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Analysis of the implementation of a framework for teachers' digital competence in preservice teacher training

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Abstract. *After a conceptual analysis of numerous frameworks for teachers' digital competence (TDC), one such framework was selected to be implemented, and the state of development of the TDC and its relationship with the introduction of computer programming have been studied. The hypothesis is that the implementation of a TDC framework within a first-year university class within an Education degree, called Computer Science and Digital Competence would help future teachers to significantly improve their TDC and, specifically, increase their knowledge of computer programming. In order to test this hypothesis, a study has been carried out with 116 students enrolled in the degree programs in Early Childhood and Primary Education at the Universidad Rey Juan Carlos. The results show that the participants were not digitally competent at the beginning of the course but that they had become significantly more so at the end of it, with a large effect size. Additionally, the prospective teachers did not understand the basic concepts of programming at the beginning of the course, but by the end their knowledge of programming concepts had improved significantly, as evidenced by the large effect size, although even by the end of the course they had not reached an adequate level of programming. The most used frequently tools among students are WhatsApp, social networks and email, but many they were not aware of tools such as podcasts or forums. In addition, the motivation of the participants to learn programming seems to be excellent.*

Keywords: *digital competence; teacher training; programming; technology applied to education*

Análisis de la implementación de un marco para la competencia digital docente en la formación inicial del profesorado

Resumen. *Después de un análisis conceptual de numerosos marcos para la Competencia Digital Docente (CDD), se seleccionó uno de ellos para implementarlo, y se estudió el estado de desarrollo del CDD y su relación con la introducción de la programación informática. La hipótesis es que la implementación de un marco de CDD dentro de un curso universitario de primer año dentro de un grado de Educación, denominado Ciencias de la Computación y Competencia Digital ayudaría a los futuros docentes a mejorar significativamente su CDD y, en concreto, aumentar sus conocimientos de programación informática. Para contrastar esta hipótesis se ha realizado un estudio con 116 alumnos matriculados en los grados de Educación Infantil y Primaria de la Universidad Rey Juan Carlos. Los resultados muestran que los participantes no eran digitalmente competentes al comienzo del curso pero que lo eran significativamente más al final del mismo, con un tamaño de efecto grande. Además, los futuros profesores no entendían los conceptos básicos de programación al comienzo del curso, pero al final su conocimiento de los conceptos de programación había mejorado significativamente, como lo demuestra el gran tamaño del efecto, incluso aunque al final del curso no había alcanzado un nivel adecuado de programación. Las herramientas utilizadas con más frecuencia entre los estudiantes son WhatsApp, las redes sociales y el correo electrónico, pero muchos desconocían herramientas como los podcasts o los foros. Además, la motivación de los participantes para aprender a programar parece ser excelente.*

Palabras clave: *competencia digital; formación docente; programación; tecnología aplicada a la educación*

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Introduction

Digital competence has become an essential skill for citizens, who need it to become a successful part of the knowledge society.

In the field of education, this skill is essential for teachers, who must transmit it to their students and ensure that the latter, too, become digitally competent. Developing this competence is a priority for the education of current students in general, and of future teachers in particular (Ertmer et al., 2012). However, the mere presence of technological resources does not guarantee the development of digital competence (Fernández-Cruz & Fernández-Díaz, 2016).

In addition to having adequate infrastructure, educational institutions should place a priority on digital and pedagogical skills in the classroom. Therefore, it is worth investigating what teachers should *know* and what they should *know how to do* in order to focus on this skill.

To fully understand this process, we must first grasp the key concepts that are used to describe it. After reviewing the literature (van Laar, van Deursen, van Dijk & de Haan, 2017), we identified the following: 21st-century skills, digital competence, digital literacy, digital skills, and electronic skills.

As part of this process, we analysed 13 digital literacy models and found that the concepts surrounding digital competence are very diverse and complex. (Iordache, Mariën & Baelden, 2017). Based on this analysis, a preliminary stage of this study (Santacruz-Valencia et al., 2019) consisted of an adaptation of the contents of the course, "ICT in Education", offered within the Early Childhood Education and Primary Education undergraduate degrees at Universidad Rey Juan Carlos (hereinafter URJC) of Madrid. The course was adapted to comply with to the National Institute of Educational Technologies and Teacher Training (hereinafter, INTEF) Teachers' Digital Competence Framework (INTEF, 2017). The course syllabus, the skills to be focused on and the name ("Computer Science and Teachers' Digital Competence") of this first-year class were modified.

In this second stage, (both before starting the new course and after students had completed it) we explored and analysed – possible improvements in these first-year students' digital competence, as well as the relationship between technology use and social and pedagogical variables. Furthermore, we analysed future teachers' abilities to understand programming concepts. This new field of research has been growing in popularity in recent decades because of the multiple benefits that can be gained when programming is taught from an early age (Pérez-Marín, Hijón-Neira & Martín-Lope, 2018).

This study aims to determine if before and (especially) after having completed the subject adapted to the INTEF framework, students were digitally competent in the five areas of the framework, and specifically, due to their recent incorporation, if they were able, both before and (especially) after completing the class, to understand basic computer programming concepts included within the area of "content creation" in said framework.

Literature review

Conceptual analysis of teachers' digital competence

A recent study (Rodríguez et al., 2019) analysed the research carried out from 2009 to 2017 on teachers' digital competence in various countries and found that this significant and influential line of research has become a highly relevant consideration in teacher training.

Regarding technology use in Education, digital teaching competence is believed to be an essential professional ability that teachers must be taught in order to effectively integrate technology into the classroom (Mishra & Koehler, 2008) and to assume new roles in emerging technological environments (Cejas, Navío & Barroso, 2016).

Here, we must note the importance of teachers' pedagogical and didactic influence on the use of ICT (Krumsvik, 2011; Adams, Cummins & Davis, 2017). Their digital competence is defined as a set of values, beliefs, knowledge, abilities, and attitudes that come together to allow them to successfully use technologies, devices, programs, and the internet, in order to search for, access, organise and use information, all with the purpose of building knowledge (Gutiérrez, 2014). Studies that have analysed the conceptual model of digital competence of university teaching staff (Durán, Gutiérrez & Prendes, 2016) have defined the concept from technological, communicative, and pedagogical perspectives, and have observed that university professors attach to information processing and to evaluating its effect on the digital training of students. Thus, digital competence has been explored on five dimensions (Prendes, Gutiérrez & Martínez, 2018): technical, information and communication, educational, self-reflection, and social and ethical skills; and three fields of application: teaching, research and management.

We build a new model based on five dimensions (technical, information and communication, educational, self-reflection, and social and ethical) and three fields of application (teaching, research, and management).

In addition, certain studies have identified various levels of mastery based on Bloom's Digital Taxonomy (Carretero, Riina & Yves, 2017), as well as some useful examples that can serve as a reference for teachers in general.

Regarding university teaching staff, some studies (Guillén, Mayorga & Álvarez, 2018) have summarised the most relevant digital competence models and highlighted the areas covered and the stages proposed for their development, although these studies do not refer to the levels of mastery of the skill. However, it is possible to identify certain factors that predict its acquisition (Guillén, Mayorga & Álvarez, 2018; Guillén-

Gámez et al., 2020). These studies conclude that teachers lack solid training in the use of ICT, which directly affects their teaching.

Teachers' Digital Competence Frameworks

There are currently many international initiatives (International Society for Technology in Education (ISTE), n.d.; Ministerio de Educación – ENLACES, 2011; UNESCO n.d.; Redecker, 2017) to improve a range of technical and pedagogical aspects of education. Some such programs consist of the implementation of training tools and programmes with the aim of fostering dialogue and the exchange of good practices when it comes to within ICT innovations and their potential and the difficulties involved. Specifically, regarding programming, it says that all computer programs are based on algorithms, which specify how a task should be carried out. Algorithmic thinking, also called computational thinking, is the foundation of computing, and there has been a growing trend towards the introduction of algorithmic thinking in schools.

In Spain, the Ministry of Education, Culture and Sport developed the Common Framework for Teachers' Digital Competence (INTEF, 2017), through INTEF, which sets out five areas of competence (information and digital literacy, communication and collaboration, creation of digital content, security, and problem solving). Its main objective is to serve as a framework that can be used to guide the training of teachers in digital competence and foster the development of a digital culture in the classroom (BOE, July 13, 2020).

There are also interesting studies (Durán, Gutiérrez & Prendes, 2016) that conceptually analyse ICT competence models of university teaching staff in Spain.

Comparative studies (Durán, Gutiérrez & Prendes, 2016) have identified the main areas of the previous frameworks and the scope of their development. The purpose of these frameworks and models is to facilitate the assessment of teachers' competence levels.

Below we have detailed some of the experiences we found in the literature that we thought were relevant, as they analyse certain factors that positively influence the development of teachers' digital competence.

The state of development of teachers' digital competence

Taking the UNESCO framework as a reference (UNESCO n.d.), a study carried out on 1,433 Primary and Secondary teachers in the Community of Madrid (Valtonen et al., 2018) found that there is still a long way to go in terms of teachers' digital competence and rated participating teachers' digital competence levels as average-poor. Primary school teachers were given a better rating than secondary school teachers, which was attributed to the training of the former.

Echoing earlier studies (Farjon, Smits & Voogt, 2019), these studies concluded that science and technology teachers had better digital skills than teachers of other areas, due to the context of their work.

Another two factors that influence the development of this skill is teachers' level of confidence in their ability to use technology, and the years of experience they have in doing so. A recent study carried out among teaching staff at a Dutch university (Mourlam et al., 2019) found that participants did not feel ready to integrate technology into their classrooms.

Other factors found to be influential have included willingness to use technology, experience, skill and the technology itself (Mourlam et al., 2019), in addition to self-perception, prejudices and attitudes (Guillén-Gámez et al., 2020; Mourlam et al., 2019; Guillén-Gámez et al., 2020), and even age, as certain studies showed more enthusiasm among younger teachers (aged 20 to 25) (Fernández-Cruz & Fernández-Díaz, 2016).

Based on the INTEF Teachers' Digital Competence Framework, a study (García, Martínez & Rodríguez, 2017) of Early Childhood and Primary Education students at the International University of Valencia highlighted the disparities in the results for different areas. The students recorded average competence levels for Information Science, advanced levels for Information Search and Evaluation and poor levels for Content Creation and Programming. The study also noted the discrepancy between ICT skills and digital competence as established by regulations (LOMCE and Royal Decrees) and their application in training current teachers.

Another study carried out by the Spanish Scientific Information Society (SCIE) with the support of the Computer Engineering Directors and Deans Conference (CODDII) (Velázquez-Iturbide, 2018) serves as a reference guide for teaching programming at pre-university levels. It states that the introduction of a new course called "Computer Science" would be of interest.

The findings of these studies, however, must be accompanied by proper assessments in order to fully understand teachers' current digital competence. Other studies (van Laar, van Deursen, van Dijk & de Haan, 2017) have put forward empirically validated theoretical instruments that measure six types of digital competence for the 21st century: information, communication, collaboration, critical thinking, creativity, and problem-solving skills. Other studies (Silva et al., 2016) have suggested that these instruments should facilitate the assessment of both objective evidence (degree of training, results, performance, etc.) and qualitative evidence (self-perception, security, motivation, etc.).

In the same vein, the results obtained from the assessment of teachers and trainee teachers show that there are low levels of objective digital competence – there seems to be a perception that they think they know more than they actually do. These results coincide with other investigations, such as a study carried out in Latin American (Tondeur et al., 2018) that found that teacher ICT training tends to be more focused on digital literacy, meaning that teachers are trained merely to use ICT rather than to think, learn and teach with ICT.

For this reason, we need to rethink teacher training, teachers' ability to work with and teach technology, and the mechanisms for evaluating and certifying such knowledge (Fernández-Cruz & Fernández-Díaz, 2016;

Guillén, Mayorga & Álvarez, 2018; Duncan, Bell & Tanimoto, 2014).

Inclusion of programming as a digital competence

The literature offers a broad range of analyses of *digital competence* (we use the term used by the European Parliament to refer to this concept, but there are many others, such as digital literacy, ICT literacy, technological literacy and digital skills) and *programming* (this term is used to define the process of writing instructions that a computer executes). For instance, the framework described above (ISTE n.d.; Ministerio de Educación – ENLACES, 2011; UNESCO n.d.; Redecker, 2017), calls for coding to be taught so that students acquire the necessary skills to develop computer applications. Just as students learn to write to be able to organize, express and exchange ideas, learning to code teaches them to organize, express and exchange ideas in new ways, in a new medium. However, it is important to bear in mind that programming involves the completion of three phases: the analysis of the problem and the design and implementation of a solution (which includes coding, or finding a solution through a specific programming language, as well as debugging and testing).

Reports such as the one produced by the Royal Society suggest that "the term ICT as a brand should be reviewed and the possibility considered of disaggregating this into clearly defined areas such as digital literacy, Information Technology and Computer Science." (Furber, 2012).

In recent years, the issues of digital competence in general and programming skills in particular have gained prominence in the field of education. For example, many countries around the world have modified their curricula to incorporate the teaching of these skills at different educational levels with the purpose of helping students to develop 21st century competencies, which are fundamental for their active participation in society and for the demands of an increasingly digitised labour market.

Many experts (Bocconi et al., 2016) have pointed out the importance of training both teachers and future teachers to ensure they are able to teach the basic notions of programming (not only writing), and to provide students with the skills needed to mentally execute what has been written and with other complementary skills to allow them to critically navigate digital content and to produce such content creatively (Carretero, Riina & Yves, 2017). This would give teachers the ability to use programming as a teaching tool within other course areas (such as mathematics, natural sciences, music, etc.).

However, the distinguishing characteristic between general digital competence and a more specific focus on programming is an emphasis on the processes and methods of problem solving and the creation of computable solutions. Spanish legislation on education (LOMCE, 2015) offers some of the most significant contributions on that relationship and supports the idea of providing content to a new generation of students who have a much deeper understanding of the digital world, and for whom the learning of programming concepts can become a means to explore other areas (the five areas of competence) or for self-expression (through programs they create).

Method

Objectives

The hypothesis of this study is that if the INTEF framework is implemented and its contents adapted to a course in the first year of the Early Childhood and Primary Education Degrees, future teachers will be able to significantly improve their overall digital competence, and specifically their knowledge of programming (given its special relevance and innovative character) from the beginning of their university studies.

In order to test this hypothesis within the INTEF framework, we posed the following research questions:

Q1. Are future teachers digitally competent at the beginning of the course?

Q2. Are future teachers digitally competent upon completion of the course?

Q3. Do future teachers understand programming basics at the beginning of the course?

Q4. Can future teachers learn programming basics using Scratch/Scratch Jr?

Q5. Are some programming concepts harder to understand than others?

Q6. From a social perspective, do future teachers use technology to interact?

Q7. From a pedagogical perspective, do future teachers use technology to learn?

Participants and Procedure

Participants (N = 116 for the overall evaluation of digital competence and N = 102 for the evaluation of Programming knowledge) included first-year students enrolled in the "Computer Science and Digital Competence" course within the Early Childhood and Primary Education degrees at URJC, Madrid (Spain).

Distribution by gender was 97.4% female and 2.56% male in the Early Childhood Education degree and 77.8% female and 22.2% male in the Primary Education degree, with most students having accessed the university via secondary education studies.

The experience took place during the second semester of the 2018-19 academic year (January-May). The study followed a quasi-experimental procedure using the same test before and after the course to measure students' overall digital competence as teachers and programming knowledge within the area of Content Creation.

Pre-tests were administered to students, who completed them individually on their computers in class. They then completed the 14-week course and subsequently took a post-test to measure improvement in both dimensions.

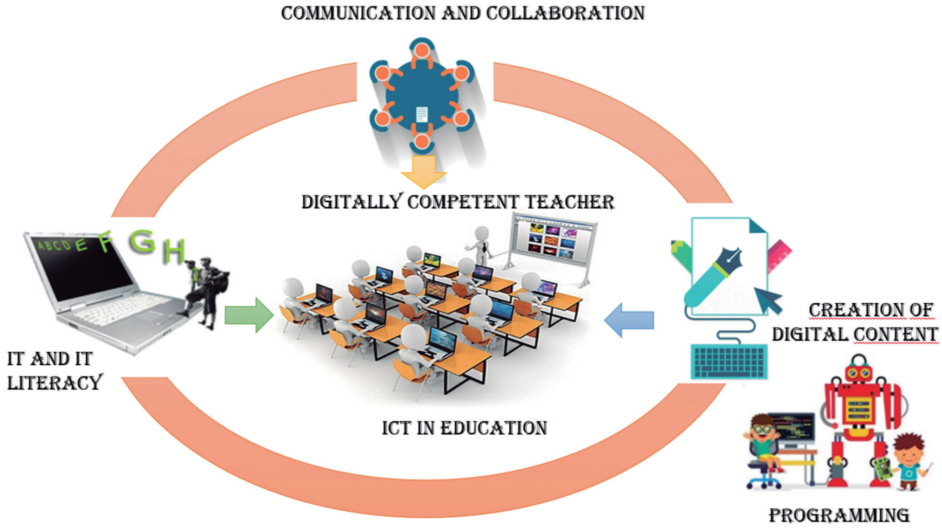

Figure 1. Global vision of ICT in Education (Created by the authors)

Curriculum, methodologies and resources used

The "Computer Science and Teachers' Digital Competence" course, formerly known as "ICT in Education", has been a first-year, six-credit course in the Early Childhood Education and Primary Education degrees since it was introduced in the 2009/2010 academic year. The two fundamental objectives of the class are, first, to introduce students to the main characteristics and possibilities of new technologies so that they are familiar with them and their use, and, second, to teach students how to use these technologies within the educational field in order to improve the quality of the teaching and learning processes.

Figure 1 illustrates the educational paradigm for introducing ICT as a complement to classes in Early Childhood Education (digital blackboards and tablets) and in Primary Education (digital blackboards, computers, and other mobile devices).

This paradigm is only possible when teachers are digitally competent, informationally literate, properly connected and able to understand technologies, so that they can create resources themselves and train their students in how to do so.

The teaching methodology of the course combines practical classes in computer rooms with more theoretical sessions in traditional classrooms, for a total of four hours a week. The content of the course is summarised in Figure 2 in the next section, and was explained in greater detail in a previous study (Santacruz-Valencia et al., 2019).

Class material is available in advance for students through the Virtual Classroom (Aula Virtual, 2020) on the university electronic learning platform. Likewise, eminently practical complementary material is provided through pre-class readings and videos, following the Flipped Classroom model. Active participation, cooperative learning, and problem-based learning through gamification are also used.

Instruments

As exploring future teachers' digital competence in a degree in Education is a novel concept in the litera-

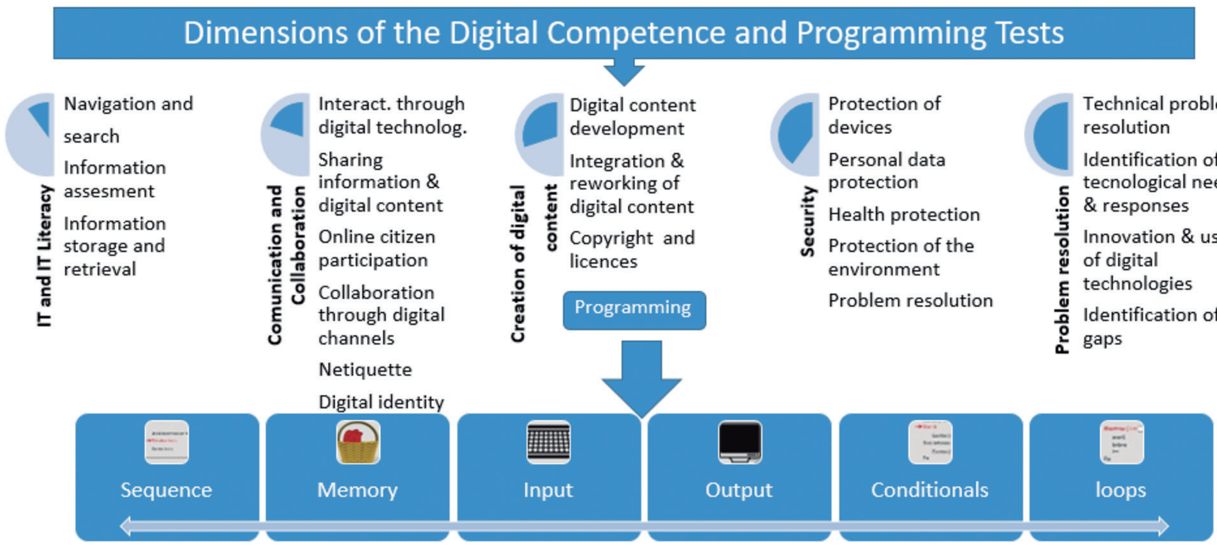

Figure 2. Dimensions of the Digital Proficiency Test (top) and the Programming Concepts Test (bottom)

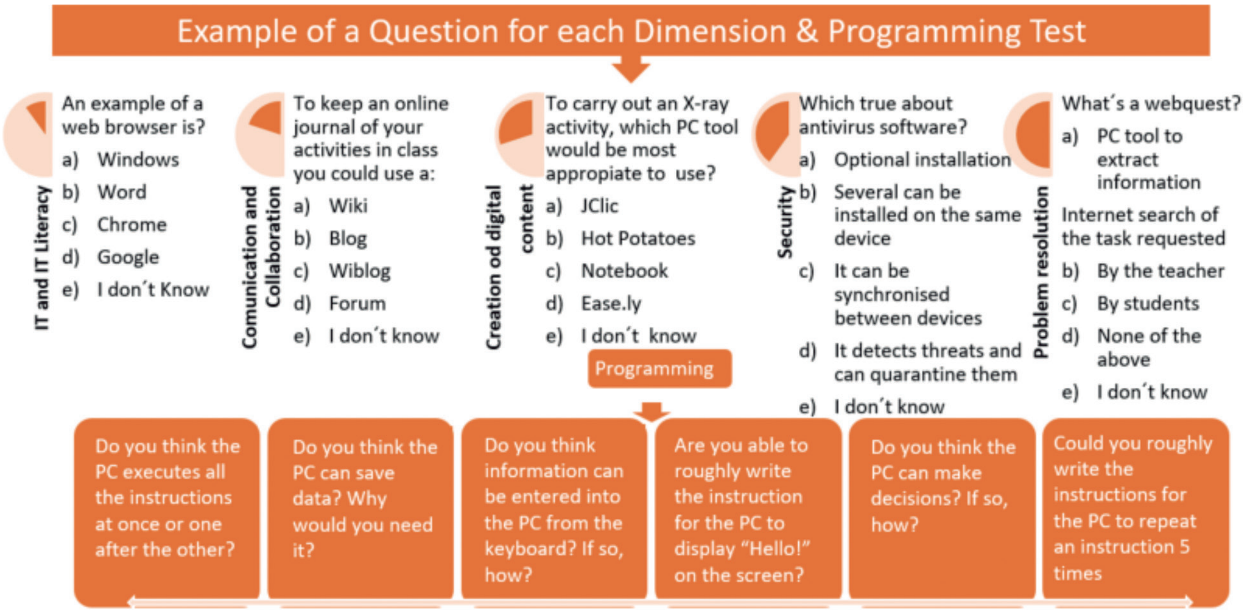

Figure 3. Example Questions for each Dimension (top) and Programming test (bottom)

ture, tests to measure this construct are only emerging now. Some have been validated, but researchers have not yet reached a consensus on a specific application according to context. For example, an on-line self-assessment test (Educalab, n.d.) exists, but it is of no quantitative value and is merely subjective. For this reason, we designed two ad-hoc questionnaires (pre- and post-test) based on the content and competences covered in the "Computer Science and Teachers' Digital Competence" class. The first pre- and post-test was intended to objectively measure students' digital competence as teachers, and a further set of pre- and post-tests was designed to measure their ability to understand the basics of programming. The questionnaires were subjected to a content validation process by experts in digital competence, including PhD holders in computer science and pedagogy, as well as primary school teachers. The tests were used in a pilot session with the population of students who had taken the same course the previous academic year (2017-18).

Figure 2 shows the dimensions covered by each of the tests. The top part shows the teachers' digital competence test dimensions, and the bottom displays the Programming test dimensions, which are an extension of dimension 3 of the former test, Creation of Digital Content. Cronbach's alpha was calculated to measure the reliability of both questionnaires, with resulting alpha values of .52 for the digital competence test, which is a moderate value (very close to good > .6), and of .7 for the Programming test, which shows good reliability.

The Teachers' digital competence assessment test was made up of 26 multiple-choice questions with five possible answers and covered the contents of the INTEF framework's five areas following the SM Formación scheme (SM Formación, 2020).

In light of the importance that is being given to the teaching of programming and computational thinking at an early age (Hijón-Neira et al., 2017), and in accordance with this study's research questions, additional attention has been given to the area of programming within the content creation dimension of the test.

The programming test consists of 15 short-answer questions to test the dimensions corresponding to the concepts of sequence, memory, input, output, conditionals and loops, and basic contents on programming.

An example of a question for each dimension and programming concept is shown in Figure 3.

Results

Quantitative Analysis

We first analysed results obtained from the teachers' digital competence test, followed by those from the Programming test, and subsequently conducted a detailed analysis of each concept to shed light on how to approach this teaching process so that future teachers can use it the classroom.

Analysis of teachers' digital competence

A descriptive analysis of the results obtained is shown. Table 1 shows the minimum, maximum, mean and standard deviation of the scores on each test (pre and post), as well as the significant results obtained in the post-test.

The minimum, maximum and mean values increase notably in the post-test results, while the dispersion decreases minimally.

Table 1. Mean and Standard deviation in the teachers' digital competence tests

	(n = 116)			
	Min	Max	Mean	SD
Pre	1.250	6.667	4.400	1.091
Post	2.083	7.917	5.643	0.957

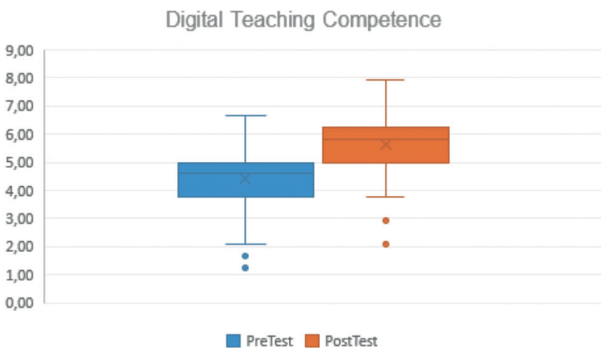

Figure 4. Box-plots for the group of students' pre-test and post-test for teachers' digital competence

Figure 4 shows the box-plots of the results from the teachers' digital competence pre- and post-tests analysis.

We carried out a one-factor analysis of variance (Anova) to analyse the pre-test and the post-test results, obtaining values of F=89.056 and *p*<.005, thus confirming that the scores on the two tests are significantly different. A data analysis and comparison of the two tests shows that the group under study meets the conditions for normality (*p*>.05 significance using the Shapiro-Wilk test), allowing us to use the Student's t-test for paired samples (*p*>.05 using the bivariate correlation test).

Results for teachers' digital competence

Table 2 shows the difference between the pre-test and the post-test in the measurements of teachers' digital competence. From these results, we can conclude that students' test scores significantly improved after completing the course (*p*<.0001).

Table 2. Study using student's t test and p-value analysis

	t test analysis	p-value
Teachers' digital competence	–1.243	.0001

In order to collect additional information on the scale of the change produced in students when applying the INTEF framework to develop teachers' digital competence, the effect size in the study group was calculated using the variation in Cohen's d (Cohen, 1988), yielding a value of *g*=1.21, corresponding to a large effect (since it was >0.5), and close to a very large effect, for which the threshold is *g*>=1.3.

According to these results, the students' digital competence as teachers significantly improved, given that the effect size is large.

Analysis of programming basics

A descriptive analysis of the results obtained is shown in Table 3. The minimum, maximum and mean values increase notably in the post-test results, although the dispersion increases.

Table 3. Mean and standard deviation in the Programming Basics tests

	(n=102)			
	Min	Max	Mean	SD
Pre	0.769	6.923	2.619	1.223
Post	0.769	8.077	3.969	1.601

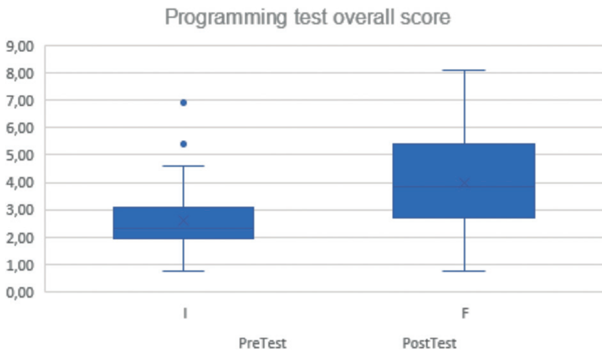

Figure 5. Box-plots for the group of students in Programming Basics pre- and post- tests

Figure 5 shows the box-plots of the results from the Programming Basics pre- and post-tests analysis.

We carried out a one-factor analysis of variance (Anova) to analyse the pre-test and the post-test results, obtaining values of F=45.80 and *p*<.005, thus confirming that the data in the two tests are significantly different.

A data analysis and comparison of the two tests shows that the group under study meets the conditions for normality (*p*>.05 significance using the Shapiro-Wilk test), allowing us to use the Student's t-test for paired samples (*p*>.05 using the bivariate correlation test).

Results for programming basics

Table 4 shows the difference between the pre-test and the post-test in the measurement of knowledge of programming basics. From these results, we can conclude that students' test scores significantly improved when following the course planning (*p*<.0001).

Table 4. Study using student's t-test and p-value analysis

	t test analysis	p-value
Programming Basics	–1.350	.0001

In order to collect additional information on the scale of the change produced in students, the effect size in the study group was calculated using the variation in Cohen's d (Cohen, 1988), yielding a value of *g*=.96, corresponding to a large effect (since it was >0.5).

According to these results, we can confirm that students' learning of Programming concepts significantly improved, given that the effect size is large.

Analysis of individual programming concepts

Despite a general improvement in the students' knowledge of programming, the average mark is not

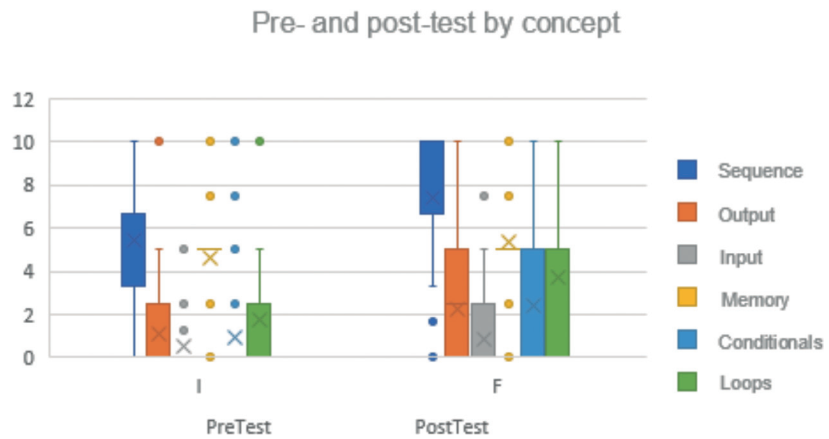

Figure 6. Box-plots for the group of students' pre- and post-test for each basic Programming concept studied

very high. Given 50% of the students fail to pass this block, the expected results have not been achieved.

For this reason, a study of each concept has been carried out to determine which concepts are the most and least difficult to understand, with the purpose of applying the results obtained to teaching and learning processes.

The minimum, maximum and mean values increase notably in the results obtained from the post-test, although the dispersion increases slightly in all concepts with the exceptions of "memory" and "sequence."

Figure 6 shows the box-plots of the results for Programming Basics pre- and post-tests assessment separated into the six different Programming Basics studied.

Results for each programming concept

Table 5 shows the difference between the pre- and post-test for the measurement of basic programming knowledge broken down into the various concepts studied. From these results, we can conclude that students' test scores significantly improved after completing the course (p<.0001). In order to collect additional information on the scale of the change produced in the students, the effect size in the study group was calculated using the variation in Cohen's d (Cohen, 1988), yielding the values shown in table 5 for each of the concepts, where a value above 0.5 corresponds to a large effect, and below 0.5 to a medium effect.

According to these results, learning was significant for all programming concepts. The effect size is large for Sequences, Output, Conditionals and Loops, and medium for Input and Memory.

Table 5. Study using student's t-test and p-value analysis (left) and effect size in the study group (right)

	t test analysis	p-value	g	Effect size
Sequences	–1.993	.0001	0.78	large
Output	–1.140	.0001	0.51	large
Input	–0.355	.025	0.25	medium
Memory	–0.784	.0001	0.45	medium
Conditionals	–1.520	.0001	0.60	large
Loops	–1.985	.0001	0.65	large

Qualitative Analysis

To complement the quantitative analysis, the following section briefly highlights the main results obtained from the multiple open-ended questions added to the end of the two questionnaires.

From a social perspective

Participants believe it is important to understand how to use digital tools that facilitate communication and teacher-student and student-student interactions. Figure 7 shows the tools that they most often use to interact.

It is surprising to see that future teachers have not used tools such as forums, podcasts, or videoconferences, or that they do not even know what they are, or what they are used for. Conversely, the three most used tools are also popular in the context of today's digital society.

From a pedagogical perspective

Participants believe that technology favours the teaching and learning process, highlighting a possible improvement in their autonomous learning. However, they are not familiar with "Learning Management Systems" beyond file exchange and sharing videos (see Figure 8).

In the pre-test, 91% of the students stated that they would like to create a computer program, compared to 5% who expressed their disinterest (0.4% did not answer), see Figure 9.

The post-test showed that, after having learned how programs such as Scratch and Scratch Jr. work, 78% continued to show an interest in coding software, compared to 17% who, after having learnt to program, expressed their disinterest (possibly due to the difficulty encountered). This increased rejection might play an important role in students' learning process and perhaps also in the teaching process as future teachers.

The level of difficulty involved in this task could also have influenced their interest and motivation. In fact, a high percentage of students started off thinking programming was difficult, but this percentage decreased after they had completed the class. Figure 10

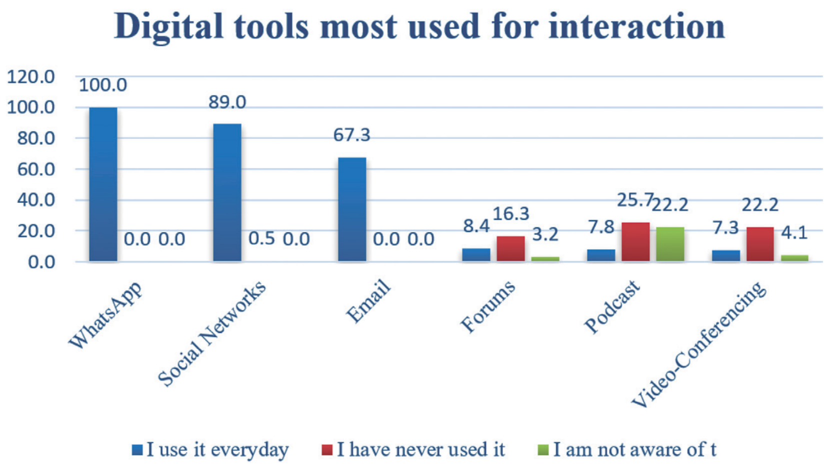

Figure 7. Digitals tools most often used for interaction

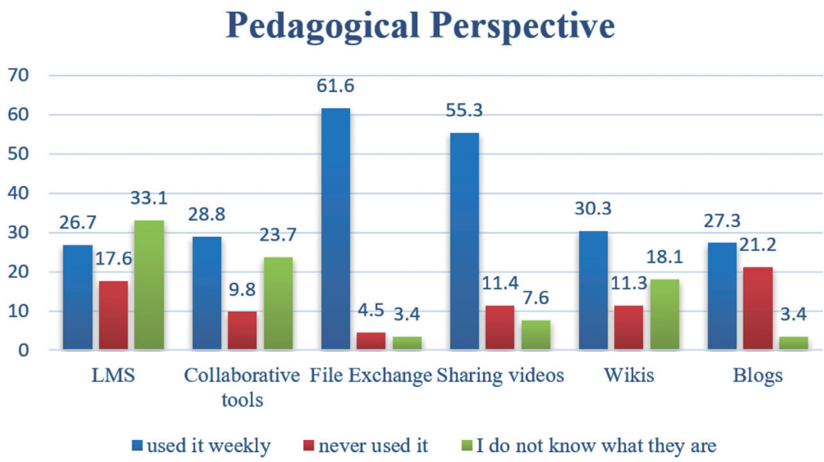

Figure 8. Digitals tools most used from a Pedagogical Perspective

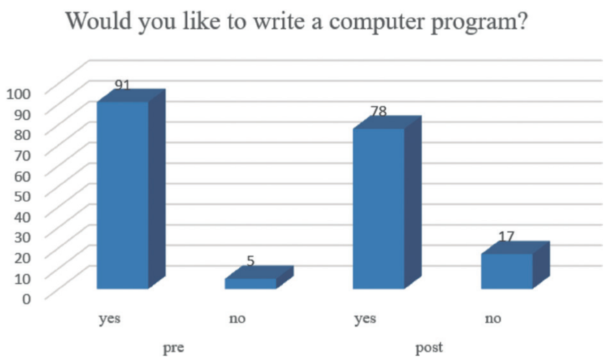

Figure 9. Motivated to learn how to program in the pre-test and post-test.

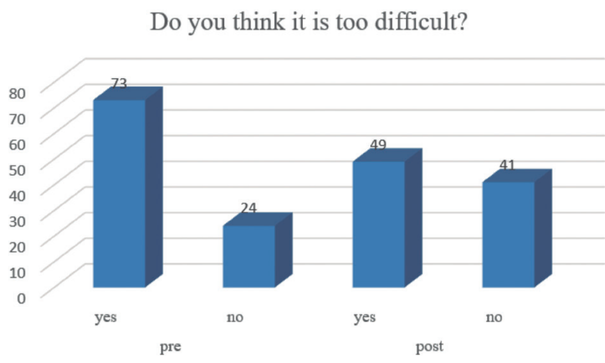

Figure 10. Assessment of the level of difficulty involved (right) in the pre-test and post-test.

shows that 73% of participants believed coding a computer program was difficult in the pre-test, compared to 24% who considered it not difficult. However, after completing the course (post-test), only 49% believed coding a computer program was difficult, compared to 41% who did not.

Discussion

The results obtained in this study are in line with another study (García, Martínez & Rodríguez, 2017) that found an incompatibility between the ICT and digital competence skills required by official regulations and their real-world application in the current training of teachers.

Furthermore, as mentioned above, the work carried out by SCIE and CODDII (Velázquez-Iturbide, 2018) recommends the compulsory teaching of "Computer Science", including programming concepts, in both primary and secondary schools. Despite this, the time allocated to the acquisition of programming basics and to improving students' ability to program is reduced to a small part of the six-credit course, which is clearly insufficient.

With the data obtained from the study carried out in the context of the "Computer Science and Teachers' Digital Competence" course – in which digital competence and basic concepts on Programming were taught with active methodologies and the evolution of 116 students was measured, using the same tests for the pre- and post-test at the beginning and at the end of the course, we have been able to answer the research questions asked at the beginning of the study:

Q1. Are future teachers digitally competent at the beginning of the course? We found that the participants were not digitally competent at that stage. Half of the participants scored below five on the pre-test, and the approximate average was 4.4. Previous studies seen in the literature review had similar results (Rodríguez, Raso & Ruiz, 2019).

Q2. Are future teachers digitally competent at the end of the course? Yes, because 50% of the participants scored above five on the post-test (Figure 2). Furthermore, students' learning significantly improved, with the effect size being large.

Q3. Do future teachers understand programming basics at the beginning of the course? No, because 50% of the participants scored below three in the pre-test, with an approximate mean of 2.6. Previous studies seen in the literature review also showed similar results.

Q4. Can future teachers learn programming basics using Scratch/Scratch Jr? Yes. These results show that students' knowledge of programming concepts significantly improved, evidenced by the large effect size, although they did not reach an adequate level (not all participants pass the course). Therefore, it might be beneficial to dedicate more time to these complicated concepts. As mentioned above, previous studies also show that the importance given to future teachers' ICT skills and digital competence is not aligned with its application in their training.

Q5. Are some programming concepts more difficult to understand than others? Yes. The most familiar concepts are sequence, output and loops, and the least familiar are input, memory and conditionals. The following concepts had the largest effects on learning (in this order): sequence, loops, conditionals, output, memory and input.

Q6. From a social perspective, do future teachers use technology to interact? Yes. The most commonly used tools are the most popular tools today (WhatsApp, social networks and email), concurring with results from other studies (Guillén, Mayorga & Álvarez, 2018; Guillén-Gámez et al., 2020), although it is surprising that participants were not at least aware of other frequently used tools such as podcasts or forums, even if they do not use them.

Q7. From a pedagogical perspective, do future teachers use technology to learn? Yes, although it sometimes seems that they use tools without knowing what exactly they are, such as learning management systems or collaborative tools. Furthermore, participants' motivation to learn how to program seems to be great. More participants believed that programming is difficult before taking the course (73%) than at the end of it (49%), which shows how important it is to dedicate time to this task to ensure that teachers can pass this knowledge on to their future students. This should make us reflect on the time spent teaching this topic, the most appropriate methodologies to teach it, and the resources needed to maintain and increase motivation towards this essential skill (Pérez-Marín, D., Hijón-Neira & Martín-Lope, 2018; Rodríguez, Raso & Ruiz, 2019).

In general, the results obtained concur with previous studies in the literature, which have noted that science and technology teachers have better digital competences than teachers in other areas (Farjon, Smits & Voogt, 2019). In this case, the pre-service teachers enrolled in Education degrees are not specialised in science and technology. These results also concur with the study by (Mourlam et al., 2019), which found that teachers do not feel fully prepared to adequately integrate technology into the classroom. Finally, the results of the evaluation of the INTEF Teachers' Digital Competence Framework carried out by the International University of Valencia (García, Martínez & Rodríguez, 2017) showed deficiencies in the areas of content creation and programming, and the results obtained in our study concurred with this.

Conclusions and future work

Students enrolled in the Early Childhood and Primary Education degrees significantly improved their overall digital competence and their knowledge of programming after completing the "Computer Science and Teachers' Digital Competence" course, which had been adapted to reflect the INTEF framework and to increase the use of active methodologies.

In an experiment carried out with 116 students in these two teaching degrees, students who at the beginning of the course were not digitally competent and lacked any prior programming experience were able to significantly improve their knowledge of these topics, as evidenced by a digital competence test, a programming concepts test and the effect size, which was large in both cases when they were tested after finishing the course.

Apart from the acquisition and improvement of the more technical aspects of digital competence, participants also noted improvements in social and pedagogical factors.

As future work, we intend to research the most appropriate teaching-learning methodology to address the content and digital competences that teachers must acquire according to the INTEF framework. Because of the above, digital and technological knowledge and skills must be developed in parallel with pedagogical skills at the level of teacher training in higher education, as this will help ensure adequate and up-to-date training of tomorrow's Early Childhood and Primary Education teachers. Without a doubt, a this represents challenge for any teacher of any educational stage.

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