational intervention for each group took place in 5 sessions with a duration of 40 minutes each. In the first 20 minutes, activities were designed aimed at strengthening the A/C skills, and in the next 20 minutes the spelling skills. The activities were guided by a special education teacher as a moderator. An engineer, who was providing technical support, and an observer responsible for registering the attendance and the scores obtained in each tests, were present in the classroom.

With the idea of minimizing differences in the educational interventions, it was sought that the three strategies were approached from the same constructivist paradigm. This means that all the activities were oriented to enhance the same skills and contents, but with a different instructional ICT support. Sessions were structured in such a way that they were dynamic and motivating. Simultaneously, the time devoted to verbal explanations was reduced to foster greater student involvement.

The educational activities and the software used in each group are briefly described below.

Control group without the use of technology: printed-guide strategy

This group executed 4 types of activities such Word search, Difference games, Mazes and Phrases.

In the Word search, the student had to discover a certain number of words, linking letters horizontally and vertically.

In the Difference games, two images were presented, and the student had to identify the differences between them by marking with an X.

In the Mazes, the student had to find a correct path to reach the goal, tracing the path with a pencil.

And finally, in the Phrases activity, sentences containing words with spelling errors were presented, the student had to encircle the word and write it correctly.

Experimental Group using technology: computer-based strategy

This group executed 3 types of activities such Epasatiempos, Tenkyu and Cerebriti.

Epasatiempos consisted in observation on how a ball was hidden in one of three glasses, after a series of movements he had to indicate where it was hidden; find the object that was different from the others; remember sounds and names of objects.

In Tenkyu the student had to use the computer mouse to guide a ball through a maze.

And in Cerebriti, the student had to exercise spelling rules and identify accent mark errors.

Experimental Group using mobile technology: iPads-based strategy

This group executed 3 types of activities such Attention Games, Classic Labyrinth, What do you know about spelling?

Attention Games asked the student to follow objects with his eyes and then select them in the order of appearance; remember a silhouette and immediately find it in a set of silhouettes; look at images and then identify the image that was not initially viewed; and find the shadow of an object.

In Classic Labyrinth, the student had to slide his finger and guide a ball through the walls of a labyrinth until he found an exit.

And, in What do you know about spelling? activity, the student had to practice different spelling rules such as the use of letters b/v, word accent mark, and dividing words into syllables.

2.4 Measures

For data collection, the Evalúa psychopedagogical battery was used, which is a standardized test normed in Chile. It includes a set of 11 batteries that begin with Evalúa 0 to Evalúa 10. Each of these test was designed for a specific educational level and includes sub-tests aimed at measuring basic cognitive, social and affective skills (García et al., 2016). For the purposes of

the present study, the subtests of attention/concentration, and visual and regulated spelling, corresponding to the Evalúa 8 for 9th grade students, and the Evalúa 9 for 10th grade students were used. Both were administered as pretest and posttest.

Attention/concentration subtest: This test consists of two tasks. In the first task, the student must look at a table of paired letters and symbols and then cross-out the matching errors, which are presented in 99 examples. The students have two minutes to carry out this task. The second task is to observe a model and then cross-out all the boxes that are the same as the model presented. For this task the student has two minutes to select the correct ones among 152 images.

Visual and regulated spelling subtest: This test consists of two tasks. The first one contains a list of 59 words in which the student must mark if the word is correctly written, using a yes/no dichotomous criterion. The time allocated for this task is four minutes. The second one, presents two almost identical words or phrases, where only one was correct. It has a total of 31 pairs of words/phrases where the student has three minutes to answer.

After the administration of the instruments, each of the tasks specified in both skills were manually reviewed following the correction guidelines of the Evalúa psychopedagogical battery. According to the score obtained in each test, the level of each student was determined. Table 1 shows the 5 levels based on the score obtained.

Table 1.
Skill-Levels based on the Evalúa Psychopedagogical Battery

Score	Level
80-99	High (5)
60-79	Mid High (4)
40-59	Intermediate (3)
20-39	Mid Low (2)
0-19	Low (1)

2.5 Data Analysis

Data analysis were performed using R studio software, the MASS package, and the nparLD, reshape2 and foreign libraries. Descriptive statistics of measures of central tendency (mean), measures of dispersion (standard deviation) and frequencies were used. Regarding the inferential statistics, the Nonparametric Analysis of Longitudinal Data in Factorial Experiments was used to verify differences between the groups and the Wald test statistic for simple time effect as the post hoc test.

3. Results

The results that we introduce in this section are linked to the main research question proposed at the beginning of this article: What is the effect of an educational intervention strategy with integration of technology on attention/concentration and spelling skills in high school students with SEN?

3.1 Attention/Concentration skill-levels before and after the intervention

In relation to the type of educational needs, Table 2 shows that the levels of attention/concentration improved after being exposed to mobile technology, specifically the strategy that used the iPads, obtaining an increase in the means, both of students with temporary SEN (pretest M = 2.00, SD = 0.71; posttest M = 3.82, SD = 1.13), as well as those with permanent SEN (pretest M = 2.00, SD = 0.76; posttest M = 3.00, SD = 0.93).

A similar situation occurred in the strategy that used a computer, the means in the levels of attention/concentration improved slightly in students with temporary SEN (pretest M = 2.13, SD = 0.52; posttest M = 2.20, SD = 0.78) and permanent SEN (pretest M = 1.70, SD= 0.68; posttest M = 1.80, SD = 0.63). (Table 2).

3.2 Spelling skill level before and after the intervention

Table 3 shows that, in relation to spelling skill, the levels improve after having participated in the strategy with the use of iPad, presenting an increase in the means of both students with temporary SEN (pretest M = 1.88, SD = 0.60; posttest M = 3.24, SD = 1.25), as well as in those with permanent SEN (pretest M = 1.63, SD = 0.74; posttest M = 2.50, SD = 0.93). Similar findings occur with the strategy with the use of a computer, although only students with temporary SEN present variations in their means (pretest M = 1.40, SD = 0.51; posttest M = 1.67, SD = 0.62). Regarding the learning printed guides strategy without the use of technologies, no variations were observed. (Table 3).

Table 2.
Attention/concentration skill-levels before and after the educational intervention

Strategy	SEN	Test	*M*	*SD*	High Level %	Mid High Level %	Intermediate Level %	Mid Low Level %	Low Level %
Printed guide-based	Temporary	Pretest	1.80	0.41	0	0	0	80	20
		Posttest	1.80	0.52	0	0	5	70	25
	Permanent	Pretest	1.50	0.55	0	0	0	50	50
		Posttest	1.50	0.55	0	0	0	50	50
Computer-based	Temporary	Pretest	2.13	0.51	0	0	0	40	60
		Posttest	2.20	0.78	0	0	6.7	53.3	40
	Permanent	Pretest	1.70	0.68	0	0	10	50	40
		Posttest	1.80	0.63	0	0	10	60	30
iPad-based	Temporary	Pretest	2.00	0.71	0	0	23.5	52.9	23.5
		Posttest	3.82	1.13	35.3	29.4	17.6	17.6	0
	Permanent	Pretest	2.00	0.76	0	0	25	50	25
		Posttest	3.00	0.93	0	37,5	25	37.5	0

Note. SEN: Special Educational Needs, *M*: Mean, *SD*: Standard Deviation.

Table 3.
Spelling skill-level before and after the intervention

Strategy	SEN	Test	*M*	*SD*	High Level %	Mid High Level %	Intermediate Level %	Mid Low Level %	Low Level %
Printed Guide-based	Temporary	Pretest	1.40	0.50	0	0	0	40	60
		Posttest	1.70	0.66	0	0	10	50	40
	Permanent	Pretest	1.17	0.41	0	0	0	16.7	83.3
		Posttest	1.17	0.41	0	0	0	16.7	83.3
Computer-based	Temporary	Pretest	1.40	0.51	0	0	0	40	60
		Posttest	1.67	0.62	0	0	6.7	53.3	40
	Permanent	Pretest	1.60	0.52	0	0	0	60	40
		Posttest	1.50	0.53	0	0	0	50	50
iPad-based	Temporary	Pretest	1.88	0.60	0	0	11.8	64.7	23.5
		Posttest	3.24	1.25	23.5	17.6	17.6	41.2	0
	Permanent	Pretest	1.63	0.74	0	0	12.5	37.5	50
		Posttest	2.50	0.93	0	12,5	37.5	37.5	12.5

Note. SEN: Special Educational Needs, *M*: Mean, *SD*: Standard Deviation.

3.3 Attention-Concentration and spelling results according to the type of strategy

It was first verified whether there were significant differences between the groups (printed guide-based strategy, computer-based strategy, and iPad-based strategy) in attention/concentration and spelling, between the pretest and posttest. The results showed statistically significant differences between the groups for both variables. For attention/concentration, $F(2.72) = 11.82$, $p < .001$; and for spelling, $F(2.71) = 13.40$, $p < .001$. Therefore, the Post Hoc test was carried out to verify which of the strategies were significant between the pretest and the posttest. It can be established, from the results shown in Table 4, that the strategy based on the use of iPad was the only significant one [F (1) = 60.35, $p < 0.01$] for attention/concentration, while, for spelling, the strategies based on the printed guide and the iPad were significant respectively [F (1) = 7.10, $p < 0.01$; F (1) = 20.33, $p < 0.01$].

Table 4.
Post Hoc tests on the dependent variables attention/concentration and spelling according to type of strategy

Attention/Concentration			
Strategy	*F*	*df*	*p-value*
Printed Guide-based	0.01	1	0.94
Computer-based	0.16	1	0.69
iPad-based	60.35	1	0.00***
Spelling			
Strategy	*F*	*df*	*p-value*
Printed Guide-based	7.10	1	0.01**
Computer-based	1.07	1	0.29
iPad-based	20.33	1	0.00***

Note. *$p<0.05$; **$p<0.01$; ***$p<0.001$

3.4 Attention/Concentration and Spelling results in relation to gender, educational level and type of SEN variables before and after the intervention

It can be established, from the results shown in Figure 1, that both the A/C and spelling levels in girls and boys were higher with the use of the iPad-based strategy. Specifically, the A/C level of girls and boys is higher after the intervention with the use of iPad by 1.67 and 1.46 points, respectively. For boys, there is also evidence of an increase in the results after the intervention with the use of the computer-based strategy (0.25 points) and, to a lesser extent, with the printed guide-based strategy (0.09 points).

Regarding spelling levels, both girls and boys improved their skill levels with the use of the three strategies by 1.25 and 1.15 points, respectively; however, the one that stands out the most is the strategy that included the use of iPad.

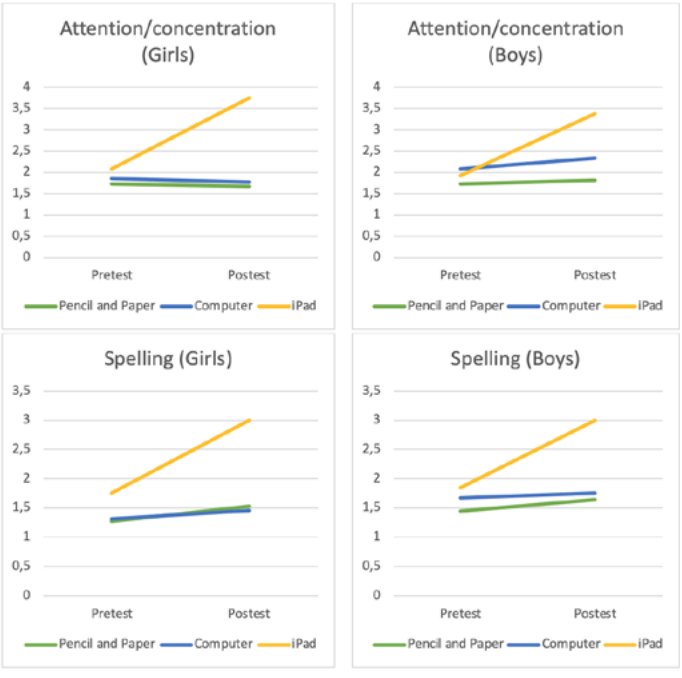

Figure 1. *Levels of A/C and Spelling in relation to gender*

From the results presented in Figure 2, it can be seen that the A/C levels of 9th grade students (pretest *M* = 1.80; posttest *M* = 3.40) and 10th grade (pretest *M* = 2.13; posttest *M* = 3.40) are higher after the educational intervention considering the use of the iPad-based strategy. This is also true regarding spelling scores, as the results show that there is also an increase in both 9th grade (pretest *M* = 1.80; posttest *M* = 2.90); and 10th grade (pretest *M* = 1.83; posttest *M* = 3.07).

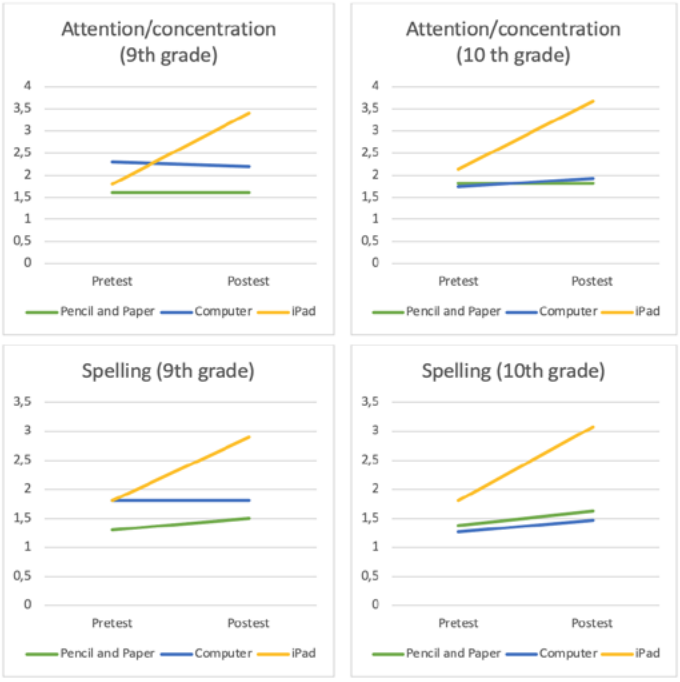

Figure 2. *Levels A/C and spelling in relation to educational level*

Now, in relation to the type of SEN, Figure 3 shows that all the students who used the iPad-based strategy, regardless of the type of educational need they have, show better levels of A/C and spelling at the end of the educational intervention. It is key to note that students with temporary educational needs show better results (pretest *M* = 2.00; posttest *M* = 3.82) than those with permanent educational needs (pretest *M* = 2.00; posttest *M* = 3.00) in levels of A/C. At the same time, it is evident that with the strategies based on printed guides and computer-based, the results remain almost identical before and after the intervention. A similar situation occurs at spelling levels, where it is highlighted that students with temporary educational needs obtain better results (pretest *M* = 1.88; posttest M = 3.24) than those with permanent educational needs (pretest *M* = 1.63; posttest *M* = 2.50).

On the other hand, as seen in Table 5, when analyzing the interaction effect of type of educational need, educational strategies, and time on attention/concentration and spelling, no significant differences were observed. A similar situation occurs with gender and educational level.

4. Discussion

The research began with five predictions which were tested based on our results.

The first prediction was supported: using an iPad based-strategy improved attention/concentration and spelling skills in high school students with SEN.

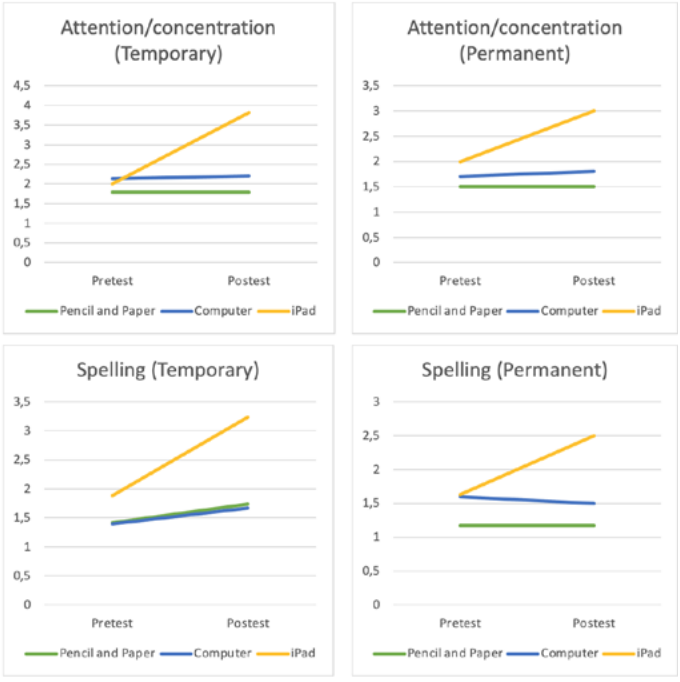

Figure 3. *A/C and spelling levels in relation to the type of SEN*

Table 5.
Main and interaction effect for attention-concentration and spelling

	Attention/ Concentration			Spelling		
	Educational Need					
	F	*df*	*p-value*	*F*	*df*	*p-value*
SEN	4.04	1	0.04	3.41	1	0.07
Strategy	10.46	2	0.00	12.51	2	0.00
Time	24.97	1	0.00	16.22	1	0.00
SEN*Strategy	0.25	2	0.78	1.27	2	0.28
SEN*Time	0.32	1	0.58	2.09	1	0.15
Strategy*Time	20.78	2	0.00	6.26	1	0.01
SEN*Strategy*Time	0.97	2	**0.37**	0.71	1	**0.44**
	Educational Level					
Educational Level	0.04	1	0.85	1.04	1	0.31
Strategy	11.41	2	0.00	12.85	2	0.00
Time	25.93	1	0.00	21.71	1	0.00
Educational Level*Strategy	2.61	2	0.07	2.26	2	0.11
Educational Level*Time	0.24	1	0.62	0.21	1	0.65
Strategy*Time	25.39	2	0.00	6.49	2	0.00
Educ. Level*Strategy*Time	1.91	2	**0.15**	0.70	2	**0.49**
	Gender					
Gender	1.96	1	0.16	1.95	1	0.16
Strategy	12.74	2	0.00	12.74	2	0.00
Time	23.94	1	0.00	23.94	1	0.00
Gender*Strategy	0.77	2	0.46	0.77	2	0.46
Gender*Time	0.93	1	0.33	0.93	1	0.33
Strategy*Time	6.29	2	0.00	6.29	2	0.00
Gender*Strategy*Time	0.03	2	**0.96**	0.03	2	**0.96**

Note. *Time means the moment when data was collected

Regarding the strategy with technology, specifically using iPads, the students presented a variation before and after the intervention in the attention/concentration levels, going from a mid-low level to an intermediate level. In relation to the spelling level, before the intervention the students were at a low level, increasing two levels after using the iPad, reaching an intermediate level. Consequently, the findings are consistent with research reporting that cognitive skills, attention/concentration, and spelling improve after the use of iPad mobile technology in students with SEN (Hetzroni & Israel, 2019; Kagohara et al., 2012; Rello et al., 2014).

In the strategy with computer use, before the intervention the students were classified at a low level of attention/concentration. After the intervention, they increased their level, classifying in the mid low range. In spelling skills, at the beginning of the intervention the students were at a low level; despite making progress within the same level after the intervention, the results were not enough for them to reach the next level. Therefore, the findings are consistent with research that shows a greater effectiveness of the use of the iPad in students with SEN compared to the computer use (Gunderson et al., 2017; Kagohara et al., 2012; LaBelle et al., 2016; Shanaa & Abulibdeh, 2019).

The second prediction was supported: using an iPad based-strategy improved both attention/concentration and spelling skills in high school students with permanent and temporary SEN. Our findings show that all students improved their cognitive abilities regardless of whether they have a temporary or permanent educational need. At an empirical level, this is consistent with previous research that has shown how the integration of mobile technology improves cognitive abilities in students with temporary educational needs such as Specific Language Disorder (Rodríguez & Cumming, 2017), Attention Deficit Disorder (Wrońska, et al. 2015), permanent educational needs such as Autism Spectrum Disorder (Aspiranti et al., 2018) and Intellectual Disabilities (Alqahtani, 2020).

The third prediction was supported: an iPad based-strategy was more effective improving attention/concentration and spelling skills in high school students with SEN than the strategies based on computer and on printed guide activities.

In this sense, it is recognized that the effective integration of mobile technology into the educational process requires the same constructivist principles as other technological tools (Clarke & Abbott, 2016). It is thus established that the incorporation of the iPad technology is more efficient than the computer-based strategy, by allowing direct manipulation where the student has greater control of the images on the touch screen. Different authors argue that this direct manipulation can become a mediator that encourages students to have confidence in themselves and grant greater independence and autonomy in learning, which would explain its educational advantages in contrast to the computer based- strategy (Stevens, 2011; Wang et al., 2016).

In the printed guides-based strategy, students do not present a variation in the level of attention/concentration before and after participating in this study. A similar situation occurs with the spelling levels, which were low from the beginning of the intervention. Although there is an improvement in spelling at the end of the intervention, it is only within the same level. Thus, these findings support a positive effect on cognitive skills of the iPad based-strategy over the printed guide. These results differ from previous research, which found significant differences in favor of the printed guide-strategy when comparing both mediums of support in students with SEN (Fabian & Topping, 2019). However, this is attributed to the frequency of use; that is, students are more familiarized to using pencil and paper within the classroom as a pedagogical activity and outside of the classroom as part of their academic assignments (Wells et al., 2016). Importantly, this does not detract from the pedagogical value of mobile technologies. Rather, it highlights the need of more knowledge, skill-building experiences, and support to incorporate technology appropriately and effectively in their practice and during teacher training (Ertmer & Ottenbreit-Leftwich, 2013).

The fourth prediction was supported: Technology (computer and iPad based-strategies) is effective to improve attention/concentration and spelling skills in students regardless of gender. The findings establish that both girls and boys improve their cognitive skills after using computers and iPad based-strategy activities. These results agree to previous findings, where digital technologies in students' learning outcomes are similar in boys and girls. Papadakis et al. (2018) for example found in their research with early childhood students' that both experimental groups (computers and tablets) significantly outperformed in knowledge about numbers and, most importantly, there was no significant difference between genders on the posttest. In the same line we found the study conducted by Pitchford et al. (2019) whom found that boys and girls from primary education learnt equally well with interactive apps designed to support reading's learning. These results, however, were found in children without educational needs.

Finally, the fifth prediction was not supported: the attention/concentration and spelling skills results are not influenced by the students' educational level. Our results indicate that both 9th and 10th graders improve their attention/concentration and spelling skills after the iPad based-strategy. Previous studies have shown that students with educational needs in lower grades compared to higher grades significantly improved their cognitive skills after the use of mobile technology (Perelmutter et al., 2017). In this sense, the results obtained were to be expected, given that the participants in 9th and 10th grades are more similar to each other, and a grade-specific test was administered.

5. Conclusions

For the purpose of this study, an educational intervention was developed in coherence with constructivist principles. The following are conclusions referring to the educational intervention with mobile technology.

First, it should be noted that students are different in terms of how they perceive and understand the information presented. In this sense, information must be provided through various modalities, visual, auditory and tactile. This means that the teacher or researcher will have to explore the characteristics of mobile technology and associated applications. It should be verified that the mobile apps answer adequately the following questions: a) Are the activities or tasks linked to the skills that are expected to be developed? b) Does the application allow the teacher to monitor student progress? c) Does the application use the incorrect answer as an opportunity for learning? d) Does the application allow you to control the speed of interaction with the content? e) Does the content presentation recognize that students learn in different ways? f) Are the multimedia resources well organized for content development? In the literature there are a variety of rubrics that allow the evaluation of the pedagogical value of applications integrated in mobile technology. For example, Mize et al.'s rubric (2019) was specifically designed considering the characteristics of students with SEN; while the Pinilla-Morales & Badilla-Quintana's rubric (2020) focuses on the pedagogical value of the apps. In this sense, this knowledge can be used as a guide to link the learning objective with the use of mobile technology.

Second, the interest of students towards the area of study must be promoted and a leading role in their own learning process must be granted. Although the qualities of mobile technology allow the students to have an active and engaged participation, the teacher must ensure that the learning objectives for each session are clear and explicit as well as the description of the activities to be developed with the technology and the practical application of this knowledge in various contexts. In short, it is necessary to answer questions such: what, how and for what, thus making the student with and without special needs be aware of their learning while generating their interest and disposition.

Third, it is necessary to emphasize that a correct design of educational instruction is an essential factor when integrating technology into the curriculum, not only when it comes to preparing activities for students with SEN, but in general. This is important because it requires not only the knowledge of technologies uses and their educational advantages but also the skills to plan and execute a didactic sequence, for which this technology constitutes the resource for the delivery of instruction.

To answer the research question that led this study: What is the effect of an educational intervention strategy with integration of technology on attention/concentration and spelling skills in high school students with SEN? it is possible to conclude that students with temporary and permanent special educational needs significantly improved their cognitive abilities after the use of technology, both using computers and iPads. Also, students who used mobile technology scored significantly higher than those who used computers and printed guides-based strategies. These three type of strategies were based on the same constructivist paradigm and all the activities were oriented to enhance the same skills and contents but with a different instructional support.

This research focused on a specific learning outcome through the Evalúa psychopedagogical battery. It would be interesting for future research based on mobile technology to complement the data collection with self-report instruments and physiological measures in order to evaluate affective and academic motivation processes while students learning. For example, exploring whether students with SEN enjoy using technology and whether their level of enjoyment is correlated with learning.

Regarding the limitations, the research design included students with neurological and developmental conditions without specifying the different types of educational needs. Future research should include analysis that would allow to determine the effects afforded by the iPads in a specific educational need, e.g. autism spectrum disorder and attention-deficit/hyperactivity disorder. In addition, it would be important to include in the research other types of technology such us augmented reality or virtual reality.

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