EXTENDED ABSTRACT

Title: Teachers' readiness to digital innovation in Italy: a regional perspective

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S03 – Challenges in the construction of composite indicators for monitoring public policies

Abstract: *(minimum1500 words)*

1. Introduction

The Covid-19 emergency has rapidly accelerated technology adoption at school, and this phenomenon will continue to evolve. Thus, teachers must be prepared for digital innovation (Pokhrel and Chhetri, 2021). A study undertaken in 2018 by the Organisation for Economic Co-operation and Development (OECD) found that, on average less than 40% of educators across the EU felt ready to use digital technologies in teaching, with divergences between the EU Member States.

In Italy, there is a pressing need to innovate and implement alternative educational and assessment strategies from policymakers. The Covid-19 pandemic has provided us with an opportunity to pave the way for introducing digital learning (Dhawan, 2020). Still, there is a need to measure and quantify the readiness of teachers and schools to successfully integrate technology into teaching. The teacher's readiness to integrated digital education is heterogeneous, and the factors fostering the use of technology can vary among teachers of different grade levels, subjects, and regions (Menabò et al. 2022).

Furthermore, the teacher's readiness to integrated digital teaching is not an easy concept to be measured because of its multidimensional nature. It depends on different dimensions (latent variables) that represent several aspects of readiness and are measured by a set of observable elementary indicators. We can refer to different elements that depend on the teacher's ability to use ICT or even to the environmental constraints where teachers live (e.g., access to infrastructures such as technological devices and internet connections). Furthermore, the teacher propensity to enhance their information and communications technology (ICT) skills plays a role in the educational digital process, as well as the school proactivity to improve teachers' digital knowledge and skills.

A formative perspective characterizes our approach. We assume that the causality is from the elementary indicators to each dimension, and a change in each dimension does not necessarily imply variations in all its measures. Accordingly, we can estimate the latent variable (dimension) by taking a weighted average of the elementary indicators that comprise the concept (Shwartz et al., 2015). This perspective is commonly used in constructing composite indicators based on objective and subjective indicators (Maggino and Zumbo, 2012).

For our analysis, we show how the fuzzy approach to multidimensional poverty measurement (Cerioli and Zani, 1990; Betti et al., 2006; Betti et al. , 2016) can be considered a helpful tool in this framework. Recognizing that different dimensions characterize the teacher's readiness to integrated digital teaching, the identification of "who is willing to digital innovation" becomes a more complicated task because the analysis is based on several elementary indicators, and it is difficult to choose a single threshold value below which teachers are classified as "not willing to digital innovation". Indeed, the practitioner should decide the cut-off value for each item, and this exercise could not be so immediate. In contrast with a crisp approach, we thus consider teachers' readiness as a matter of degree (fuzzy concept) by specifying a membership function to the set of ready teachers (ranging from 0 to 1).

We use a representative sample of teachers provided by the National Institute to evaluate the education and training system (INVALSI). Our empirical strategy investigates the dimensions that define the teacher's readiness to integrated digital teaching. Then we aim to answer the following research questions: i) What is the stage of teacher education and teacher competencies in the digital transformation process?; ii) Do the dimensions differ by grade levels, subjects, and regions? This exercise can be a valuable tool for Italian policymakers in the framework of the Digital Education Action Plan (2021-2027). The teachers' opinions need to be considered in designing change toward innovation and developing digital skills at school.

2. Method

We dispose of a set of single indicators that summarize a set of D dimensions that measure different aspects of teachers' readiness concerning the teaching profession. We apply a fuzzy approach to summarize each dimension d (d=1…D).

Let x_{ij} be the value assumed by a single indicator j by teacher i, with categories ordered from the lowest value of digital readiness to the highest. Thus, each unit i with $x_{ij} < min(x_{ij})$ is undoubtedly considered in situation of high risk to not be willing to digital innovation and each unit *i* with $x_{ij} > max(x_j)$ is undoubtedly considered as be willing to digital innovation. The units *i* that satisfy $min(x_j) < x_{ij} < max(x_j)$ are considered as partly digitally ready. We use the membership function of Betti and Verma (2008), defined as follows:

$$\mu_j(x_{ij}) = \frac{F(c_{j,i}) - F(1)}{F(C_j) - F(1)}, j = 1, \dots, K;\ i = 1, \dots, n\ , \qquad (1)$$

where $c_{j,i}$ is the category of the j-th indicator, corresponding to the i-th teacher, and $F(c_{j,i})$ is its corresponding cumulative function. When the indicator assumes a value equal to one (lowest level of the readiness to digital innovation), then $F(c_{j,i}) = F(1)$, and therefore, $\mu_j(x_{ij})$ is equal to zero. Instead, when the item assumes the highest level of the readiness to digital innovation (e.g., C_j), then the numerator of Eq. (1) is equal to the denominator, and therefore, $\mu_j(x_{ij})$ is equal to one. Membership function values between 0 and 1 indicate intermediate degrees of readiness to digital innovation.

In order to summarize the information for each dimension d, we use the weighted average across the indicators holding to dimension d, as follows:

$$\mu_d(i) = \sum_k w_{(d)k} \mu_j(x_{ij}) \,/\, \sum_k w_{(d)k} \quad (2)$$

We also use a data-driven weighting system that has been proposed by Betti and Verma (2008), thus $w_{(d)k}$ is the weight of the *k*-th single indicator in the *d*-th dimension, computed as

$$w_{(d)k} = w^a_{(d)k} * w^b_{(d)k} \qquad (3)$$

The weight for each item k is composed of two factors. The first factor is the coefficient of variation and the second is a measure based on correlations among items within each given dimension d. Finally, in order to summarize the information for each subgroup s of analysis (s=grade levels, subjects and regions) and dimension we compute an overall fuzzy index μ_d that is defined as the average value of individual values $\mu_d(i)$, as follows:

$$\mu_d = \frac{1}{n_s}\sum_{i=1}^{n_s} \mu_d(i) \quad (4)$$

where n_s is the sample size of subgroup s.

3. Data

For this study, we use data administrated by the National Institute for the evaluation of the education and training system (INVALSI). The INVALSI database provided a valuable resource to investigate the characteristics of the Italian school system as whole. We refer only to the data referring to the sample survey devoted to the teacher's opinion on various aspects of school life (see Falorsi et. 2019). We use data from this survey referred to the academic year 2020/21. The COVID-19 pandemic has led to a reformulation of the teacher questionnaire. It has been more focused on the teacher use of ICT before and during the emergency period, as well as other helpful information concerning the availability of good ICT infrastructures at home and actions carried out by each school to facilitate and improve digital teacher skills (https://invalsi-serviziostatistico.cineca.it/documenti/ss/rilevazioni_integrative_ss/Nota%20Metodologica%20Insegnante%202020-21.pdf).

This survey covers teachers engaged in three different subjects (Italian, Mathematics, and English), who provide instruction in programs at the ISCED 1 level (primary education - 5th grade), at the ISCED 2 level (lower secondary education - 8th grade), and at the ISCED 3 level (upper secondary education - 13th grade). The sample size consists of 5815 teachers employed in 966 schools. Table 1 presents the sample size of teachers and schools (in brackets) by grade and subject. The wide sample size allows us to carry out an analysis disaggregated at the regional level. We consider the five macro-regions (NUTS LEVEL-1) defined by the National Institute of Statistics (ISTAT): North-West, North-Est, Centre, South, and Islands[1].

[1]The following classification of Italian macro areas is considered: North-West (Liguria, Lombardia, Piemonte and Valle d'Aosta), North-East (Emilia Romagna, Friuli-Venezia Giulia, Trentino-Alto Adige and Veneto), Center (Lazio, Marche, Toscana, and Umbria), South (Abruzzo, Campania, Molise, Puglia, Basilicata, Calabria) and Islands (Sardegna and Sicilia).

Table 1 Sample size of teachers and schools (in brackets)

GRADE	Italian	Mathematics	English	Total
Primary education - 5th Grade	681 (402)	624 (364)	655 (382)	1960 (433)
Lower secondary education - 8th Grade	363 (203)	336 (189)	343 (197)	1042 (216)
Upper secondary education - 13th Grade	762 (409)	719 (397)	704 (393)	2185 (447)
Total	1806 (905)	1679 (845)	1702 (865)	5187 (966)

For the empirical analysis, we consider a total of 49 elementary indicators arranged in four dimensions using a measurement perspective based on formative indicators (Jarvis et al., 2003; Diamantopoulos and Winklhofer, 2001). The first dimension (D1) measures "ICT expertise in education", the second dimension (D2) measures "Constraints linked to digital teaching", the third dimension (D3) measures "Actions to enhance propensity to ICT skills", the fourth dimension (D4) measures "School support to digital teaching activities". These dimensions are composed of a set of 15, 5, 9, and 14 elementary indicators, respectively.

4. Results

Empirical bootstrap 95% confidence intervals for the differences have been estimated (Efron & Tibshirani, 1998) to test whether there is a significant difference for each overall index μd between subgroups in each dimension. When the interval includes zero, at a significance level of 0.05, we cannot reject the hypothesis of no difference between groups. Findings generally stress significant differences between grades, subjects, and macro-regions in several dimensions.

Thus, if the stage of teacher education and teacher competencies in the digital transformation process differ, educational policies should consider this heterogeneity to be fully effective.

Keywords: *(maximum 6 words)*
Teachers' digital readiness, Multidimensional and fuzzy approach; inequality, COVID impact

JEL codes: I28, C1, I21,

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