QTIMES
JOURNAL OF EDUCATION
Technology and Social Studies

ISSN: 2038-3282

Pubblicato il: gennaio 2024

Registrazione Tribunale di Frosinone N. 564/09 VG

Assessing teacher beliefs about the value of digital technology in instruction: Initial evidence of factor structure and reliability of the TECNOVAL questionnaire

Valutare le credenze degli insegnanti sul valore delle tecnologie digitali nella didattica: Prime evidenze della struttura fattoriale e dell'affidabilità del questionario TECNOVAL

di

Laura Carlotta Foschi
lauracarlotta.foschi@unipd.it
University of Padua

Abstract:
The paper presents the construction and psychometric property analysis of a questionnaire (TECNOVAL) developed to investigate in-service teachers' beliefs about the value of digital technology in instruction. The study examined the instrument's data properties, factor structure, and reliability in a sample of 137 Italian primary and secondary school teachers. Preliminary analysis of data properties revealed that data follow an approximately normal distribution. The exploration of the factor structure produced a one-factor solution consistent with the expectations. The factor also demonstrated good internal consistency reliability: adequate Cronbach's α, McDonald's ω, average inter-item correlation, and corrected item-total correlation. Although some psychometric properties have yet to be evaluated, TECNOVAL can be a useful tool for assessing teacher beliefs about the value of digital technology in instruction in the Italian school context.

Keywords: Digital Technology; Educational Technology; Teachers; Teacher beliefs; Scale development.

Abstract:
Il contributo presenta la costruzione e l'analisi delle proprietà psicometriche di un questionario (TECNOVAL) sviluppato per indagare le credenze degli insegnanti sul valore delle tecnologie digitali nella didattica. Lo studio ha esaminato le proprietà dei dati, la struttura fattoriale e l'attendibilità dello strumento in un campione di 137 insegnanti di scuola primaria e secondaria. L'analisi preliminare delle proprietà dei dati ha evidenziato una distribuzione approssimabile alla normale. L'esplorazione della struttura fattoriale ha rilevato un fattore coerente con le aspettative. Il fattore ha dimostrato una buona attendibilità in termini di coerenza interna: adeguate α di Cronbach, ω di McDonald, correlazione media inter-item e correlazione item-totale corretta. Sebbene alcune caratteristiche psicometriche restino ancora da valutare, TECNOVAL può essere utile per valutare le credenze degli insegnanti sul valore delle tecnologie digitali nella didattica nel contesto scolastico italiano.

Parole chiave: Tecnologie digitali; Tecnologie didattiche; Insegnanti; Credenze degli insegnanti; Costruzione di scale.

1. Introduction

In educational contexts, there is a continuous advancement and increasing widespread of Information and Communication Technologies (ICTs), and the importance of ICTs in education will continue to increase (Willis et al., 2019). Integrating technology into teaching and learning is a complex and challenging process (Tondeur et al., 2017; OECD, 2019), and seamless integration of ICT still need to be achieved (European Commission, 2019). The COVID-19 pandemic has further underscored the critical importance of effective technology use in education, yet many teachers struggled to adapt their pedagogical practice to the new mode made mandatory by school closures (Schlichter, 2020; Scully et al., 2021), i.e., so-called *Didattica a Distanza* in Italy, also called in different ways according to different meanings and requirements (e.g., distance education or teaching or learning, remote teaching, emergency remote teaching, online learning). Researchers have identified several factors, both individual and institutional, associated with the effectiveness of online teaching and learning in response to the COVID-19 pandemic. Individual factors included, for example, teachers' digital skills, beliefs, particularly those of self-efficacy, and perceived online presence (e.g., Bond, 2021; Howard et al., 2021; Huber & Helm, 2020). Institutional factors, on the other hand, included, for example, the technical and pedagogical support provided by schools (Howard et al., 2021), technology adoption in schools (Ewing & Cooper, 2021; Huber & Helm, 2020), as well as school vision and leadership (Karakose et al., 2021). Conversely, lack of ICT skills, knowledge of subject-specific technology strategies, self-efficacy, motivation, and access to technical resources have hindered teachers from successfully integrating technology into their pedagogical practice (Bell & Barr, 2023). In addition, Ewing and Cooper (2021) indicated that the adoption of emergency technology in schools prevented the purposeful integration of technology. The literature has long questioned what factors influence successful teachers' adoption of digital practices. In general, understanding why ICT integration varies among teachers' everyday practices has often involved examining these two sets of barriers (Ertmer, 1999, 2005; Ertmer et al., 2015; Hew & Brush, 2007). Barriers to integration exist both inside and outside of teachers (Park & Ertmer, 2007). First-order barriers are external and concern factors such as environmental readiness and suitability, e.g., Internet access, availability of and access to ICT and software, as well as the lack of time for professional development, planning time, or administrative support. Second-order barriers are internal and mainly include teachers' beliefs and attitudes towards ICT. Second-order barriers can interfere with teachers' technology integration even when first-order barriers are overcome (Ertmer, 1999; Park & Ertmer, 2007). First-order barriers are easier to recognise and fix. In contrast, second-order barriers may require major changes in teachers' beliefs and daily teaching practices: teachers must believe in "new ways of both seeing and doing things" (Ertmer, 2005, p. 26) for technology integration to be effective. In short, to promote teachers' technology integration practice in the classroom, it has been advocated that second-order barriers to technology integration should be identified and overcome (Ertmer, 2005; Hew & Brush, 2007; Kim et al., 2013). Knowledge and understanding of teachers' beliefs that make technologies differently integrated into teaching would help to improve technology integration training (Kim et al., 2013). In line with this, after theoretically framing teachers' beliefs about technology, the paper presents the construction and psychometric property analysis of a questionnaire. The questionnaire, denominated "TECNOVAL", was developed to investigate in-service teachers' beliefs about the value of digital technology in instruction. TECNOVAL was developed as part of continuous professional development (CPD) and training activities on educational innovation with primary and secondary school teachers (e.g., Foschi, 2021, 2022a, 2023). The aim was to have an instrument to assess teachers' beliefs before and after CPD and training activities, both to direct them and to analyse any changes. This study examines the item and data properties, factor structure and reliability of the TECNOVAL questionnaire in a sample of Italian teachers.

2. Theoretical framework

2.1 Teacher beliefs about technology

Despite the extensive literature on teacher beliefs, it is difficult to find a shared definition. The research proposes theoretical frameworks that differ in conceptualisation and operationalisation, and thus in measurement instruments. "The difficulty in studying teachers' beliefs has been caused by definitional problems, poor conceptualisations, and differing understandings of beliefs and belief structures" (Pajares, 1992, p. 307). What emerges from the literature is the difficulty in formulating a unitary definition of the construct "beliefs", which emerges as a "messy construct" (ibid.). Ultimately, "teacher beliefs" have been used inconsistently (Kim et al., 2013). The definition of teacher beliefs about technology has no consensus either. Some researchers consider teacher beliefs to be beliefs about the value of technology for student learning (e.g., Polly et al., 2010). Some regard teacher beliefs as self-efficacy regarding technology use (e.g., Abbitt, 2011), while others as a combination of self-efficacy, beliefs about the value of technology, and beliefs about teaching and learning with technology (e.g., Park & Ertmer, 2007). Similarly, for some researchers, teachers' beliefs about technology consist of three related but independent components: pedagogical beliefs about learning and teaching, self-efficacy beliefs about technology use, and beliefs about the perceived value of technologies for student learning (Miller et al., 2003). In this paper, beliefs are understood as the personal system of more or less structured opinions, generalisations, expectations, values, and rules of thumb (Hermans et al., 2008). These include beliefs about technology, broadly understood as personal beliefs or opinions about the importance of technology for teaching, its positive or negative impact on student learning, and the benefits it can bring to the learning-teaching process (Russell et al., 2003).

2.2 The relevance of teacher beliefs

It has been repeatedly emphasised that teachers' beliefs reflect, predict, and determine their pedagogical practice (Pajares, 1992; Wilkins, 2008). Beliefs are a foremost influencing factor in many areas of education (Borg, 2003), and technology is not exempt from this influencing phenomenon (Galvis, 2012). Research has shown that teachers' beliefs are one of the most important factors affecting teacher technology integration practices (Chien et al., 2014; Galvis, 2012; Ottenbreit-Leftwich et al., 2010; Palak & Wells, 2009). Research on teachers' beliefs has demonstrated how these influence teachers' classroom technology integration and are often its main predictors (Ertmer & Ottenbreit-Leftwich, 2010; Ertmer et al., 2012). It has also shown how teachers' beliefs, given equal knowledge and skills, are the discriminating factor that leads a teacher to lean towards the use of technology or not (Kim et al., 2013).
When it comes to the integration of technology into teaching and learning, it is crucial to consider mainly two types of beliefs, i.e. pedagogical beliefs and beliefs about the value of technology. Indeed, teachers' technology integration in teaching is affected by their pedagogical beliefs, i.e., what they believe about the nature of teaching and learning (Ertmer et al., 2015; Tondeur et al., 2017). These beliefs influence the frequency of technology use and how it is used. Research indicates that teachers who hold constructivist (student-centred) beliefs tend to be very active users of technology (Ertmer et al., 2015). For example, Sang et al. (2011) and Tondeur et al. (2008) found that constructivist pedagogical beliefs were positively associated with teachers' reported frequency of technology integration in classrooms. In general, constructivist beliefs have been shown to positively affect technology use, while traditional-transmission beliefs (teacher-centred) negatively impact it (Hermans et al., 2008; Taimalu & Luik, 2019; Tondeur et al., 2008, 2017). In addition to the frequency of technology use, pedagogical beliefs are also related to how technology is used. Research indicates that teachers with traditional vs. constructivist beliefs tend to use technology in different ways (Ertmer et al. 2015). Teachers' low-level technology uses (e.g., using technology to present a lecture or ask students to complete drill-and-practice exercises) tend to be associated with more traditional beliefs (Ertmer, 2005; Ertmer et al., 2012; Hermans et al., 2008; Park & Ertmer, 2007). In contrast, high-level uses (e.g., using technology for engaging students in collaborating with peers and inquiry-based activities) tend to be associated with constructivist beliefs (ibid.).
As anticipated, apart from pedagogical beliefs, another crucial factor when we talk about the integration of technology into teaching and learning is the subject matter of this study, i.e. the beliefs about the value of technology, as shown below.

2.3 Beliefs about the value of technology

As just mentioned, this study will focus on beliefs about the value of technology. Research on teachers' beliefs about technology has highlighted the relevance of the "value" attributed to technologies for teaching and student learning (Ottenbreit-Leftwich et al., 2010; Park & Ertmer, 2007). Research indicates that when teachers perceive technology to have value in the teaching and learning process, they tend to use it more frequently in their pedagogical practices (Hsu, 2016;

Ottenbreit-Leftwich et al., 2010; Taimalu & Luik, 2019; Zhao & Frank, 2003; Zhao et al., 2002). In other words, beliefs about the value of technologies greatly enhance teachers' perceptions about the effectiveness of technologies for teaching and learning, and thus, such beliefs can significantly impact the subsequent use of technologies in their pedagogical practices (Ottenbreit-Leftwhich et al., 2010; Park & Ertmer, 2007). Moreover, research suggests that teachers who hold more facilitative value beliefs (e.g., believing that technologies are important for classroom instruction; believing that technologies are valuable in sustaining student learning) tend to leverage their resources effectively to overcome external barriers to technology integration (Snoeyink & Ertmer, 2001; Vongkulluksn et al., 2018). Given the considerable preparation required - i.e. the precious energy, resources, and time spent - for meaningful technology integration, these value beliefs toward technology become even more salient; teachers are unlikely to invest in it if the technology is not valued (Coppola, 2004; Zhao & Cziko, 2001). Therefore, it seems reasonable to assume that before integrating technology into their teaching practices, teachers must first assign value to its use (Zhao & Cziko, 2001). Teachers must believe that the use of technology will lead to good teaching and the desired learning outcomes (Taimalu & Luik, 2019). Research has found that teacher beliefs about the value of technology are a strong predictor of the quantity and quality of technology integration; in particular, teachers with higher value beliefs tend to use technology for student-centred instruction and higher-order learning tasks (Vongkulluksn et al., 2018). In conclusion, beliefs are strongly related to technology use, especially beliefs attributed to value (Ertmer & Ottenbreit-Leftwich, 2010; Ottenbreit-Leftwich et al., 2010).

3. Method

This study examines the item and data properties, factor structure, and reliability of the TECNOVAL questionnaire in a sample of Italian primary and secondary school teachers. The study is a scale development research using factor analysis. Exploratory factor analysis (EFA) was used as opposed to confirmatory factor analysis (CFA), as the aim was to appraise the underlying factor structure empirically and not to explicitly and formally test a priori hypotheses on the data structure (Hair et al., 2010).

3.1 Procedure

Data were collected via an online survey submitted to teachers involved in CPD and training activities on educational innovation in several schools. In addition to TECNOVAL and demographic data, the survey collected data on the teachers' perceived competence in teaching activities involving digital technologies and the topics they were interested in addressing in training activities.

3.2 Participants

The survey was administered to a sample of 137 teachers: 23 (16.8%) primary, 33 (24.1%) lower secondary, and 81 (59.1%) upper secondary school teachers. Age ranged from 20 to 64 (M = 42.9; SD = 11.5), and years of teaching ranged from 0 to 39 (M = 15.1; SD = 11.9). Teachers' subjects were, in descending order: Italian and Literature (27 teachers, including 4 in addition to History, 1 to History and Geography, and 3 to History and Latin); Mathematics (19 teachers, including 7 in addition to Science); English (10); German (9); Law and Economics (8); Catholic Religion (6); Physical Education (6); IT and Technology (5 teachers, of which 3 IT, 1 Technology, and 1 both);

Business Administration (5); Support (4); Plant Design and/or Topography (4); Science (3); Philosophy and Humanities (2); Art and Image or History of Art (2); Spanish (2); Geography (2); Laboratories (2); Music (1); Communication Theory (1); French (1); Physics (1); Graphic design (1). The remaining 16 teachers indicated multiple subjects, e.g., "Italian, Mathematics, History, Art and Image, Geography" or "Mathematics, Science, Music, Physical Education".

According to the 10:1 ratio guidelines, the participants to be included in an EFA should correspond to the number of items multiplied by ten (Marascuilo & Levin, 1983; Nunnally & Bernstein, 1994); in the present study, the minimum number of teachers should be 60. The number of teachers involved is, therefore, appropriate. The number is even more appropriate considering more specific guidelines that identify the communality of items and the ratio of number of items to number of factors as key parameters for determining the optimal number of participants (e.g., Hogarty et al., 2005; MacCallum et al., 1999; Mundfrom et al., 2005). Considering what Mundfrom et al. (2005) proposed, the minimum necessary sample size is identified using three population characteristics: level of communality (communality refers to the proportion of the variance of an observed variable - i.e., an item - that is explained by the common factors), number of factors, and variable-to-factor ratio. In the present sample, the level of communality can be considered "wide" as variables' communalities have values from .24 to .62 (see column "h^2" in Table 2), the factor is one, and the variable-to-factor ratio is 6:1. Considering the *excellent-level criterion* (.98), the minimum necessary sample size was 50.

3.3 Instrument

The literature review was aimed at identifying existing instruments suitable for the present study purpose, i.e., assessing in-service teachers' beliefs about the value of digital technology in instruction. The studies considered most significant were those by (in alphabetical order): Hsu (2016); Ottenbreit-Leftwich et al., 2010; Papanastasio and Angeli (2008); Park and Ertmer (2007; also used by Taimalu and Luik, 2019); Vongkulluksn et al. (2018); Willis et al. (2019). However, no single instrument was found to be perfectly tailored for the specific purpose of this study for the reasons explained below. The most suitable instrument was the Survey of Factors Affecting Teachers Teaching with Technology (SFA-T3) proposed by Papanastasio and Angeli (2008). The survey included two subscales of interest for the instrument to be developed, i.e., "Beliefs about the value of the computer" (seven items) and "The computer as an agent for change" (three items). The survey investigated these variables in the context of in-service teachers, unlike other instruments investigating variables such as beliefs about the perceived value of computers for instructional purposes in pre-service teachers (e.g., Park & Ertmer, 2007). The survey also investigated these variables through subscale items, unlike other studies that investigated teacher value beliefs associated with using technology through open-ended questions, interviews, observations, and/or e-portfolios (e.g., Hsu, 2016; Ottenbreit-Leftwich et al., 2010). Moreover, the two SFA-T3 subscales refer to the computer in general, unlike studies that measured the importance of using ICT in teaching and learning by asking teachers to rate their perceived importance of a range of ICT tools (e.g., Email, Social Media) (e.g., Willis et al., 2019). Finally, although the items used by Vongkulluksn et al. (2018) (originally from Kopcha, 2012) referred to in-service teachers and were noteworthy, they were only three and partially overlapped with those of Papanastasio and Angeli (2008).

Ultimately, six items were written inspired by the two subscales of the SFA-T3 and the theoretical framework outlined above. Technological and teacher heterogeneity, as well as contextual factors, were considered in item writing. Firstly, all items were written considering digital technology in general and not specific ICT tools. The aim was to investigate beliefs about the value of digital technology in general rather than towards specific tools, which could not even be defined before the training experience. Secondly, items were written to consider the specific target group of in-service teachers without distinction of school grade, subjects, or teaching practices. Thirdly, the set of items was written with a specific reference to the teachers' teaching experiences. I.e., the sentence "The questionnaire contains some statements related to the use of digital technologies in instruction" introduced the questionnaire to reflect the contextualised approach to the assessment of the value of digital technologies in instruction.

In conclusion, the instrument developed - i.e., "Questionnaire on the value of digital technologies in instruction", denominated TECNOVAL - consisted of six items, two of which were reverse (R) (see Table 2). The six items were formatted with a 5-point Likert-type response scale ranging from 1 = strongly disagree to 5 = strongly agree.

3.4 Data analysis

Data analyses were performed using SPSS, except for the parallel analysis and McDonald's ω, which were conducted with jamovi[1]. Firstly, the scores of Item2 and Item5 were reversed. Secondly, a preliminary analysis of data properties was carried out. Thirdly, the appropriateness of the data for EFA was verified. Fourthly, EFA was conducted.

Preliminary analysis of data properties. Preliminary analyses involved the analysis of item and scale distribution and reliability analysis. Examining the distributional properties of the data before conducting more complex structural analyses is crucial to guide the choice of the correlation matrix to be analysed and the factor extraction method. Departures from normality are important because they affect the Pearson correlation coefficients among measured variables used for the computation of factor analysis results and can, therefore, result in misleading findings (Goodwin & Leech, 2006). Item analysis considered the following descriptive statistics: number of valid cases, minimum and maximum score, mean, standard deviation, skewness, and kurtosis. It also analysed item redundancy and item discrimination. The items are supposed to measure a single construct, so item discrimination analysis was performed by considering the set of items (i.e., as one scale). Reliability analyses were performed similarly: Cronbach's α, McDonald's ω, inter-item correlation, and corrected item-total correlation.

Appropriateness of the data for EFA. In order to assess the factorability of the correlation matrix and thus the possibility of proceeding with EFA, Bartlett's test of sphericity (Bartlett, 1950) and Kaiser-Mayer-Olkin measure of sampling adequacy (KMO; Kaiser, 1974) were considered. The former had to produce a statistically significant pseudo-chi-square value (*pseudo* χ^2) value ($p < .05$) to justify the application of EFA. The latter should be above a minimum of .50 to indicate that the correlation matrix is factorable, as should be the univariate KMO values. KMO values ≥.70 are desired (Hoelzle & Meyer, 2013).

EFA. After confirming that the correlation matrix was factorable, it was submitted for EFA. The method used to estimate the common factor model was the principal-axis factoring. The Kaiser-

[1] Version 2.3: www.jamovi.org.

Guttman criterion (Guttman, 1954), the parallel analysis (Horn, 1965), and the visual scree-test (Cattell, 1966) were used to determine the appropriate number of factors to retain. As the items were supposed to measure a single construct, determining a rotation method was not essential. However, if this were not the case, to honour the reality that almost everything measured in the social sciences is correlated to some degree (Meehl, 1990; Thurstone, 1947), an oblique rotation was employed to allow factor intercorrelations to emerge (Child, 2006; Fabrigar et al., 1999; Gorsuch, 1983). It was an oblimin rotation (Child, 2006), specifically direct oblimin (delta = 0) (Jennrich & Sampson, 1966). Criteria for determining factor adequacy were established a priori. Weak factor loadings are not consequential (Gorsuch, 1983), respecting the parsimony principle. Given the number of participants in this study, factor loadings ≥ .44 were considered salient, i.e., both practically and statistically - at the 1% level- significant as per Norman and Streiner (2014). Variables whose factor loadings were salient on more than one factor (or that did not saturate on any) would be rejected to honour simple structure (Thurstone, 1947), more precisely, approximate simple structure (McDonald, 1985). These criteria were combined with other criteria to identify acceptable EFA solutions. Specifically: (a) each factor should be saliently loaded by at least three measured variables (Child, 2006; Chiorri, 2011); (b) each factor should demonstrate reliability in terms of internal consistency with McDonald's ω (McDonald, 1999) and Cronbach's α (Cronbach,1951) ≥ .70 (Fabrigar et al., 1999; Nunnally & Bernstein, 1994), and adequate average inter-item correlation (AIC) for specific constructs in the .40-to-.50 range (Clark & Watson, 2019); (c) all factors should be theoretically meaningful-conceptually interpretable (Worthington & Whittaker, 2006), just as variables saliently loading on the same factor should share the same theoretical meaning while variables saliently loading on different factors should refer to conceptually different constructs (Chiorri, 2011).

4. Results

4.1 Preliminary analysis of data properties

Table 1 shows the psychometric properties and reliability of the questionnaire items. There were no missing cases. The minimum and maximum values of the five-point Likert-type response scale were chosen at least once, as were the other values of the scale. All items had a standard deviation of at least .80 and a mean score between 2 and 4, except Item1 (M = 4.26), indicating that the responses' range and variability were adequate (Chiorri, 2011; DeVellis & Thorpe, 2021). All items showed skewness and kurtosis values between -1 and +1 (Muthén & Kaplan, 1985), except Item1 (SK = -1.06). The item discrimination was large ($ds \geq 2.61$). The average corrected item-total correlation was .60 (range .45; .70); all items, therefore, showed a value above the minimum optimal value recommended by Nunnally and Bernstein (1994), i.e., .30. The total scale score was normally distributed (D'Agostino-Pearson normality test: $K^2 = 4.742$, $p = .093$; see also Table 3).

4.2 Reliability

The Cronbach's α value was .83 (95% CI = .78; .87), which indicates good internal consistency according to the guidelines of George and Mallery (2003). This value does not appear to be the result of redundancies between items as their maximum correlation was .58. In addition, no item had an α value greater than the calculated α value if the item dropped (in the case of Item3, α equalled the calculated α if the item dropped). McDonald's ω value (.83) also indicates good internal consistency. Moreover, the corrected item-total correlations were all above the minimum optimal value of .30

(Nunnally & Bernstein, 1994). Finally, the AIC was .44 (min = .26; max = .58), which is adequate for a specific construct such as the one considered here (Clark & Watson, 2019).

	Item1	Item2	Item3	Item4	Item5	Item6
N	137	137	137	137	137	137
Min	1	1	1	1	1	1
Max	5	5	5	5	5	5
M	4.26	3.89	3.62	3.84	3.86	3.62
SD	.84	.90	.95	.92	1.08	.92
SK	-1.06	-.51	-.33	-.46	-.61	-.25
KU	.93	-.19	-.32	-.32	-.47	-.49
d	2.97	3.09	2.61	3.27	3.91	3.06
r_{it}	.54	.70	.45	.61	.62	.66
α dropped	.81	.78	.83	.79	.79	.78
ω dropped	.81	.78	.83	.80	.80	.79

d = item discrimination effect size. r_{it} = corrected item-total correlation.

Table 1. Psychometric properties and reliability of TECNOVAL items.

4.3 Appropriateness of the data for EFA

As just pointed out, univariate SK and KU were not extreme (Curran et al., 1996) but rather within the range [-1; +1] (Chiorri, 2011). No item had both SK and KU values outside the range. Given this and the distributional properties outlined above, a Pearson correlation matrix was deemed an appropriate input for EFA (Goodwin & Leech, 2006). Bartlett's test of sphericity was significant (*pseudo* $\chi^2 = 270.882$, $df = 15$, $p < .001$) and the KMO value (.84) was meritorious (Kaiser, 1974), as were the univariate KMOs (all ≥ .80). Therefore, it was determined that the correlation matrix was factorable and thus appropriate for EFA.

4.4 EFA

EFA followed the principal-axis factoring extraction method with direct oblimin rotation. The Kaiser-Guttman criterion, the parallel analysis and the scree-test suggested the retention of one factor, and the same indicated the theoretical framework. Therefore, the one-factor solution was examined and found to be adequate. All six variables saliently loaded the factor, with factor loadings ranging from .49 to .79 (see Table 2). The initial eigenvalue of the factor was 3.243, and the factor explained 54.05% of the variance in the correlation matrix. Consistent with the items' meaning and the theoretical framework, the factor was labelled "Technology as a valuable instructional tool". As outlined above (see "Reliability" and Tables 1 and 3), the reliability coefficients of the TECNOVAL were acceptable for research purposes.

	Factor 1	h^2
	Factor loadings	**Extraction**
1. Technology is a valuable tool for teachers. *1. Le tecnologie sono uno strumento prezioso per i docenti.*	.612	.375
2. Technology improves the way of teaching. *2. Le tecnologie migliorano il modo di insegnare.*	.789	.623
3. Whatever I can do with technology, I can do just as well without. (R) *3. Quello che posso fare con le tecnologie, lo posso fare altrettanto bene senza.*	.487	.238
4. Technology helps teachers to teach in more effective ways. *4. Le tecnologie aiutano i docenti a insegnare in modi più efficaci.*	.684	.467

5. Technology does not improve teaching. (R) *5. Le tecnologie non migliorano l'insegnamento.*	.689	.475
6. Technology improves the way students learn. *6. Le tecnologie migliorano il modo in cui gli studenti imparano.*	.741	.549
Total variance explained	Total	% of Variance
Initial eigenvalue	3.243	54.05%
Extraction sums of squared loadings	2.726	45.44%

h^2 = communalities = proportions of variance accounted by the common factors.

Table 2. Total variance explained, factor matrix, and communalities of TECNOVAL items.

	Min	Max	M (95% CI mean)	SD	SK	KU	α	ω	AIC
Technology as a valuable instructional tool	12	30	23.09 (22.40-23.79)	4.12	-.235	-.588	.83	.83	.44

% CI = 95% Confidence interval for the mean (lower bound - upper bound). The CI of the mean assumes the sample means to follow a t-distribution with N - 1 degrees of freedom.

Table 3. Descriptive statistics and internal consistency of the TECNOVAL scale score.

5. Discussion

The study found that the six items of the TECNOVAL coalesced into one factor and showed good internal consistency in a sample of Italian primary and secondary school teachers. Consistent with the items' meaning and the theoretical framework, the factor was labelled "Technology as a valuable instructional tool". The conceptual domain of the items regards the extent to which teachers believe that digital technologies are of value to instruction. The similarity of the factor loadings, i.e., the narrow range (.30) of factor loadings (Chiorri, 2011), further supports the interpretation of factor significance just outlined. Nevertheless, Item3 should be carefully considered as it seems to explain little variance (communality = .238). However, the variance common to the measured variables should be at least 10% (corresponding to a communality of .10) (Chiorri, 2011), and Item3 exceeds this threshold, which is far exceeded by other items. Future studies should consider this item to evaluate a possible questionnaire revision (Child, 2006). This study also has limitations that must be considered in the results' interpretation and generalisation. The sample size may appear limited. Nevertheless, this study aimed to provide initial evidence of the factor structure and reliability of the TECNOVAL questionnaire, and considering parameters based on the assessment of various characteristics, the sample used in this study has an adequate size (see "Participants" section). In any case, future studies need to consider a more representative sample of teachers by school grade. For example, in the school year 2022/2023 (see *Portale Unico dei Dati della Scuola*[2]), the proportions of teachers were as follows: 34.6% primary, 24.1% lower secondary, and 41.3% upper secondary school teachers. Rather than the sample size, the sampling used (essentially of convenience) limits the results' generalisability to the teacher population. A future large-scale survey with adequate sampling would solve the two sample issues just mentioned. Ultimately, the TECNOVAL value shall be judged with further analysis, e.g., by conducting a CFA on new data and assessing some psychometric

[2] Data elaborated by the author based on: https://dati.istruzione.it/espscu/index.html?area=anagScu.

characteristics such as construct validity and test-retest reliability. In general, the value of an instrument should be judged by the meaningfulness of its relationships with external criteria and its replicability across samples, methods, and studies (Gorsuch, 1983).

6. Conclusions

To promote technology integration in teachers' pedagogical practices, it has been argued that second-order barriers to technology integration (i.e., those internal to teachers and mainly including their beliefs and attitudes towards ICT) should be identified and overcome (Ertmer, 2005; Ertmer et al., 2015; Hew & Brush, 2007; Kim et al., 2013). In particular, it is crucial to consider mostly two types of beliefs, i.e. pedagogical beliefs and beliefs about the value of technology. This study considered specifically the second type of beliefs. Research indeed indicates that when teachers perceive technology to have value in the teaching and learning process, they tend to use it more frequently and in more challenging ways in their pedagogical practices (Vongkulluksn et al., 2018). In addition, research shows that one method for enhancing technology integration in the classroom might be to acknowledge and promote the use of technology in relation to teachers' value beliefs (Ottenbreit-Leftwich et al., 2010) and that knowing and understanding teachers' beliefs would help improve technology integration training (Kim et al., 2013). The present study aligned with this by developing a questionnaire, denominated "TECNOVAL", to investigate in-service teachers' beliefs about the value of digital technology in instruction. In fact, having an instrument to assess teachers' value beliefs appeared useful in deriving relevant information for designing and redesigning teachers' CPD and training experiences that are effective in fostering the integration of digital technologies into educational practices. In conclusion, although some psychometric properties still need to be evaluated, the TECNOVAL - in addition to other instruments (cf., Foschi, 2022b) - may be a useful tool for assessing teacher beliefs about the value of digital technology in instruction. It could be used, for example, before and after teacher CPD and training activities, both to direct them and to analyse any changes, as well as for designing, monitoring and evaluating Design (Project)-Based-Research, Action-Research or Training-Research experiences.

References:

Abbitt, J. T. (2011). An investigation of the relationship between self-efficacy beliefs about technology integration and technological pedagogical content knowledge (TPACK) among preservice teachers. *Journal of digital learning in teacher education*, *27*(4), 134-143.

Bartlett, M. S. (1950). Tests of significance in factor analysis. *British Journal of Statistical Psychology*, *3*(2), 77-85.

Bell, E., & Barr, D. (2023). Barriers to technology integration in the A-level history classroom in Northern Ireland. *Irish Educational Studies*, 1-22.

Bond, M. (2021). Schools and emergency remote education during the COVID-19 pandemic: A living rapid systematic review. *Asian Journal of Distance Education*, *15*(2), 191-247.

Borg, S. (2003). Teacher cognition in language teaching: A review of research on what language teachers think, know, believe, and do. *Language teaching*, *36*(2), 81-109.

Cattell, R. B. (1966). The scree test for the number of factors. *Multivariate behavioral research*, *1*(2), 245-276.

Chien, S. P., Wu, H. K., & Hsu, Y. S. (2014). An investigation of teachers' beliefs and their use of technology-based assessments. *Computers in Human Behavior*, *31*, 198-210.
Child, D. (2006). *The essentials of factor analysis* (3rd ed.). New York: Continuum.
Chiorri, C. (2011). Teoria e tecnica psicometrica: Costruire un test psicologico. Milano: McGraw-Hill Education.
Clark, L. A., & Watson, D. (2019). Constructing validity: New developments in creating objective measuring instruments. *Psychological assessment*, *31*(12), 1412-1427.
Coppola, E. M. (2004). *Powering up: Learning to teach well with technology*. New York: Teachers College Press.
Curran, P. J., West, S. G., & Finch, J. F. (1996). The robustness of test statistics to nonnormality and specification error in confirmatory factor analysis. *Psychological methods*, *1*(1), 16-29.
DeVellis, R. F., & Thorpe, C. T. (2021). *Scale development: Theory and applications* (5th ed.). Thousand Oaks: Sage publications.
Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: strategies for technology integration. *Educational Technology Research and Development*, *47*(4), 47-61.
Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration?. *Educational technology research and development*, *53*(4), 25-39.
Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of research on Technology in Education*, *42*(3), 255-284.
Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & education*, *59*(2), 423-435.
Ertmer, P. A., Ottenbreit-Leftwich, A., & Tondeur, J. (2015). Teacher beliefs and uses of technology to support 21st century teaching and learning. In H. R. Fives & M. Gill (Eds.), *International handbook of research on teacher beliefs* (pp. 403–418). New York: Routledge, Taylor & Francis.
European Commission (2019). *2nd survey of schools ICT in education. Objective 1: Benchmark progress in ICT in schools*. Luxembourg: Publications Office of the European Union.
Ewing, L. A., & Cooper, H. B. (2021). Technology-enabled remote learning during COVID-19: Perspectives of Australian teachers, students and parents. *Technology, pedagogy and education*, *30*(1), 41-57.
Fabrigar, L. R., Wegener, D. T., MacCallum, R. C., & Strahan, E. J. (1999). Evaluating the use of exploratory factor analysis in psychological research. *Psychological Methods*, *4*(3), 272-299.
Foschi, L. C. (2021). Innovative aspects and evaluation methods in a teachers' continuous professional development training experience. *Italian Journal of Educational Technology*, *29*(1), 46-64.
Foschi, L. C. (2022a). Valutare un'attività di formazione per docenti in servizio sull'uso didattico delle tecnologie digitali: analisi inferenziali e del contenuto della loro esperienza. *Lifelong, Lifewide Learning*, *18*(41), 154-174.
Foschi, L. C. (2022b). Costruzione, struttura fattoriale e attendibilità di uno strumento per indagare le percezioni e l'atteggiamento degli insegnanti verso l'uso delle tecnologie digitali nella didattica. *Italian Journal of Educational Research, 29, 62-75.*
Foschi, L. C. (2023). Pianificare, implementare e valutare attività formative per l'uso didattico delle tecnologie digitali: una proposta di progettazione rivolta a insegnanti in servizio. *RicercAzione*, *15*(1), 71-

85.
Galvis, H. A. (2012). Understanding beliefs, teachers' beliefs and their impact on the use of computer technology. *Profile Issues in Teachers Professional Development*, *14*(2), 95-112.
George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference. 11.0 update* (4th ed.). Boston: Allyn & Bacon.
Goodwin, L. D., & Leech, N. L. (2006). Understanding correlation: Factors that affect the size of r. *Journal of Experimental Education*, *74*(3), 251-266.
Gorsuch, R. L. (1983). *Factor analysis* (2nd ed.). Hillsdale: Erlbaum.
Guttman, L. (1954). Some necessary conditions for common-factor analysis. *Psychometrika*, *19*(2), 149-161.
Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (7th ed.). Upper Saddle River: Pearson Prentice Hall.
Hermans, R., Tondeur, J., Van Braak, J., & Valcke, M. (2008). The impact of primary school teachers' educational beliefs on the classroom use of computers. *Computers & Education*, *51*(4), 1499-1509.
Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational technology research and development*, *55*(3), 223-252.
Hoelzle, J. B., & Meyer, G. J. (2013). Exploratory factor analysis: Basics and beyond. In I. B. Weiner, J. A.
Hogarty, K. Y., Hines, C. V., Kromrey, J. D., Ferron, J. M., & Mumford, K. R. (2005). The quality of factor solutions in exploratory factor analysis: The influence of sample size, communality, and overdetermination. *Educational and psychological measurement*, *65*(2), 202-226.
Horn, J. L. (1965). A rationale and test for the number of factors in factor analysis. *Psychometrika*, *30*(2), 179-185.
Howard, S. K., Tondeur, J., Siddiq, F., & Scherer, R. (2021). Ready, set, go! Profiling teachers' readiness for online teaching in secondary education. *Technology, Pedagogy and Education*, *30*(1), 141-158.
Hsu, P. S. (2016). Examining current beliefs, practices and barriers about technology integration: A case study. *TechTrends*, *60*(1), 30-40.
Huber, S. G., & Helm, C. (2020). COVID-19 and schooling: evaluation, assessment and accountability in times of crises - reacting quickly to explore key issues for policy, practice and research with the school barometer. *Educational assessment, evaluation and accountability*, *32*, 237-270.
Jennrich, R. I., & Sampson, P. F. (1966). Rotation for simple loadings. *Psychometrika*, *31*(3), 313-323.
Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika*, *39*(1), 31-36.
Karakose, T., Polat, H., & Papadakis, S. (2021). Examining teachers' perspectives on school principals' digital leadership roles and technology capabilities during the COVID-19 pandemic. *Sustainability*, *13*(23), 13448.
Kim, C., Kim, M. K., Lee, C., Spector, J. M., & DeMeester, K. (2013). Teacher beliefs and technology integration. *Teaching and teacher education*, *29*, 76-85.

Kopcha, T. J. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers & Education*, *59*(4), 1109-1121.
MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong, S. (1999). Sample size in factor analysis. *Psychological methods*, *4*(1), 84-99.
Marascuilo, L. A., & Levin, J. R. (1983). *Multivariate Statistics in the Social Sciences*. Monterey: Brooks/Cole.
McDonald, R. P. (1985). *Factor analysis and related methods*. Hillsdale: Lawrence Erlbaum.
McDonald, R. P. (1999). Test theory: A unified treatment. Mahwah: Laurence Erlbaum Associates.
Meehl, P. E. (1990). Why summaries of research on psychological theories are often uninterpretable. *Psychological Reports*, *66*(1), 195-244.
Miller, S., Meier, E., Payne-Bourcy, L., Shablak, S., Newman, D., Wan, T. W., Casler, E. C., & Pack, G. (2003). Technology as a catalyst for change: A leadership model for transforming urban teacher programs. *Paper presented at the annual meeting of the American Educational Research Association*, Chicago.
Mundfrom, D. J., Shaw, D. G., & Ke, T. L. (2005). Minimum sample size recommendations for conducting factor analyses. *International Journal of Testing*, *5*(2), 159–168.
Muthén, B., & Kaplan, D. (1985). A comparison of some methodologies for the factor analysis of non-normal Likert variables. *British journal of mathematical and statistical psychology*, *38*(2), 171-189.
Norman, G. R., & Streiner, D. L. (2014). *Biostatistics: The bare essentials* (4th ed.). Shelton: People's Medical Publishing.
Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric Theory* (3rd ed.). New York: McGraw Hill.
OECD (2019). *TALIS 2018 Results (Vol. 1): Teachers and School Leaders as Lifelong Learners*. Paris: OECD Publishing.
Ottenbreit-Leftwich, A. T., Glazewski, K. D., Newby, T. J., & Ertmer, P. A. (2010). Teacher value beliefs associated with using technology: Addressing professional and student needs. *Computers & Education*, *55*(3), 1321-1335.
Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of educational research*, *62*(3), 307-332.
Palak, D., & Walls, R. T. (2009). Teachers' beliefs and technology practices: A mixed-methods approach. *Journal of Research on technology in Education*, *41*(4), 417-441.
Papanastasiou, E. C., & Angeli, C. (2008). Evaluating the use of ICT in education: Psychometric properties of the survey of factors affecting teachers teaching with technology (SFA-T3). *Journal of educational technology & society*, *11*(1), 69-86.
Park, S. H., & Ertmer, P. A. (2007). Impact of problem-based learning (PBL) on teachers' beliefs regarding technology use. *Journal of research on technology in education*, *40*(2), 247-267.
Polly, D., Mims, C., Shepherd, C. E., & Inan, F. (2010). Evidence of impact: Transforming teacher education with preparing tomorrow's teachers to teach with technology (PT3) grants. *Teaching and teacher education*, *26*(4), 863-870.
Russell, M., Bebell, D., O'Dwyer, L., & O'Connor, K. (2003). Examining teacher technology use: Implications for preservice and inservice teacher preparation. *Journal of teacher Education*, *54*(4), 297-310.

Sang, G., Valcke, M., van Braak, J., Tondeur, J., & Zhu, C. (2011). Predicting ICT integration into classroom teaching in Chinese primary schools: Exploring the complex interplay of teacher-related variables: Teacher variable and ICT integration. *Journal of Computer Assisted Learning*, *27*(2), 160-172.

Schlichter, A. (2020). *The Impact of Covid-19 on Education: Insights from Education at a Glance*. Paris: OECD Publishing.

Scully, D., Lehane, P., & Scully, C. (2021). 'It is no longer scary': digital learning before and during the Covid-19 pandemic in Irish secondary schools. *Technology, Pedagogy and Education*, *30*(1), 159-181.

Snoeyink, R., & Ertmer, P. A. (2001). Thrust into technology: How veteran teachers respond. *Journal of educational technology systems*, *30*(1), 85-111.

Taimalu, M., & Luik, P. (2019). The impact of beliefs and knowledge on the integration of technology among teacher educators: A path analysis. *Teaching and Teacher Education*, *79*, 101-110.

Thurstone, L. L. (1947). *Multiple factor analysis*. Chicago: University of Chicago Press.

Tondeur, J., Hermans, R., van Braak, J., & Valcke, M. (2008). Exploring the link between teachers' educational belief profiles and different types of computer use in the classroom. *Computers in human Behavior*, *24*(6), 2541-2553.

Tondeur, J., Van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: a systematic review of qualitative evidence. *Educational technology research and development*, *65*, 555-575.

Vongkulluksn, V. W., Xie, K., & Bowman, M. A. (2018). The role of value on teachers' internalization of external barriers and externalization of personal beliefs for classroom technology integration. *Computers & Education*, *118*, 70-81.

Wilkins, J. L. (2008). The relationship among elementary teachers' content knowledge, attitudes, beliefs, and practices. *Journal of Mathematics Teacher Education*, *11*(2), 139-164.

Willis, R. L., Lynch, D., Fradale, P., & Yeigh, T. (2019). Influences on purposeful implementation of ICT into the classroom: An exploratory study of K-12 teachers. *Education and Information Technologies*, *24*(1), 63-77.

Worthington, R. L., & Whittaker, T. A. (2006). Scale development research: A content analysis and recommendations for best practices. *The counseling psychologist*, *34*(6), 806-838.

Zhao, Y., & Cziko, G. A. (2001). Teacher adoption of technology: A perceptual control theory perspective. *Journal of technology and teacher education*, *9*(1), 5-30.

Zhao, Y., & Frank, K. A. (2003). Factors affecting technology uses in schools: An ecological perspective. *American educational research journal*, *40*(4), 807-840.

Zhao, Y., Pugh, K., Sheldon, S., & Byers, J. (2002). Conditions for classroom technology innovations. *Teachers College Record*, *104*(3), 482-515.