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The role of teacher support in the acquisition of digital skills associated with technology-based learning activities: the moderation of the educational level

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Abstract

The presence of the technology in the lives of young students does not guarantee that they know how to use it as a learning resource. Likewise, doubts remain about the role of teacher support in the digital literacy of their students. Assuming the moderating capacity of educational level, the aim of this study was to understand to what extent teacher support can determine students' ability to use technology as a learning resource. In order to respond to this objective, the Model for Developing Effective e-Learners (MDEeL) was used. A multigroup analysis with structural equations and a simple quota sample of secondary education (N = 300) and higher education (N = 300) students in Spain were used. The results showed that the influence of teaching support on basic digital skills associated with the use of the Internet as a learning resource was moderated by educational level. The study provides an approach that allows teacher support for digital literacy to be evaluated in the context of student learning practices.

Keywords: Digital literacy, Digital skills, Internet access, Online learning, Secondary education, Higher education

Introduction

Research findings indicate that, in order for students to increase their school performance using information and communication technology (ICT), they must know how to learn through this medium (Tang & Chaw, 2016). The learning process increasingly requires the ability to access, locate, extract, evaluate, organize and present digital information (Argentin et al., 2014). For a person to learn effectively in a digital world, a wide range of skills and literacies beyond technical competence must be considered (Buckingham, 2010; Gilster, 1997).

In educational practice, the younger generation of learners is perceived as having "natural abilities" to use ICT, sophisticated technological expertise, and even new cognitive abilities (Ahn & Jung, 2016). However, there is a discrepancy between the use of technologies for social purposes and the productive use of technologies by students for effective learning (Blau & Presser, 2013; Blau, Peled, et al., 2014; Blau, Grinberg, et al., 2018; Burnett & Merchant, 2015; Shamir-Inbal & Blau, 2016).

Past studies also indicate that while many young people are skilled in using technology, a significant proportion do not have skills to be considered "expert" and largely depend on the support networks - family, friends and school - of the students (Eynon & Malmberg, 2012).

Therefore, students need to receive support for digital literacy, and there are numerous studies that have analyzed examples of good practices in schools (Coiro & Hobbs, 2017; Gibson & Smith, 2018) and in higher education (Littlejohn et al., 2012). However, there are doubts that the so-called digital natives (Prensky, 2001) can be digitally trained by their teachers, both in primary schools (Porat et al., 2018) and in higher education (McMahon, 2014; Ng, 2012).

At the same time, despite government and institutional efforts (European Commission, 2021; Organization for Economic Cooperation and Development [OECD], 2018a) to integrate digital literacy and skills into the school curriculum, it is difficult to find evidence that links the digital skills of adolescents and young people to learning outcomes and practices (Livingstone et al., 2021), and it is necessary to identify and assess the digital skills that allow them to learn efficiently (Gibson & Smith, 2018). There are studies that maintain that the educational context determines the way in which technology is used, the required digital skills, as well as the type of support from the teacher (Littlejohn et al., 2012; Sharpe & Beetham, 2010). However, there is a lack of studies that empirically show how the educational context moderates digital skills associated with technology-based learning practices and the role of teacher support.

To fill this gap, the authors used the Model for Developing Effective e-Learners (MDEeL) (Beetham & Sharpe, 2019; Sharpe & Beetham, 2010) to assess basic digital skills associated with the use of technology for academic achievement and the role of teacher support. Assuming the moderation of the educational level, in the current study the following objectives were raised: (a) identify the basic digital skills associated with technology-based learning activities, and (b) measure the extent to which teacher support strengthens such skills. Within the framework of other broader approaches (Konstantinidou & Scherer, 2022), this study approaches the analysis of the role of the teacher inefficient use of technology as a learning resource.

Framework

In order to understand the role of the teacher in helping their students learn efficiently from digital environments, the authors used the model for developing effective e-learners (MDEeL) (Beetham & Sharpe, 2019; Sharpe & Beetham, 2010) because it provides a developmental sequence that describes how learners progress toward using technology effectively for learning.

Although it is a model designed for the planning and self-assessment of learners, teachers and institutions, in this study it was used as a theoretical framework for research given its affinity with the research framework on the digital divide (Selwyn, 2004; van Deursen & Helsper, 2015).

Functional access

In this first stage of the model, the essential concern refers to whether students have access to the technologies, resources and services that they need in order to learn. Although this was the initial concern of studies on the digital divide, currently, access to the Internet is wide spread among a large part of the world's population and is no longer such an issue. Young people understand the usefulness and simplicity of using the Internet, especially through mobile technology. Research indicates that this could facilitate its use for learning (Apuke & Iyendo, 2018). However, for a person to learn through the use of ICT, the fact that they continuously and autonomously access the Internet does not guarantee that they will do so in an adequate way in an educational context (see Porat et al., 2018). Although there are studies that have found a positive association between diverse and autonomous access to the Internet and digital skills (Haddon et al., 2020), there are doubts regarding whether more frequent use results in better skills (Duvenage et al., 2020).

Digital skills and practices

Once students have functional access to digital technology, resources and services, MDEeL focuses attention on the set of technology-based practices, which require appropriate digital skills.

Classrooms are conceptualized as a place where learning occurs through physical and digital spaces, providing students with a variety of options in terms of the content and experiences studied, which requires students to possess new skills (Greenhow et al., 2009). To solve this problem, recent studies have considered the educational level as a determining factor in the useful skills required to benefit from the use of technology (Gibson & Smith, 2018). For example, regarding school education, digital technology has expanded the media and changed the formats of reading material with which children and young people interact, which has meant that the skills they need to read such texts have changed (Kervin

& Mantei, 2016). In this new scenario, a wide range of skills and literacies beyond technical competence must be considered (Buckingham, 2010), and it is important that students are able to select, critique and use different modes and media, using them creatively, persuasively and for different purposes (Burnett & Merchant, 2015).

Likewise, technology has transformed learning in higher education and significantly increased the prevalence of digital learning environments (Sharp, 2018). In this new learning context, students must spend considerable time searching for, and analyzing, information, discovering new developments and creating new content. However, Sharpe & Beetham's (2010) meta-analysis of the diversity of higher education students in terms of their experience with technology-enhanced learning, revealed that they are confident in using the Internet, but they usually lack critical and investigative skills for the interpretation of information.

Creative appropriation

The notion of "creative appropriation" is the final part of the model sequence. That is, students use the available technologies in a creative way (i.e., beyond what is recommended by the tutors) to achieve their own goals, managing and customizing the resources they need. Creative appropriation (Sharpe & Beetam, 2010) means that students use the skills and practices they have developed to create their own learning environments. In tune with this approach, Coiro and Hobbs (2017) proposed a model with five digital skills (access, analyze & evaluate, create, reflect and act) that operate together in a spiral of empowerment through the processes of consumption and creation of messages and content. However, few studies address this model.

Some of these studies analyzed the digital skills associated with the use of the Internet in schools. Through the meta-analysis of Haddon et al. (2020), digital skills were linked to better learning outcomes for children and it seemed likely that the benefits for learning outcomes were greater when there was a cognitive link between the dimensions of digital skills and the particular learning outcome (p. 88). More specifically, Eynon and Malmberg (2012) found that skills in searching for information online predicted the ability to search for information for homework purposes, and another study found a positive association between information skills and the use of reliable information (Metzger et al., 2013).

Other studies using theoretical frameworks found more complex associations. For example, Tang and Chaw (2016), using the Bawden framework (2008) (underpinnings, background knowledge, central competencies, attitudes and perspectives), found an association between basic operational skills and the capacities for the search, critical analysis, and integration of information, and the capacity for effective learning. The study conducted by Scherer et al. (2017), which explored profiles of ICT use in schools and at home for different purposes, found a positive relationship between operational, information and creative skills and increased learning opportunities (i.e., breadth of resources and formats used to learn). Similarly, Tirado-Morueta et al. (2017), through the use of a hierarchical model for digital literacy, showed an association between operational and information skills and Internet opportunities for their academic work, although this association was mediated by creative skills, which suggested a hierarchical organization among the required skills. Likewise, there is also evidence that suggests that classroom activities based on the use of digital applications can also be a source of digital literacy. For example, Reich et al. (2012) found that the use of wiki provides the students with skills such as expert thinking, complex communication, and new media literacy.

Teacher support

The frequent exposure of young people to ICT is associated with a high degree of self-confidence in their ability to engage with the various digital technologies (Burton et al., 2015). However, the predisposition of the student to use ICT is insufficient to guarantee that they use technology efficiently (Sharpe & Beetham, 2010), and there are studies which show that teacher support, understood as the availability of teaching guidance for the efficient use of technology, remains a critical determinant of the technology-based learning practices adopted by learners (Margaryan et al., 2011).

Although there is evidence of a positive association between students' self-reported abilities and teacher support in the school context (Santos et al., 2019), there are certain aspects of teachers that can act as moderators (for example, teacher self-efficacy, teacher motivation and collaboration) (Konstantinidou & Scherer, 2022; Zhu et al., 2019). However, in the context of higher education, the literature review and audit of 15 UK centers by Littlejohn et al. (2012) did not show evidence of direct support from teachers as a digital literacy strategy. These findings support the idea that the educational level can condition the influence of teaching support as a determinant factor in the development of digital skills associated with efficient technology-based learning practices. For example, the study conducted by Gibson and Smith (2018) indicates that while a critical and investigative mindset should be strengthened in schools, resources (i.e., platforms, databases, digital repositories, bibliographic managers, open access journals) should be provided in schools and higher education, etc., in order to encourage more autonomous digital literacy.

Hypotheses

In order for students to improve their academic efficiency when using technology, it is necessary that they know how to learn through ICT (Tang & Chaw, 2016). They must have the digital skills required to carry out academic activities mediated by the Internet.

Although evidence shows that young people's digital wisdom is an urban legend (Kirschner & van Merriënboer, 2013), constant use of the Internet predisposes them to engage in new tasks and challenges in a digital environment (Littlejohn et al., 2012), and makes it easier for them to acquire digital skills (Xavier, 2011). Although the empirical evidence does not allow us to conclude that students who frequently use the Internet tend to have a high level of digital skills, there are numerous studies that have identified high levels of operational skill (Livingstone et al., 2021). Likewise, studies from the trans-literacy approach (i.e., referring to the ability to read, write and interact with a set of platforms, tools and media) have shown that the transfer of skills from a social context to the school setting can occur if schoolwork is continued after hours and students have access to do so (Aillerie, 2019). Therefore, the following hypotheses were formulated:

H1. Students who have functional access to the Internet in multiple contexts will have a high level of operational skills (H1a) and will frequently carry out technology-based learning activities (H1b).

Regarding the digital competences required to learn in a digital context, numerous conceptual frameworks (e.g., Ala-Mutka, 2011; Bawden, 2008; Ng, 2012) and empirical tests (e.g., Helsper & Eynon, 2013; Porat et al., 2018; van Deursen & Helsper, 2015) have been proposed. Furthermore, some are primarily associated with technical-operational skills (e.g., Oblinger & Oblinger, 2005), whereas others have focused on cognitive and social-emotional aspects (e.g., Eshet-Alkalai, 2012; Greene et al., 2014). Recently, Helsper et al. (2020) identified, after a rigorous process of systematically reviewing the literature and quantitative and qualitative validation, a model of four basic dimensions of digital skills: (a) technical and operational skills, (b) navigation and information processing skills, (c) communication and interaction skills, and (d) content creation and production skills. Each of these dimensions includes functional and critical aspects and can also be combined to generate more complex skills (Livingstone et al., 2021). However, it is unclear what kinds of digital skills are most associated with technology-based learning activities (Livingstone et al., 2021). Taking into account the dimensions most frequently indicated in the frameworks on digital skills (Helsper et al., 2020) and preceding findings (Eynon & Malmberg, 2011; Metzger et al., 2013; Scherer et al., 2017; Tang & Chaw, 2016; Tirado-Morueta et al., 2017), the following hypotheses were formulated:

H2. Students who have a high level of digital operational (H2a), communication (H2b), creative (H2c) and information (H2d) skills will frequently carry out technology-based learning activities.

However, to understand the digital empowerment of students, it is necessary to address how these skills relate to each other. Although there are conceptual models, such as the cyclical model proposed by Coiro and Hobbs (2017) or the model by Helsper et al. (2020) from which the critical aspects of skills are emphasized, there are few empirical studies that focus on the analysis of their relationships (e.g., Tirado-Morueta et al., 2017). In this context, the authors formulated the following hypotheses:

H3. Students who have a high level of operational skill will also have a high level of communication (H3a), creativity (H3b), and information (H3c) skills.

H4. Students who have a high level of digital communication skills will also have a high level of creative (H4a) and information (H4b) skills.

H5. Students who have a high level of creative ability will also have a high level of information skills.

Regarding the role of teaching support in the acquisition of skills for students to use technology efficiently in their learning, findings showed that obtaining educational benefits from the technology depends largely on teacher support (Eynon & Malmberg, 2011; Margaryan et al., 2011; Zhu et al., 2019) due to their influence on student skills (Haddon et al., 2020). The following hypotheses were formulated:

H6. Students who frequently receive support from their teachers will frequently carry out technology-based learning activities, due to its relationship with operational (H6a), communication (H6b), creative (H6c) and information (H6d) skills.

Qualitative moderation hypothesis

In order to identify the digital skills required for the creative appropriation of technology (Sharpe & Beetham, 2010), it is necessary to address the set of educational practices in which technologies are used, which are different depending on the educational level (Gibson & Smith, 2018). While in secondary education, students need skills that allow them to read critically and interpret materials in multiple formats (Kervin & Mantei, 2016), in higher education, students must tackle their academic tasks autonomously and collaboratively given that the prevalence of digital learning environments has increased markedly (Sharp, 2018). Consequently, both the frequency of activities based on the use of technology and the basic skills required will depend on the educational level.

In addition, regardless of the educational level, teachers must consider that among their functions, they need to provide their students with the necessary tools to navigate the web autonomously and critically and ensure they are capable of achieving their own goals. However, while secondary education students may need direct support from the teacher, in higher education, it may be more appropriate to provide resources that allow more autonomous information searching and production (Gibson & Smith, 2018). Therefore, the influence of teacher support on digital skills will be more significant in secondary education.

Finally, there are findings that suggest that academic activity outside school hours may involve a transposition of the student's social and informal practices to their educational practices (Aillerie, 2019). Therefore, given the degree of academic demand in higher

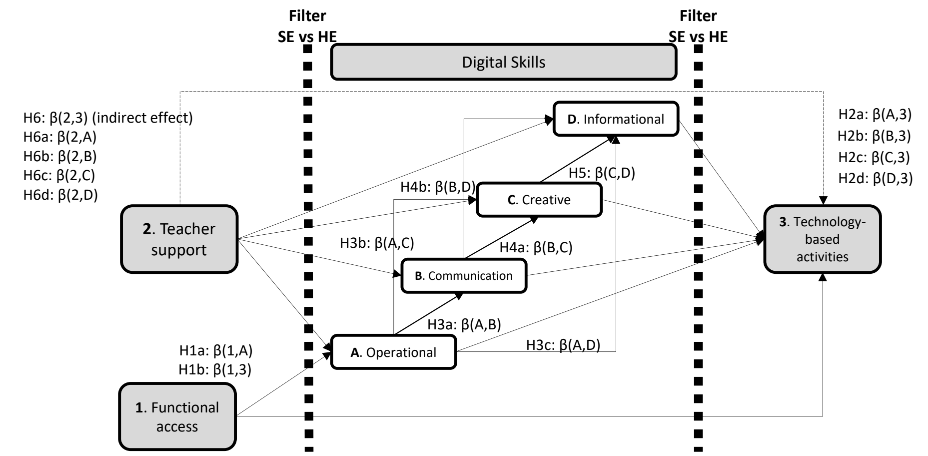

Fig. 1 Graphical representation of the hypothesis

Note: SE = Secondary Education; HE = Higher Education

education students, the association between functional access to ICT and the frequency of technology-based learning activities will be higher.

Methodology

Participants

To test the hypotheses, a sample of secondary and higher education students who usually use technology to carry out their learning activities was sought. Given the lack of statistical data and data protection measures, simple choice quota sampling (i.e., a certain number of participants will be chosen from each stratum) was chosen. The participants were randomly chosen from those centers and teachers who collaborated in the study.

Informed consent was requested from the directors of educational centers, parents/legal guardians and the participants themselves, and the data were subsequently obtained, after informing the participants about the objectives and beneficial implications of the study for students. The study was approved by the Ethics Research Board of the University of Huelva.

A total of 600 Spanish students were included in the sample. Three hundred secondary education students (aged 13-18 years old) from diverse public secondary schools, and 300 university students of educational science (aged 19-34 years old) from diverse public universities. A total of 32% of secondary education students were male and 68% were female, and 19.7% of university students were male and 80.3% were female.

Measurements

To carry out the study, the frequency with which students carry out technology-based activities was considered as a dependent variable. The independent variables were

(a) teacher support and (b) students' functional access to technology. The mediating variables were digital skills (operational, communication, creative and information). And the moderating variable was the educational context, which in the case of the current study was the educational level.

For the measurements of the variables, a questionnaire with seven scales was used. The scales used and the reliability indices obtained after their application are described in the following paragraphs.

Functional access (FA) refers to physical access to technologies, resources and services that students need in order to carry out their school/academic activities (Sharpe & Beetham, 2010). To measure functional access, participants were asked about their frequency of Internet use at home, in their school, in public spaces, and while on the move (Livingstone et al., 2011). Response options ranged from 1 – never; 2 – almost never; 3 – sometime in a month; 4 – sometime during the week; 5 – daily to 6 – continuously. The variable was the mean value of the responses to each item (Mean (f_{home}, $f_{study\ center}$, $f_{public\ spaces}$, f_{move})).

The framework used to measure digital skills (DS) was an adaptation of the scales used by Helsper et al. (2020) and van Deursen et al. (2014), using language understandable to both groups of students. The framework used the following domains, with values from 1 (not at all true of me) to 4 (very true of me): (a) operational skills, as the ability to configure and install software, connect, and share information on the Internet; (b) information skills, as the ability to search, select and evaluate information in digital media; (c) communication skills, as the ability to know how to exchange meaning with other humans using social networks, virtual communities and platforms; (d) creative skills, as the ability to create and/or recreate content in multiple formats.

In the operational skills scale ($\alpha = .78$), items such as "I know how to adjust privacy settings", "… to connect to a WIFI network", or "… to install apps on a mobile device" were used. In the information skills scale ($\alpha = .78$), items such as "I generally compare different websites to decide if information is true", "I am confident selecting search results" or "I use systems to save / share documents in the cloud" were used. In the communication skills scale ($\alpha = .79$), items such as "I use a wide range of tools for online communication", "I am able to actively share information, content and resources through online communities, networks and collaboration platforms", or "I know and apply the set of rules of general behavior on the Internet" were used. And in the creative skills scale ($\alpha = .79$), items such as "I would feel confident putting video content I have created online", "I know how to create something new from existing online images, music or video" or "… to design a website, blog or wiki" were used.

To measure the teacher support (TS) received from the school/university students, the scale developed in the EU Kids online project was used (Livingstone et al., 2011), with values from 1 (never) to 4 (very frequently). This scale measured the degree of support provided by the institution's teachers to help students learn how to use the Internet (α = .91), and items such as "encouraged me to explore and learn things on the Internet", "helped me when I found something difficult to do or to find on the Internet" and "made rules about what I can do on the Internet" were used.

Lastly, technology-based activities (TBA), refers to how often students use technologies in their common activities at school or university. To measure technology-based activities, PISA items (OECD, 2018b) were used (α = .69), with response options ranging from 1 – never; 2 – almost never; 3 – sometime in a month; 4 – sometime during the week; 5 – daily to 6 – continuously. The question was "how often do you use the Internet for the following activities when you are at school or university?" and items such as "… making presentations", "checking out information on the school/faculty website", "doing group work with other students" and "communicating with teachers (e.g., submitting homework or asking a question)" were used.

The results for convergent and discriminant validity of the measures of the research instrument are shown in the Appendix. In summary, both alpha and composite reliability were of acceptable levels. Likewise, the analysis of the average variance extracted (AVE) showed values higher than .50. To test the discriminant validity, the √AVE was calculated for each construct. Its value was higher than the Pearson correlation with the rest of the constructs (Table 1).

Data analysis

The Structural Equation Modeling (SEM) was used with the Amos 18.0 software to test the hypotheses posited in Figure 1 and the following adjustment criteria were established following the recommendations of Hair et al. (2006) for the number of observed variables ≤ 12 and the sample size observed > 250. For the absolute measurements of adjustment, the χ^2 ($p > .05$) and the root mean square error of approximation (RMSEA) was used (0 < RMSEA < .07). For the incremental measurement of fit, the incremental fit index (IFI) and comparative fit index (CFI) were used (0.95 < IFI < 1; 0.95 < CFI < 1). Lastly, for the measurement of parsimonious fit, the normed χ^2 (χ^2/df) was used ($1 < \chi^2/df <$ 3-5).

Table 1 Correlations and discriminant validity

		1	2	3	4	5	6	7
1	Functional access	1						
2	Operational skills	.11**	*.75*					
3	Information skills	.13**	.13**	*.84*				
4	Communication skills	.15**	.29**	.36**	*.86*			
5	Creative skills	.02	.26**	*.23***	.43**	*.73*		
6	Technology-based activities	.25**	.18**	.21**	.30**	.21**	*.71*	
7	Teacher support	-.01	.13**	.11**	.08*	.17**	*.09**	*.83*

Notes: In italics the square root of average variance extracted (AVE) is indicated. For functional access it was not possible to calculate √AVE since it is a mean value.

To verify the qualitative moderation of the educational level, an invariance analysis was carried out using the test recommended by Byrne (2008, 2013). This test consists of checking if there is a difference between the fit of the configurational model (n = 600) and the restricted model. The restricted model considers that the parameters in the samples of secondary (n = 300) and higher education students (n = 300) are equivalent. Therefore, if there is a significant difference between the configurational model and the restrictive model, the hypothesis of qualitative moderation will be accepted.

The restrictive models assumed that (a) the indices of regression between the functional access and operational skills (H1a) and technology-based activities are established as equal (H1b), (b) the indices of regression between digital skills and technology-based activities (H2a, H2b, H2c, & H2d) are established as equal, (c) the indices of regression between digital skills (H3a, H3b, H3c, H4a, H4b & H5) are established as equal, (d) the indices of regression between the teacher support and technology-based activities (H6) and digital skills (H6a, H6b, H6c, & H6d) are established as equal, and (e) the indices of regression between the intercepts (variances) are established as equal. If model (a), (b), (c), (d) and/or (e) are not accepted (i.e., models are not equivalent), it would be demonstrated that educational level moderates the associations (a), (b), (c), (d) and/or (e).

In order to compare the configural multigroup model and restrictive models, a Chi-square difference test ($\Delta\chi^2$) was used. However, given the sensitivity of χ^2 to sample size and non-normality (Hair et al., 2006), Cheung and Rensvold (2002) proposed the increase in CFI (ΔCFI), to determine whether the compared models are equivalent. In this sense, when the difference between the CFI of the two models is greater than 0.01, the less restrictive model is accepted and the other rejected. In this study, both criteria ($\Delta\chi^2$ and ΔCFI) were used.

Finally, to compare the differences between the parameters, the critical ratio (CR) between parameters was used, in such a way that if the critical ratio exceeds 1.96, the parameter is significantly different between the two groups at a level of $p < .05$ (Byrne, 2013).

Results

To verify the qualitative moderation of the educational level, the basic structural model was used to verify the formulated hypotheses, while the multigroup structural model was used to understand the moderation.

Basic structural model

The structural equation model was applied to statistical analysis and the assumption of normality of the variables used were examined. An analysis of skewness and kurtosis (see Table 2) was used. Curran et al. (1996) establish the limits, in absolute value, up to which a normal distribution can be considered, at values between -2 and +2 for asymmetry and

Table 2 Descriptive analysis

	Mean (SD)						
	Total	Secondary Education	Higher Education	Min	Max	Asymmetry (SE)	Kurtosis (SE)
Functional access	4.89 (0.93)	4.65 (1.01)	5.14 (0.78)	1	6	-.89 (.10)	.41 (.20)
Operational skills	3.50 (0.72)	3.45 (0.80)	3.55 (0.62)	1	4	-2.25 (.10)	6.26 (.20)
Information skills	2.14 (0.77)	1.99 (0.80)	2.29 (0.70)	1	4	.23 (.10)	-.50 (.20)
Communication skills	2.38 (0.77)	2.27 (2.48)	2.48 (0.69)	1	4	.00 (.10)	-.65 (.20)
Creative skills	2.34 (0.71)	2.40 (0.76)	2.29 (0.65)	1	4	.09 (.10)	-.44 (.20)
Technology-based activities	3.80 (1.05)	3.39 (1.07)	4.20 (0.86)	1	6	-.29 (.10)	-.46 (.22)
Teacher support	2.16 (0.74)	2.21 (0.80)	2.11 (0.67)	1	4	.53 (.10)	-.07 (.20)

Note: SE = Standard Error

between -7 and +7 for kurtosis. The variables showed a normal distribution except for the operational skills that showed a skewness greater than 2.

In order to verify the hypotheses, a basic model was conducted. Table 3 shows the coefficients that reveal the direct and indirect effects between the variables. An indirect effect indicates the effect of a determinant variable on another one, through its effect on other variables that intervene in the model. Figure 2 illustrates the associations established in the model, as well as the variances explained from functional access, digital skills and academic use. Lastly, after testing the validity of the causal structure, the adjustment indices obtained were acceptable: χ^2 /df = 4.49; RMSEA = .076 (90% confidence interval = .049, .107); CFI = .975 and IFI = .976. The model explained 19% of the variance found in *online learning activities*, 8% in operational skills, 25% in communication skills, 44% in creative skills and 26% in information skills.

Once the good fit of the model and predictive capacity of the model was demonstrated, the relationships were analyzed to verify the validity of the hypotheses.

First, the results showed a strong association of *functional access* with *operational skills* (β = .12, p < .001) (H1a) and with *technology-based activities* (β = .22, p < .001) (H1b).

Second, a significant association of technology-based activities with operational skills (β = .14, p < .001) (H2a), *communication skills* (β = .16, p < .001) (H2b) and *information skills* (β = .09, p < .05) (H2d) was found. However, creative skills were not significantly associated with *technology-based activities* (β = .08, p > .05) (H2c).

Third, all digital skills were directly associated with each other. Specifically, *operational skills* were associated with *communication skills* (β = .45, p < .001) (H3a), creative skills (β = .22, p < .001) (H3b), and *information skills* (β = .14, p < .001) (H3c). Likewise, communication skills were associated with creative (β = .47, p < .001) (H4a) and information skills (β = .33, p < .001) (H4b). Finally, *creative skills* were associated with information skills (β = .22, p < .001) (H5).

Table 3 Parameters in the basic structural model

Hypotheses	Direct effects	Indirect effects
H1a. Functional access → Operational skills	.12***	
H1b. Functional access → Technology-based activities	.22***	
H2a. Operational skills → Technology-based activities	.14**	
H2b. Communication skills → Technology-based activities	.16***	
H2c. Creative skills → Technology-based activities	.08	
H2d. Information skills → Technology-based activities	.09*	
H3a. Operational skills → Communication skills	.45***	
H3b. Operational skills → Creative skills	.22***	
H3c. Operational skills → Information skills	.14***	
H4a. Communication skills → Creative skills	.47***	
H4b. Communication skills → Information skills	.33***	
H5. Creative skills → Information skills	.10*	
H6. Teacher support → Technology-based activities	.03	.12**
H6a. Teacher support → Operational skills	.26***	
H6b. Teacher support → Communication skills	.12**	
H6c. Teacher support → Creative skills	.15***	
H6d. Teacher support → Information skills	.08*	
R^2 Operational skills	.08	
R^2 Communication skills	.25	
R^2 Creative skills	.44	
R^2 Information skills	.26	
R^2 Technology-based activities	.19	
χ^2/df	4.49	
p	.000	
IFI	.976	
CFI	.975	
RMSEA	.076 (.049-.107)	

**p* < .05; ***p* < .01; ****p* < .001

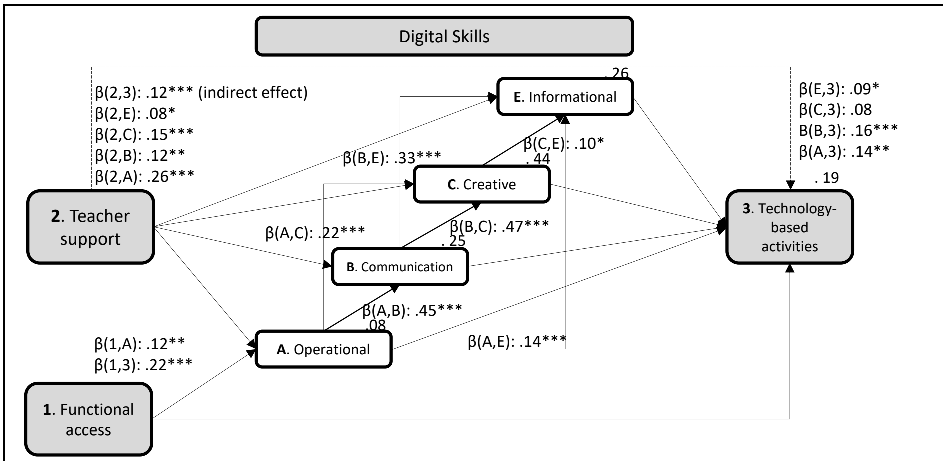

Fig. 2 Structure and parameters in the basic model

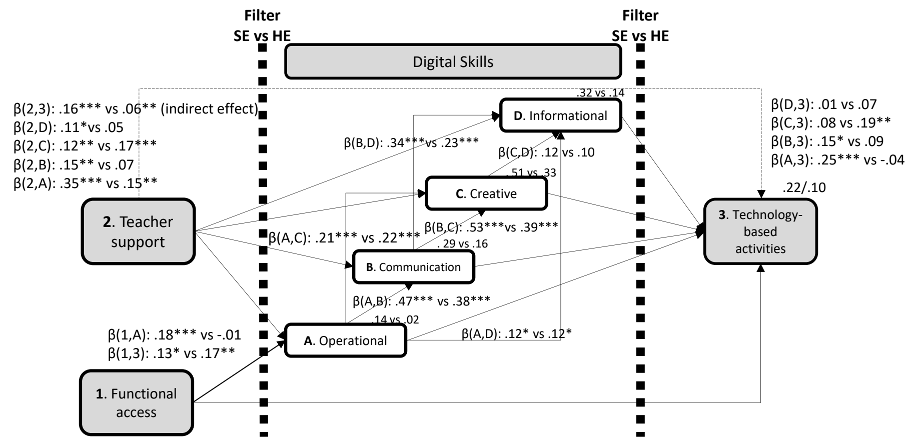

Fig. 3 Moderate structural model by educational stage

Notes: The two parameters from left to right represent the values of secondary education and higher education, respectively. SE = Secondary Education; HE = Higher Education

The results did not show a significant direct association of teacher support with *technology-based activities* (β = .03, *p* > .05), but rather an indirect association mediated by digital skills (β = .12, *p* < .01) (H6). Likewise, the data showed a direct and significant association of *teaching support* with *operational skills* (β = .26, *p* < .001) (H6a), *communication skills* (β = .12, *p* < .01) (H6b), *creative skills* (β = .15, *p* < .001) (H6c) and *information skills* (β = .08, *p* < .05) (H6d).

Structural model moderate by educational level

Table 4 and Figure 3 show the regression indices of the associations established in the multi-group model, the variances and critical ratio between educational level (Secondary Education and Higher Education). After testing the causal structure of each model, the indices of adjustment obtained were acceptable (χ^2/df = 3.396; RMSEA = 0.063 (90% confidence interval [CI] = .043, .085); IFI = .963 and CFI = .961).

Regarding the association of *functional access* with *operational skills* and *technology-based activities*, the data from the multigroup analysis showed that the parameters associating *functional access* with *operational skills* (H1a) and *technology-based activities* (H1b) were equivalent (Δ CFI = .001). There no was moderation due to educational level. More specifically, the greatest differences between educational levels are found in the relationship between *functional access* and *operational skills* (H1a). In this sense, the CR values show that the association was higher in the secondary education group than in high education group (CR = -2.257).

Table 4 Multi-group model, invariance analysis and critical ratio

Hypothesis		Secondary Education		Higher Education		Critical Ratio (CR)
		Direct effects	Indirect effects	Direct effects	Indirect effects	
H1a. Functional access → Operational skills		.18***		-.01		-2.257*
H1b. Functional access → Technology-based activities		.13*		.17**		0.33
H2a. Operational skills → Technology-based activities		.25***		-.04		-3.63*
H2b. Communication skills → Technology-based activities		.15*		.09		-0.65
H2c. Creative skills → Technology-based activities		.08*		.19**		1.001
H2d. Information skills → Technology-based activities		.01		.07		0.637
H3a. Operational skills → Communication skills		.47***		.38***		-2.171*
H3b. Operational skills → Creative skills		.21***		.22**		0.575
H3c. Operational skills → Information skills		.12*		.12*		-0.128
H4a. Communication skills → Creative skills		.53***		.39***		2.533*
H4b. Communication skills → Information skills		.34***		.23***		-1.038
H5. Creative skills → Information skills		.12		.10		-0.052
H6. Teacher support → Technology-based activities		.05	.16**	.05	.06**	-0.522
H6a. Teacher support → Operational skills		.35***		.15**		-1.748
H6b. Teacher support → Communication skills		.15**		.07		-0.96
H6c. Teacher support → Creative skills		.12**		.17***		0.707
H6d. Teacher support → Information skills		.11*		.05		-0.567
R^2 Operational skills		.15		.02		3.018*
R^2 Communication skills		.29		.16		3.558*
R^2 Creative skills		.52		.33		1.29
R^2 Information skills		.32		.14		2.461*
R^2 Technology-based activities		.22		.10		3.048*
χ^2/df (p)	3.396 (.001)					
IFI	.963					
CFI	.961					
RMSEA	.063(.043-085)					
Δ ($\chi^2_{configural}$, χ^2_{TS-DS}) (p)	4.768 (.312)					
Δ (CFI $_{configural}$, CFI $_{TS-DS}$)	.001					
Δ ($\chi^2_{configural}$, χ^2_{DS-TBA}) (p)	13.028 (.011)					
Δ (CFI $_{configural}$, CFI$_{DS-TBA}$)	.012					
Δ ($\chi^2_{configural}$, χ^2_{DS}) (p)	19.400 (.007)					
Δ (CFI $_{configural}$, CFI$_{DS}$)	.016					
Δ ($\chi^2_{configural}$, χ^2_{FA-TBA}) (p)	.107 (.743)					
Δ (CFI $_{configural}$, CFI $_{FA-TBA}$)	.001					
Δ ($\chi^2_{configural}$, $\chi^2_{intercepts}$) (p)	35.353 (.045)					
Δ (CFI $_{configural}$, CFI $_{intercepts}$)	.041					

*p ≤ .05; **p ≤ .01; ***p ≤ .001.

Regarding the association of digital skills with *technology-based activities*, the data showed that the parameters that associated digital skills with *technology-based activities* were not equivalent (Δ CFI = .012). More specifically, in secondary education the association between *operational skills* and *technology-based activities* (H2a) was higher than in higher education (CR = -3.63). However, in secondary education students, the relationship between operational and communication skills with technology-based activities was significant, while in higher education students, a significant association between creative skills and online activities was found.

Regarding the relationships between digital skills, both models were not equivalent (ΔCFI = .011). However, the meaning and strength of the relationships between variables was very similar. Specifically, according to the CR, the association of operational skills with communication skills (CR = -2.171), and communication skills with creative skills (CR = 2.533) were statistically higher in secondary school students.

Regarding teacher support, the data showed that the parameters that associated *teacher support* with digital skills and *technology-based activities* were equivalent. The difference between the CFI in the configural model and the restricted model was lower than 0.01 (ΔCFI = .001). Therefore, the data showed that the educational level did not moderate the association of *teacher support* with digital skills and *technology-based activities*. However, in secondary education students, teacher support was significantly associated with all digital skills, while in higher education students, significant relationships were only found with operational and creative skills.

Lastly, the data showed that the variances explained by both models were not equivalent (ΔCFI = .041). The secondary education model explained the variation in digital skills and technology-based activities better than the higher education model. Teacher support and functional access were better predictors of skill acquisition and frequency of technology-based activities in high school students than in higher education students.

Discussion

The Internet as a resource in formal education systems has become more pervasive. Researchers have pointed out that despite the fact that digital natives have grown up immersed in technology, using this technology for learning purposes requires different skills and strategies than simply using technology to socialize or for routine tasks (Aziz, 2010; Margaryan et al., 2011; Ng, 2012).

The findings of this study showed that in order for young students to use the Internet in their academic activities, it is important to have frequent access to the Internet. It is a medium with which they are familiar and which they feel confident using in their academic activities (Littlejohn et al., 2012). However, the results do not support the idea that frequent access from multiple contexts can be a channel for digital literacy, since no association was observed with digital skills, except for operational ones. However, functional access to the Internet seems to be a facilitating factor for the use of technology as a learning resource, to the extent that part of the school/academic work is done outside of school hours (Aillerie, 2019). In this sense, the association of functional access with the frequency of technology-based activities was greater in higher education, possibly due to its higher level of academic demand compared to secondary education. These findings provide evidence of a possible transposition of students' practices (see Ivaniç et al, 2007) from their social context to an educational context (Beetham & Sharpe, 2019; Facer & Selwyn, 2010).

Likewise, unlike university students, in the group of secondary education students, operational skills were associated with functional access (Livingstone et al., 2021). These data suggest that constant Internet use can predispose the younger students to efficiently use technology for educational purposes (Littlejohn et al., 2012) and makes it easier to acquire operational digital skills (Xavier, 2011).

As expected, the data showed that the basic dimensions of digital skills associated with the frequency of technology-based activities depend on educational practice (Gibson & Smith, 2018), with the frequency of technology-based activities being much higher among students in higher education since they usually carry out their academic tasks through digital resources and platforms (Sharp, 2018). Thus, the multigroup analysis showed that while for secondary education students the "operational" and "communication skills" were significant for sharing information and communication with peers, for higher education students, creative skills were significant, possibly due to a greater use of the Internet for the presentation of their work. However, although the search for information to complete tasks was present in both samples of students, unlike other studies, the use of critical skills in academic work related to the Internet could not be confirmed (Eynon & Malmberg, 2012; Metzger et al., 2013). These results suggest that an in-depth analysis of the type of academic activities that are being required of students should be conducted.

The results of the analysis of the relationships between digital skills suggest a staggered organization between digital skills with a greater number of functional items such as operational, communicative and creative skills (Tirado-Morueta et al., 2017). Likewise, information skills, with a greater number of critical items, showed a stronger association with those other dimensions that had more critical components. These results support approaches in which the didactic sequence moves from the functional to the critical.

The results showed a significant association between the support of teachers and the digital skills of students, both in secondary and higher education students. The results support the belief that students' digital literacy depends, in part, on teacher support (Eynon & Malmberg, 2012). However, the influence of teacher support on students' digital skills was greater in the secondary education sample than in the higher education sample. While in secondary education teacher support correlated positively with all digital skills, in higher education, teacher support only correlated with operational and creative skills. In general terms, these data suggest that the direct support of the teacher is more necessary in the initial or middle educational stages, while university students can acquire these skills more autonomously (Gibson & Smith, 2018).

Likewise, in both secondary education and university students, teaching support was indirectly associated with technology-based activities. The association of teaching support with technology-based activities was totally mediated by students' digital skills. Therefore, regardless of educational level, teacher support was a critical factor for the use of technology as a learning resource (Margaryan et al., 2011), to the extent that it facilitates the development of skills among students (Haddon et al., 2020).

The results confirm the scarce educational support available to students to carry out their academic tasks in light of the new opportunities offered by the Internet (Littlejohn et al., 2012; Selwyn, 2009). Although students may transpose their social digital practices to the educational context in order to carry out their learning tasks, they receive little direct support from teachers focused on such activities (for example, developing new knowledge, collaborating with their peers, evaluating the validity and reliability of information, ethical and responsible behavior, etc.). This lack of situated support can be particularly problematic in secondary education due to students' greater reliance on teachers for the development of their digital skills (Buckingham, 2007; Margaryan et al., 2011; Sharpe & Beetham, 2010).

Conclusions

The growing presence of the Internet as a learning resource in formal education sparks increasing interest in ensuring that students have the necessary skills to use technology intelligently to support their learning. However, doubts remain about the role of teachers in strengthening the digital capabilities of their students.

This study, using a quota sample of secondary and higher education students in Spain, sought to identify the basic skills required to learn how to use technology for educational purposes and the influence of teacher support on the acquisition of such skills.

The authors used the MDEeL as a conceptual framework to situate the role of teacher support in the acquisition of digital skills associated with the use of technology as a learning resource.

The results of the multigroup analysis showed that the educational level – and therefore the educational practice – conditions the digital skills associated with the school/academic use of technology, as well as the importance of teacher support in the acquisition of skills. For secondary education students, it was more relevant than for higher education students to have teacher support for the acquisition of digital skills.

Finally, the relationships between learning activities with the use of technology and digital skills suggest a path of informal digital literacy that is worth exploring in depth.

Limitations and future studies

One of the study's limitations is the use of self-administrated questionnaires, considering that there are studies that show that adolescents tend to overestimate their digital skills (e.g., Sharpe & Beetham, 2010). In this sense, it is advisable to assess digital skills through more objective or observational techniques (e.g., Ng, 2012; Porat et al., 2018).

The results of the study showed that the educational context conditioned the type of digital skills required, as well as the determination of teacher support, so it is advisable to carry out studies that focus on specific educational contexts.

Although in this study the basic dimensions of the skills and academic work of the students have been used, allowing for the possibility to verify that the educational level moderates the digital skills required and the determination of the support of the teacher, it will be advisable to carry out studies that delve into the academic activities and the digital skills associated with them.

Finally, in order to contrast the results, it is advisable to carry out other studies that consider the sociodemographic aspects due to their possible covariation.

Appendix

Constructs	Items	Load	*Mean (SD)*		Alpha	CR	AVE
			Secondary School	*Higher Education*			
Teacher support	Have any teachers at your school/university done these things?						
	Suggested ways to use the Internet safely	.843	2.20 (0.96)	2.11 (0.79)	.91	.93	.69
	Encouraged me to explore and learn things on the Internet	.833	2.36 (0.95)	2.38 (0.78)			
	Made rules about what I can do on the Internet	.820	2.28 (1.03)	2.12 (0.86)			
	Helped me when I found something difficult to do or find on the Internet	.838	2.25 (0.98)	2.15 (0.80)			
	Explained why some websites are reliable	.845	2.24 (1.01)	2.23 (0.82)			
	Suggested ways to behave towards other people	.813	2.12 (1.01)	2.00 (0.93)			
	Helped me in the past when something has bothered me on the Internet	.792	1.90 (0.99)	1.79 (0.83)			
	Helped me create digital materials	.637	2.45 (1.07)	2.12 (0.84)			
Operational skills	I know how to adjust privacy settings	.708	3.09 (1.34)	3.38 (1.03)	.78	.87	.57
	I know how to connect to a WIFI network	.767	3.73 (0.77)	3.75 (0.69)			
	I know when I should and shouldn't share information online	.834	3.52 (0.90)	3.54 (0.76)			
	I know how to change who I share content with (e.g., friends, friends of friends or public)	.668	3.25 (1.24)	3.32 (1.18)			
	I know how to install apps on a mobile device	.806	3.73 (0.83)	3.75 (0.65)			
Informational skills	I generally compare different websites to decide if information is true	.793	2.13 (0.98)	2.30 (0.85)	.78	.76	.57
	I am confident selecting search results	.835	2.03 (0.93)	2.53 (0.82)			
	I feel confident in my evaluation of whether a website can be trusted	.814	1.81 (0.89)	2.06 (0.87)			
	I use systems to save / share documents in the cloud	.570	2.23 (1.02)	2.37 (0.90)			
Communication skills	I use a wide range of tools for online communication	.780	2.20 (1.00)	2.44 (0.82)	.79	.78	.61
	I am able to actively share information, content and resources through online communities, networks and collaboration platforms.	.791	2.40 (1.03)	2.70 (0.85)			
	I know and apply the set of rules of general behavior on the Internet (e.g., net-labels)	.773	2.29 (1.12)	2.38 (0.96)			
	I am able to manage different digital identities depending on the context and its purpose	.805	2.26 (1.09)	2.42 (0.94)			
Creative skills	I would feel confident putting video content I have created online	.833	2.87 (1.04)	2.80 (0.90)	.69	.81	.53
	I know how to create something new from existing online images, music or video	.856	2.80 (1.05)	2.66 (0.92)			
	I know which different types of licenses apply to online content	.598	2.16 (1.09)	1.93 (0.95)			
	I know how to design a website, blog or wiki	.593	1.79 (1.01)	1.79 (0.84)			
Technology-based activities	How often do you use the Internet for the following activities when you are at school or university?						
	Making presentations	.776	2.71 (1.18)	3.37 (1.20)	.68	.85	.50
	Practising something I am learning	.799	3.25 (1.53)	3.73 (1.27)			
	Checking out information on the school/faculty website	.779	2.99 (1.47)	4.54 (0.91)			
	Doing group work with other students	.583	4,36 (1,54)	4.86 (1.31)			
	Communicating with teachers (e.g., submitting homework or asking a question)	.521	2.39 (1.51)	2,74 (1.05)			
	I look for information on the Internet to carry out the assignments	.742	3.62 (1.56)	4.53 (1.69)			

Note: CR = Composite reliability; AVE = Average variance extracted

Abbreviations

AVE: Average variance extracted; CFI: Comparative fit index; DS: Digital skills; FA: Functional access; ICT: Information and communication technology; IFI: Incremental fit index; MDEeL: Model for Developing Effective e-Learners; OECD: Organization for Economic Cooperation and Development; RMSEA: Root mean square error of approximation; SEM: Structural Equation Modeling; TBA: Technology-based activities; TS: Teacher support.

Authors' contributions

All authors contributed to the study conception and design. Material preparation and data collection were performed by RGR, AHG and PCP. The analysis was performed by RTM and the first draft of the manuscript was written by RTM and JIAG. All authors commented on previous versions of the manuscript, read and approved the final manuscript.

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Declarations

Competing interests
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