Throwing Out the Baby with the Bathwater: Consequences of Covid-19 on the ICT Readiness of Italian Teachers

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Abstract

COVID-19 has accelerated the integration of Information and Communication Technology (ICT) into the Italian educational system; in this perspective, this paper focuses on the integration of ICT in Italian schools, with three objectives: i) to measure the readiness of teachers to integrate ICT into educational practices, ii) to assess whether the pandemic has had a significant effect on this readiness, and iii) to study whether there are significant differences at the regional level. Our findings highlight the multidimensional nature of "ICT readiness," the pandemic's significant influence in some dimensions, and the high level of ICT readiness among teachers in Southern regions, challenging the conventional North-South educational divide in Italy.

1. Introduction

Since the 1990s, countries worldwide have invested substantial resources in equipping schools with technological facilities and training teachers to integrate technology into their teaching methods. International organizations, such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Organization for Economic Co-operation and Development (OECD), have recognized technology as a catalyst for improving education quality. The European Union, through initiatives like ET2020 and the Digital Agenda for Europe, has actively promoted the Integration of Information and Communication

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Technology (ICT) in schools to enhance students' competencies, foster innovation, and improve creativity (European Commission, 2000).

At the heart of the European cooperation process, there is, among others, the development of educational systems that enhance the individual potential and creativity of pupils and students; in addition, national development is directly related to the quality of education provided (Shoaib *et al*., 2023). ICT could be a powerful tool in this regard and in promoting equity in education too. In Belgium, Denmark, Ireland, Spain, Italy, Hungary, Malta, Poland, Slovenia, Finland, and the United Kingdom, the use of ICT is also promoted to address students with disabilities or learning difficulties and socially disadvantaged students. Despite these efforts, challenges persist in achieving full ICT integration. Figures from the International Computer and Information Literacy Study (ICILS) in 2018 reveal that over 33% of 13-14-year-olds lacked fundamental digital skills. Additionally, there are stark disparities in internet connectivity, with only 6% of children and young individuals under 25 in low-income countries having household internet access compared to 87% in high-income countries, according to UNICEF (2020). In response to the COVID-19 pandemic, the European Union has intensified its commitment to digital education through the Digital Education Action Plan (2021-2027). The pandemic has accelerated the integration of ICT in education (Mesmar, Badran, 2022), particularly in more developed countries, marking a significant shift compared to the pre-COVID period (Tadesse, Muluye, 2020). However, several factors can impede progress, including the availability of school resources, such as hardware and trained support staff. Access to appropriate technological tools is identified as a primary obstacle, alongside the lack of specific training programs for teachers.

The role of teachers is crucial in incorporating ICT in the classroom, regardless of the technological resources available (William *et al*., 2000). Teachers' attitudes, perceptions, and confidence in using ICT influence their choice of incorporating technology into the educational process. Confident and proficient teachers can create interactive and engaging lessons, personalize education, provide access to a broader range of learning materials, and encourage social interaction and collaboration (Phan, Dang, 2017). Teacher beliefs and skills are identified as significant factors influencing technology integration. Educators who lack conviction in the benefits of ICT may hesitate to incorporate technology regularly. Hence, the readiness to use ICT in teaching becomes fundamental, requiring a multidimensional perspective that considers teachers' propensity and the support provided by schools (D'Agostino *et al*., 2023). In Italy, ICT for pedagogical issues is included in the core curriculum for initial education for teachers in secondary education (Ranguelov *et al*., 2011). The digital innovation of the educational system is a fundamental pillar of "La Buona Scuola" school reform

(Law 107/2015): tools, teaching, content, and skills are the main elements of this Plan. Here, too, the Plan stresses that the education field must not focus on technology but on its interactions with new educational models that also include teacher educational innovation training. Nevertheless, the OECD Teaching And Learning International Survey (TALIS) finds that the percentage of Italian school leaders who reported a shortage and inadequacy of digital technology for education is higher than the involved OECD average and that of Italian teachers who feel discreetly prepared to use ICT for teaching is lower (OECD, 2018). In 2022, the Italian Digital Economy and Society Index ranked 18th out of all 27 EU countries, but improved from 2019, before the advent of the COVID-19 pandemic, when it ranked 24th (European Commission, 2020, 2022). Indeed, due to the global COVID-19 crisis prompting the closure of educational institutions in numerous nations, more than 90 percent of ministries of education have implemented several digital and broadcast remote learning policies (UNICEF, 2020). Italy was one of the first countries to face the emergency with a very long period of school closure.

Educators had to adapt quickly and were required to resort to digital resources, often with little training, to ensure the uninterrupted progress of student education and thus enhance their professional skills (Nusche, Minea-Pic, 2020; Sharma *et al*., 2022). This transition has posed an incomparable challenge even for educators with a strong command of ICT (Flack *et al*., 2020). The few previous existing empirical studies concerning Italy focus on the impact of the COVID-19 pandemic on student performance and on how this effect varies between schools and subjects (Bertoletti *et al*., 2023), even fewer those that focus on the teachers' perspective. The study carried out by Giovannella *et al*. (2020) through a survey involving 336 Italian teachers demonstrates, in addition, the capacity of the Italian school system and its technological infrastructures to ensure educational continuity during the COVID-19 pandemic with some concern about inclusivity, technology adequacy and teachers' readiness as the two main factors of the perception of sustainability of e-learning and the desire to continue using it in a third of the teachers; moreover, they have noted that the more technological approaches can simulate traditional ones and the more teacher training is provided, the more favorable the conditions are. In conclusion, while the integration of ICT in education has been a long-standing goal, challenges persist. The COVID-19 pandemic has acted as a catalyst, but the readiness of teachers and support from educational institutions remain critical for successful and sustained ICT integration. Developing a comprehensive framework to measure readiness is essential for shaping policies that promote and accelerate the integration process. From this perspective, the purpose of this study is to measure the teachers' readiness towards ICT from a multidimensional perspective using data

from the National Institute for the Evaluation of Education and Training System (INVALSI). In detail, our objectives are to assess the degree to which Italian teachers are prepared to fully integrate ICT into educational practice using a multidimensional perspective; secondly, to evaluate whether the pandemic has had a significant effect on this readiness, and to study if there are significant differences at the regional level.

2. Data

The National Institute for the Evaluation of Education and Training System (INVALSI) annually evaluates Italian students across various school tiers, including primary and secondary education. These assessments involve standardized tests that gauge students' proficiency in reading, mathematics, and english. The INVALSI outcomes contribute to the central government's comprehension of the overall performance of the education system, facilitating comparisons both within and among schools on a spatial scale (at the national, regional, and county levels) and over time. The INVALSI survey comprises two separate surveys with variations in the test administration method. The primary survey is a comprehensive census survey where teachers within each Italian school and class administer the tests. Additionally, a probabilistic sample of schools and classes is selected for test administration, overseen by external observers. This sample survey yields more timely and higher-quality data due to the presence of external administrators, mitigating or eliminating potential instances of teachers' cheating, as highlighted by Longobardi *et al*. (2018). At the same time, the sample survey enhances the depth of information gathered by INVALSI by administering targeted questionnaires to principals and teachers within the sample. This approach broadens the spectrum of available covariates, allowing for the collection of pertinent data at multiple levels of analysis. One of the various facets of school life that the INVALSI explores involves examining how teachers incorporate new technologies to enhance both instructional methodologies and evaluation practices. From this perspective, it is interesting to assess variations in teachers' attitudes toward the use of ICT before and after COVID-19 to verify whether the restrictions due to the pandemic have promoted the integration of new technologies into teaching practices. For this purpose, we pooled the sample data collected before the COVID-19 pandemic (school year 2018/2019) with the most recent data acquired after the pandemic (school year 2021/2022), coinciding with the lifting of school restrictions. Based on self-reports, the data were collected at the regional level (NUTS 2) from a sample of 3,885 teachers of grade 10, comprising 1,993 Italian teachers and 1,892 mathematics teachers. Table 1 reports

Table 1 – Size of Teachers' Sample by Teaching Discipline, Macro-area and School Year

Area	*Before Covid-19 (s.y.2018/19)*			*After-Covid-19 (s.y.2021/22)*			*Total*		
	Italian	*Math*	*Total*	*Italian*	*Math*	*Total*	*Italian*	*Math*	*Total*
North-West	234	229	463	166	173	339	400	402	802
North-East	261	244	505	159	163	322	420	407	827
Centre	293	283	576	199	185	384	492	468	960
South	262	243	505	211	211	422	473	454	927
Islands	123	89	212	85	72	157	208	161	369
Italy	1,173	1,088	2,261	820	804	1,624	1,993	1,892	3,885

Source: Authors' elaborations from INVALSI teacher's questionnaire data

the sample size distribution categorized by teaching discipline, macro-regional area, and school year (pre/post-Covid).

To compare the information between the two surveys and examine a comprehensive array of items from the teachers' questionnaire associated with integrating ICT into teaching practices, we selected only common variables between the two surveys. Following the COVID emergency, the structure of the teachers' questionnaire for the school year 2021/22 was modified by INVALSI, contextualizing and focusing the questions on the changes in teaching processes caused by the pandemic. Consequently, although it is not possible to fully exploit the entire informational "heritage" of both surveys, the set of items usable for pre and post-COVID comparison consists of 13 items, which represent a sufficient number to outline a framework of the dimensions composing ICT readiness.

Table 2 provides the list and description of these items measuring a particular action or teacher assessment that enables us to measure the ICT readiness of teachers. These variables represent the potential set of indicators that are single observable manifestations of the latent multidimensional concept of "readiness to ICT". The scale of each item has been reversed, when needed, to ensure they move in the same direction: a higher value of the indicator corresponds to a greater likelihood that teachers possess a high level of readiness for ICT[1].

1. In addition, the answer "I don't know" of the items from D1a and D1b has been recoded by assigning them the median value.

Table 2 – List of Common Items Selected from Invalsi Teachers' Questionnaire Over the Surveys Conducted Before and After the Covid-19 Pandemic (s.y.2018/19 and s.y. 2021/22)

Item	*Survey Questions*	*Type of Variable (answers) Categorical variable*
D1a	How much does the teacher believe that the transition from the paper test to the computer test helped in the understanding of the questions?	(1=Strongly Disagree; 2=Little agree; 3=Fairly agree; 4=Strongly agree; 5=I do not know)
D1c	How much does the teacher believe that the computer test increases the assessment objectivity?	(1=Strongly Disagree; 2=Little agree; 3=Fairly agree; 4=Strongly agree; 5=I do not know)
D2a	Frequency of use of computer tests made available on the INVALSI site	(1=Never or almost never; 2=Sometimes; 3=Often Always, 4= Nearly always)
D2b	Frequency of use of computer tests on other platforms	(1=Never or almost never; 2=Sometimes; 3=Often Always, 4= Nearly always)
D2c	Frequency of use of computer tests prepared by the teacher	(1=Never or almost never; 2=Sometimes; 3=Often Always, 4= Nearly always)
D2d	Frequency of use of the computer lab	(1=Never or almost never; 2=Sometimes; 3=Often Always, 4= Nearly always)
D10a* D6a**	Frequency of use of ICT supports for teaching (computer)	(1=Regular use; 2=Occasional use; 3=Not use; 4=Not present at school)
D10b* D6b**	Frequency of use of ICT supports for teaching (Multimedia Interactive Whiteboard)	(1=Regular use; 2=Occasional use; 3=Not use; 4=Not present at school)
D10d* D6d**	Frequency of use of ICT supports for teaching (Smartphone)	(1=Regular use; 2=Occasional use; 3=Not use; 4=Not present at school)
D10e* D6e**	Frequency of use of ICT supports for teaching (Tablet)	(1=Regular use; 2=Occasional use; 3=Not use; 4=Not present at school)
D10f* D6f**	Frequency of use of ICT supports for teaching (e-learning platforms)	(1=Regular use; 2=Occasional use; 3=Not use; 4=Not present at school)
D10g* D6g**	Frequency of use of ICT supports for teaching (educational software)	(1=Regular use; 2=Occasional use; 3=Not use; 4=Not present at school)
D11f* D7f**	Assessment method: Frequency of use of assessment platforms	(1=Never or almost never; 2=Sometimes; 3=Often Always, 4= Nearly always)

Note: * Item of the questionnaire for math teacher; ** Item of the questionnaire for Italian teacher.
Source: Authors' elaborations from INVALSI teacher's questionnaire data

3. Method

We used the approach proposed by D'Agostino *et al*. (2022) to synthesize the information provided from the list of items described in Table 2. We first employed Exploratory Factor Analysis (EFA) to check whether there are one or more underlying dimensions to the multidimensional concept of ICT readiness. Then, Confirmatory Factor Analyses (CFA) were performed to test and confirm what was detected by EFA. To summarize the information on each dimension, we implemented the fuzzy approach proposed by Betti *et al*. (2016). This methodology allows us to preserve the richness of the data information being based on the computation of a membership function that measures different degree levels of the ICT readiness of teachers instead of the simple dichotomy of being ready or not ready for ICT.

Formally, let x_{ij} be the category of item j (j=1…J) observed for teacher i (i=1…n) and let the levels of each item j be ordered from the lowest value of readiness for using ICT – $\min(x_j)$ – to the highest value – $\max(x_j)$. The membership function for the *i-th* teacher and the *j-th* indicator is defined as:

$$\mu_j\left(x_{ij}\right) = \frac{F\left(x_{ij}\right) - F\left(\min\left(x_j\right)\right)}{F\left(\max\left(x_j\right)\right) - F\left(\min\left(x_j\right)\right)} \qquad [1]$$

where $F(x_{ij})$ is the corresponding cumulative distribution function of x_{ij}.

When the teacher's degree of readiness for using ICT is insufficient then $\mu_j(x_{ij})=0$; on the contrary, if it is completely adequate, $\mu_j(x_{ij})=1$; an intermediate level of readiness for using ICT is defined by $0 < \mu_j(x_{ij}) < 1$.

Let d (d = 1, …, D) be one of the possible dimensions that summarize teachers' readiness to use ICT. The multidimensional fuzzy index for *i-th* teacher in the *d-th* dimension is given by computing the weighted average across all the indicators of that dimension d:

$$\mu_d\left(i\right) = \sum_j w_{(d)j}\mu_j\left(x_{ij}\right) / \sum_j w_{(d)j} \qquad [2]$$

where $w_{(d)j}$ is the system of weights proposed by Betti and Verma (2008), computed as the product of two factors:

$$w_{(d)j} = w^a_{(d)j} * w^b_{(d)j}. \qquad [3]$$

The first factor $w^a_{(d)j}$ is directly proportional to the variability of the *j-th* indicator. Thus, if an indicator has a low percentage of teachers associated with the lowest levels of ICT readiness and is therefore judged to be critical, it will receive a high $w^a_{(d)j}$ weight component. The second factor $w^b_{(d)j}$ is inversely proportional to the average correlation between the *j-th* indicator and all other indicators of the same

d-th dimension. Therefore, an indicator that is highy correlated with the other indicators within the same dimension will have a low $w^{b}_{(d)j}$ weight component.

The average value of individual values $\mu_d(i)$ defines the overall fuzzy readiness to use ICT of the entire population of teachers as follows:

$$\mu_d = \frac{1}{n}\sum_{i=1}^{n}\mu_d(i) \qquad [4]$$

4. Results

Table 3 summarizes the results obtained using EFA in combination with CFA, taking the 13 elementary items described in Table 2 as input. The selected items load in different dimensions that we named D1 (ICT for teaching), D2 (ICT for assessing), and D3 (Expectations for ICT). While considering different items compared to D'Agostino *et al*. (2022)[2], our findings similarly reveal that more than one dimension describes the readiness to use ICT. The first dimension encompasses various facets of the teacher's ability to facilitate teaching through ICT tools (hereinafter referred to as ICT for TEACHING). Specifically, within this dimension, seven items show how frequently teachers employ technology. This dimension involves the application of diverse ICT tools, including computers, Multimedia Interactive Whiteboards, smartphones, tablets, e-learning platforms, and assessment platforms.

The second dimension evaluates teachers' proficiency in efficiently using computer-based testing and assessments, hereafter referred to as ICT for ASSESSING. The widespread adoption of computer-based testing in recent years has been extensively discussed in the literature, with various studies outlining both the advantages and challenges associated with implementing such assessments for students (McFadden *et al*., 2021; Jeong, 2014). Within the ICT for ASSESSING dimension, three indicators assess the frequency with which teachers employ computer tests, either provided by the INVALSI or other platforms. Furthermore, this dimension considers the extent to which educators utilize the computer lab and its resources. The third dimension allows us to assess the teacher's attitudes and expectations toward adopting new educational tools, hereafter denoted as EXPECTATIONS for ICT.

The two items of this dimension are related to teachers' expectations regarding how computers contribute to the efficient and effective implementation of assessments for student learning outcomes. This dimension focuses on some topics, including whether computer-based testing impartially caters to the diverse needs of all students, assists in understanding assessment questions, and improves the objectivity of evaluating student performance.

2. As already mentioned, the selection of items was constrained by the availability of the same set of indicators in both periods during which the survey was conducted.

Table 3 – Description of the Three Fuzzy ICT Readiness Dimensions

Dimension	*Description*	*Number of Items*	*List of items*
D1: ICT for teaching	It reflects the capacity to support the teaching process using Information and Communication Technology	7	D10a*/D6a**, D10b*/D6b**, D10d*/D6d**, D10e*/D6e**, D10f*/D6f**, D10g*/D6g** D11f*/D7f**
D2: ICT for assessing	It expresses the ability to make effective use of computer tests	4	D2a, D2b, D2c, D2d,
D3: Expectations for ICT	It reflects a positive attitude toward new educational tools	2	D1a, D1c

Note: * Item of the questionnaire for math teacher; ** Item of the questionnaire for Italian teacher.
Source: Authors' elaborations from INVALSI teacher's questionnaire data

Table 4 reports the values of the fuzzy index of the readiness to use ICT for every dimension before and at the end of the COVID-19 pandemic and the 95% bootstrap confidence intervals of these differences, respectively. Focusing on dimension 1, which expresses the frequency of ICT tools usage, there is a substantial increase in the mean value of the fuzzy index, rising from 0.57 to 0.75. This difference is statistically significant based on the bootstrap interval. It can be explained as an effect of the pandemic, which compelled all teachers, even those less inclined to use it before COVID, to integrate ICT into teaching. Dimension 2, related to the use of ICT for assessment, shows a higher average after COVID-19, but this difference is not statistically significant. The pandemic

Table 4 – Differences in the Fuzzy ICT Readiness Dimensions Before and After the Covid-19 Pandemic

Dimension	*Before Covid-19 (s.y. 2018/19)*	*After Covid-19 (s.y. 2021/22)*	*Difference (2021-2018)*	*95 % Bootstrap confidence interval*	
D1: ICT for teaching	0.573	0.756	0.183	0.172	0.194
D2: ICT for assessing	0.367	0.378	0.011	-0.006	0.028
D3: Expectations for ICT	0.660	0.624	-0.036	-0.053	-0.019

Source: Authors' elaborations from INVALSI teacher's questionnaire data

has likely increased teachers' inclination to use digital tools for teaching. Still, at the same time, it has not influenced the methods of assessing students' competencies, which have remained tied to traditional approaches. Unexpectedly, it seems that the COVID-19 pandemic has resulted in a reduction of expectations regarding the effectiveness of ICT in teaching. The average values for this dimension significantly declined post-COVID. Before the pandemic, teachers likely harbored high expectations for these tools, even though they were not extensively utilized in teaching. Subsequently, these expectations partially disappointed after these tools were employed effectively, possibly due to a lack of a systematic path to understanding and integrating these technologies.

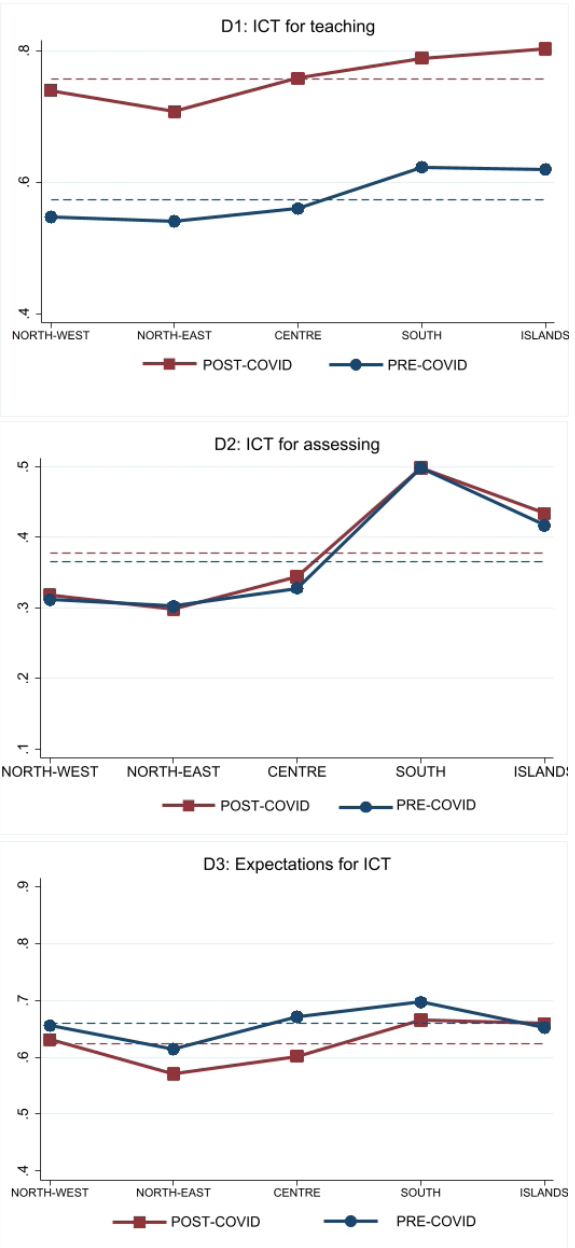
The analysis disaggregated by macro-regions adds further interesting conclusions. Figure 1 shows the index μ_d by the five macro-regions usually used in official statistics for regional comparisons (Northern-west, Northern-east, Centre, South, and Islands) over the two periods. For all three dimensions, the dynamics observed at the national level are substantially replicated at the macro-regional level. As a result, an increase in ICT for teaching is observed in each area, while variations in ICT for assessing appear small within each area. At the same time, the values of expectations for ICT are decreasing, except for the Islands area, where the averages for the two periods seem unchanged.

The differences between areas deserve more attention. Indeed, interesting differences emerge between teachers in Northern Italy and those in the Southern regions, with the latter demonstrating a higher ICT readiness for each dimension, regardless of pre- or post-pandemic period.

In Table 5, the aspect of territorial differences is emphasized by testing them both before and after the pandemic compared to the country's average. As indicated by the fuzzy indicator, positive deviations from the national average suggest that a specific area is more favourably positioned regarding the dimension under examination. Our findings underline that teachers from the southern area and the Islands report higher values than the country's average for each dimension. On the contrary, northern teachers consistently consistently rank below the Italian average in all three aspects of ICT readiness. At the same time, the position of teachers in the Central region is less well defined, as they align around the national average for dimensions 1 and 3 but fall significantly below for dimension 2. These results are particularly noteworthy as they deviate significantly from the typical North-South gap observed in Italy, where teachers and students from the North usually outperform their counterparts in the South (Longobardi, Pagliuca, 2013).

Up to this point, we have examined the impact of the pandemic on territorial differences in teachers' readiness to use ICT, without considering their individual characteristics.

Figure 1 – Averages by Regional Macro-area of the Fuzzy ICT Readiness Dimensions Before and After the Covid-19 Pandemic



Source: Authors' elaborations from INVALSI teacher's questionnaire data

Table 5 – Differences Between the Averages of Each Italian Macro-area and the National Average for the Three Fuzzy ICT Readiness Dimensions Before and After the Covid-19 Pandemic

Area	*D1: ICT for Teaching*		*D2: ICT for Assessing*		*D3: Expectations for ICT*	
	Pre Covid	*Post Covid*	*Pre Covid*	*Post Covid*	*Pre Covid*	*Post Covid*
North-West	-0.025***	-0.017*	-0.054***	-0.060 ***	-0.004	0.007
North-East	-0.032***	-0.049***	-0.063***	-0.080 ***	-0.045***	-0.053***
Centre	-0.013	0.002	-0.037***	-0.034 ***	0.012	-0.022
South	0.050***	0.032***	0.133***	0.120 ***	0.037***	0.041***
Islands	0.047***	0.046***	0.052***	0.056 ***	-0.007	0.035*

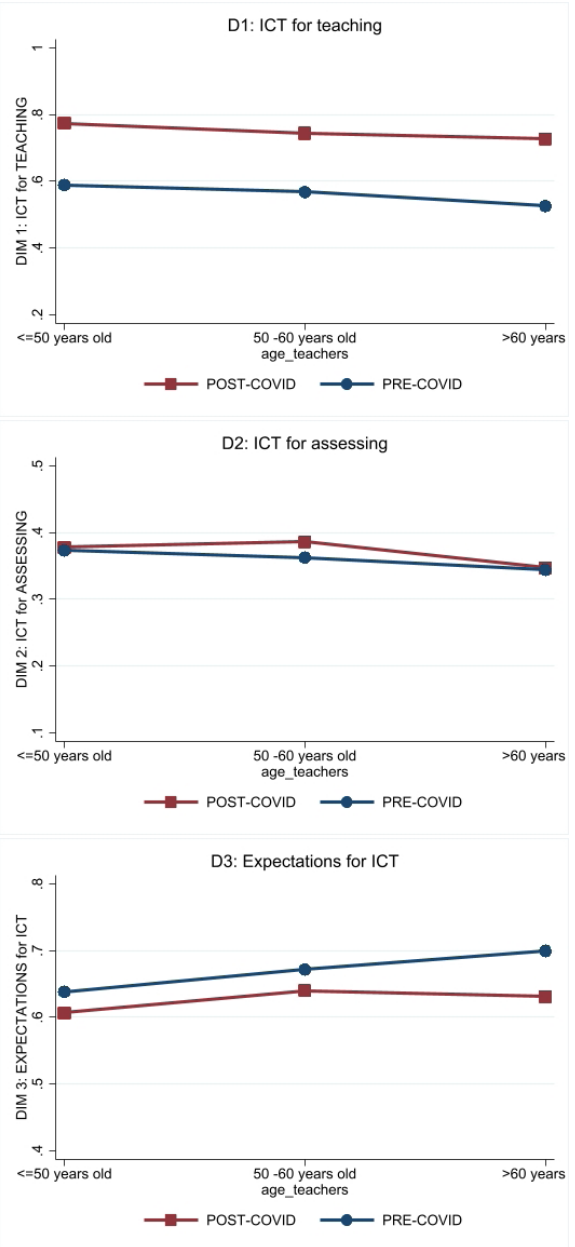
Note: Statistical significance level estimated by bootstrap procedure (reps=1000): * p < 0.1; **p < 0.05; ***p < 0.01.

Source: Authors' elaborations from INVALSI teacher's questionnaire data

Several studies analyze the relationship between ICT integration and teacher characteristics (Šabić *et al*., 2022; Gil-Flores, 2017) focusing on the age of the teacher, which emerges as one of the elements that most significantly determines the teacher's inclination toward the use of technological tools (Peng *et al*., 2023; Lucas *et al*., 2021, Mannila *et al*., 2018). To explore this relationship, we computed the weighted average of the overall membership function $\mu_d(i)$ defined in equation [2] for each of the three dimensions by the age of the teacher (see Figure 2). A notable increase in the average values of the first dimension (ICT for teaching) is observed across all age groups following the COVID-19 pandemic. Concurrently, it is noteworthy that, during both periods, teachers aged over 60 show a lower average level in dimension 1 compared to their counterparts under 50, confirming that younger teachers show a stronger inclination to integrate ICT into their teaching practices.

The difference in the use of ICT for assessing (D2) among different age groups of teachers seems negligible in the comparison before and after the pandemic, mirroring what has been observed both at the national level (Table 4) and within macro-areas (Figure 1). The expectation regarding the effectiveness of ICT experienced a decline after the pandemic, but this decline is more pronounced among teachers above the age of 60. A broader interpretation of the results suggests that COVID-19 has promoted a greater diffusion of ICT, especially among older teachers who initially exhibited a lower inclination to change their teaching methods. However, this forced march towards ICT integration has led to a decline in expectations, particularly for this category of teachers who may have been more intrigued by new technologies but did not necessarily used them.

Figure 2 – Averages by the Teacher's Age of the Fuzzy ICT Readiness Dimensions Before and After the Covid-19 Pandemic



Source: Authors' elaborations from INVALSI teacher's questionnaire data

5. Conclusions

The availability of INVALSI data, which surveyed 2,261 and 1,624 representative teachers across all Italian regions in 2018/2019 and in 2021/2022, allowed us to measure the degree of readiness of Italian teachers to integrate ICT into their educational practice from a multidimensional and fuzzy perspective. With respect to the contribution of D'Agostino *et al*. 2022 we added an empirical investigation to test whether the COVID-19 pandemic has accelerated the process of ICT integration. Findings could serve as a starting point for proposing policies at the national and regional levels to promote and enhance this process, which the onset of the COVID-19 pandemic has already spurred.

Based on the set of items selected to be common over the two surveys, we confirm the multidimensional nature of the readiness of ICT as in D'Agostino *et al*. 2022: the readiness to ICT can be summarized by three different dimensions. Synthesizing measurements such as the frequency of computer use, interactive platforms, educational software, computer labs, and computer testing, the first and second dimensions reflect the capacity to support the teaching and assessment processes using Information and Communication Technology. Conversely, the third dimension is associated with teachers' perceived likelihood of success in utilizing ICT for educational purposes. After the pandemic, at the national level, there has been a significant improvement in the D1 dimension "ICT for teaching." In contrast, dimension 2, concerning ICT use for assessment, exhibits a higher average but lacks statistical significance, indicating that assessment methods remained traditional despite increased digital teaching. Surprisingly, dimension 3 reveals a reduction in expectations regarding ICT effectiveness in teaching post-COVID-19, possibly stemming from pre-pandemic high expectations and subsequent partial disappointment due to effective yet non-systematic technology integration.

The variations observed at the national level for each of the three dimensions are reflected similarly in each macro area of Italy. Finally, the most intriguing finding is that southern regions exhibit higher readiness levels for digital innovations, particularly for the first two dimensions. In contrast, the northern macro area consistently falls below the overall national average, both before and after the COVID-19 pandemic. The reasons for the ranking of Italian macro-regions across the four dimensions are complex to detect. A large majority of investment spending in education in the southern region has been on ICTs (Giusti *et al*., 2015). This may have pushed teachers in southern Italy to invest time and effort in ICT. Second, in a period of restriction of national public spending on education, EU structural funding disproportionately favored the southern regions (Giusti *et al*., 2015; Römisch, Jestl, 2017). The interaction between this "technology shock [...] to change the teaching culture" and the overall financial

resources in education might play a role in understanding the variation in our indicators among Italian regions: teachers in Southern Italy may have tried to make the best use of their ICT resources.

In order to propose and implement further research developments, it is essential to outline some limitations of the present study. Firstly, the results focus on comparing the academic year prior to the pandemic (2018/19) with the academic year 2021/22, during which the critical phase had been surpassed but the emergency was not yet completely resolved. However, to obtain a more comprehensive picture of the COVID's effect in the short-to-medium term, extending the comparison to data from subsequent academic years would be beneficial.

Additionally, measuring the long-term effect of COVID on ICT readiness presents challenges. Departing from the pandemic period, it becomes increasingly difficult to distinguish between the direct effects of COVID and those resulting from the growing pervasiveness of new technologies in the educational sector. For instance, simply consider the burgeoning and swift dissemination of AI algorithms (AI), which were once confined to a select group of experts, these algorithms have now permeated various domains, including education.

Another limitation of the analysis pertains to data availability. As mentioned (section 2), the variables used to define fuzzy indices were selected based on common items in both INVALSI surveys. However, Italy currently lacks a systematic assessment of digital competencies among both teachers and students. Therefore, conducting targeted investigations to evaluate teachers' ICT readiness in greater detail – examining not only their technology usage but also how it impacts their teaching methods – would be desirable.

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Sommario

Gettare via il bambino con l'acqua sporca: le conseguenze del COVID-19 sull'ICT readiness degli insegnanti italiani

Il COVID-19 ha accelerato l'integrazione della Tecnologia dell'Informazione e della Comunicazione (ICT) nel sistema educativo italiano; in questa prospettiva l'articolo analizza l'integrazione dell'ICT nelle scuole Italiane focalizzandosi su: i) come misurare la preparazione dei docenti ad integrare l'ICT nelle pratiche educative; ii) valutare se la pandemia abbia significativamente accelerato l'utilizzo dell'ICT; iii) evidenziare eventuali differenze a livello territoriale. I risultati indicano la multidimensionalità del concetto di "prontezza" all'uso dell'ICT, rivelando un'accelerazione selettiva su alcuni dei suoi aspetti durante la pandemia. Inoltre, contrariamente al tradizionale divario Nord-Sud, si nota una maggiore propensione verso l'ICT tra i docenti delle regioni meridionali.