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Level of digital competencies in students of Information and Communication Technologies (ICT) at an Ecuadorian university

Nível de competências digitais em estudantes de tecnologias da informação e comunicação em uma universidade equatoriana

Nivel de competencias digitales en estudiantes de la carrera de tecnologías de la información y comunicación en una universidad ecuatoriana

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Emphasize integration of digital competency development throughout ICT curricula, employing strategies from the outset to enhance student proficiency. The insights presented may help teachers and educational managers make better decisions.
Originality/value:
Using original empirical evidence, the article highlights the necessity for tailored digital competency programs within technical education, acknowledging variance in student proficiency despite their academic focus.

ABSTRACT

The present research consists of an exploratory study on student digital competencies. The objective is to analyze the level in its five areas: information, communication, content creation, security and problem solving, in students of the subject 'Computer Projects' of the ninth cycle of the systems engineering career of the Technical University "Luis Vargas Torres" of Esmeraldas. The research had a quantitative approach, with a non-experimental design and two intact groups. As an instrument, a test called "Ikanos", for testing digital competencies of universal character and validated in university students in Europe and Latin America. The results showed that the two groups are not equivalent and have an Intermediate level. This indicated that, despite being students of the ICT career, they could not be placed mostly in Advanced and Expert level. It is concluded about the need to include the development of digital competence as a fundamental element throughout the academic curriculum, from the beginning of the career of Information and Communication Technologies of UTLVTE, implementing strategies, from the first academic cycle, in the career.

Keywords: Digital competence, Virtual environment, Information and communication technologies (ICT), Education, Ecuador.

RESUMO

Esta pesquisa consiste em um estudo exploratório sobre as competências digitais dos alunos. O objetivo é analisar o nível em suas cinco áreas: informação, comunicação, criação de conteúdo, segurança e resolução de problemas, em alunos da disciplina "Projetos de Computação" do nono ciclo do curso de Engenharia de Sistemas da Universidade Técnica "Luis Vargas Torres" de Esmeraldas. A pesquisa teve uma abordagem quantitativa, com um projeto não experimental e dois grupos intactos. O instrumento utilizado foi um teste chamado "Ikanos", um teste universal de competências digitais validado em estudantes universitários na Europa e na América Latina. Os resultados mostraram que os dois grupos não são equivalentes e têm um nível intermediário. Isso indicou que, apesar de serem estudantes de TIC, eles não conseguiram se colocar principalmente nos níveis Avançado e Especialista. Concluímos sobre a necessidade de incluir o desenvolvimento da competência digital como um elemento fundamental em todo o currículo acadêmico, desde o início do curso de Tecnologias da Informação e Comunicação da UTLVTE, implementando estratégias, desde o primeiro ciclo acadêmico, no curso de graduação.

Palavras-chave: Competência digital, Ambiente virtual, Tecnologias da informação e comunicação (TIC), Educação, Ecuador.

RESUMEN

La presente investigación, consiste en un estudio exploratorio sobre competencias digitales estudiantiles. El objetivo es analizar el nivel en sus cinco áreas: información, comunicación, creación de contenido, seguridad y resolución de problemas, en estudiantes de la asignatura 'Proyectos Informáticos' del noveno ciclo de la carrera de ingeniería de sistemas de la Universidad Técnica "Luis Vargas Torres" de Esmeraldas. La investigación tuvo un enfoque cuantitativo, con diseño no-experimental y dos grupos intactos. Como instrumento, un Test llamado "Ikanos", para comprobación de competencias digitales de carácter universal y validado en estudiantes universitarios de Europa y Latinoamérica. Los resultados mostraron que los dos grupos, no son equivalentes y tienen un nivel Intermedio. Esto indicó que, a pesar de ser estudiantes de la carrera de TIC, no pudieron ubicarse mayoritariamente en nivel Avanzado y Experto. Se concluye sobre la necesidad de incluir el desarrollo de la competencia digital como un elemento fundamental a lo largo de todo el currículo académico, desde el inicio de la carrera de Tecnologías de la Información y Comunicación de la UTLVTE, implementando estrategias, desde el primer ciclo académico, en la carrera.

Palabras clave: Competencia digital, Entorno virtual, Tecnologías de la información y comunicación (TIC), Educación, Ecuador.

INTRODUCTION

In Ecuador, the city of Esmeraldas is located in the north, on the border with Colombia, in a small and low-income province in the national context. It is home to the Universidad Técnica Luis Vargas Torres de Esmeraldas (UTELVT), a public university created in 1970, which serves a total of approximately 8,000 students per semester in its five faculties: Faculty of Engineering, Faculty of Social Sciences and Services, Faculty of Administrative and Economic Sciences, Faculty of Agricultural Sciences and Faculty of Pedagogy. It also has an extension located in La Concordia (Santo Domingo de los Colorados).

With the emergence of COVID-19, caused by SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus), in December 2019, in Wuhan, China, a pandemic with high transmission speed began (Sorooshian, 2020; Yi et al., 2020), which forced the government of Ecuador to make the forced decision to move teaching to virtual scenarios.

In the city of Esmeraldas, given the socioeconomic situation of the students and the limited experience of the teachers in working in virtual environments and ICT tools, the implementation of distance learning academic activities has not been carried out in a planned manner for this type of education.

It has been observed that teachers have made the transition to ICT-mediated teaching without adequate planning and with limited use of specific strategies for the virtual environment. In many cases, they have sought to replicate in some way what was done in the physical classroom without fully adapting to the virtual environment.

The creative, critical and safe use of ICTs is indispensable for the achievement of objectives related to the use of leisure time, learning, work, inclusion and participation in society (Villarreal-Villa et al., 2019). Digital competencies also facilitate other teamwork skills, such as metacognition, stimulation of creativity and innovation, and contribute to intellectual dialogue.

Since 2008, the School of Engineering implemented the Computer Systems Engineering program in response to the needs of the citizens of Esmeraldas, who had to migrate to other cities to obtain a degree in this area. The ICT career, currently has about 600 students per academic period.

Given the recent implementation of the Information and Communication Technologies program at UTELVT, it has not yet been explored how professional competencies are being developed in students. Nor has it been studied whether the strategies used by teachers are promoting that students are able to use ICTs to continue learning autonomously throughout their lives. Technology is not neutral since it develops in the social and economic environment, and these factors, in addition to impacting and molding technology, also affect individual choices as demonstrated by previous studies in the same context of the UTELVT (Toala Ponce, et al., 2024).

In addition to the professional competencies of the career, it is necessary to promote digital competencies in students, which allow them to continue learning throughout their lives. Currently, studies show that, both in students and teachers, digital competencies are a very relevant issue, becoming a real challenge for educational systems, in addition to their contribution to the development of the knowledge society (Gómez-García et al., 2020; Sánchez-Caballé et al., 2020).

In view of the above, the following question arises:

What is the level of digital competencies achieved by the students of the ninth cycle of the Information and Communication Technologies career in the subject 'Computer Projects', in the five areas, during the II academic period of 2021 at the Luis Vargas Torres Technical University of Esmeraldas?

Educational scenarios are undergoing significant changes globally, driven both by technological advances and the need to adopt distance modalities and make use of Information and Communication Technologies (ICT), especially in the wake of the COVID-19 pandemic. However, many teachers lack adequate training to enable them to adapt quickly and effectively to these changes. Often, they have not yet developed effective instructional methodologies in virtual environments for the specific subjects they teach.

The results of this research can contribute with knowledge of the reality of engineering students in terms of their digital competencies. It can also provide knowledge, adjusted to the Ecuadorian university reality, to promote the use of methodologies in virtual environments for the development of digital skills required in a changing world.

Thus, the general objective is to analyze the level of digital competencies in the five areas: information, communication, content creation, security and problem solving, in students of the subject "Computer Projects" of the ninth cycle of the Information and Communication Technologies career at the Luis Vargas Torres Technical University of Esmeraldas.

Literature review

Education and ICT

For Area and Pessoa (2012), a digitally literate individual is one who has built a digital identity as an autonomous, educated citizen with democratic values, through continuous learning in formal and informal contexts with ICTs. They argue that there are five major dimensions involved in the learning, acquisition and development of digital competencies: cognitive, instrumental, socio-communicational, axiological and emotional.

Table 1 provides a series of definitions of the concept of digital competence offered by various authors. In these definitions, one common point stands out: the importance of a confident and critical approach to the use of Information and Communication Technologies (ICT). This perspective is essential for carrying out a variety of tasks, ranging from collaboration to knowledge construction and effective problem solving.

Table 1. Definitions of Digital Competence (DC)

Definition	Author
Critical and safe use of Information Society Technologies for work, leisure and communication. Relying on basic ICT skills: use of computers to retrieve, evaluate, store, produce, present and exchange information, and to communicate and participate in collaborative networks through the Internet (p.6).	European Parliament and the Council, (2006)
It is a group of combined elements (knowledge, skills, abilities and capacities) that are mobilized and integrated by virtue of a series of personal attributes, in concrete contexts of action (p.11).	Pavié (2011)
Values, beliefs, knowledge, skills and attitudes to adequately use technologies, including computers, software and the Internet, which allow and enable the search, access, organization and use of information in order to build knowledge (p. 202).	Gutierrez (2011)
Set of tools, knowledge and attitudes that intervene in the technological, communicative, media and informational fields that make up a complex and multiple literacy (p.13).	Gisbert, González and Esteve (2016).
Safe and critical use of information society technologies. Taking into account that the capacity for critical management of information is of greater importance in virtual environments, which demands that people must have the necessary skills to access databases on the Internet (p.3).	Revolt (2011)
Students' ability to deal critically and reflectively with academic and social situations in a digital environment (p.57).	Universidad de la Sabana (2015).
Safe and critical use of information society technologies for work, leisure and information (p.5)	European Commission (2007)
The sum of all the skills, knowledge and attitudes in technological, informational, multimedia and communicative aspects, which give rise to a complex multiple literacy (p.8).	Gisbert and Esteve (2011)
It is one that involves the creative, critical and safe use of ICTs in order to achieve objectives related to work, employability, learning, use of leisure time, inclusion and participation in society. In addition to the adaptation to the changes introduced by new technologies in literacy, reading and writing, a new set of knowledge, skills and attitudes needed today to be competent in a digital environment (p.10).	Ministry of Education, Culture and Sport, Spain (2015).
Specific set of tools and applications required when using ICTs and digital media to perform tasks, solve problems, communicate information, manage information, collaborate, create and share content; and build efficient and effective knowledge, in a critical, autonomous, reflective way, for work, participation, learning and socialization (p.32).	Ferrari (2012)

Source: own elaboration with the specialized literature

One of the most recognized models in the field of digital competence is the one formulated within the DIGCOMP project (Ferrari, 2013). This project establishes a common reference framework for digital competencies, with the purpose of promoting their development in Europe. The proposed model encompasses five fundamental dimensions, detailed in Table 2.

Table 2. Summary of the DIGICOMP Digital Competence Model (González, Román and Prendes, 2018, p.6).

DIGCOM MODEL		
Description	**Dimensions**	
Digital competence model structured in five dimensions, five areas and 21 competencies.	Dimension 1	Five Areas: Information, communication, content creation, security, problem resolution
	Dimension 2	21 competencies
	Dimension 3	Three levels of competence: Basic, Intermediate and Advanced.
	Dimension 4	Examples of Knowledge, Skills and Abilities.
	Dimension 5	Two levels of competence application.

Note: Ikanos Project of the Basque Government. http://www.innova.euskadi.eus/v62-ikanos2/es

This approach is based on a holistic understanding of digital competence, which encompasses knowledge as well as skills and attitudes. From this holistic perspective, five broad competency areas are identified, as presented in Table 3. These areas in turn are broken down into a total of 21 specific competencies, reflecting the complexity and breadth of skills required in the contemporary digital environment.

Table 3. Areas and competencies of the DIGCOMP Model of Digital Competencies

Areas	Competencies
Information	Browse, search and filter information
	Evaluate information
	Saving and retrieving information
Communication	Interact through technology.
	Sharing information and content
	On-line citizen participation.
	Collaborate through digital channels.
	Managing digital identity
	Netiquette
Content creation	Develop, integrate and redesign contents
	license and copyright
	Programming
Security	Device protection
	Personal data protection and digital identity.
	Health protection
	Environmental protection
Troubleshooting	Technical troubleshooting.
	Identification of needs and technological responses
	Innovation and creative use of technology
	Identification of gaps in digital competencies

Note: based on (Aristizabal and Cruz, 2018, p.99).

Technology together with its contributions, give way to the evolution and transformation of the areas of knowledge in an accelerated manner, giving value to education, as a discipline to take on new challenges that achieve a more thorough study (Herrera, 2015). In this sense, for Granados (2015) the use of ICT leads to a change of traditional media such as paper, pencil and blackboard, advancing in the updating of methods and didactic means according to the needs of today.

Difficulties can be overcome by explicitly planning the use of the chosen ICTs and valuing the continuous effort required from students. The most technologically skilled professionals use ICT more frequently in the classroom, introducing greater changes in their teaching practice (Echegaray, 2014).

Carrera and Coiduras (2012) propose that digital training should be based on four axes:

1. Telematic tools. Use of tools for collaborative work in network and web 2.0 tools for electronic edition in network.
2. Edition of digital documents. Creation of documents applying the multimedia language, in diverse digital formats and supports. Efficient presentation of multimedia information through specific devices.
3. Networked information resources. Use of aggregators and social bookmarks for network information management. Access to professional resources and specific online spaces related to the training provided.
4. Ethical, legal and safe use of the network. Application of strategies for the safe use of networks. Acting respectfully preserving the privacy rights of individuals in the activity carried out on the Internet. Ethical and legal use of digital information.

Research background

Rincón (2018) analyzed the development process of student digital competencies, in educational spaces mediated by ICT, to understand the educational process in a comprehensive manner. He conducted a quantitative research with a descriptive scope, through the application of a Likert-type scaling questionnaire, which was applied to 98 cases of the first grade, because they took the subjects: ICT in education and Information Technologies, applied to schools.

It was found that the appropriation in the use of ICTs by students was concentrated to a greater extent in the element of knowing, where they recognize the benefits and implications of the use of ICTs for accessing and searching for quality information in an educational scenario. Students showed a positive attitude towards the achievement of their digital

competencies through ICT-mediated educational scenarios.

González, Román and Prendes (2018) carried out a training proposal in digital competencies for university students, based on a task-based learning method. The students carried out five tasks with a duration of two weeks each, linked to one of the dimensions of digital competence, within the framework of the DIGCOMP model: 1) Content curation. Area: information. 2) Safe use of the Internet. Area: security. 3) Development of infographics. Area: content creation. 4) Network communication plan. Area: communication. 5) Practical cases. Area: problem solving.

A self-diagnostic digital questionnaire was applied, developed in the Ikanos project, promoted by the Basque Government and based on the European Framework for Digital Competence as a pretest and posttest assessment (European Commission, 2006 and 2016). After evaluating the experience, it was found that students acquired digital competences and expressed their satisfaction with the applied methodology.

Roig and Pascual (2012) from the University of Alicante, based on a previous work by Guzmán (2008), analyzed the digital competence of student teachers, including the areas of computer use, use and frequency of use of ICT and basic competencies in ICT use. Their objective was to know the digital competencies, in terms of the use and mastery of ICT, by future teachers. They developed a questionnaire on Digital Basic Competences 2.0 of University Students (COBADI), which included the general use of the Internet and ICT for communication, collaboration, search and processing of information; interpersonal competences to use ICT at the university and virtual and social communication tools at the university. As a data collection tool, the questionnaire validated by Guzmán (2008), Use of ICT in university students, was used. In general, the results obtained show a good level of use and mastery of ICT tools, as well as a good level of digital competence.

Gisbert, Espuny and González (2011) developed the Inventario de Competencias TIC (INCOTIC) questionnaire, a tool specifically aimed at self-assessing the digital competence of university students. This questionnaire has six blocks: a) identification data; b) access to digital resources; b) actual degree of ICT use in general; c) training in ICT or through ICT; d) self-perception of their ICT competence, understood as technological literacy and f) a section on their attitude towards ICT, posing various situations and contexts of application so that they can express their opinion.

After the piloting process of the instrument, in which 50 subjects participated, its degree of reliability was calculated, determining Cronbach's Alpha coefficient, which was equal to 0.932. The authors concluded that the INCOTIC-Grado tool is only one of the many steps that must be taken to ensure that their students, at the end of their undergraduate studies, have acquired sufficient levels of digital competence, which must be demanded of a university graduate in the 21st century, and which the labor market already requires of any professional.

Albertos, Domingo and Albertos (2016) conducted a research, whose purpose was the development of digital competence in the university classroom, through the work methodology of action research. The research was framed in the qualitative paradigm and in a multimodal perspective, in the use of instruments. Two strategies were used to instruct students in the professionalized use of social networks and the Internet: one formative and the other practical. The first consisted of a theoretical session on the professional use of the Internet and social networks, and corresponded to the phase of reflection on digital competence. The second was the action plan, which was based on the voluntary creation of a personal blog by the students.

The students were able to develop the capabilities and resources necessary to channel their digital knowledge and skills towards a use more related to their professional careers. The authors concluded that training oriented to the development of digital competencies should be both theoretical and practical, as well as functional. That is, applicable to the academic context and transferable to any other extra-academic context, especially to areas related to their professional future

METHODOLOGY

The research had a quantitative approach, with a non-experimental design and two intact groups of the subject "Computer Projects" of the ninth period of the Information and Communication Technologies career. Regarding digital competences, a pretest was carried out for both groups.

The study population comprised all students enrolled in the subject "Computer Projects", belonging to the Information and Communication Technologies career at the Luis Vargas Torres Technical University of Esmeraldas, corresponding to the ninth level of the second academic period of 2021.

Table 4 summarizes the fundamental characteristics of this subject within the course curriculum. Although it was originally designed as a face-to-face course, due to the circumstances generated by the pandemic, it was adapted to a distance learning modality making use of Information and Communication Technologies (ICT).

Table 4. Characterization of the subject "Computer Projects" (Syllabus "Computer Projects" UTLVTE, 2016, p.2).

IT Projects	
Career Semester	9th
Modality	On-site
Credits	3
Hours	120
Students	30 per parallel

Source: own elaboration with the research data

The sample consisted of a total of 73 students, comprising both genders and distributed in two parallel courses: 9A and 9B. For this purpose, a full sample of the total population was used. The distinctive demographic characteristics of both sections are condensed in Table 5.

Table 5. Characterization of the courses of the subject "Computer Projects" (II-2021)

Students	**Group (9A)**	**Group (9B)**
Men n (%)	25 (75.53%)	22 (56.41%)
Women n (%)	9 (26.47%)	17 (43.59%)
Total (n)	34	39
Age (years)		
Average (*X*)	23.47	25.0
DE	3.12	4.35
Range	21-34	21-36

Source: own elaboration with the research data

Variables

Demographics

Two uncontrolled variables were measured in the students: age (years at the beginning of the course "Computer Projects") and sex (two categories, male and female).

As this was a non-experimental research design, it had only one variable, which is digital competencies.

Techniques and Instruments

To measure the level of digital competencies of the students, a self-diagnostic questionnaire was used, elaborated in the Ikanos project of the Basque Government, based on the European DC Framework (European Commission, 2006 and 2016, for which, permission for use was obtained from its authors. The test consists of 26 items, distributed in five areas and 21 competencies. The instrument has been previously used in universities in Spain, Europe, Mexico, Colombia, Peru, and Chile.

This instrument was previously used by the author, in an exploratory study with students of the subject "Computer Maintenance", belonging to the same career, of Information and Communication Technologies of the UTLVTE (Rentería, 2021), where a Cronbach's alpha was reported, for the entire questionnaire of α = 0.942. This showed that it is a highly reliable instrument.

In the current research, to determine the level of reliability of the questionnaire, Cronbach's Alpha coefficient was calculated. The formula for its calculation was as follows:

$$\alpha = \frac{k}{k-1}\left[1 - \frac{\sum Vi}{Vt}\right]$$

K=Number of items of the instrument.

$\sum Vi$=Sum of the variances of each item.

Vt=Total variance.

In the research, the instrument showed high reliability for the data, in the Pretest its Cronbach's alpha, was α = 0.94 and in the Posttest it was α = 0.95, for the whole questionnaire. This indicates that it is a highly reliable instrument.

RESULTS AND DISCUSSION

To explore digital competencies, the test developed by the IKANOS group based on the DIGCOM model was applied at the beginning and at the end of the academic period. For group 9A of the 34 students, 32 (94.11 %) answered both the pre-test and post-test, while for group 9B, there were 33 students (84.61%) of the 39 participants This was the sample used for the comparison of both groups.

When comparing the pretest means of digital competencies of the intact groups, it was found that the group corresponding to 9A presented a higher mean than group 9B, statistically significant in the two-tailed t-student test for unpaired samples, both in the total ($p=0.005$) and in each of the areas ($p<0.05$), except for the area of communication ($p=0.1467$) (See Table 6).

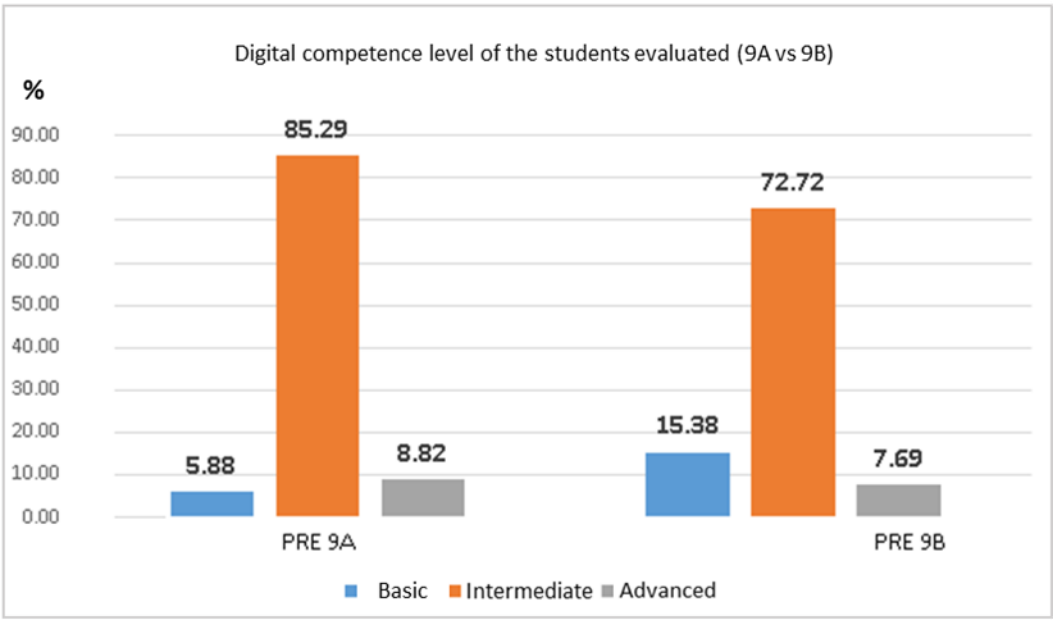
Table 2. Pretest comparison of group 9A vs. group 9B.

Digital Competence	**Groups**				**Student's t-test**	
	(9A) n=33		**(9B)** n=34			
Field	***M***	***DE***	***M***	***DE***	***gl***	***t***
Information	5.05	2.15	3.39	2.18	64	-3.27*
Communication	5.49	1.76	4.82	1.92	64	-1.59
Content creation	5.10	1.80	3.50	2.06	64	-3.44**
Security	6.69	1.53	5.85	1.67	64	-2.21*
Troubleshooting	5.41	1.75	4.26	2.14	64	-2.46*
Total	27.73	7.31	21.82	8.94	64	-3.06*

Note. own elaboration with the research data.

When comparing the distribution by level of digital competence achieved in both groups, which is illustrated in Figure 1, it was found that in both groups the highest percentage of students perceived themselves as being at an intermediate level: 85.29% in group 9A and 72.72% in group 9B.

Figure 1. Level of digital competence of group 9A and group 9B



Note. own elaboration with the research data.

After reviewing the literature, an exploration of these levels of digital competence was carried out using the Ikanos test. It was found that, despite being intact groups in terms of training or courses to develop their digital competencies, the two groups were not equivalent in the test. The two groups were not equivalent in the test, being the values of digital competence of group 9B, significantly lower in each of the areas with those of group 9A, except in the area of communication.

We must consider that these results belong to Systems Engineering students. Regarding the levels of digital competence (Basic, Intermediate, Advanced and Expert), in both groups the highest percentage of students were at the

"Intermediate" level. Although at the beginning it was expected that the majority of the student percentage would be at the "Advanced" and "Expert" levels. But it is known that the career has not implemented didactic strategies for the development of digital competencies in the subjects they teach. This is due to the fact that there are no academic regulations that require teachers to use instructional methodologies mediated by ICT for this purpose. This is consistent with what was mentioned in the theoretical review carried out in this research, in which all the authors reviewed conclude that there is a very favorable attitude towards the development of the level of digital competencies in students when ICT is implemented as a transversal axis in the teaching-learning system.

It should be noted that UTLVTE is a face-to-face university and that due to the COVID-19 pandemic, it required the use of the virtual modality. However, many teachers were not trained to implement didactic strategies according to the virtual environments for the subjects they teach, so that, even following the same syllabus, students in different parallels of the same subject, have been able to experience different practices in virtual learning environments.

Teaching-learning methodologies with strategies and techniques reinforced with formative technologies, constitute the right environment for the development of digital competencies, in university students and in particular in engineering students, who use ICT for the attainment of knowledge (Vivas, Ortega and Navarro, 2016).

One aspect that deserves reflection is that no student was positioned at the "Expert" level with respect to the digital competencies test. Taking into account that in addition to being students of Information and Communication Technologies, these correspond to the "Z" generation, because they were born in the late 90s, early 2000s (Diaz, Santos and Matellanes, 2021), so it was expected that their self-perception of digital competence would be higher, since they use the network to learn about their environment and to shape their own ideas, opinions and attitudes. However, access to this large amount of information also increases the degree of misinformation and false news (García, 2021; Miller and Bartlett, 2012).

It should be noted with respect to the results of the two groups, what Solar and Díaz (2009) already pointed out: "Teachers face their professional activity through an idiosyncratic system of knowledge that is the product of the personal elaboration that they make of their ideas in a given institutional and social context" (p. 183). In other words, teachers plan, use strategies and carry out evaluations according to what they believe to be the right thing to do. However, as Heras (2017) refers, it is essential to constantly improve the mastery of didactics in the university teaching environment, which allows overcoming the deficiencies that each teacher recognizes in their academic tasks.

CONCLUSIONS

Regarding the research question, on the levels of digital competence (Basic, Intermediate, Advanced and Expert), the findings show, in general, an "Intermediate" level of digital competence in the students of the subject "Computer Projects" of the ninth cycle, of the Information Technologies career, during the second academic period of 2021. This is not enough for students of the ICT specialty.

Regarding the exploration of the digital competencies of the students. Despite being intact groups, the test results showed that the values of group 9A were significantly higher in all areas of digital competence than those of group 9B. Except for the area of communication.

The findings highlight the imperative importance of integrating digital competence as a fundamental element throughout the academic curriculum. In this sense, it is necessary to implement strategies that promote the development of digital competencies from the beginning of the career. This measure would contribute to establish a solid and progressive base, starting in the first academic cycle of the Bachelor's Degree in Information and Communication Technologies at UTLVTE. In this way, as they advance in the cycle, they increase their expertise and their chances of reaching the expert level.

This strategy would result in an evolutionary process in which students, as they progress through their training, experience a gradual increase in both their technical proficiency and their ability to address digital challenges with an expert approach. By emphasizing the continuous development of digital competencies from the earliest steps in the career, students are given the opportunity to strengthen their skills in a relevant and constantly evolving context, which can ultimately equip them more effectively to address digital and technological challenges in a proficient and advanced manner.

Main limitations of the study and future research

One significant limitation lies in the non-equivalence of the intact groups despite similar training backgrounds, indicating potential confounding variables that were not accounted for. This suggests a need for more rigorous experimental designs or control measures to better isolate the effects of digital competency interventions. Moreover, the reliance on a single instrument, the "Ikanos" test, may not fully capture the complexity and breadth of digital competencies, potentially

leading to incomplete assessments. Future research, as proposed in the Table 3, could benefit from incorporating multiple assessment tools or methodologies to provide a more comprehensive understanding of student digital competencies. Furthermore, the focus on a specific cohort of students from the Systems Engineering discipline at a single university limits the generalizability of findings. Future studies could broaden the scope by including diverse student populations and educational contexts to assess the transferability of results. Lastly, given the rapidly evolving nature of technology and its impact on education, longitudinal studies could offer valuable insights into the long-term development and retention of digital competencies among students.

Table 3 Future research agenda proposal

Topic/Context	Variables	Methods	Possible Approaches and Suggestions for Future Study
Equivalence of Groups	Training Background, Digital Competencies	Non-experimental design, "Ikanos" test	1. Implement randomized controlled trials to ensure equivalence between groups. 2. Conduct qualitative interviews to identify potential confounding variables. 3. Employ propensity score matching to account for group differences.
Assessment Tools	Digital Competencies	"Ikanos" test	1. Compare results from "Ikanos" test with alternative assessment tools (e.g., self-reported surveys, performance-based tasks). 2. Conduct focus groups to gather qualitative data on students' perceptions of their digital competencies. 3. Utilize mixed-methods approaches to triangulate findings from different assessment tools.
Generalizability	Student Populations, Educational Contexts	Quantitative approach	1. Replicate study across diverse universities and disciplines to assess generalizability. 2. Compare results between face-to-face and virtual learning environments. 3. Explore cultural and regional differences in digital competency development.

Note. Own author elaboration

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