





Use of technologies and academic performance in adolescent students

Uso de tecnologías y rendimiento académico en estudiantes adolescentes

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ABSTRACT

Technologies have acquired strategic importance and have been defined as unprecedented educational tools. In this study, we analysed the use that 1,488 Spanish adolescents made of five tools (i.e. search engines, wikis, blogs, podcasts and instant messaging), and the impact that use of these tools had on their academic performance in science, mathematics, Spanish language and English. To this end, we explored frequency of use, time spent, purpose, place of use and level of satisfaction for each of the tools, as well as academic performance in the four subjects analysed, using the HEGECO instrument. Results revealed differential patterns in the use of technologies according to purpose, and in academic performance according to sex, age and use of the tools. Adolescents used search engines and wikis to carry out academic tasks, and podcasts for entertainment. In relation to academic performance, females presented better mean performance in linguistic subjects, and younger adolescents did so in all the subjects analysed. In relation to use of tools, the use of search engines was associated with better performance in science, Spanish language and English, while the use of podcasts was associated with better performance in mathematics. The implications of these results are discussed and evaluated.

RESUMEN

Las tecnologías han adquirido una importancia estratégica, llegándose a definir como herramientas educativas sin precedentes. En este estudio se analiza el uso que 1.488 adolescentes españoles hacen de cinco herramientas; motores de búsqueda, wikis, blogs, podcast y mensajería instantánea, y se estudia el impacto de dicho uso en su rendimiento académico en Ciencias, Matemáticas, Lengua Castellana e Inglés. Para ello, se explora la frecuencia de uso, el tiempo dedicado, la finalidad, el lugar de uso y el grado de satisfacción con cada herramienta, así como los logros académicos obtenidos en las cuatro asignaturas analizadas, a través del instrumento HEGECO. Los resultados muestran patrones diferenciales en el uso de las tecnologías en función de la finalidad y en el rendimiento académico en función del sexo, de la edad y del uso de herramientas. Los adolescentes utilizan herramientas como motores de búsqueda y wikis para realizar tareas académicas y el podcast para divertirse. Relativo al rendimiento académico, las mujeres presentan un rendimiento promedio superior en las áreas lingüísticas, así como los adolescentes más jóvenes en todas las asignaturas analizadas. En función del uso de herramientas, el uso de motores de búsqueda se relaciona con un mayor rendimiento en Ciencias y en las áreas lingüísticas y el uso de podcast con un mayor rendimiento en Matemáticas. En este sentido, y a la luz de los resultados se discuten y se valoran las implicaciones.

KEYWORDS | PALABRAS CLAVE

ICT, academic performance, adolescents, secondary education, educational technology, digital competence, learning, educational context.

TIC, rendimiento académico, adolescentes, educación secundaria, tecnología educativa, competencia digital, aprendizaje, contexto educativo.



1. Introduction

Learning and knowledge technologies have been defined as 'unprecedented educational tools' (Pantoja & Huertas, 2010: 225). They encompass search engines, wikis, blogs, instant messaging and podcasts or video and audio files that allow users to create, collaborate, connect, share and participate in a learning community (García-Martín & García-Sánchez, 2013; Yuen & Yuen, 2010).

Recent years have witnessed the steady incorporation of technologies in schools (Bocyl, 2015). Hence, the variables that have traditionally been related to academic performance must now be expanded to include technologies, especially those that correspond to the institutional technology environment, accessibility and internet use. These tools are viewed as new determinants of academic performance since they affect student work at different levels and in different ways (Duart, Gil, Pujol, & Castaño, 2008; Han & Shin, 2016; Torres-Díaz, Duart, Gómez-Alvarado, Marín-Gutiérrez, & Segarra-Faggioni, 2016).

Several authors have examined young people's use of technologies and the impact of some of these tools on their academic performance (Junco, 2015; Noshahr, Talebi & Mojallal, 2014; Wentworth & Middleton, 2014). Tools such as wikis are a widely used resource among adolescents (Soler-Adillon, Pavlovic, & Freixa, 2018), as is instant messaging, which facilitates direct personal communication and thus increases trust and a sense of intimacy among young people (Cetinkaya, 2017; Noshahr, Talebi, & Mojallal, 2014).

Furthermore, seeking information on the Internet involves selecting appropriate sources and then extracting, organising and integrating the information obtained, helping students acquire problem-solving abilities. Furthermore, participation in chats improves communication and interaction skills (Jonassen & Kwon, 2001; Ndege, & al., 2015; Tabatabai & Shore, 2005).

In support of these assertions, the results of various studies show that both computer use and the type of activity engaged in contribute significantly to explain not only the academic performance in young people but also the greater academic success in higher education achieved by those who make balanced use of technologies (Gil, 2012; Torres-Díaz & al., 2016).

In contrast, other studies have found no relationship between academic performance and technology usage and access to education, reporting no significant correlation between marks and the time students spend using technologies (Noshahr, Talebi, & Mojallal, 2014). It has also been reported that the use of technologies can affect student performance in one particular area but not in others. For example, it has been found that computer use in education does not contribute significantly to improving students' performance in mathematics, but does do so in science (Antonijevic, 2007; Wittwer & Senkbeil, 2008).

Research has yielded contradictory results, underlining the need to conduct new studies that analyse students' technology usage patterns. Likewise, it is also necessary to determine use of these tools in schools and its influence on students' academic performance during adolescence, a stage characterised by psychosocial and cognitive changes that are being affected by the exponential increase in the use of technologies (Montes-Vozmediano, García-Jiménez, & Menor-Sendra, 2018; Risso, Peralbo, & Barca, 2010).

Hence, the aim of this study was to analyse adolescent students' use of five technologies and determine the impact of these on their academic performance.

1.1. Research questions

In order to determine whether the use of technology influences adolescent students' academic performance and achievement, we investigated: (i) adolescent students' use of five technology tools (search engines, wikis, blogs, podcasts and instant messaging) and (ii) the impact of the use of these tools on adolescent students' academic performance.

Our research questions were as follows:

1) What are adolescent students' patterns of use of technology tools (search engines, wikis, blogs, podcasts and instant messaging)? Our hypothesis was that most adolescents would use the tools analysed, mainly in the home and in most cases for entertainment purposes.

2) Does the use of technology tools in the classroom exert an influence on adolescent students' academic performance? We hypothesised that the more technology tools (search engines, wikis, blogs, podcasts and instant messaging) were used in the classroom, the better the students' academic performance would be in the four core subjects analysed (mathematics, science, Spanish language, and English); that female students would present better academic performance than male students; and that older adolescents would present the best performance.

2. Material and methods

2.1. Sample

We surveyed 1.488 students aged between 12 and 18 years old, of which 698 were male and 790 females, distributed evenly between four courses of compulsory secondary education (CSE: 1st year n=397, 2nd year n=403; 3rd year n=324; 4th year n=364). This was a representative sample obtained through the intentional sampling of nine Spanish educational centres attended by students from both rural and urban areas. All these educational centres are located in Castile and Leon.

2.2. Research instrument

A questionnaire was designed, the Hegeco, consisting of three differentiated parts: 1) the first part consisted of three questions about students' general personal details: age, gender and educational level; 2) the second part included thirty specific questions about use,

frequency, time spent, purpose, place of use and levels of satisfaction for five technology tools (search engines, wikis, blogs, podcasts and instant messaging), and (iii) the third part consisted of thirty questions about use of these tools in the classroom and about academic performance, the most recent marks in four core subjects of compulsory secondary education (science, mathematics, Spanish language and English). Two identical versions of the questionnaire were designed, an online version (through Google Forms) and a print version

A detailed analysis of questionnaire responses revealed differential patterns in the use of technologies according to purpose. Adolescents used tools such as search engines and wikis to do homework and academic tasks, podcasts for entertainment and instant messaging to interact with others. Therefore, they consciously selected tools depending on the purpose, which may be due to the broad functional knowledge that young people have of these tools.

to facilitate the collection of data. A principal component analysis (PCA) was run on the questionnaire. The suitability of PCA was assessed prior to analysis. The overall Kaiser-Meyer-Olkin (KMO) measure was 0.883 with individual KMO measures all greater than 0.7, classifications of 'middling' to 'meritorious' according to Kaiser (1974). Bartlett's test of sphericity was statistically significant ($p < .0005$), indicating that the data was factorizable.

PCA revealed twenty-two components that had eigenvalues greater than one and which explained 67,2% of the total variance. Visual inspection of the scree plot indicated that five components should be retained. In addition, a five-component solution met the interpretability criterion. As such, five components were retained.

The five-component solution explained 35.99% of the total variance. The Varimax orthogonal rotation was employed to aid interpretability. The rotated solution exhibited 'simple structure' (Thurstone, 1947). The interpretation of the data was consistent with the use of technology tools and academic performance to measure academic success with strong loadings of blogging items, on Component 1 that explained 11,16% of variance, podcasting items on Component 2 which elucidated 9,33% of variance, wikis items on Component 3 that explained 6,60% of variance, instant messaging items on Component 4, which elucidated 4,46% of variance, and academic performance items on Component 5 that explained 4,42% of variance. In addition, the questionnaire had a high level of internal consistency as determined by a Cronbach's alpha of 0.800.

2.3. Procedure

After the questionnaire had been designed, it was validated by five experts from Spanish universities, and its application in educational centres was authorized by General Directorate of Innovation and Educational Equity in Castile and Leon, in accordance with deontological standards for scientific research. Various educational centres (schools and colleges) providing Compulsory Secondary Education were informed about the study. To this end, initial telephone contact was established with the head teachers of the respective centres, and then, prior to

administration of the questionnaire, informed consent was sought and obtained from the nine educational participating centres. The instrument was administered in the classrooms during the tutoring period in order to minimize interference with students' education. For the same reason, questionnaire administration required a maximum of 20 min for each group of students.

3. Analysis and results

3.1. Descriptive analysis

To answer research question 1, on adolescent students' patterns of use of technology tools, we analysed descriptive statistics for the variables corresponding to the following items: use, frequency, time spent, purpose, place of use and levels of satisfaction for five technology tools (search engines, wikis, blogs, podcasts and instant messaging)

First, in relation to use, as presented in Figure 1, almost all students reported using search engines such as Google or Safari (98%) and instant messaging such as WhatsApp or Telegram (96%), followed by podcast (90%), wikis (89%) and blogs (60%).

In regard to frequency, adolescents stated that they used instant messaging (79%) and podcasts (55%) every day, and search engines (49%) and wikis (34%) several times a week. For time spent, students indicated that they spent between one and three hours a day using tools such as podcasts (45%) and instant messaging (38%), whereas they spent less than one hour a day using other tools such as wikis (67%) and search engines (51%).

With regard to purpose, 86% reported using search engines and wikis to carry out academic homework and tasks [e.g. $F_{\text{homework}}=1293$ versus $F_{\text{social interaction}}=456$; $p<.001$] [e.g. $F_{\text{homework}}=1283$ versus $F_{\text{social interaction}}=26$; $p<.001$]. Meanwhile, 87% reported using podcasts for entertainment [e.g. $F_{\text{entertainment}}=1306$ versus $F_{\text{homework}}=230$; $p<.001$] and instant messaging to interact with others [e.g. $F_{\text{social interaction}}=1304$ versus $F_{\text{homework}}=321$; $p<.001$].

In relation to the place of use, the tools were mainly used in the home. Thus, home was the place where 95% reported using search engines [e.g. $F_{\text{home}}=1413$ versus $F_{\text{school}}=388$; $p<.001$], 91% instant messaging [e.g. $F_{\text{home}}=1368$ versus $F_{\text{school}}=123$; $p<.001$], 89% podcasts [e.g. $F_{\text{home}}=1328$ versus $F_{\text{school}}=99$; $p<.001$] and 84% wikis [e.g. $F_{\text{home}}=1262$ versus $F_{\text{school}}=335$; $p<.001$]. Finally, as shown in Figure 2 (next page), students' level of satisfaction with the tools was high in the case of instant messaging (81.5%), podcasts (73%) and search engines (60%), and average in the case of wikis (50%) and blogs (14%).

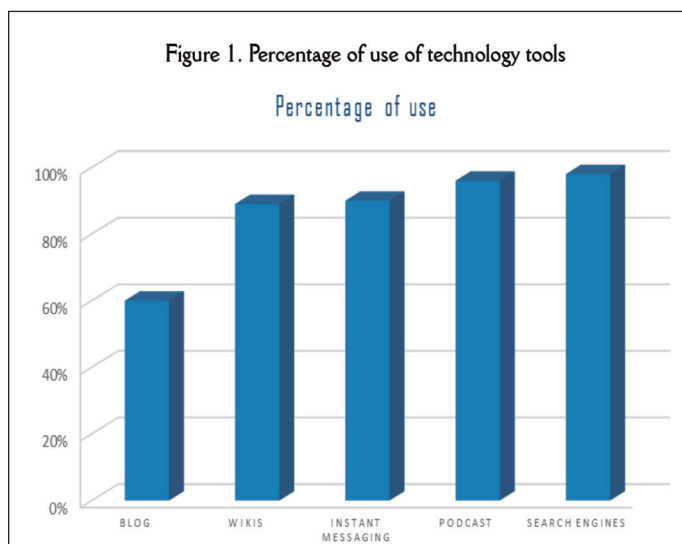
3.2. Multivariate Linear Analysis (GLM)

To answer research question 2, on the influence of the use of technology tools on adolescent students' academic performance, we carried out multivariate analyses where between-subject factors were the questionnaire variables referring to students' academic performance in four core subjects (science, mathematics, Spanish language, and English) and grouping variables were gender, educational level, age and use of tools.

Application of the GLM revealed statistically significant multivariate contrasts. The Durbin-Watson statistic yielded a value of 1.956 for the independence of residuals. The R^2 for the general model was 56.8% with an adjusted R^2 of 55.4%, indicating a large effect size when considering gender, age, educational level and use of tools in the subjects, since we obtained statistically significant differences in students' academic performance ($F[41,1224]=39.306$, $p<0.0005$).

Tests for between-subject effects when considering gender, age, educational level and use of tools as grouping

Figure 1. Percentage of use of technology tools



variables, yielded statistically significant differences. In addition, a post-hoc analysis and contrast of means for academic performance in the four core subjects (science, mathematics, Spanish language, and English) also evidenced statistically significant differences. Therefore, we obtained statistically significant differences in students' academic performance in the four subjects analysed, and in performance in the trimester and the previous academic year.

In science, we found statistically significant differences in student performance according to age and use of tools. As it can be seen in Table 1, taking age as the grouping variable,

we observed differences in the mark of students aged between 12 and 15 years old and those aged between 16 and 17, in favour of the youngest [e.g., $M_{12yrs}=2.63$ versus $M_{17yrs}=1.44$; $p<.001$]. As regards to the use of tools, we found differences between students who used search engines, wikis, podcasts and blogs on science, and those who did not use them, whereby students who routinely used these tools presented better performance [e.g., $M_{UseOfSearchEngines}=2.64$ versus $M_{Non-UseOfSearchEngines}=2.39$; $p<.001$].

In mathematics, as shown in Table 2, we obtained statistically significant differences in student performance according to educational level, age and use of tools. With regard to educational level, we observed differences between 1st and 2nd-year students and those in their 4th year, in favour of the former [e.g., $M_{1stCSE}=2.44$ versus $M_{4thCSE}=2.16$; $p<.001$]. In addition, for age, we found differences between students aged 12 and 13 years old and those aged 17, in favour of the younger students [e.g., $M_{12yrs}=2.52$ versus $M_{17yrs}=1.63$; $p=.001$]. Lastly, in relation to use of tools, we detected differences in mathematics between students who used podcasts and those who did not, whereby the former presented better performance [e.g., $M_{UseOfPodcasts}=2.57$ versus $M_{Non-UseOfPodcasts}=2.29$; $p=.002$].

In the Spanish language, we found statistically significant differences in student performance according to the four grouping variables: gender, educational level, age and use of tools, as presented in Table 3. With regard to gender, females presented better performance in this subject [e.g., $M_{Female}=2.59$ versus $M_{Male}=2.26$; $p<.001$]. In

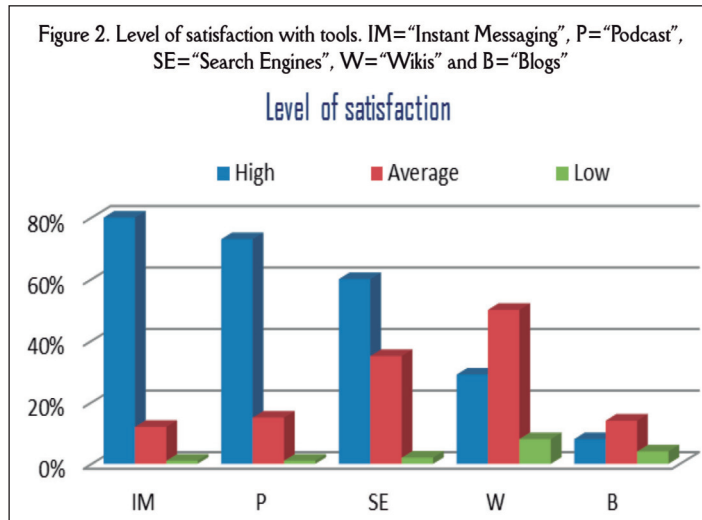
relation to educational level, we observed significant differences in the mark between 2nd-year students and those in the 1st and third years, in favour of the former [e.g., $M_{2ndCSE}=2.57$ versus $M_{1stCSE}=2.36$; $p=.008$]. Regarding age,

		M	p			M	p	
Age	12 vs. 16	12	2.63	.001	Search engines	Yes	2.64	
		16	2.07			No	2.39	
	12 vs. 17	17	1.44	<.001		Wikis	Yes	2.66
		13 vs. 16	13				2.53	No
	13 vs. 17	16	2.07	<.001	Podcast	Yes	2.75	
		17	1.44			No	2.50	
	14 vs. 16	14	2.67	<.001		Blogs	Yes	2.67
		16	2.07				No	2.51
	14 vs. 17	17	1.44	<.001				
		15 vs. 16	15		2.53			
15 vs. 17	16	2.07	.018					
	17	1.44		<.001				

Note. Only variables that show statistically significant results are displayed ($p<.05$)

we found differences between students aged between 12 and 16 years old and those aged 17, in favour of the former [e.g., $M_{12yrs}=2.47$ versus $M_{17yrs}=1.53$; $p<.001$].

Lastly, in relation to the use of tools, we detected differences in student performance between those who used



search engines and those who did not, in favour of the former [e.g., $M_{UseOfSearchEngines}=2.50$ versus $M_{Non-UseOfSearchEngines}=2.39$; $p=.036$] and between students who used blogs on this subject and those who did not, whereby the former presented better performance [e.g., $M_{UseOfBlogs}=2.45$ versus $M_{NonUseOfBlogs}=2.23$; $p=.010$].

In the English language, as shown in Table 4 (next page) we obtained statistically significant differences in student performance according to all four grouping variables. In relation to gender, females displayed better mean performance [e.g. $M_{Female}=2.64$ versus $M_{Male}=2.42$; $p<.001$]. As regards to educational level, we observed significant differences in the mark between 1st year students and those in the 4th year, in favour of the former [e.g., $M_{1stCSE}=2.62$ versus $M_{4thCSE}=2.42$; $p=.038$]. Regarding age, we detected differences between students aged 12 to 16 years old and those aged 17, and between students aged 12 and 13 years old and those aged 16, in all cases in favour of the younger students [e.g., $M_{12yrs}=2.76$ versus $M_{17yrs}=1.38$; $p<.001$].

In regard to the use of tools, we found differences between students who used search engines in this subject and those who did not, and between those who used podcasts and those who did not. In both cases, students using these technologies in the subject presented better performance [e.g. $M_{UseOfPodcasts}=2.83$ versus $M_{Non-UseOfPodcasts}=2.48$; $p<.001$].

In relation to the performance of students in all subjects in the previous trimester, statistically, significant differences were observed according to gender and age. As regards to gender, females obtained a better mean mark [e.g., $M_{Female}=2.60$ versus $M_{Male}=2.37$; $p<.001$], while for age, we found differences between students aged 12 to 15 years old and those aged 17, whereby the younger students presented better performance [e.g., $M_{12yrs}=2.63$ versus $M_{17yrs}=1.53$; $p<.001$].

In relation to the performance of students in all subjects in the previous academic year, statistically, significant differences were observed according to all four grouping variables. As regards to gender, females obtained a better mark [e.g., $M_{Female}=2.86$ versus $M_{Male}=2.66$; $p<.001$]. For educational level, we observed significant differences between 1st and 2nd-year students, in favour of the former [e.g., $M_{1stCSE}=2.86$ versus $M_{2ndCSE}=2.69$; $p=.050$].

Turning to age, we obtained differences between students of all ages except those aged 16, whereby the youngest

		M	p			M	P		
Gender	Males	2.26	<.001	Age	12 vs. 17	12	2.47	<.001	
	Females	2.59				17	1.53		
Educational level	1stCSE VS 2ndCSE	1stCSE	2.36		13 vs. 17	13	2.51	<.001	
		2ndCSE	2.57				17		1.53
	2ndCSE VS 3thCSE	2ndCSE	2.57			14	2.42		<.001
		3thCSE	2.38				17		
Use of tools	Search Engines	Yes	2.50	15 vs. 17	15	2.48	<.001		
		No	2.39			17		1.53	
	Blogs	Yes	2.45	16 vs. 17	16	2.21	.045		
		No	2.23			17		1.53	

Note. Only variables that show statistically significant results are displayed ($p<.05$)

students achieved the highest mean mark [e.g., $M_{12yrs}=3.01$ versus $M_{17yrs}=2.00$; $p<.001$].

Lastly, in relation to use of tools, we detected differences in student performance between those who used wikis and those who did not, in favour of the former [e.g., $M_{UseOfWikis}=2.79$ versus $M_{Non-UseOfWikis}=2.62$; $p=.016$] and between those who used blogs and those who did not, in favour of the latter [e.g., $M_{Non-UseOfBlogs}=2.80$ versus $M_{UseOfBlogs}=2.75$; $p<.001$].

4. Discussion and conclusions

The aim of this study was to analyse adolescent students' use of five technologies (search engines, wikis, blogs,

podcasts and instant messaging) and determine the impact of such use on their academic performance in four core subjects (science, mathematics, Spanish language, and English).

First, our results indicate that these adolescents knew about and used all the tools analysed. Nine out of ten students aged between 12 and 18 years old conducted Internet searches, viewed or shared audio and video files, consulted information on wikis and used instant messaging applications. This evidences that young people today make heavy use of such technologies, in agreement with the results obtained in various other studies (Gross, Juvonen, & Gable, 2002; Valkenburg & Peter, 2007). We also found that our subjects mainly used these technologies in the home. Thus, although increasing use is made of technology tools in the classroom, there is still a clear tendency to use them outside of the school context.

Table 4. Differences in English language performance

		M	p			M	p	
Gender	Males	2.42	<.001	Age	12 vs. 16	12 2.76 16 2.13	<.001	
	Females	2.64			12 vs. 17	12 2.76 17 1.38		
Educational level	1 st CSE VS 4 th CSE	1 st CSE	2.62	.038	13 vs. 16	13 2.57 16 2.13	.037	
		4 th CSE	2.42					
Use of tools	Search Engines	Yes	2.67	<.001	Age	13 vs. 17	13 2.57 17 1.38	<.001
		No	2.43			14 vs. 17	14 2.50 17 1.38	
	Podcasts	Yes	2.83	<.001	Age	15 vs. 17	15 2.53 17 1.38	<.001
		No	2.48			16 vs. 17	16 2.13 17 1.38	

Note. Only variables that show statistically significant results are displayed ($p < .05$)

In addition, a detailed analysis of questionnaire responses revealed differential patterns in the use of technologies according to purpose. Adolescents used tools such as search engines and wikis to do homework and academic tasks, podcasts for entertainment and instant messaging to interact with others. Therefore, they consciously selected tools depending on the purpose, which may be due to the broad functional knowledge that young people have of these tools (García-Martín & García-Sánchez, 2013).

Second, in relation to the positive influence on academic performance exerted by use in the classroom of the five technology tools examined, it should be noted that our results revealed differential patterns in performance according to the variables gender, age and use of tools.

Females presented significantly better mean performance than males in the linguistic subjects of Spanish language and English. These results coincide with those reported in several other studies (Cerezo & Casanova, 2004; Costa & Tabernero, 2012; Sheard, 2009), and may be due to stronger development of communication skills in females. Meanwhile, younger adolescents aged 12 and 13 years old presented better performance in all four areas (science, mathematics, Spanish language, and English), in contrast with the results reported in other studies indicating that older adolescent students display the best performance (Sheard, 2009). The results obtained can be explained by the existence of a higher number of students aged 14 to 18 who were repeating a year.

Lastly, this study indicates that use of technology tools in the classroom significantly affects adolescent students' performance in the subjects analysed (science, mathematics, Spanish language, and English), exerting a positive influence on science, Spanish language, and English and a negative one on mathematics. In this respect, students who used search engines presented significantly better performance in Science, Spanish language and English. Meanwhile, in mathematics, students who did not use any technology tool in the classroom, except podcasts, presented significantly better performance. These results partially coincide with those obtained in other studies indicating that use of the same technology tool in education can have a positive impact in some areas and a negative one in others (Antonijevic, 2007; Torres-Díaz, Duarte, Gómez-Alvarado, Marín-Gutiérrez, & Segarra-Faggioni, 2016).

Our results add to the literature on the use of technologies and academic performance and represent the first step in research on the academic effects on adolescent students of the use of various technology tools. The present study has significant implications for the use of technologies in the classroom, as it is important that teachers know

when and why young people use technologies, which ones they use and which ones exert positive influences on adolescent students' academic performance when used in the classroom.

Teachers must carefully select technology tools according to the subjects to address because it has been shown that writing, publishing and reading blog content is an effective means to teach and learn one's native language. Similarly, information searches, translations and listening to or viewing audio and video files are useful for teaching and learning a foreign language.

However, this study presents some limitations. This was a cross-sectional study since data were collected in a single moment in time. It would be desirable to conduct longitudinal research to understand students' academic performance throughout the entire secondary stage. In addition, besides self-report data from students, future research should include other measures of the use of technologies and academic performance when possible. It would also be useful to conduct more studies on the way in which use of other technology tools can enhance academic performance. The ultimate aim of such research would be to provide a quality education for adolescent students.

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