

Challenges in the development of digital competence in secondary school teachers

Retos en el desarrollo de la competencia digital en docentes de secundaria escala

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ABSTRACT

Keywords

Digital competence; basic education; ICT; high school teacher

Currently, due to emerging paradigms of teaching and learning as a result of health contingency, digital competence has become a necessity in educational centers. Furthermore, the new teaching role is no longer just that of being a facilitator of face-to-face learning, but now it generates knowledge, communicates and transmits emotions through various virtual environments. This paper has as aim to identify the level of digital competence in secondary level teachers, as well as the factors associated with it. The study has a quantitative approach, with a correlational scope, transactional temporality, with an observational prediction control and a retrospective chronological order of events. As a result of the research, a low level of digital competence was identified among secondary school teachers in Merida, Yucatan, Mexico. There was evidence that the factors that were significantly associated with this competence were age and training in the use of Information and Communication Technologies (ICT). This sets the foundations for the design of teacher training proposals focused on the development of their digital competence.

RESUMEN

Palabras clave

Competencia digital; enseñanza básica; TIC; docente de secundaria

En la actualidad, debido a los paradigmas emergentes de enseñanza y aprendizaje como consecuencia de la contingencia sanitaria, la competencia digital se ha vuelto una necesidad en los centros educativos; a la par, el nuevo rol docente ya no contempla solamente el ser un facilitador del aprendizaje presencial, sino que ahora genera conocimiento, se comunica y transmite emociones a través de los diversos entornos virtuales. El presente artículo tiene como objetivo identificar el nivel de competencia digital del docente de secundaria, así como sus factores asociados. El estudio corresponde a un enfoque cuantitativo, con un alcance correlacional, de temporalidad transeccional, con un control de asignación observacional y un orden cronológico de los hechos. Como resultado de la investigación, se identificó un nivel bajo respecto a la competencia digital en los docentes del nivel secundaria de Mérida, Yucatán, México. También se evidenció que los factores que se relacionan significativamente con el constructo fueron la edad y la capacitación en el uso de las tecnologías de la información y la comunicación. Lo anterior sienta las bases para el diseño de propuestas de capacitación para el desarrollo de la competencia digital.

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INTRODUCTION

In the educational context, information and communication technologies (ICTs) have created the opportunity to reconfigure teaching practice according to the new environments through which knowledge is produced and disseminated. In this area, the teacher represents a key agent for the creation of new strategies that integrate the use of ICTs in the teaching-learning process. Therefore, he or she must be a digitally literate professional, that is, one who has skills, attitudes and knowledge related to the use of technology for the benefit of teaching in face-to-face or online environments (Claro *et al.*, 2018; De Paepe *et al.*, 2018; Llamas and Macias, 2018; Ibrahim *et al.*, 2019; Cabrales, 2020; Varela and Valenzuela, 2020).

In addition, the technological boom that characterizes the knowledge society has led to a proliferation of studies associated with the impact of ICTs in different contexts. In the field of education, it has been of particular interest to know the level of teachers' digital competence, defined as the combination of knowledge, skills and attitudes that they must possess to use technology in the teaching-learning processes (Council of the European Union, 2018) and to identify the strengths and areas of opportunity that the agents responsible for the formative process of students have. As a result of these investigations, it has been determined that teachers still do not reach high levels of digital competence (Falcó, 2017; Martínez *et al.*, 2018; Matamala, 2018).

Likewise, it is important to mention that the way in which this construct has been assessed focuses on self-perception questionnaires (Acosta, 2017; Aguilar and Pérez, 2017) which, although they generate a first approximation to the phenomenon of interest, present a limitation in relation to validity formed by the bias of subjective perception (Acosta, 2017). In addition, the studies have had as their main focus the higher level (Henríquez *et al.*, 2018), a situation that generates the opportunity to evaluate digital competence in basic education, based on a test of maximum execution that, beyond perception, deals with the resolution of cases that evidence the level of mastery of digital technologies.

The objective of this research was to identify the level of digital competence of secondary school teachers, based on a maximum performance instrument, as well as the factors associated with it.

DIGITAL COMPETENCE OF TEACHERS

Digital teaching competence represents a multidimensional concept that involves various areas of mastery in terms of the appropriate use of technologies, ranging from basic digital knowledge and skills to

understanding and using ICTs creatively, critically and safely (INTEF, 2017; Unesco, 2019).

The following is a chronological overview on some frameworks of teaching digital competence that allowed to guide what a 21st century teacher must know and execute to perform successfully in virtual environments. In this regard, Marqués (2000) proposes four dimensions for the development of the competencies required by teachers immersed in digital environments: technical, professional updating, teaching methodology and attitude. Similarly, the United Nations Educational, Scientific and Cultural Organization (Unesco) (2008) proposes three dimensions of digital competence that are presented in a scaled manner: first, basic notions of ICT are acquired, then their use is deepened, and finally knowledge is generated based on them.

Área and Pessoa (2012) establish five areas of digital competence: instrumental, cognitive, socio-communicational, axiological and emotional, in which basic aspects of the use of technologies and their internalization for their ethical use are presented. For its part, the Ministry of Public Education (SEP) (2016), through the @prende 2.0 program, establishes nine digital skills necessary for citizens in our times: critical thinking, creative thinking, information management, communication, collaboration, use of technology, digital citizenship, self-monitoring and computational thinking. In these dimensions, the promotion of understanding of the human, social and cultural issues surrounding the use and exploitation of ICTs stands out. In the same vein, the Common Framework of Digital Teaching Competence of the National Institute of Educational Technologies and Teacher Training (INTEF) (2017) presents five areas of digital proficiency: information and information literacy, communication and collaboration, content creation, security and problem solving.

Finally, in 2019, Unesco made an important update regarding the ICT competencies of teachers, highlighting their importance in pedagogy, curriculum design and learning assessment, in order to reinterpret the curriculum to teach and learn effectively in a knowledge society and devise innovative assessment strategies that allow continuous improvement in the training of students.

After analyzing the various frameworks of digital competencies possessed by teachers, discussed above, it was recognized that there were similarities in the dimensions of technical training and differences in the aspects of responsible and ethical use of ICTs. In this context, the digital competencies that every teacher should develop were obtained and, therefore, the dimensions and indicators that allowed their assessment in this study (see Table 1).

Table 1. Areas of digital competence for teachers

Area of competence	Descripción
Technique	Basic knowledge of computers and computer equipment management
Informational	Efficient search and selection criteria for the content available on the web
Communication	Creation and dissemination of content in the virtual environment Communication and interaction in digital communities
Digital Citizenship	Ethical conduct in relation to the use of ICTs Protection of your own digital devices and content
Pedagogical	Integration of digital resources into teaching practice
Attitude towards ICT	An open and critical attitude towards the information society

Source: Ruiz *et al.* (2021).

Factors associated with teachers' digital competence

The specialized literature has shown that teaching digital competence is not an isolated construct, but is directly linked to other variables (Sandia *et al.*, 2018), such as age, gender, level of schooling and training in the use of ICT.

Age

There are studies showing that as the age of teachers increases, their level of teaching digital competence decreases (Fernández and Fernández, 2016; Valdivieso and González, 2016; Solís and Jara, 2019). Research has also been found that proves that age is not a factor associated with ICT adoption (Hammond *et al.*, 2011; Campos and Ramírez, 2018).

Gender

This factor also presents differences; on the one hand, we identify those studies that refer that men have a higher level of digital competence in contrast to women (Barrantes *et al.*, 2014; Roig *et al.*, 2015; Romero *et al.*, 2016; Cabezas and Casillas, 2017). On the other hand, authors such as Gebhardt *et al.* (2019) state that women demonstrate better mastery in the use of technologies compared to men.

Level of schooling

Empirical evidence has highlighted that the level of schooling of the teacher is linked to his or her level of digital competence. In other words,

the higher their level of schooling, the greater their technological proficiency (Valdivieso and González, 2016; Zempoalteca *et al.*, 2017; Sandia *et al.*, 2018).

Training in the use of ICTs

Various research evidences that training in the use of ICT is related to the level of digital competence of teachers (Laura, 2015; Badia *et al.*, 2015; Zempoalteca *et al.*, 2017), the more trained the teacher is in the area of ICT, the higher his or her level of digital competence.

METHOD

Design

The study is quantitative in approach, as it arose after identifying a research problem, which was intended to be explained through the review of specialized literature and the use of techniques for data collection and statistical analysis (Creswell, 2012). Specifically, the data were compiled through the administration of a measurement instrument with the objective of determining the relationship between the level of digital competence of general secondary school teachers and variables such as age, gender, level of schooling and training in the use of ICT.

In terms of scope, this research is correlational, as it sought to measure the degree of association between the factors: age, gender, level of schooling and training in the use of ICTs, and the level of digital competence of teachers who teach at the secondary level. In relation to the collection and analysis of the information, the study is classified as transectional, due to the fact that it was conducted at a single point in time (Creswell, 2012). In terms of the allocation control, the study is of the observational type since the researcher did not manipulate the variables, only observed, measured and analyzed them. Finally, the research is of the retrospective type, considering that its design was subsequent to the events studied (Argimon and Jiménez, 2004).

Participants

Due to the covid-19 pandemic, which affected the world since March 2020, teachers and students were unable to attend classes in person, which activated the work in virtual mode. Given this inconvenience, a non-probabilistic snowball sample was used, which, according to Cohen *et al.* (2018), is applicable when the researcher has difficulties in accessing and collecting data at the research site. Fifty-two secondary level teachers from Mérida, Yucatán (men and women equally divided) participated in the study.

Participants ranged in age from 20 to 60 years old. Specifically, 36% (n=19) were between 31 and 40 years old; 14% (n=7) between 51 and 60 years old and the remaining 50% (n=26) were distributed between 20 and 50 years old.

With respect to the level of schooling, it was found that most of the teachers (69%) have completed their studies up to the bachelor's degree level. In turn, 23% have a master's degree and the remaining percentage is divided between those who have studied up to the level of university technician (4%) and those who have completed a specialty (2%) or doctorate (2%).

Regarding the use of ICTs, it was found that most teachers (73%) have received some type of training in the area of technology; however, 27% report that they have not.

Instrument

To collect the information and identify the level of digital competence for secondary school teachers proposed by Ruiz *et al.* (2021), an instrument was used consisting of a total of 65 items that inquire about the sociodemographic data of the teachers, as well as the six areas of digital competence previously mentioned. The technical, informational and communication areas are evaluated based on a maximum execution test (PEM), while the dimensions of digital citizenship, pedagogy and attitude towards ICT are assessed based on a typical execution test (PET).

Study variables

Study variables, their conceptualization, the way in which they were operationally considered in the research and the number of items they address are the result of the analysis of the literature review regarding the conceptual construction and definition of the indicators of teachers' digital competence, and the analysis of the associated factors (see Table 2).

Table 2. Specification of study variables

Variable	Conceptual definition	Operational definition	Type of measurement	Reagents
Sex	Biological characteristic that distinguishes people into males and females	Information provided in section I: general data, associated with sex	Nominal	1

Age	Time in years the person has lived	Information provided in section I: general data, associated with age	Ordinal	2
Level of schooling	Highest stage of study a person has attained, according to the national education system	Information provided in section I: general data, associated with level of schooling	Ordinal	3
Training in the use of ICT	Formal, informal or extracurricular activities that aim to generate a change related to teachers' digital competences	Information provided in section II: ICT training, associated with the presence or absence of ICT training and the type of training (formal, informal, extracurricular)	Nominal	4 y 5
Digital Competence	Integration of knowledge, as well as skills and attitudes that allow individuals to function in a computerized society, through the use of ICTs	Information provided in sections III and IV, associated with the dimensions of digital literacy (technical, informational, communicative, digital citizenship, pedagogy and attitude towards ICTs)	Ordinal	6 al 65

Regarding the psychometric tests, at a first level, content validity was carried out through the judgment of four experts in technology in order to elaborate a punctual evaluation of the instrument (Skjong & Wentworth, 2000). The modifications included: precise wording of the instructions for each section of the instrument, precision of the answers to the sequential ordering items of the PEM and spelling correction of some of the PET items.

Next, the reliability test was performed, associated with the accuracy or consistency of the results obtained in the relevant instrument.

of the results obtained in the same measuring instrument (Kerlinger and Lee, 2002). In this sense, internal consistency was used based on the Cronbach's alpha measure to guarantee the reliability of the instrument, which reported a value of 0.91. Specifically, the reliability obtained in each dimension was: 0.71 technical dimension, 0.70 informational dimension, 0.72 communicative dimension, 0.74 digital citizenship dimension, 0.85 pedagogical dimension, and 0.85 ICT attitude dimension.

Since each dimension obtained a coefficient equal to or higher than 0.70 (Argimon and Jiménez, 2004), the instrument designed was considered reliable.

Data collection

The procedure to obtain the information is described below:

- 1) Arrangements were made with the SEP to express interest in conducting the study in various secondary level institutions in the city of Mérida, Yucatán, in order to gain access to them.
- 2) The directors of the participating institutions were provided with the electronic address so that the teachers could access the instrument in digital format.
- 3) The managers of the selected institutions sent the link of the instrument to the teachers. It was ensured that the instrument had an informed consent form that allowed the participants to know the purpose of the study. Through this document, the teachers accepted or refused to collaborate in the research based on a dichotomous question that could be answered as: "Yes, I accept to participate in the study" or "No, I do not accept to participate in the study".

Data analysis

Data analysis was carried out using the JAMOV program. To determine the level of digital competence, two procedures were applied; in the first, a score between 0 and 100 was given to each participant according to their answers: for the PEM, the total number of correct answers in relation to the total number of questions was considered. In the case of the PET, since a Likert scale was used with ranges between 1 and 5, the formula described below was used

$$\text{Calificación} = \left(\frac{\sum_{i=1}^K I_j - \overline{\text{mín}}}{\overline{\text{máx}} - \overline{\text{mín}}} \right) \times 100$$

Where:

Donde:

I_j = la puntuación en cada ítem

$\overline{\text{mín}}$ = el valor mínimo de la suma

$\overline{\text{máx}}$ = el valor máximo de la suma

As part of the second procedure, the grading scale proposed by Ruiz *et al.* (2021) was used, which considers the following:

- Level 0 to 60% of correct scores: has a low level of digital competence.
- Level 61 to 80% of correct answers: medium level of digital competence.
- Level 81 to 100% of successes: has a high level of digital competence.

To identify the factors associated with digital competence, two tests of association were used. In the case of the variables sex and training in the use of ICTs, the point biserial test was run, which is employed in dichotomous variables (Corder & Foreman, 2014).

For the variables age and level of schooling, Spearman's coefficient was used, also known as ordered ranks, which represents a measure of correlation between ordinal variables (Pérez, 2008). Finally, the multiple linear regression model was used to determine whether the variables age, sex, level of schooling and ICT training were jointly significant in predicting digital competence.

Ethical considerations

In adherence to the Code of Ethics of the American Educational Research Association (AERA) (2011), this research guaranteed the anonymity of the participants, as well as the integration of an informed consent stating the objectives and scope of the study.

RESULTS

As part of the descriptive analysis, the results obtained in each of the dimensions of teaching digital competence considered in this study are described below, followed by the overall score with respect to the assessed construct.

Dimensions of the digital competence of teachers

Technical dimension

According to Figure 1, 73% of the items concerning the technical dimension were answered correctly by most of the participants, while 27% were answered incorrectly. In particular, it is evident that the items answered incorrectly by most of the teachers correspond to the performance of tasks in the main office automation programs.

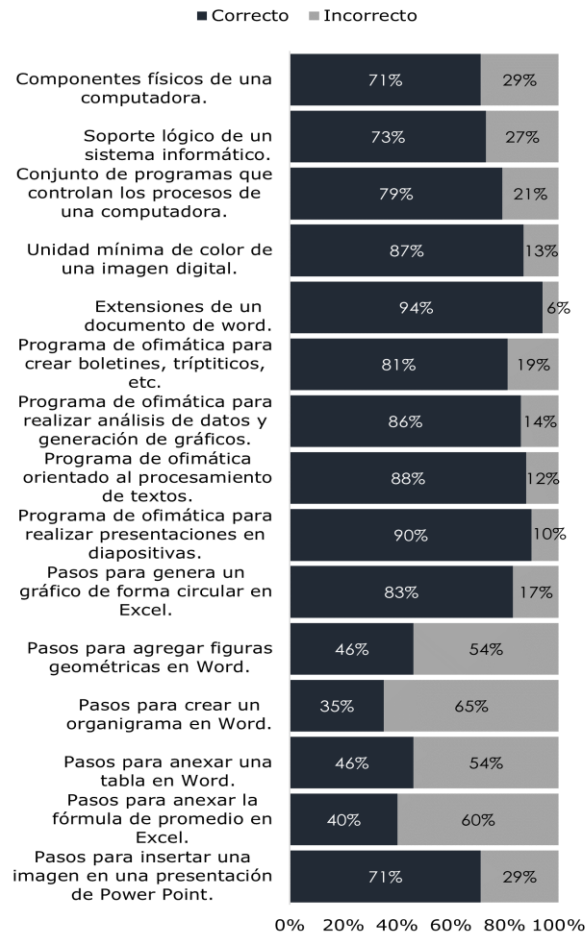


Figure 1. Technical dimension.

Information dimension

Graph 2 indicates that 72% of the items were answered incorrectly by the majority of the teachers. Meanwhile, 28% was distributed between the item that was answered correctly by most of the participants (14%) and the item that obtained half of the correct and incorrect answers (14%). Specifically, it was identified that teachers do not know the criteria and strategies for the effective search and selection of information in digital media.

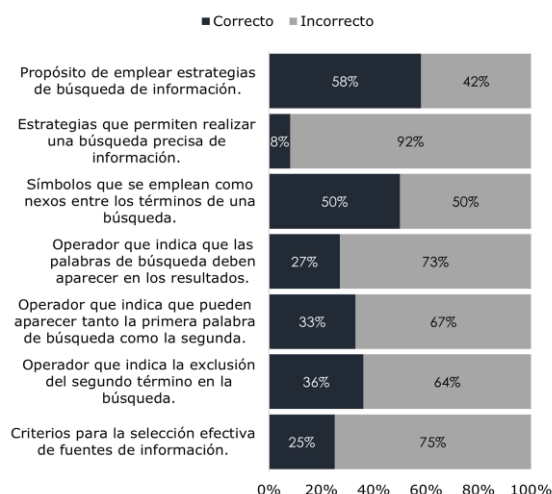


Figure 2. Informational dimension.

Communicative dimension

Graph 3 shows that 38% of the items were answered correctly by most of the teachers; however, 62% did not answer correctly. Specifically, it can be seen that teachers do not know the tools that allow participation in discussion forums, as well as the software for audio and video editing.

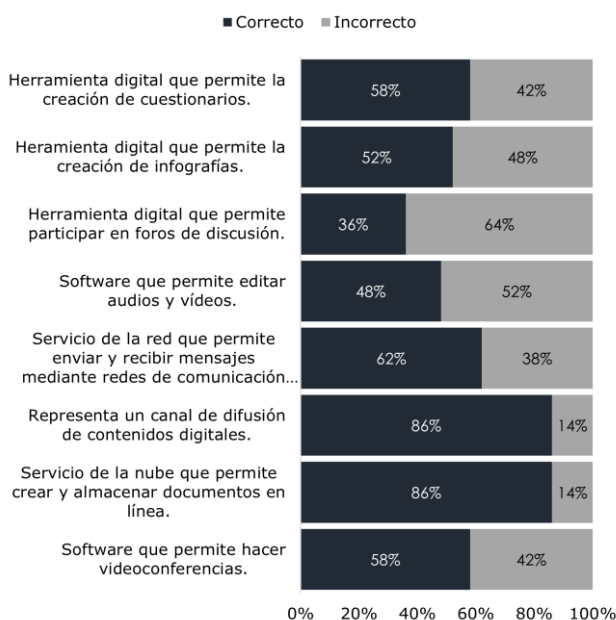


Figure 3. Communicative dimension.

Digital citizenship dimension

Of the teachers' responses on the high scale (almost always and always), 72% frequently carry out activities in compliance with ethical and legal conduct in relation to the use of ICTs, and with the protection of their own digital devices and content (see Graph 4).

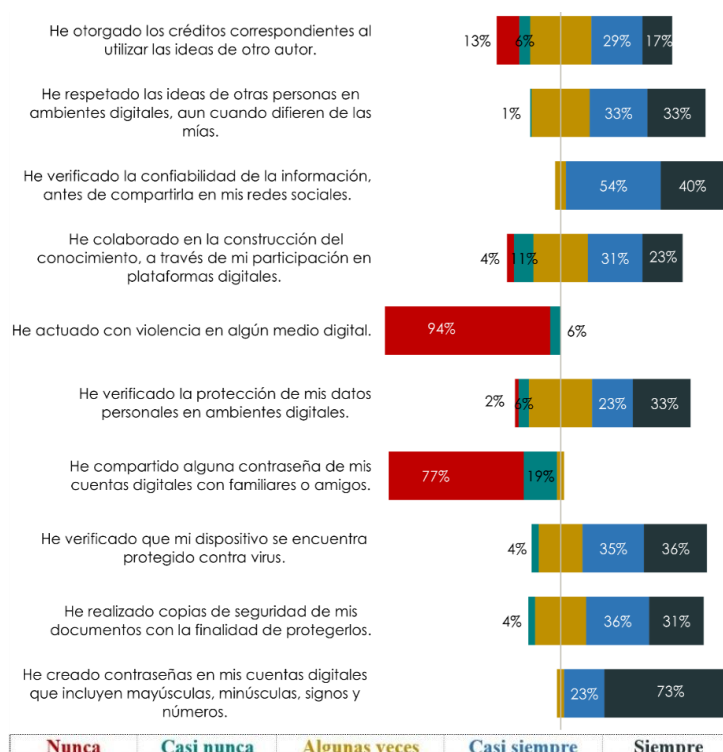


Figure 4. Digital citizenship dimension.

Pedagogical dimension

From the response of teachers in the high scale (almost always and always), 40% show that they carry out activities associated with the integration of digital resources in teaching practice, such as designing digital tools for visual representation, using open educational resources, consulting content in digital sources and promoting the creation of digital content in students with a high degree of frequency. Likewise, it is evident that the creation of videos and other types of digital content, the design of questionnaires and the promotion of the search for information in reliable digital sources to students are activities that teachers occasionally carry out, while the use of videoconferences is a strategy that is rarely used (see Graph 5).

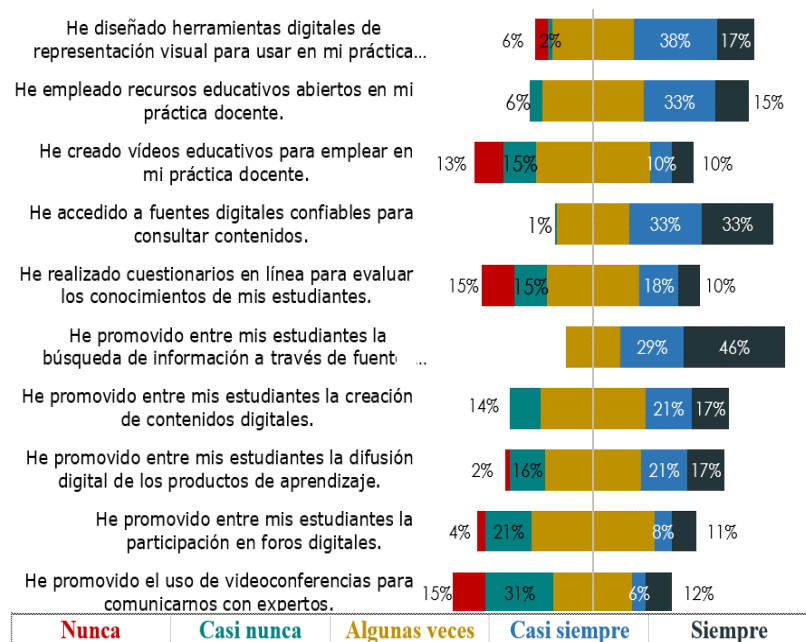


Figure 5. Pedagogical dimension.

Attitude to ICT dimension

The 42% of the teachers' answers in the high scale (almost always and always) show that they maintain an open and critical attitude towards today's society. Specifically, the use of digital resources to explore topics of interest in today's world and the autonomous consultation of videos for the benefit of professional practice stand out, while the self-evaluation of digital competencies, ICT training, the use of digital resources to explore topics of interest or contribute to the solution of a problem in the workplace and the reflection of the information provided on the network are activities that are sometimes performed (see graph 6).

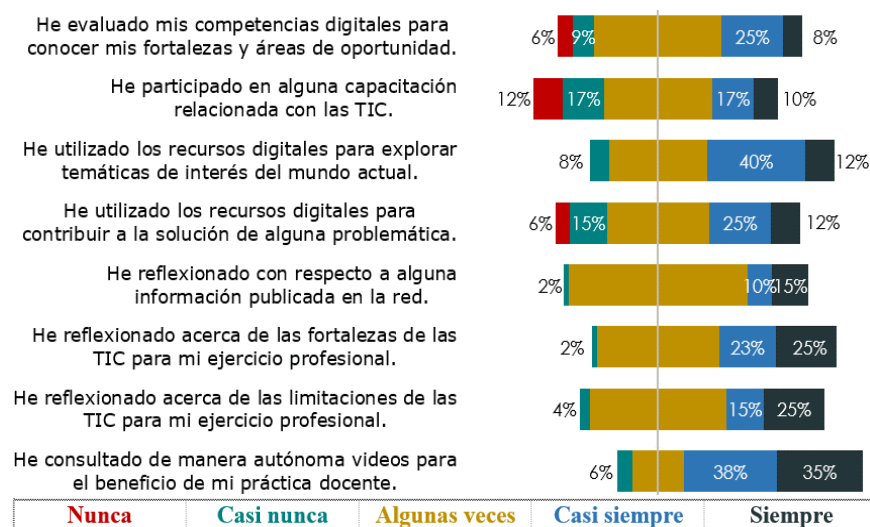


Figure 6. Attitude to ICT dimension.

Level of digital competence of teachers

Based on the scale described in the methodology section, it was found that most of the participants (60%) have a low level of teaching digital competence (see Graph 7).

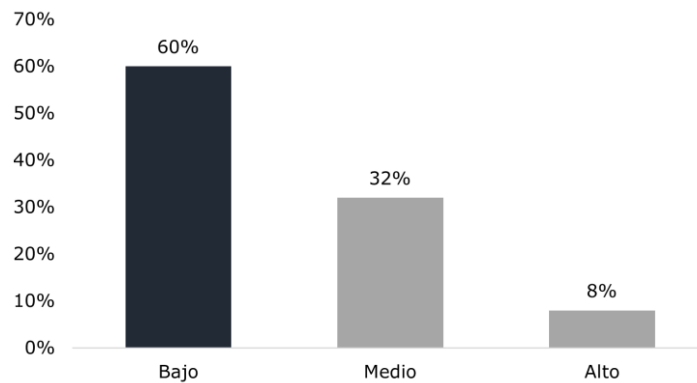


Figure 7. Level of digital competence of teachers.

To analyze the relationship between the level of digital competence and the factors with which it is linked, two tests of association were performed: 1) Spearman correlation, for age and level of schooling; and 2) point biserial correlation, for gender and training in the use of ICT.

As can be seen in Table 3, there are two factors that have a significant relationship with the level of digital competence ($P < .05$): 1) age, which was inversely associated with digital competence, i.e., younger teachers have a higher level of digital competence than those of older ages; and 2) receiving training, directly associated with higher digital competence.

Table 3. Correlation between the level of digital competence and associated factors

Variables	Correlation	Significance
Age	-.485	<.001
Sex	-.184	.096
Level of schooling	.183	.098
Training in the use of ICT	.450	<.001

To consolidate the analyses of the relationship between the factors, we sought to determine whether the variables age, sex, level of schooling and training in the use of ICTs were jointly significant in predicting digital competence. For this purpose, multiple linear regression was used. The results indicate that the resulting model was significant ($F(4,47)=8.79$, $p<.001$) and explained up to 37.9% of the level of digital competence. The model had no problems of normality, homoscedasticity or multicollinearity. As can be seen in Table 4, again the only variables that were significant were age and receiving training.

Table 4. Digital Competence Prediction Model

Predictor	Beta	Standard Error	p	Standardized coefficient	I.C. 95%	
					Inf.	Sup.
Intercept	65.543	5.38	< .001			
Being a woman	-4.43	2.61	.096	-.376	-.823	.069
Age	-5.207	1.32	< .001	-.439	-.664	-.215
Level of schooling	.820	1.41	.563	.067	-.164	.298
Get trained	9.766	3.01	.002	.830	.316	1.345

DISCUSSION

The research findings show that secondary level teachers have a low level of digital competence, which coincides with the studies of Falcó (2017), Martínez *et al.* (2018) and Matamala (2018), where it is evident that teachers still do not reach high levels in the use of ICT.

The association of certain variables with the construct studied was identified. One of these is age, which is inversely related to teachers' digital competence; that is, younger teachers have a higher level of digital proficiency than those of older ages. In this regard, Fernández and Fernández (2016), Valdivieso and Gonzáles (2016) and Solís and Jara (2019) agree that younger teachers are characterized by being more competent in the use of ICT than older teachers. Likewise, it was recognized that training in the area of ICT represents a determining factor in the level of digital competence: the more training, the higher the level of proficiency. This finding coincides with Laura (2015), Badia *et al.* (2015) and Zempoalteca *et al.* (2017), who state that the more trained the teacher is in the area of ICT the higher his or her level of digital competence.

According to the results of this study, gender is not significantly related to the level of teachers' digital competence, which suggests that both men and women are capable of developing digital skills to the same extent. This finding disagrees with that mentioned by Barrantes *et al.* (2014), Roig *et al.* (2015), Romero *et al.* (2016) and Cabezas and Casillas (2017), who establish that men have a higher level of digital competence in contrast to women; in turn, these results differ from the study by Gebhardt *et al.*

(2019), where it is shown that women have a better command in the use of technologies.

Similarly, it was identified that the level of schooling has no relationship with the level of teachers' digital competence; this report disagrees with the results of Valdivieso and Gonzáles (2016), Zempoalteca *et al.* (2017) and Sandia *et al.* (2018), who show that the higher the level of schooling, the higher the level of digital competence.

CONCLUSIONS

This research shows that the general level of secondary school teachers in Merida was assessed as low. In the technical dimension, it is important to continue developing skills to execute advanced office automation functions, which imply a sequence of steps, such as the automation of the content of a scientific paper. Regarding the informational dimension, it was evidenced that teachers do not know the purpose of using information search strategies, as well as those criteria that contribute to the effective selection of information sources in digital media, which are vital for the construction and dissemination of knowledge.

In addition, in the communicative dimension, it was demonstrated that they do not know the tools that allow them to participate and interact in discussion forums and build multimedia resources through the edition of audios and videos. In contrast to the weaknesses found in the previous factors, in dimensions such as digital citizenship, it is identified that teachers carry out, with a high degree of frequency, activities in compliance with ethical and legal conduct in relation to the use of ICTs, as well as the protection of their own devices and digital content. In the pedagogical part, they integrate digital tools in the teaching-learning process through different strategies (visual representation tools, design of questionnaires, creation of educational videos, among others); finally, in the dimension of attitude towards the use of ICT, teachers perceive constant training in the use of technology as an area for improvement.

The findings show that teachers' digital competence is not an isolated construct, but is associated with different factors that are necessary for its consolidation. In particular, it was found that age is a factor that has an inverse relationship between the education professional and the mastery of digital media, while ICT training maintains a direct relationship.

Finally, this study sought to have a first approach to deepen the digital competence of teachers in Merida, Yucatan along with the factors associated with the construct. Therefore, and based on the results obtained, it is necessary to design and implement training programs based on the dimensions assessed, so that teachers continue to develop their digital competencies, in order to appropriate new technologies for the benefit of their professional practice.

At the same time, it opens the panorama for future quantitative research in which diverse teachers of the secondary level of all the localities of the state of Yucatan are involved in order to obtain generalizable results; in addition, this study is a starting point for qualitative research that allows to deepen through multiple data collection techniques the reason why the teachers who participated in the study obtained a low level regarding their digital competence.

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