

Evaluation of the ICT Competencies of Teachers according to the Model of the Ministry of National Education in Colombia: An analysis using Structural Equation Models

Cesar-Augusto Hernández-Suárez¹, Juan-Diego Hernández-Albarracín²,
Javier Rodríguez-Moreno³

1. Mg. in Teaching Basic Sciences with a mention in Mathematics, Universidad Francisco de Paula Santander, Cúcuta, Colombia, cesaraugusto@ufps.edu.co
2. PhD in Educational Sciences, Universidad Simón Bolívar, Cúcuta, Colombia, juan.hernandez@unisimon.edu.co
3. Doctor of Education, University of Jaén, Spain, jrmoreno@ujaen.es

ABSTRACT

This study assesses the information and communication technology (ICT) competencies of primary and secondary school teachers in Norte de Santander and Cúcuta, employing the ICT competency model developed by the Ministry of National Education of Colombia. A structural equation model was employed to analyze data from a sample of 538 teachers to identify causal relationships between general ICT competence and specific competencies, including technological, pedagogical, communicative, management, and investigative competencies. The findings substantiate the reliability of the employed instrument and underscore the significance of integrating ICT to enhance educational practice. ICT competence exerts a pronounced influence on all the specific competences assessed, thereby providing a robust foundation for the development of teacher training programs that optimize the use of ICT, particularly in the post-pandemic context, promoting more effective and adaptive education.

KEYWORDS: Digital skills, Education, Professional development, Educational innovation, Information technology.

1. Introduction

The advent of digital transformation has precipitated a profound transformation in the manner by which information is accessed and learning occurs, giving rise to significant shifts in numerous facets of daily life, including the sphere of education. The integration of information and communication technologies (ICT) in the field of education has enhanced pedagogical practices, enabling educators to address contemporary challenges, particularly in the context of the post-pandemic era.

The contemporary education system is confronted with the pivotal challenge of equipping teachers with the requisite competencies to respond to the demands of an increasingly digitized society. The acquisition of digital skills has become a fundamental element of teacher training, as it is essential to enhance the quality of education and guarantee that students develop competencies that are pertinent to the 21st century. In Colombia, the Ministry of National Education (Mineducación) established in 2013 an ICT competency framework for teachers that seeks not only the acquisition of technical skills but also their integration into pedagogical practice, to promote meaningful and adaptive learning. This model underscores the significance of teachers employing ICT as a pedagogical instruments and as a means of fostering interactive and collaborative learning.

The advent of the SARS-CoV-2 pandemic precipitated the accelerated adoption of digital technologies in the field of education, thereby exposing considerable deficiencies in the preparation of educators and underscoring the imperative for the Ministry of Education to update its ICT competency model. While these challenges were already present, the health crisis made them more apparent, underscoring the necessity to assess and enhance this model to guarantee its relevance and efficacy in the present educational context.

Despite advancements in the incorporation of ICT in education, recent studies have revealed that there are still deficiencies in its effective implementation in the classroom. The dearth of sufficient training, constraints on technological resources, and reluctance to embrace change persist as significant impediments (Cabero, 2010). Martínez-Garcés and Garcés-Fuenmayor (2020) and Díaz-Arce and Loyola-Illescas (2021) highlight the challenges faced by teachers due to insufficient preparation in digital skills, such as a lack of adaptation to online platforms, which negatively affects educational quality.

The importance of research on information and communication technology (ICT) competencies has grown in recent years, as evidenced by the increase in scientific production in this field (Rodríguez García et al., 2019). The importance of ICT competencies for the integration of these technologies in education has been underscored by numerous studies, which have demonstrated a positive impact on learning outcomes (Esteve, 2014; Gisbert et al., 2019). In the context of special education, these competencies are of paramount importance for the inclusion and support of students with special needs (Krainer & Guerra, 2012). Nevertheless, the level of proficiency in ICT competencies remains relatively low, underscoring the necessity for training methodologies that prioritize pedagogical considerations over technological aspects (Almerich et al., 2011; Jiménez-Pérez et al., 2023; Durán et al., 2016; Gamboa et al., 2018). Further research is required to understand the causes of variations in digital competence levels depending on the context and to propose effective solutions (Madsen et al., 2023; Tomczyk et al., 2023).

Insufficient training in ICT skills has a detrimental effect not only on the educational use of these technologies but also on other teaching skills that are necessary for professional development (Durán, 2018; García et al., 2022). Molnar and Nagy (2022) emphasize that the enhancement of digital competencies is a fundamental aspect of teacher professional development and the improvement of educational

quality. García-Ruiz and Luque-Jiménez (2024) investigate the impact of initial and ongoing ICT training on the digital competence of secondary school teachers. They find that enabling qualifications and ICT training have a substantial influence on teachers' technological skills.

In addition to training, other factors influence the development of ICT skills. Hernández (2018) conducted an analysis of the perception and adaptation of ICT by teachers, identifying key dimensions such as communication, information management, and evaluation. Hernández (2023) investigates the impact of technological knowledge management on teacher training and the implementation of hybrid educational models.

The pandemic served to exacerbate pre-existing problems, thereby demonstrating the existence of a digital divide and the dearth of technological preparation among a considerable number of teachers. The absence of continuous training and an aversion to change represent significant impediments to the integration of ICT in education. Furthermore, a discrepancy has been identified between the training received and its practical application (Martínez-Garcés & Garcés-Fuenmayor, 2020; Díaz-Arce & Loyola-Illescas, 2021). Furthermore, limited accessibility to technology and connectivity has also constrained the integration of ICTs by teachers and students, which has had a detrimental impact on the equitable development of digital skills (International Commission on the Futures of Education, 2020). This deficiency in technological training (García-Zabaleta et al., 2021) constituted a significant impediment to teachers' ability to adapt to online teaching.

The inadequate preparation of teachers in ICT skills has had a detrimental impact on the quality of education, both during and after the pandemic. The inefficiency in selecting and applying digital tools has resulted in a reduction in student interaction and participation, which has, in turn, led to a decline in motivation and academic commitment (Jiménez, 2017). Furthermore, this deficiency constrained educators' capacity to devise and assess efficacious pedagogical strategies during the pandemic, which in turn impacted educational outcomes and the equity of learning opportunities (ECLAC-UNESCO, 2020; Gómez-Arteta & Escobar-Mamani, 2021).

Educators must receive continuous training in ICT to enhance the quality of their teaching and to enable them to adapt to technological changes. García et al. (2022) emphasize the relationship between digital skills training and educational improvement, underscoring the necessity for a comprehensive approach that encompasses both technological and pedagogical elements. As highlighted in the Ministry of Education report (2022), the importance of continuous training for teachers in adapting to changing technological environments cannot be overstated.

It is of the utmost importance to assess and improve these competencies to guarantee the quality of education. In the absence of an appropriate assessment, the mastery of these skills may be overestimated, thereby limiting the effectiveness of the educational program. In accordance with the ICT competency model established by the Ministry of Education, it is imperative to implement suitable methodologies for a comprehensive evaluation of the validity and theoretical coherence of these competencies. Hernández et al. (2016) discovered that, although teachers attain fundamental levels of technological and pedagogical competencies, domains such as

research and management necessitate further advancement.

In the department of Norte de Santander, the research is centered on the necessity of evaluating and adapting the ICT competency model proposed by the Ministry of Education of Colombia. The objective of this study is to identify the specific educational particularities and requirements of the region to ensure that the development of digital competencies among teachers is relevant and effective. In light of the local context, the research objectives extend beyond the validation of instruments utilized to assess ICT competencies. They also encompass the formulation of recommendations that facilitate a more seamless integration of these technologies into pedagogical practices.

The northern Colombian region, which has been affected by the armed conflict, drug trafficking, and the Venezuelan migration crisis, is confronted with considerable challenges that have a detrimental impact on the quality of education (Hernández Albarracín et al., 2022). The research conducted in this region has identified a need for continuous and adaptive training programs that enhance teachers' digital competencies, aligning them with technological advancements and post-pandemic conditions. It is of the utmost importance to assess the long-term impact of these competencies on educational quality and their adaptation to changes in the educational environment to ensure an effective and sustainable integration of ICT in teacher training.

The United Nations Sustainable Development Goals (SDGs) (2015), in particular SDG 4, are concerned with ensuring inclusive, equitable, and quality education, as well as promoting lifelong learning opportunities for all. The incorporation of information and communication technologies (ICT) into education is a vital step towards achieving these goals. By facilitating access to innovative educational resources and interactive pedagogical methods, ICT can significantly enhance learning outcomes. Furthermore, information and communication technologies (ICTs) are instrumental in reducing technological inequality and ensuring equitable access to educational opportunities.

In regions such as Norte de Santander, where pronounced technological inequalities exist, the strengthening of teachers' technological skills can catalyze change, thereby contributing to a more inclusive and equitable education system. The National Development Plan (NDP) 2022-2026 (Government of Colombia, 2022) identifies connectivity and digital literacy as indispensable for social and economic advancement. Nevertheless, obstacles such as the digital divide in rural regions and the necessity for ongoing training in ICT persist (Molina-Pacheco & Mesa-Jiménez, 2018).

The experience of the Pact for Education in Norte de Santander (Hernández Albarracín et al., 2023) demonstrates the value of community participation in the formulation of public policies and the significance of a territorial approach in ICT teacher training. Effective training models encourage creativity and a constructive outlook, thereby facilitating collaboration in the implementation of innovative methodologies (Robalino Campos & Koner, 2006).

The incorporation of information and communication technologies (ICT) into the educational process is crucial for enhancing its overall quality. This study assesses the information and communication technology (ICT) competencies of teachers in Norte de Santander, examining their influence on the development of effective training programs. A structural equation model (SEM) based on the framework of the Ministry of Education of Colombia will be employed to validate measurement scales and explore the predictive factors influencing the development of these competencies, concerning existing literature.

ICT Competencies Model of the Ministry of National Education of Colombia

In 2013, the Ministry of Education developed a model of information and communication technology (ICT) competencies for teachers. The objective of this model is twofold: firstly, to integrate these technologies into the educational system and secondly, to improve educational quality through pedagogical innovation. The model, which is detailed in the document "ICT Competencies for Teacher Professional Development," aims to facilitate the transformation of pedagogical practices through the effective and meaningful use of ICT.

The model is based on four key principles: relevance, which ensures the adaptation of training to the needs of the teaching context; practicality, which promotes learning through the direct use of ICTs; collaboration, which promotes work in learning networks; and inspiration, which stimulates creativity and critical thinking in teachers.

In essence, the model aims to equip teachers with the skills to integrate ICT into their educational practice, thereby promoting innovative pedagogical strategies that enrich the learning of both teachers and their students and enable them to access knowledge and generate positive changes in their environment.

Predictor Variables of the Structure of the ICT Competencies Model of the Ministry of National Education of Colombia

In 2013, the Ministry of Education developed a framework of information and communication technology (ICT) competencies for teachers to advance educational innovation and enhance the quality of teaching. This model is aligned with national policies, such as the National Development Plan 2010-2014 and the Education Sector Plan (2010-2014), and responds to the specific needs of the Colombian educational context. It is designed to prepare teachers for the challenges of the 21st century and the digital age. The framework is based on international trends in teacher education and training, with previous studies and recommendations by UNESCO (2011) and ISTE (2011) serving as a reference point. Additionally, the most recent updates from these bodies, UNESCO (2019) and ISTE (2023) have been incorporated. The model prioritizes the training of educators in the integration of information and communication technologies (ICTs) into the curriculum and methodology of teaching, encompassing five essential competencies:

Technological Competence: The capacity to utilize technological instruments in the context of pedagogical practice. The scope of the model extends from a fundamental grasp of an array of tools to their ingenious deployment in the creation of novel learning environments. The objective is to utilize information and communication

technologies (ICT) not merely as instrumental tools, but as catalysts for pedagogical innovation, thereby transforming educational practices to enhance student learning.

Pedagogical Competence: The incorporation of information and communication technologies (ICT) into novel pedagogical strategies. This entails the identification and implementation of ICT-mediated pedagogical strategies to enhance learning outcomes, even to the extent of assuming a leadership role in innovative educational projects. In alignment with constructivist approaches, it fosters active and collaborative learning, complemented by continuous teacher training and lifelong learning.

Communicative Competence: The use of information and communication technologies (ICT) to enhance communication and collaboration. The process commences with the identification of digital communication channels and culminates in the formulation of sophisticated communication strategies designed to facilitate interaction and collaboration. It underscores how information and communication technologies (ICTs) have transformed interaction and collaboration in the educational field, facilitating the creation of more collaborative and participatory learning environments.

Management Competence: The implementation and efficient management of educational resources and processes with the aid of information and communication technologies (ICT). The curriculum progresses from an introduction to planning tools to an advanced examination of applications designed to enhance educational management, including learning management systems and institutional improvement projects. The objective is to facilitate the effective administration of educational resources and processes. This entails a focus on key areas such as planning, organization, administration, and evaluation, which are identified as essential for advancing educational improvement in alignment with the Education Sector Plan (2010-2014).

Research Competence: The application of information and communication technologies (ICT) for the advancement of research and the generation of new knowledge. From the utilization of fundamental search and analysis tools to the deployment of state-of-the-art technologies in research projects that yield novel insights. It responds to the significance of research in the professional development of teachers and the generation of new knowledge, in alignment with the country's priorities and the advancement of the National Science and Technology System.

Each of these competencies is developed in three levels of complexity. The initial level, exploration, allows teachers to become familiar with the tools and their potential in education. The second level, integration, implies the autonomous and adapted use of ICT in educational processes. Finally, the third level, innovation, allows for the application of technologies in creative and advanced ways to transform learning.

Structural Equation Models for the Evaluation of ICT Competencies in Teachers

The effective integration of information and communication technologies (ICT) in teaching practice, evaluated through instruments based on the Ministry of Education model and validated with structural equation modeling (SEM), is essential to meet

the demands of a digitalized society. This document presents a synthesis of studies that demonstrate the effectiveness of SEM as a means of validating digital competencies in educational contexts. The approaches described are then applied to teachers in Norte de Santander.

The SEM enables a comprehensive examination of the causal relationships between general ICT competence and specific competencies, thereby facilitating an understanding of their influence on pedagogical practice (Ruiz Díaz, Pardo Merino, & San Martín Castellanos, 2010; Romero & Barrios, 2020). Moreover, it permits the direct and indirect effects of ICT on education to be examined, thus validating relationships and adjusting the educational model in accordance with the empirical results and identified needs (García, Martínez, & Hernández, 2021).

As indicated by the existing literature, SEM is essential for the validation of digital competence instruments, as it allows for robust research methodologies to be employed (Escobedo Portillo, Hernández Gómez, Estebané Ortega, & Martínez Moreno, 2016). This approach is also pertinent to the training of prospective teachers, as it has been demonstrated that ICT competence has a positive impact on all the specific competences assessed (Cabero-Almenara et al., 2020; 2022).

While previous studies have provided a robust foundation for understanding ICT competencies in Colombian teachers, there remains a significant gap in our understanding of the factors that effectively predict their development (Carrera et al., 2021). The implementation of SEM will serve to validate these relationships and allow for the requisite adjustments to be made to the educational model in accordance with the empirical results and needs identified, as has been demonstrated in similar contexts (Sánchez et al., 2020).

2. Methodology

Study Design

The present study employs a quantitative and cross-sectional design. It is recommended that the use of SEM be employed. This methodology permits the assessment of causal relationships between latent and observed variables, thereby facilitating a comprehensive understanding of the ICT competencies of teachers.

Sample

The sample consisted of 538 teachers of basic and secondary education in the Norte de Santander and Cúcuta regions of Colombia. Of these, 361 were women and 177 were men. The mean age of the participants was 44.3 years. The participants were selected through simple random sampling in order to ensure an equitable representation of the different educational zones and teaching characteristics, including educational level and experience.

Justification of Sample Size

The sample size was determined following the methodology set forth by Hair et al. (2014) and the recommendations put forth by Vargas Halabí and Mora Esquivel (2017). In this study, $I = 85$ observable variables (items) were considered. This

indicates that, on average, each construct is associated with 17 observable items. Similarly, $C = 5$ latent variables (constructs) were considered, resulting in a relationship of $m = \frac{I}{c} = \frac{85}{5} = 17$

In accordance with the stipulations set forth by Hair et al. (2014), the sample size (N) must be a minimum of 10 times the maximum number of indicators for a construct or the maximum number of structural pathways directed towards a construct. Nevertheless, to mirror actual procedures in Partial Least Squares Structural Equation Modeling (PLS-SEM) investigations with a considerable number of items relative to constructs and to permit adaptability in modeling techniques, this guideline is modified through the application of a specific factor contingent on the structure of the model $k = \frac{N}{\max(m,p)}$

The adjustment factor k is calculated as the sample size (N) divided by the maximum between the maximum number of indicators of a single construct (m) and the maximum number of paths directed to a construct (p). The latter is conservatively considered to be approximately 5, given the relationship between items and incoming paths. Thus, $k = \frac{N}{\max(m,p)} = \frac{538}{\max(17,5)} = \frac{538}{17} \approx 31.65$ with k calculated, the adjusted formula becomes $N \geq k \times \max(m,p)$. Applying the specific values, it obtains $N \geq 31.65 \times 17 = 537.055$.

In conclusion, it is determined that a minimum of 537 observations are required under this adjusted rule. Because this research proposes 538 observations, it can be concluded that the sample size is sufficient for the validation of the model, given the specific characteristics of the model and the robustness required for the desired inferences.

Instrument

A structured self-perception questionnaire was employed, based on the model proposed by Mineducación (2013) and adapted from Hernández et al. (2016). The ICT Competency Survey assesses teachers' proficiency in five key competencies: The aforementioned competencies are classified as follows: Technological (CCT), Pedagogical (CCP), Communicative (CC), Management (CCG), and Research (CCI). The instrument for data collection included 85 items distributed across the five latent variables, which pertain to ICT competencies. Each item was evaluated using a five-point Likert scale, where 1 indicates a lack of competence, 2 indicates a minimal level of competence, 3 indicates competence, 4 indicates a high level of competence, and 5 indicates a very high level of competence. This methodology allows for a comprehensive assessment of teaching competence in ICT, enabling an in-depth analysis of how these technologies are integrated into pedagogical practice.

Procedure

The survey was administered to teachers in person and electronically via the Google Forms platform, distributed via email in the second half of 2023. This approach ensured efficiency and consistency in the collection and analysis of data, with prior informed consent from the rectors of the educational institutions.

Instrument Validation

Phase I: Content validation. The aim of content validation is to determine the relevance of the items to the theoretical dimensions defined by the researcher and their appropriateness to the linguistic and cultural characteristics of the target population. To achieve this, the expert judgment technique (Polit & Beck, 2006) was used to assess the relevance of each item in relation to the five ICT competencies. In accordance with the model proposed by Hernández et al. (2016) and the guidelines established by the Ministry of Education (2013), the following five competencies were considered: Technological, Pedagogical, Communicative, Management and Research.

The process of expert judgment followed the footsteps of Lynn (1986), which defined the objective of evaluating the scale of ICT competencies through the criteria of sufficiency, clarity, coherence, and relevance in relation to the theoretical foundation and the context studied. Nine judges with experience in technologies, education, and statistics were selected, who were provided with an informed consent form, the theoretical foundations of ICT competencies from the Ministry of Education (2013), the demographic characteristics of the context, the evaluation criteria, and the rating scale.

Since the scale was previously validated, a revalidation was conducted (DeVellis, 2017) to adapt it to current needs and post-pandemic changes to ensure that it remains relevant and effective (Nunnally & Bernstein, 1994; Messick, 1989).

The evaluation considers sufficiency (whether the items are sufficient to measure the dimension), clarity (whether the statement of the item is clear), coherence (logical relationship to the dimension), and relevance (importance of the item for its inclusion in the instrument). The measurement scale for each criterion is 1: not applicable, 2: low level, 3: moderate level, and 4: high level.

Two statistics were used to calculate the agreement between judges: Lawshe's (1975) Content Validity Index (CVI) and Nieto's (2002) Content Validity Coefficient (CVC). The Content Validity Ratio (RVC), proposed by Lawshe, is determined with the formula, where $RVC = \frac{n - \frac{N}{2}}{\frac{N}{2}}$ n is the number of specialists who qualify the item as essential and N is the total number of evaluators.

For this study, with 9 evaluators, all rated the items as essential. Therefore, the calculation is as follows:

$$RVC = \frac{n - \frac{N}{2}}{\frac{N}{2}} = \frac{9 - \frac{9}{2}}{\frac{9}{2}} = \frac{4.5}{4.5} = 1$$

The CVI is the average of the RVCs of all items. Since all items were rated as essential by the 9 evaluators, each RVC is 1.0, resulting in a CVI of 1.0. According to Davis (1992), a $CVI \geq 0.80$ indicates an adequate set of items. Lawshe (1975) suggests that the interpretation of the CVI depends on the number of evaluators: for several evaluators between 9 and 40, the CVI value should be between 0.29 and

0.78. In this case, an IVC of 1.0 exceeds both criteria, indicating excellent content validity for the items evaluated.

The Content Validity Coefficient is calculated using the formula, where $CVC = \frac{Mx}{Vmax} - Pei$, where Mx is the average of the score given by the experts for each item, $Vmax$ is the average maximum score that the item could achieve, and Pei is the error assigned to each item, calculated as, where $\left(\frac{1}{j}\right)^j$ where j is the number of participating experts.

For this study, with 9 evaluators, all rated the items with the maximum score. On the rating scale, it is from 1 to 5. Therefore, $Mx = 5$ and $Vmax = 5$. The error assigned to each item (Pei) is calculated as: $Pei = \left(\frac{1}{9}\right)^9 = 1.95 * 10^{-9}$. Since this value is extremely small, it is considered insignificant compared to the other variables. Now, the process calculates the $CVC = \frac{Mx}{Vmax} - Pei = \frac{5}{5} - 1.95 * 10^{-9} \approx 1$. Nieto (2002) recommends keeping only those items with a CVC greater than 0.80 (Balbinotti, 2004). In this case, with a CVC of approximately 1, the items far exceed both criteria, indicating excellent content validity.

Phase II: Construct validation. The objective of this phase was to collect data for each item of the instrument and subsequently analyze it using SEM. The data were imported into the SPSS 24 software to perform the necessary analyses to validate the instrument, evaluate its reliability, and assess the relationships between competencies using model fit indicators. These results will be explained in greater detail in the subsequent section.

Phase III: Criterion validity. In this phase, the updated instrument was compared with the validated test applied in 2016 to ensure that the results obtained were consistent and valid in different educational contexts. In the 2016 study, the instrument demonstrated high reliability on all scales, with Cronbach's Alpha coefficients of 0.874 for Technological Competence (TCC), 0.950 for Pedagogical Competence (CCP), 0.906 for Communicative Competence (CC), 0.972 for Management Competence (CCG), and 0.953 for Research Competence (CCI), resulting in a total Cronbach's Alpha of 0.976 for the instrument. These findings demonstrate a robust internal consistency for the instrument. The following sections will explain the phases of SEM and reliability analysis, as they pertain to the current study.

Data Analysis

For the purpose of data analysis, the SEM was employed with the AMOS software, whereby exploratory and confirmatory factor analyses were conducted in order to validate the instrument and evaluate the relationships between ICT competencies. Model fit indicators, including the Chi-squared, RMSEA, and Tucker-Lewis index (TLI), were employed to ascertain the suitability of the proposed model. The reliability of the instrument was evaluated using Cronbach's alpha to ensure the internal consistency of the elements that comprise each competency. Moreover, descriptive statistics were provided for each specific competency, thus

complementing the structural analysis conducted using SEM.

3. Results

Structural equation model phases

The study employed a structured methodology comprising several fundamental phases. These phases were designed to validate the instrument and evaluate the competencies of the participating teachers. The following section outlines the phases of the SEM model that were employed in the course of this research.

Model Specification. The model specification represents the initial phase in the construction of the SEM. In this phase, the hypothetical relationships between the latent variables and the observed variables are established. In the present study, five latent competencies were defined. Technological Competence (TC), Pedagogical Competence (PC), Communicative Competence (CC), Management Competence (CG), and Research Competence (IC) are all influenced by ICT Competence (ICT), which serves as the main exogenous variable, as illustrated in Table 1.

Table 1. Latent and Observed Variables

	Item	Descriptor
Technological Competence (TC)	TC.1	I develop learning activities applying ICTs.
	CT.2	I use digital content in the development of learning activities.
	CT.3	I use educational software in the design of learning activities.
	CT.4	I value the quality of the information available on educational and specialized portals.
	CT.5	I value the quality of the information available in search engines.
	CT.6	I evaluate the quality of information in multimedia materials (videos and educational software).
	CT.7	I combine technological tools to improve the planning of my pedagogical practices.
	CT.8	I integrate technological tools to improve my pedagogical practices.
	CT.9	I design digital learning content through the appropriate use of technological tools.
	TC.10	I publish digital learning content using technological tools.
	CT.11	She designed virtual learning environments to strengthen the development of competencies in students.
	CT.12	Designed virtual learning environments to form and strengthen learning communities or networks.
	TC.13	I use technological tools to facilitate meaningful learning in students.
	TC.14	I use technological tools to encourage critical thinking in students.
	CT.15	I am aware of the existing intellectual property and licensing rules regarding the use of other people's and my information.
Pedagogical Competence (CP)	CP.1	I encourage my learning through personal initiative as a teacher.
	CP.2	I keep my knowledge and practices in my discipline up to date.
	CP.3	I identify educational problems in my teaching practice.
	CP.4	I propose educational projects that allow reflection on learning among students.
	CP.5	I propose educational projects that allow reflection on the production of knowledge.
	CP.6	I apply strategies and methodologies supported by ICT to plan and monitor my teaching work.
	CP.7	Promotion of autonomous learning in students through the use of ICTs.
	CP.8	I stimulate collaborative learning in students with ICT support.

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	CP.9	I attend to the needs and interests of students.
	CP.10	I solve the learning problems that arise among students.
	CP.11	I strengthen students' skills to solve real-life problems.
	CP.12	Design of ICT-mediated learning environments considering the cognitive and psychological development of students.
	CP.13	Design of learning environments mediated by ICT considering the physical and social development of students.
	CP.14	I propose educational projects mediated with ICT that encourage reflection on one's learning.
	CP.15	I propose educational projects mediated with ICT that promote the production of knowledge.
	CP.16	I assess learning outcomes when planning and employing ICT.
	CP.17	I promote a culture of monitoring, feedback, and constant improvement through evaluation.
Communicative Competence (CC)	CC.1	I communicate with students using ICT synchronously.
	CC.2	I communicate with students using ICT asynchronously.
	CC.3	I communicate appropriately with researchers and advisors using ICT synchronously.
	CC.4	I communicate appropriately with researchers and advisors using ICT asynchronously.
	CC.5	I surf the Internet efficiently.
	CC.6	I respect intellectual property and licensing rules when sharing information over the Internet.
	CC.7	She actively participated in networks and communities through practical ICT-mediated activities.
	CC.8	I encourage the participation of students in ICT networks and communities for educational purposes.
	CC.9	I systematize and monitor the successful use of ICT in the teaching-learning process.
	CC.10	I promote effective communication in the educational community.
	CC.11	It contributed to improving the processes of school coexistence.
	CC.12	I use different texts and interfaces to convey information and express my ideas.
	CC.13	I combine various resources in communication for educational purposes.
	CC.14	I design ways of representing information for educational purposes.
	CC.15	I contribute with my knowledge to the repositories of humanity's knowledge on the internet.
	CC.16	I encourage students to publish the results of their research on websites or scientific repositories.
Management Competence (GC)	CG.1	I identify the elements of school management that can be improved through the use of ICT in different institutional activities.
	CG.2	I know the school policies that regulate privacy during the use of ICTs.
	CG.3	I know the school policies for the use of ICT in relation to environmental impact.
	CG.4	I know the school policies for the use of ICTs that contemplate the health risks for users.
	CG.5	I identify my professional development needs for educational innovation through ICT.
	CG.6	I propose processes for improving and monitoring the use of ICT in school management.
	CG.7	Development of processes for the improvement and monitoring of the use of ICT in school management.
	CG.8	I adopt school policies that regulate the existing privacy for the use of ICT in my institution.
	CG.9	I adopt existing school policies for the use of ICT in my institution in relation to environmental impact.

	CG.10	I adopt existing school policies for the use of ICT in my institution that take into account the health risks for users.	
	CG.11	I select training programs appropriate for my professional development needs for educational innovation with ICT.	
	CG.12	I have access to training programs in educational innovation with ICT appropriate for my professional development needs.	
	CG.13	I evaluate the benefits and utilities of ICT tools in school management, responding to the needs of my institution.	
	CG.14	I evaluate the benefits and utilities of ICT tools in the projection of the IEP, responding to the needs of my institution.	
	CG.15	I develop school policies for the use of ICT in my institution that regulate privacy.	
	CG.16	I develop school policies for the use of ICT in my institution in relation to environmental impact.	
	CG.17	I develop school policies for the use of ICT in my institution that contemplate the health risks of users.	
	CG.18	I encourage the training of my colleagues to integrate ICT in an innovative way into their pedagogical practices.	
	CG.19	I encourage my colleagues to integrate ICT in innovative ways into their pedagogical practices.	
	Research Competence (IC)	CI.1	I document observations of my professional environment with the support of ICT.
		CI.2	I document observations of my pedagogical practice with the support of ICT.
		CI.3	I identify sources of information that facilitate my research processes.
		CI.4	I identify networks that facilitate my research processes.
		CI.5	I identify databases that facilitate my research processes.
		CI.6	I search for information available on the Internet.
		CI.7	I organize and sort the search results.
		CI.8	I analyze the information found available on the internet.
		CI.9	I represent data and information derived from scientific research.
CI.10		I interpret data and information that I have compiled for research purposes.	
CI.11		I use professional support networks in the development of my research.	
CI.12		I use specialized platforms (repositories, databases, scientific software) for the development of my research.	
CI.13		I contrast with my students the information from multiple digital sources with a critical and reflective attitude.	
CI.14		I disseminate the results of my research using ICT tools.	
CI.15		I participate in networks for the collective construction of knowledge with students and/or colleagues with the support of ICT.	
CI.16		I participate in virtual communities for the collective construction of knowledge with students and/or colleagues with the support of ICT.	
CI.17		I participate in collaborative projects for the collective construction of knowledge with students and/or colleagues with the support of ICT.	
CI.18		I use the information available on the Internet with a critical and reflective attitude.	

Proposed causal relationships. The following section examines the proposed causal relationships between teachers' ICT competence and its impact on specific competencies within their pedagogical practice, as illustrated in Table 2.

Table 2. Proposed Causal Relationships

Causation	Description of the Relationship	Support Author(s)
CTIC → CCT	ICT competence influences technological competence, facilitating the integration and creative application of digital	Gisbert, et al., 2019); Hilton, J. T. (2016); Althubyani, 2024; Agreda, et al., 2016).

	tools in the classroom.	
CTIC → CCP	ICT competence affects pedagogical competence, improving teachers' ability to integrate technologies into teaching strategies.	Esteve (2014); Mishra & Koehler, 2006; Koehler, M., & Mishra, p. 2009; Ertmer & Ottenbreit-Leftwich, 2010; Tzafilkou, Perifanou, & Economides, (2023).
CTIC → CC	ICT competence improves digital communication and collaboration between teachers and students.	Hernández, 2023; In 2016, The New Testament of The Church of Jesus Christ of Jesus Christ of Churches, 2016, Young People's March 2014, 2014; Rahimi, & Mosalli, (2024).
CTIC → CCG	ICT competence enhances management competence, optimizing the administration of digital educational resources.	García et al. 2022; Trust, 2017; Redecker, & Punie, 2017; Pina Stranger, Moreira, & Mizova, (2023).
CTIC → CCI	ICT competence facilitates research competence, improving teachers' ability to conduct educational research using advanced technologies.	Molnar & Nagy (2022); (Trust, 2017); Ertmer, & Ottenbreit-Leftwich, 2010; Old, Ambros, & Tomczyk, (2023).

The proposed relationships are based on the theory that teachers' ICT competence directly influences their specific competencies, including technology, pedagogy, communication, management, and research (Mineducación, 2013). This competence entails the capacity to integrate digital technologies in an efficacious manner into the educational process, which is indispensable for the cultivation of the particular abilities that are requisite for professional-pedagogical practice.

In accordance with constructivist theory, the use of ICT encourages active and student-centered learning, thereby facilitating the construction of knowledge. Research has demonstrated that teachers who possess high levels of ICT proficiency tend to adopt innovative pedagogical approaches, such as project-based learning and flipped learning, which rely extensively on technology (Ertmer & Ottenbreit-Leftwich, 2010). Moreover, proficiency in ICT enhances digital communication abilities, which are essential for managing interactions and collaborations remotely (Baran, 2016). Such skills also facilitate the management of digital educational resources and participation in online communities of practice, thereby enriching knowledge management and educational research (Trust, 2017).

Identification of the Model. In the model identification phase, the parameters of the model are estimated to ascertain whether the model has been correctly identified. This entails ensuring that the number of parameters to be estimated does not exceed the number of available equations. In order to assess the identifiability of the model, the maximum likelihood estimation (MLE) method was employed within the AMOS software.

Parameter estimation. The estimation of parameters was conducted using the AMOS software. In this phase, the values of the unknown parameters and their respective measurement errors were determined. The parameters encompass the factor loads of the variables observed in the latent variables, in addition to the correlations and variances. The results of the estimation are presented in Table 3 for the reader's convenience.

Table 3. Factor Charges by Competition

Technological Competence (CCT)		Pedagogical Competence (CCP)		Communicative Competence (CC)		Management Competence (GCC)		Research Competence (ICC)	
Item	Factorial Load	Item	Factorial Load	Item	Factorial Load	Item	Factorial Load	Item	Factorial Load
CT.1	0.726	CP.1	0.710	CC.1	0.712	CG.1	0.721	CI.1	0.713
CT.2	0.734	CP.2	0.698	CC.2	0.719	CG.2	0.719	CI.2	0.717
CT.3	0.711	CP.3	0.704	CC.3	0.715	CG.3	0.722	CI.3	0.719
CT.4	0.758	CP.4	0.712	CC.4	0.720	CG.4	0.725	CI.4	0.721
CT.5	0.745	CP.5	0.709	CC.5	0.717	CG.5	0.718	CI.5	0.723
CT.6	0.735	CP.6	0.715	CC.6	0.722	CG.6	0.720	CI.6	0.725
CT.7	0.716	CP.7	0.718	CC.7	0.718	CG.7	0.723	CI.7	0.727
CT.8	0.727	CP.8	0.720	CC.8	0.725	CG.8	0.726	CI.8	0.729
CT.9	0.739	CP.9	0.713	CC.9	0.723	CG.9	0.724	CI.9	0.731
CT.10	0.741	CP.10	0.721	CC.10	0.726	CG.10	0.727	CI.10	0.733
CT.11	0.733	CP.11	0.727	CC.11	0.728	CG.11	0.729	CI.11	0.735
CT.12	0.720	CP.12	0.714	CC.12	0.724	CG.12	0.731	CI.12	0.737
CT.13	0.728	CP.13	0.722	CC.13	0.727	CG.13	0.732	CI.13	0.739
CT.14	0.732	CP.14	0.719	CC.14	0.730	CG.14	0.734	CI.14	0.741
CT.15	0.729	CP.15	0.725	CC.15	0.732	CG.15	0.736	CI.15	0.743
		CP.16	0.728	CC.16	0.734	CG.16	0.738	CI.16	0.745
		CP.17	0.730			CG.17	0.740	CI.17	0.747
						CG.18	0.742	CI.18	0.749
						CG.19	0.744		

The parameter estimates indicated that all observed variables exhibited significant loadings in their respective latent competencies, with acceptable measurement errors.

Adjustment Assessment. The model's fit was evaluated using a variety of goodness-of-fit measures. These measures are classified into three categories: absolute measures, incremental measures, and measures of parsimony (Table 4).

Table 4. Initial Model Adjustment Measures

Category	Fit Measurement	Value Obtained	Acceptability Level
Absolute Adjustment Measures	Chi-square (X^2)	2670.059	Acceptable
	RMSA (Root Mean Square Error of Approximation)	0.062	Acceptable
Incremental Adjustment Measures	CFI (Comparative Fit Index)	0.866	Acceptable
	TLI (Tucker-Lewis Index)	0.861	Acceptable
Parsimony Measures	PRATIO (Parsimonious Ratio)	0.837	Acceptable
	PCFI (Parsimonious Comparative Fit Index)	0.775	Acceptable

The results demonstrate that the model exhibits a favorable overall fit, with fit values falling within the acceptable range. The interpretation of the results entails an analysis of the standardized coefficients, which elucidates the relationships between the latent and observed variables, as illustrated in Table 5.

Table 5. Key Results

Relation	Standardized Coefficient	Level of Significance
CTIC → CCT	0.72	p < 0.05
CTIC → CCP	0.68	p < 0.05
CTIC → CC	0.70	p < 0.05

CTIC → CCG	0.74	p < 0.05
CTIC → CCI	0.76	p < 0.05

The findings substantiate the hypothesis that ICT competence exerts a considerable influence on the specific competences under assessment.

Comparison of Proposed Models. To evaluate and compare the proposed models, several fit measures were used, including absolute, incremental, and parsimony measures, as shown in Table 6.

Table 6. System of structural equations

Models	Absolute fit measures			Incremental adjustment measures			Parsimony adjustment measures			
	Chi-square	CMIN/DF	RMSA	CFI	TLI	NFI	FOLLOWED	PCFI	PNFI	AIC
Model 1	,000.	3,465	,075	,801	,795	,742	,971	,777	,720	12557,164
Model 2	,000.	3,193.	,071	,823	,818	,762	,970	,798	,739	11609,416
Model 3	,000.	2,856	,065	,851	,846	,788	,968	,823	,763	10438,286
Model 4	,000.	2,670.	,062	,866	,861	,802	,967	,837	,775	9791,089
Model 5	,000.	2,520.	,059	,878	,874	,813	,965	,848	,785	9271,353

Table 6 illustrates the progressive enhancement of the model specification, which leads to an improved fit. Model 5, which exhibits the most optimal adjustment measures, demonstrates an effective equilibrium between adjustment and parsimony, effectively reflecting the relationships between teachers' ICT competencies and their respective specific competencies.

Model Respecification. It was carried out to improve the initial adjustment. Adjustments were made based on the modification indices and the underlying theory.

Elimination of variables with non-significant factor loads. This adjustment entails the removal of observed variables that fail to demonstrate a significant relationship with their corresponding latent variables. Factor loads serve to indicate the degree of association between an observed variable and a latent variable. In the event that the observed variable is not significant, it can be eliminated without affecting the validity of the model. This results in a more parsimonious representation of the relationships between variables, as well as a reduction in noise and an improvement in the model's fit.

Inclusion of new causal relationships based on the literature. This adjustment entails the introduction of novel causal relationships between latent and observed variables, with the support of prior research findings. This may entail the incorporation of pathways of influence that were not initially considered in the model. The incorporation of relationships documented in the literature serves to enhance the completeness of the model, thereby facilitating a more accurate reflection of the intricate nuances of the relationships between variables. This, in turn, optimizes the model's fit and capacity to elucidate the observed data.

SEM results. To demonstrate the efficacy of these modifications, the resulting adjustment measures following respecification are presented in Table 7.

Table 7. Respecified Model Adjustment Measures

Fit Measurement	Value Obtained	Acceptability Level
Chi-square (χ^2)	2520.059	Acceptable
RMSA (Root Mean Square Error)	0.059	Acceptable
CFI (Comparative Fit Index)	0.878	Acceptable
TLI (Tucker-Lewis Index)	0.874	Acceptable
PRATIO (Parsimonious Ratio)	0.848	Acceptable
PCFI (Parsimonious Comparative Fit Index)	0.785	Acceptable

The adjustments made significantly improved the fit of the model, as indicated by goodness-of-fit measures.

Figure 1: Proposed Structural Equation Model

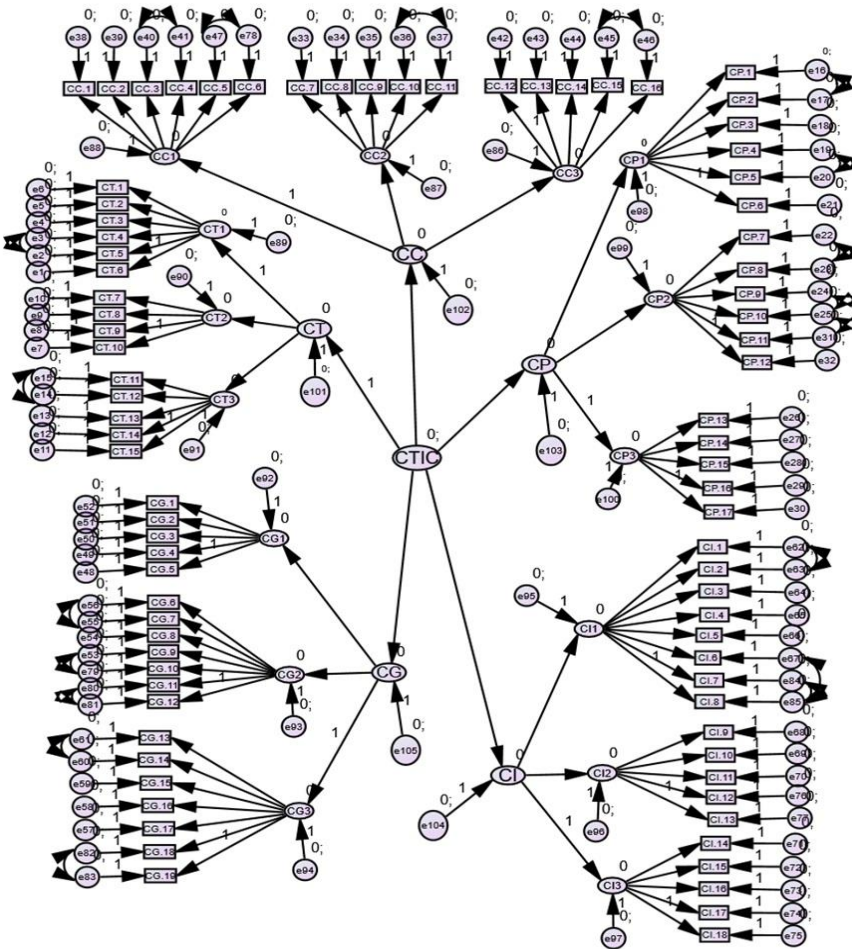


Figure 1 demonstrates the impact of general ICT competence (CTIC) on the

development of specific competencies among teachers, as conceptualized within the SEM Model 5 framework. The factor loads and causal relationships illustrate the interactions between variables, with fit measures confirming the validity and reliability of the model. This analysis is of great importance for the comprehension and enhancement of ICT competencies within the educational sector. It demonstrates that the respecifications have notably enhanced the fit of the model.

Reliability Analysis

A reliability analysis is an essential component of the validation process for measurement instruments, particularly in educational settings where the assessment of complex competencies such as ICT is concerned. In this study, the reliability of the instrument was evaluated using Cronbach's alpha coefficient, which is widely recognized as a robust indicator of the internal consistency of the scales used.

Case Processing Summary. A total of 538 cases were subjected to processing. All cases were deemed valid and eligible for inclusion. The decision to delete the list was based on an analysis of all the procedure variables.

Reliability Statistics

Table 5. Reliability Statistics

Measure	Value
Cronbach's alpha	0.990
Cronbach's alpha based on standardized elements	0.990
Number of items	85

The reliability of the instrument was evaluated using Cronbach's alpha coefficient, which yielded a value of 0.990, indicative of high internal consistency. Furthermore, Cronbach's alpha based on standardized elements yielded a value of 0.990. A total of 85 elements were evaluated, thereby confirming the robustness and reliability of the instrument.

Variables with High Correlations. The identification of highly correlated variables in Table 6 provides valuable information that can be utilized to optimize measurements and enhance the efficiency of the model. The correlations demonstrate the existence of shared influences between the factors, thereby enabling the structure of the analysis to be adjusted in a manner that ensures the maintenance of accuracy and clarity in the results, while simultaneously preserving the integrity of the model.

Table 6. Observable variables with high correlations

Variable 1	Variable 2
CT11	CT12
CP4	CP5
CP14	CP15
CC3	CC4
CG2	CG3
CG3	CG4
CG6	CG7
CG8	CG9
CG9	CG10
CG13	CG14
CG15	CG16
CG15	CG17

CG16	CG17
CG18	CG19
CI1	CI2
CI4	CI5
CI6	CI8
CI9	CI10
CI10	CI11
CI14	CI15
CI15	CI16
CI16	CI17

As illustrated in Table 6, variables that assess analogous aspects of a construct tend to exhibit a high degree of correlation. For example, in the domain of Technological Competence, the variables TC11 and TC12 demonstrate a high degree of correlation, as do CP4 and CP5 in the domain of Pedagogical Competence. This suggests that these variables are measuring closely related skills. In the domain of Management Competency, the high correlation between CG15, CG16, and CG17 may indicate some redundancy, given that they capture similar content. Nevertheless, this high correlation serves to validate the measurements, providing consistent evidence across different indicators and contributing to a more robust and detailed assessment of how teachers manage and utilize ICT in their professional environment.

The high correlations between IQ15, IQ16, and IQ17 in Research Competence reflect both the complexity and internal coherence of this competence. Although these correlations may suggest multicollinearity, they have been properly addressed to ensure the stability and accuracy of the model, thereby guaranteeing a faithful representation of the interrelationships. The identification of highly correlated variables is essential for the validation and refinement of the model, enabling informed decision-making without compromising its integrity. Notwithstanding the potential for redundancy, each variable offers a distinctive perspective that enhances the comprehension of the phenomenon under investigation. It is imperative to maintain these variables in order to accurately represent the progression from explorer to innovator, as outlined in the ICT competence framework of the Ministry of Education (2013). This ensures a precise depiction of the educational phenomenon.

Table 7. Reliability Statistics of Specific Competencies

Competence	Cronbach's alpha	Number of Elements
Technological Competence (TC)	0.947	15
Pedagogical Competence (CP)	0.958	17
Communicative Competence (CC)	0.946	16
Management Competence (GC)	0.977	19
Research Competence (IC)	0.972	18

The competencies evaluated have been found to exhibit excellent internal consistency, as indicated by Cronbach's Alpha values. The results indicate excellent internal consistency for the following competencies: technological (0.947), pedagogical (0.958), communicative (0.946), management (0.977), and investigative (0.97). These values indicate that the items of each competency consistently and reliably measure their respective constructs.

Average Scale if the Element Has Been Deleted

Variable	Mean Scale	Scale Variance	Total Correlation of Corrected Elements	Cronbach's Alpha if the Element has Been Deleted
CT.1	281.70	4107.777	0.626	0.990
CT.2	281.61	4108.804	0.621	0.990
CT.3	282.14	4092.983	0.646	0.990
CT.4	281.54	4109.336	0.598	0.990
CT.5	281.50	4105.088	0.618	0.990
CT.6	281.66	4097.558	0.631	0.990
CT.7	281.57	4102.172	0.646	0.990
CT.8	281.56	4097.111	0.690	0.990
CT.9	281.91	4087.432	0.689	0.990
CT.10	282.40	4081.219	0.635	0.990
CT.11	282.17	4083.541	0.697	0.990
CT.12	282.28	4078.900	0.700	0.990
CT.13	281.72	4087.120	0.731	0.990
CT.14	281.85	4084.349	0.747	0.990
CT.15	281.95	4089.191	0.612	0.990
CP.1	281.36	4109.077	0.645	0.990
CP.2	281.35	4109.025	0.637	0.990
CP.3	281.34	4107.681	0.691	0.990
CP.4	281.88	4085.635	0.719	0.990
CP.5	281.95	4083.411	0.748	0.990
CP.6	281.71	4088.308	0.728	0.990
CP.7	281.79	4088.250	0.755	0.990
CP.8	281.75	4084.902	0.786	0.989
CP.9	281.30	4116.001	0.607	0.990
CP.10	281.28	4112.293	0.641	0.990
CP.11	281.24	4115.539	0.618	0.990
CP.12	281.85	4082.093	0.748	0.990
CP.13	282.05	4077.262	0.794	0.989
CP.14	282.15	4071.190	0.791	0.989
CP.15	282.16	4071.811	0.806	0.989
CP.16	281.91	4079.017	0.785	0.989
CP.17	281.60	4101.503	0.650	0.990
CC.1	282.00	4086.756	0.653	0.990
CC.2	282.00	4090.890	0.630	0.990
CC.3	282.36	4074.200	0.709	0.990
CC.4	282.38	4075.927	0.699	0.990
CC.5	281.39	4099.243	0.637	0.990
CC.6	281.41	4101.818	0.615	0.990
CC.7	282.04	4070.436	0.757	0.990
CC.8	282.14	4071.436	0.767	0.990
CC.9	282.06	4070.445	0.790	0.989
CC.10	281.60	4098.058	0.674	0.990
CC.11	281.30	4112.045	0.591	0.990
CC.12	281.75	4097.291	0.683	0.990
CC.13	281.63	4093.903	0.726	0.990
CC.14	281.80	4084.933	0.752	0.990
CC.15	282.13	4077.001	0.749	0.990
CC.16	282.53	4080.480	0.641	0.990
CG.1	281.86	4081.938	0.789	0.989
CG.2	281.90	4077.393	0.747	0.990
CG.3	281.94	4077.240	0.757	0.990
CG.4	281.91	4077.588	0.745	0.990
CG.5	281.68	4088.440	0.739	0.990

CG.6	282.07	4071.882	0.813	0.989
CG.7	282.06	4072.786	0.817	0.989
CG.8	282.07	4068.359	0.818	0.989
CG.9	282.08	4071.402	0.809	0.989
CG.10	282.09	4072.738	0.806	0.989
CG.11	281.90	4077.880	0.783	0.989
CG.12	281.84	4072.676	0.795	0.989
CG.13	281.92	4074.839	0.837	0.989
CG.14	281.94	4071.458	0.834	0.989
CG.15	282.30	4071.497	0.784	0.989
CG.16	282.29	4069.448	0.776	0.989
CG.17	282.28	4067.678	0.778	0.989
CG.18	282.20	4076.304	0.759	0.990
CG.19	282.07	4069.298	0.792	0.989
CI.1	282.11	4075.853	0.741	0.990
CI.2	282.07	4077.510	0.743	0.990
CI.3	281.86	4075.414	0.777	0.989
CI.4	281.79	4074.607	0.790	0.989
CI.5	281.82	4067.794	0.797	0.989
CI.6	281.46	4095.116	0.684	0.990
CI.7	281.65	4082.791	0.714	0.990
CI.8	281.44	4095.718	0.671	0.990
CI.9	282.29	4062.576	0.773	0.990
CI.10	282.19	4060.937	0.774	0.990
CI.11	282.17	4060.634	0.782	0.989
CI.12	282.17	4065.599	0.751	0.990
CI.13	282.23	4064.765	0.778	0.989
CI.14	282.39	4063.977	0.791	0.989
CI.15	282.36	4067.282	0.772	0.990
CI.16	282.40	4063.351	0.766	0.990
CI.17	282.38	4068.125	0.748	0.990
CI.18	281.78	4087.682	0.666	0.990

No item when deleted gives a higher alpha value.

The internal consistency of the ICT competency scales is high, with a Cronbach's alpha of 0.990, indicating a notable coherence between the items and a reliable measurement of the constructs. The high correlations between the items and the total scale indicate that each item makes a significant contribution to the overall measure. Furthermore, the removal of any item does not notably enhance Cronbach's alpha, thereby substantiating its pivotal role within the scale. These results ensure accurate and reliable assessments, which will be useful both in future research and in practical applications.

4. Discussion

The present study corroborates the substantial impact of ICT proficiency on all the evaluated specific competencies (technological, pedagogical, communicative, managerial, and research), substantiating the reliability of the employed instrument and underscoring the pivotal role of ICT in teacher professional development. These findings reaffirm the relevance of the Mineducación model (2013), which advocates for the integration of ICT in teaching practice.

The integration of ICTs in education facilitates innovation and improves teaching practices by enabling teachers to incorporate digital tools into the classroom, thereby fostering critical competencies in students, including critical thinking and problem-solving (Esteve, 2014; Gisbert et al., 2019; Ertmer & Ottenbreit-Leftwich, 2010; Mishra & Koehler, 2006). Furthermore, ICT competencies facilitate the design of interactive and collaborative learning experiences, which are crucial in the contemporary educational context (Puentedura, 2014; Baran, 2016).

The study underscores the significance of teacher education programs that incorporate robust ICT components to enhance technological and pedagogical competencies and facilitate the implementation of innovative approaches, such as project-based learning and flipped learning (Ertmer & Ottenbreit-Leftwich, 2010). In a similar vein, Trust (2017) and García et al. (2022) posit that professional development programs should provide personalized and continuous learning opportunities, enabling educators to remain abreast of technological and pedagogical advancements.

Notwithstanding these advances, the study acknowledges limitations, including sample size and representativeness, as well as the necessity for enhanced technological infrastructure in certain institutions. This is vital for the equitable and sustainable integration of ICT in education (Cabero, 2010; Díaz-Arce & Loyola-Illescas, 2021). Furthermore, it is essential to acknowledge the variability of results according to the level of education and the field of study. Teachers in basic education encounter distinct challenges compared to those in secondary education, where more sophisticated tools are utilized (Almerich et al., 2011; Jiménez-Pérez et al., 2023).

The advent of the global pandemic caused by the SARS-CoV-2 virus has brought to the fore the necessity for individuals to possess the requisite digital competencies, thereby exposing deficiencies in the technological preparedness of educators and precipitating the accelerated integration of digital technologies within the educational sector (Martínez-Garcés & Garcés-Fuenmayor, 2020). Nevertheless, significant challenges remain, including resistance to change and the necessity for institutional and technical support (Cabero, 2010; Díaz-Arce & Loyola-Illescas, 2021).

In conclusion, educational policies must continue to facilitate and endorse the advancement of ICT abilities among educators. It is imperative that the ICT competency model, as outlined by Mineducación (2013), be periodically updated to reflect advancements in technology and the evolving needs of the educational landscape (Mineducación, 2022). A comparison of the findings of this study with those of international research offers a broader view and allows for the identification of best practices that are adaptable to the Colombian context (Madsen et al., 2023; Tomczyk et al., 2023). The continuous reinforcement of ICT competencies must be an integral component of teacher professional development, as it is a crucial factor in enhancing educational quality and adapting to technological advancements (Molnar & Nagy, 2022; García-Ruiz & Luque-Jiménez, 2024).

5. Conclusions

This study corroborates the significance of ICT competence in the advancement of

specific competencies among teachers, underscoring its substantial impact on the technological, pedagogical, communicative, managerial, and research domains. These findings provide a robust foundation for the development of teacher education programs that integrate ICT in a meaningful and effective manner, thereby promoting inclusive and high-quality education. It is of the utmost importance that teachers are adequately prepared to incorporate ICT into their professional practice, thereby ensuring that students develop the requisite skills for success in the 21st century.

The SEM model, constructed based on teachers' ICT competencies, facilitated the identification of notable causal relationships between general ICT competence and specific competencies. The results obtained lend support to the hypothesis that ICT competence has a positive effect on teachers' technological, pedagogical, communicative, managerial, and research competencies. These findings emphasize the necessity for the development of teacher training programs that are centered on the effective utilization of ICT in education.

It is recommended that future studies include a larger and more diverse sample that considers variables such as age, gender, teaching experience, and access to technology. Furthermore, longitudinal research will facilitate the observation of changes in ICT competencies and their impact on academic performance, thereby contributing to the continuous improvement of teacher training programs. It is imperative that this research also considers the efficacy of formative approaches tailored to specific contexts, ensuring the requisite technological infrastructure for equitable and sustainable implementation. Furthermore, the incorporation of qualitative methodologies, such as interviews and focus groups, will facilitate a more profound comprehension of the experiences and challenges encountered by teachers in integrating ICT into their pedagogical practices, thereby enhancing their preparedness to adopt such technologies in the classroom.

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