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Questionnaire for digital technologies and leadership practices: the validity and reliability study

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ABSTRACT

The exponential progress and massive utilization of digital technologies has significant implications for leadership theory and for leadership practices that remain unexplored in the current literature. This study provides insights into the validity and reliability of the questionnaire for digital technologies and leadership practices (QDTLP), through research conducted in 215 elementary schools in the Peloponnese region of Greece. The research consists of three parts: i) a pilot study to assess the stability and reliability of the initial QDTLP version; ii) study 1 to examine the validity and reliability using exploratory and confirmatory factor analysis; and iii) study 2 to further assess the validity and reliability using confirmatory factor analysis (CFA). The QDTLP was designed and developed after a systematic literature review in the field of digital technologies and school leadership practices, to investigate if, and to what extent, the utilization of digital technologies affects the leadership practices in elementary schools. The research findings provide strong evidence for content and construct validity as well as reliability of the 4-factor and 22-item QDTLP research instrument.

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1. INTRODUCTION

In our age, which, given the exponential progress, the wide acceptance, and the massive utilization of digital technologies, is called digital age [1]–[4], it is difficult to make decisions and discuss about any aspect of the social context without a reference to the digital technologies, especially to the advanced internet technologies [5]–[7]. The continuous progress in the field of digital technologies during the last 15 years has resulted the emergence of direct communication, interaction, collaborative action, and social networking as defining features of digital age. These concepts are deeply intertwined with the essential qualitative aspects of how individuals learn, participate, collaborate, exchange ideas, provide mutual support, make choices and decisions, critique [8]–[12].

Recent studies about digital technologies and school leadership [13] pointed out that digital technologies have "significant implications for theory, practice and leadership development that, so far, remain largely unexplored in the mainstream academic literature." Wart *et al.* [12] noted that "discussion of how leadership has been affected by the digital revolution is curiously absent." In the same direction, Malakyan [14] noted that no-particular discussion has been developed in the international literature, regarding the smooth transition of leadership from the pre-digital to the digital era and underlines that such a

discussion could bridge the distance between the digital natives and digital immigrants, and to smooth the transition from traditional/hierarchical approaches, to modern/distributed, shared, collective approaches to leadership in the digital age.

Furthermore, as stated by Harris [9], the crisis of the COVID-19 pandemic, which created a new context regarding the scale and the ways of using digital technologies in the field of education, "has dramatically changed perceptions on leadership and on leadership practices" and it has "shifted school leadership dramatically towards distributed, collaborative and networked practices." School principals and those responsible for coordinating and supporting the teaching – learning process followed leadership practices, which they could not even imagine a short time before the COVID-19 pandemic crisis, in the sense that both, as well as the other members of each school community (teachers, students, parents, experts), used digital technologies in a massive way and created, emerged and utilized on an unexpectedly wide scale and particularly effectively, networks of people and networked practices for communication, teaching, learning, and leadership in the school context. These networks, by their nature, are widely distributed, collective, and collaborative.

In the European context, the European Union (EU) –as a supranational economic and political entity of 27 European countries, among which is Greece– perceives the role of digital technologies as vital for education and training, recognizes that it is necessary to "redefine education and training for the digital age", and envisages "a high-quality, inclusive and accessible digital education in Europe" for the current decade [2]. Greece, as EU member, shows that understands the need to adapt the Greek educational system to the digital age, follows the European reference frameworks and implements the EU's vision, policies, and actions for education in the digital age. To this end, Greece has implemented policies to strengthen the technological infrastructure, connectivity, and digital equipment in schools and educational organizations, and has implemented a series of actions to promote the utilization of digital technologies in teaching and learning process, the development of digital skills of teachers and learners, as well as for the promotion of innovation, creativity and change in schools and other educational organizations.

The questionnaire for digital technologies and leadership practices (QDTLP) in elementary school investigates the perceptions of principals, vice-principals, teachers, and special educational staff for the digital age, and whether–and to what extent–the utilization of digital technologies affects the leadership practices in elementary school of Peloponnese region in Greece. The development of the QDTLP research instrument is the result of a systematic process, that consists of five phases as shown in Figure 1. In the first phase the questionnaire items are developed or selected, in the second phase the initial version of the questionnaire is specified, in the third phase the pilot testing of the initial questionnaire version takes place, in the fourth phase the reliability and validity of the questionnaire are examined, and in the fifth phase the final version of the research tool is formed [15]–[18].

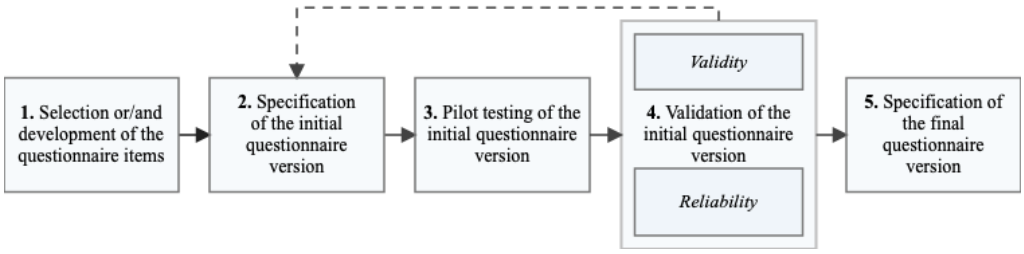

Figure 1. The five-phases process for the development of the QDTLP

2. METHOD

2.1. Research design

The purpose of this research was to evaluate the validity and reliability of the QDTLP research instrument. This goal was achieved by employing a quantitative survey research design, that entails the systematic collection and statistical analysis of numerical data through a structured questionnaire [17], [19], to investigate various aspects of the perceptions held by principals, vice-principals, teachers, and special educational staff for the digital age. It also investigates whether, and to what extent, the utilization of digital technologies affects the leadership practices in elementary school.

The research was carried out through three distinct studies: pilot study, study 1, and study 2. The pilot study evaluated the consistency and reliability of the initial QDTLP version. Study 1 examined validity and reliability through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), while study 2 further assessed validity and reliability using CFA.

The research protocol was approved by the Research Ethics Committee of the University of Peloponnese (Protocol number: 7636/29-03-2022). Written permission was given by the Regional Directorate of Primary and Secondary Education of Peloponnese (Protocol numbers: 2262/06-04-2022 and 756/02-02-2023), to conduct pilot study and study 1 during the period between April 2022 and August 2022, and study 2 during the period between April 2023 and August 2023. These studies conducted in 215 elementary schools of Peloponnese region in Greece.

2.2. Population, sample, and data collection

The population of this research consisted of 3,199 principals, vice-principals, teachers, and special educational staff, who worked during the school years 2021-2022 (pilot study and study 1) and 2022-2023 (study 2) in 215 elementary schools of Peloponnese region in Greece. The sample size was determined considering that Harrington [20] and Kline [21] recommend a sample-to-item ratio of at least 5:1, although 10:1 is preferable, and Taherdoost [22] emphasizes that the choice of sample size should reflect the complexity of the population and research goals, thereby reducing sampling error as size increases. Based on these guidelines, the Taherdoost's formula for sample size calculation [22] and the Raosoft sample size calculator [23] were utilized to calculate the necessary sample size for specified confidence levels and margins of error, suggesting a sample size of 344 for 95% confidence level and a 5% margin of error or a sample size of 550 for a 99% confidence level and a 5% margin of error.

Stratified sampling was used to select the participants of the study. The research population was divided into distinct subsets (strata) based on specific characteristics (e.g., geographic area, age, gender) and then sampling was performed, taking a random sample from each subset (stratum) of the research population. This approach ensured that the final sample provided proportional representation of each distinct subset of the population [17], [19], [24].

The pilot study was conducted during the first half of April 2022. The initial QDTLP version was applied as a web survey [25]–[27] into five strata, with stratification criterion the geographical area (i.e., the regional unit of Peloponnese in which the survey respondents worked during the pilot study), and it was answered from 55 participants. This approach ensured the proportional representation of each stratum in the sample of pilot study (n_1 =10, n_2 =7, n_3 =14, n_4 = 9, n_5 =15).

Study 1 was carried out between mid-April 2022 and late-June 2022. The QDTLP was applied as a web survey to the five above-mentioned strata with the same stratification criterion as in pilot study and answered by 502 principals, vice-principals, teachers, and special educational staff. This ensured that each regional unit of Peloponnese was proportionally represented in the sample of study 1 (n_1=90, n_2=62, n_3=134, n_4=81, n_5=135) for 98.52% confidence level and a 5% margin of error.

Study 2 was conducted during the period between early-April 2023 and late-June 2023, with the same research design as study 1. The QDTLP was answered by 505 participants, ensuring the proportional representation of each regional unit of Peloponnese in the sample of study 2 (n_1=91, n_2=62, n_3=134, n_4=82, n_5=136) for 98.56% confidence level and a 5% margin of error. Detailed demographic information about the participants in study 1 and study 2 is shown in Table 1.

Table 1. Demographic data of the participants in study 1 and study 2

Variable	Category	Study 1		Study 2	
		N=502	%	N=505	%
Gender	Female	336	66.9	331	65.6
	Male	166	33.1	174	34.4
Age	up to 29	37	7.4	15	3.0
	30-39	128	25.5	139	27.5
	40-49	122	24.3	114	22.6
	50-59	198	39.4	211	41.8
	60 and more	17	3.4	26	5.1
Years of work experience	up to 3	41	8.2	25	5.0
	4-6	39	7.7	42	8.3
	7-9	41	8.2	43	8.5
	10 and more	381	75.9	395	78.2
Years of work at this school	up to 3	207	41.2	195	38.6
	4-6	85	16.9	85	16.8
	7-9	44	8.8	37	7.3
	10 and more	166	33.1	188	37.2

2.3. Research instrument

The QDTLP was developed to investigate whether, and to what extent, the utilization of digital technologies affects the leadership practices in elementary schools. The language of the questionnaire was

Greek. The selection or/and development of the questionnaire items, as well as the formation of the initial questionnaire version (Figure 1) were based on a systematic literature review in the field of digital technologies and school leadership practices [1]–[8], [10]–[12], [28]–[30].

A list of 37 potential questionnaire items was specified; 9 items were related to the research participants' perceptions about digital age and its' emblematic elements (i.e., direct communication, interaction, collaborative action, and social networking), 13 were related to the leadership practices in elementary schools by utilizing digital technologies, 8 were related to emblematic elements of digital age and the way they were utilized in elementary school's leadership practices, and 7 were related to the research participants' digital skills. Some of the potential questionnaire items were based on the prior research in the field of educational leadership and school leadership practices, especially on the research instrument IB distributed leadership questionnaire (IBDLQ) [31]. These items were used after written permission by Dr. Dexter Phillips and translated from English to Greek by a group of qualified English language teachers who were also excellent Greek speakers. This thorough translation aimed to ensure the conceptual, item, semantic, operational and measurement equivalence, and the cross-cultural adaptation of these questionnaire items [32]. More specifically, the first subgroup of them translated the original English form of these items into Greek (forward translation) and the second one translated the Greek form back into English (backward translation). Afterwards, the two subgroups compared the backward with the forward translated form of these questionnaire items, discussed about the differences in concepts or expressions, and finalized the translation/adaptation process.

Then, another group of experts–experienced elementary school teachers, elementary school principals, educational work coordinators, researchers, and academics–reviewed the potential questionnaire items and provided feedback on how well each item measured the target construct in question. This task according to previous studies [15], [16] is related to the content validity that refers to the extent to which a research tool is representative to the construct that it designed to measure, and–as a process–plays important role in the phase of the development and/or selection of the questionnaire items. To this end, the group of experts reviewed in an extensive way how relative, meaningful, and effective each item was, and their feedback was considered for the appropriate adaptation of the questionnaire before the subsequent pilot testing phase.

The initial QDTLP version consisted of 33 items, separated into four sections, and used a 6-point Likert scale from strongly disagree (1) to strongly agree (6). The first section included 8 items, related to the research participants' perceptions about digital age and its' emblematic elements (i.e., direct communication, interaction, collaborative action, and social networking). The second section contained 11 items related to the leadership practices in elementary schools by utilizing digital technologies. The third section consisted of 7 items related to emblematic elements of digital age and the way they were utilized in elementary school's leadership practice, and the fourth section included 7 items related to the research participants' digital skills.

2.4. Pilot study

The pilot study assessed the consistency and reliability of the initial QDTLP version. Instrument's consistency across time avoiding recall, learning or carry over effects, and test-retest reliability was examined with a time interval of two weeks between test and retest [17], [20], [33], [34]. The overall Cronbach's alpha value in consistency test was .937 and the Cronbach's alpha based on standardized items was .939; in consistency retest the Cronbach's alpha values were .964 and .966, respectively. According to individual item statistics results, the Cronbach's alpha value if item dropped ranged between .965 and .962, while item-rest correlations ranged from .443 to .845. Given that Cronbach's alpha value above .700 considered as acceptable, above .800 perceived as good, and above .900 considered as excellent [21], [35], the consistency and reliability of the initial QDTLP version was at an excellent level; subsequently, additional analysis could be performed to identify the underlying factors–latent variables and test the construct validity.

2.5. Data analysis

The data collected in study 1 and study 2 were analyzed using JASP and Jamovi for macOS, open-source statistical packages [36]–[40]. EFA was applied in study 1 dataset to identify the underlying factors/latent variables and test the construct validity of the questionnaire [41], [42]. CFA was applied in both study 1 and study 2 datasets to verify the factor structure, that was identified during the EFA process, and to estimate the scale's reliability [20], [21], [35], [41], [43]. Additionally, scale statistics (including Cronbach's alpha, average inter-item correlation, mean, standard deviation), individual item statistics (Cronbach's alpha if item dropped, inter-item correlation, mean, standard deviation), and the intraclass correlation coefficient (ICC) with a ninety five percent confidence interval (95% CI) were calculated for both study 1 and study 2 datasets.

3. RESULTS AND DISCUSSION

3.1. Results of study 1

3.1.1. Evaluation of normality and outlier assumptions

The normality assumption for study 1 data (n =502) evaluated using skewness and kurtosis indices [35]. Kline [21] notes that skewness and kurtosis values are not considered as problematic when they are within specific ranges; and Harrington [20] suggests that "only variables with skew index absolute values greater than 3 and kurtosis index absolute values greater than 10 are of concern." The skewness values in study 1 dataset ranged from -0.673 to -1.601, and kurtosis values ranged from -0.242 to 3.995.

In the evaluation of outlier assumption, considering the research orientation and the specific features of the study 1 sample, it was judged to be reasonable and acceptable for the values of each item to range from strongly disagree (1) to strongly agree (6). Consequently, univariate values that could be marked as outliers were maintained within the study 1 dataset. Furthermore, the sample was checked for non-typical patterns of values (i.e., the same value in all items) and multivariate outliers, with no combinations found that negatively affected the structure of the model in question.

3.1.2. Exploratory factor analysis

The results of the EFA with maximum likelihood (ML) estimation method with an oblimin rotation, and on parallel analysis to specify the number of factors resulted in a Kaiser-Meyer-Olkin (KMO)=.928, and a statistically significant Bartlett's test of sphericity (Chi-square=7287.557, degrees of freedom (df)=253.000, p<.001). These results indicated that the variables are highly correlated and is reasonable to continue with results of the factor analysis [20]. Regarding the items elimination procedure during the EFA, the following criteria were considered: i) each item should measure a single feature, so each item should be consistent with the meaning and content of a single factor [20]; ii) each item should have a factor loading of .32 or greater [20], [21], [35]; iii) cross-loading items with a factor loading difference between factors less than .10 should be eliminated [35]; iv) each factor should contain at least three items [20], [21]; and v) the number of factors that should be retained, created according to the simulated data from parallel analysis.

The item removal procedure started from the items that appeared with a factor loading less than .40, following a more conservative approach than the above-mentioned item elimination criterion. Five items (A27, A26, A24, A22, A17) with factor loadings less than .40 were eliminated. The EFA process was applied a second time and two items (A23 and A25) with factor loading less than .40 were eliminated. The EFA process was applied three more times, where three items (A16, A20, A19) with factor loading less than .40 were eliminated, and the EFA process was applied for a final time. The item removal procedure completed with the elimination of the ten aforementioned items.

The remaining 23 items, at the end of EFA, were grouped into four factors as shown in Table 2. The factor digital skills consisted of 6 items (A28, A29, A30, A31, A32, A33) with factor load ranging from .84 to .77 and an overall factor load .80. The factor leadership practices consisted of 5 items (A09, A10, A11, A12, A18) with factor loading ranging from .82 to .47 and an overall factor load .67. The factor digital age consisted of 8 items (A01, A02, A03, A04, A05, A06, A07, A08) with factor ranging from .76 to .52 and an overall factor load .60. The factor teacher leadership consisted of 4 items (A13, A14, A15, A21) with factor load ranging from .92 to .43 and an overall factor load .67. The cumulative variance rate of the four mentioned factors was 57.4%, indicating that these factors were able to interpret in a sufficient way the information of the 23 variables [20].

3.1.3. Confirmatory factor analysis

To confirm the factor structure of the questionnaire identified in the EFA, the CFA process was applied. The CFA, such as EFA, is based on common factor model [20], [41], and focuses on investigating the relationships between the items and the underlying factors of a specified model, a theory or a research based conceptual construction. Furthermore, the CFA assesses if the specified model fit data adequately or it should be revised [20], [35], [41]. Thus, four categories of model fit indices can be used [20], [21], [41]: i) absolute fit indices, i.e., model Chi-square (χ^2), Root Mean Square Residual (RMR), Standardized Root Mean Square Residual (SRMR); ii) parsimony correction indices, that "incorporate a penalty for poor parsimony" [20], i.e., Root Mean Square Error of Approximation (RMSEA), Close Fit (CFit); iii) comparative fit indices, that "evaluate the fit of a model relative to a more restricted, nested baseline model" [20], i.e., Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) or Non-Normed Fit Index (NNFI); and iv) predictive fit indices, that "access model fit in hypothetical replication samples of the same size" [21], i.e., Akaike information criterion (AIC) and expected cross-validation index (ECVI).

As suggested by several researchers [20], [21], [41], RMSEA close to .06 or less, Chi-square/df ratio less than 3, SRMR close to .08 or less, CFI close to .95 or greater and TLI close to .95 or greater, are evidence of a good fit of the specified model to the data. Also, RMSEA close to .08 or less, Chi-square/df ratio less than 5, SRMR close to .08 or less, CFI close to .90 or greater, and TLI close to .90 or greater,

suggest acceptable fit of the specified model to the data with a reasonable approximation error. The above-mentioned model fit indices were used to evaluate the fit of the initially specified CFA model. The ML analysis resulted an acceptable fit of the four-factor initially specified CFA model, as RMSEA value (.079) is marginally less than .08, Chi-square/df ratio (920.65/224=4.110) is less than 5, SRMR value (.054) is less than .08, CFI (.903) is almost equal to .90, and TLI (.890) is close to .90. These fit indices values also revealed a reasonable approximation error [21], and so the initially four-factor specified CFA model needs to be modified, by identifying the areas in which this model does not fit well [20].

Table 2. Factor loadings of the QDTLP

	Factors and items	EFA *	CFA-1 **	CFA-1r ***	CFA-2 ****
	Digital skills (f1)	.795	.817	.821	.753
A29	My school supports teachers in the development of their digital skills.	.84	.82	.85	.80
A28	The principal of my school has the skills needed to utilize digital technologies productively in the context of his/her daily work.	.81	.73	.81	.65
A31	My school principal organizes professional development activities to enhance the digital skills of school staff.	.80	.88	.82	.80
A32	My school principal is actively involved with teachers in professional development activities to enhance their digital skills.	.79	.89	.84	.80
A33	My school supports the use of new instructional ideas and innovations that develop students' digital skills.	.77	.85	.87	.76
A30	Teachers who take on leadership positions in my school have the digital skills that allow them to fulfil their roles effectively.	.77	.74	.74	.71
	Leadership practices (f2)	.667	.805	.805	.764
A10	Digital technologies facilitate the active participation of my school's teachers in decision-making on instructional issues.	.82	.86	.86	.77
A11	Digital technologies make it possible for teachers in my school to meet on a regular basis to discuss about the learning needs of students.	.76	.80	.80	.74
A09	My school uses digital technologies to overcome spatio-temporal or other obstacles in the decision-making process on instructional issues.	.68	.82	.82	.71
A12	My school has expanded its potential by using digital technologies to promote collective leadership practices.	.62	.83	.83	.84
A18	Digital technologies are contributing in a crucial way to the shaping of my school's leadership practices.	.47	.72	.72	.76
	Digital age (f3)	.599	.614	.613	.582
A02	The pace and extent of digital innovation has made digital technologies a key driver of progress on a global scale.	.75	.72	.74	.68
A03	Interaction is one of the emblematic elements of the digital age.	.67	.76	.67	.61
A01	Direct communication is one of the emblematic elements of the digital age.	.61	.68	.62	.49
A05	Social networking is one of the emblematic elements of the digital age.	.58	.55	.61	.52
A04	Digital technologies have redefined important aspects of modern life.	.57	.52	.56	.59
A07	Collaborative action is one of the emblematic elements of the digital age.	.56	.72	.66	.57
A08	Overcoming conventional spatio-temporal boundaries is one of the most dynamic elements of the digital age.	.54	.51	.55	.59
A06	Digital technologies -directly or indirectly- affect every aspect of modern social reality	.52	.46	.52	.61
	Teacher leadership (f4)	.665	.776	.798	.817
A14	Teachers in my school use digital technologies to exchange ideas and help one another to solve problems related to instructional issues.	.92	.90	.92	.93
A13	Teachers in my school exchange ideas about teaching strategies and share teaching materials through digital technologies.	.84	.85	.85	.89
A15	Teachers in my school utilize digital technologies to improve the quality of the instructional process.	.49	.63	.62	.63
A21	My school uses digital technologies to operate an informal network of communication and collaboration between schoolteachers.	.43	.73		

* EFA: Exploratory factor analysis of the initially specified QDTLP version.
** CFA-1: Confirmatory factor analysis of the initially specified four-factor model.
*** CFA-1r: Confirmatory factor analysis of the revised four-factor model to the same dataset.
**** CFA-2: Confirmatory factor analysis of the revised four-factor model to a new dataset.

Additionally, marginally acceptable discriminant validity was demonstrated, as the estimated factor covariance between factors of the four-factor initially specified CFA model, was .29 for f1-f3, .37 for f3-f4, .52 for f2-f3, .66 for f1-f4, .71 for f1-f2, and .79 for f2-f4. Also, the average variance extracted (AVE) value of each pair of factors appeared greater than their squared correlation (r^2) [44], [45]; the AVE was equal to .688, .652, .420, and .630 for f1, f2, f3, and f4, respectively, while the r^2 for f1-f3 was equal to .850, for f3-f4 was .139, for f2-f3 was .274, for f1-f4 was .436, for f1-f2 was .500, and for f2-f4 was .619. Furthermore, the heterotrait-monotrait (HTMT) ratio was below .85, as factors' HTMT ratios ranged from .277 to .821.

The model revision process was started with the examination of i) modification indices for covariances (i.e., adding error covariances between two errors), for variances (i.e., adding variances between latent variables), for regression (i.e., adding regression paths to the model); and ii) localized areas of strain (i.e., residuals) [20]. The modification indices are analogous to single df Chi-square tests [20], and modification indices values above 3.84 are considered as indicators of changes that would result improvements in CFA model fit to the data [20], [35]. However, it is critical to be noted that that if modification indices do not make sense, given the conceptual framework of the research study or prior research, should not be made regardless of how significant the improvement in model fit is.

The modification indices created by JASP and Jamovi for macOS statistical packages were examined taking into consideration the conceptual framework of this research. The examination suggested changes to the initially specified CFA model, that were related to the large modification indices values for residual covariances to four pairs of items (A31-A32, A28-A30, A03-A07, A03-A01). These modifications were considered to enhance the model fit and relevance to the study's theoretical underpinnings.

The largest modification indices value (168.26) suggests adding residual covariance between items A31 and A32, both of which are part of digital skills factor. The item A31 investigates if, and to what extent, the school principal organizes professional development activities to improve the digital skills of the school staff, and the item A32 investigates whether, and to what extent, the school principal actively participates with the teachers in professional development activities to improve their digital skills. It makes sense that principal's involvement to the organization of school's staff professional development activities to improve their digital skills, would be related to his active participation alongside teachers in these professional development activities, thus adding residual covariance between items A32 and A31 would be a plausible choice.

The second larger modification indices value (127.62) suggests adding residual covariance between items A28 and A30. The item A28 investigates if, and to what extent, the school principal has the skills required for the productive use of digital technologies in his/her everyday work, and the item A30 investigates if, and to what extent, teachers who assume leadership positions in the school have the digital skills that enable them to fulfill their roles effectively. Both items are part of digital skills factor and related to the digital skills of those who assume leadership positions in the school, so adding residual covariance between items A28 and A30 would be a reasonable decision.

After that, an issue for consideration was the addition of residual covariance between items A03-A07 and items A03-A01 (the modification indices value of these two pairs of items was 27.80 and 22.69 respectively), as it appeared to affect in a positive way the discriminant validity between the digital skills and digital age factors. These three items (A03, A07, A01) evaluate if, and to what extent i) interaction; ii) collaborative action; and iii) direct communication are emblematic elements of digital age. In this context, the addition of a residual covariance between these two pairs of items would be reasonable.

Another issue for consideration was that of item 21, which in EFA appeared with the weakest loading (.425) on teacher leadership factor, and it also had a loose conceptual relationship to the other three items of this factor (A13, A14, A15). Item A21 investigates whether school uses digital technologies to operate an informal network of communication and collaboration between schoolteachers, while the other three items of the same factor investigate if schoolteachers utilize digital technologies: i) to exchange ideas about teaching strategies and share teaching materials (A13); ii) to exchange ideas and help one another to solve problems related to instructional issues (A14); and iii) to improve the quality of the instructional process (A15). Additionally, item A21 appeared to relate in a negative way the discriminant validity between the leadership practices and teacher leadership factors. For these reasons the item A21 was eliminated.

The addition of a residual covariance to the four above-mentioned pairs of items and the elimination of item A21 led to the formation of a revised CFA model. The subsequent CFA process (CFA-1r), we conducted using the same dataset and ML as estimator, resulted noticeably smaller, than in the initial CFA model, fit indices values. Furthermore, RMSEA=.058 with a 90% interval of .053 and .064, Chi-square/df ratio 539.891/199=2.713, p<.001, SRMR=.050, CFI=.950, TLI=.942, NNFI=.942, AIC=25632.500, ECVI=1.378, and GFI=992, provide strong evidence of a good/close fit of the four-factor revised CFA model as presented in Figure 2.

There was also evidence of acceptable discriminant validity, as the estimated factor covariance between factors of the revised four-factor CFA model (Figure 2) was .31 for f1-f3, .35 for f3-f4, .50 for f2-f3, .63 for f1-f4, .71 for f1-f2, and .76 for f2 and f4, suggested that the latent variables were related, but the correlations were not so high to indicate that they were measuring the same construct [20]. In the same direction, the AVE value of each pair of factors appeared greater than their r^2 [44], [45]; the AVE value was equal to .662, .652, .390, and .683 for f1, f2, f3, and f4, respectively, while the r^2 for f1-f3 was equal to .094, for f3-f4 was .123, for f2-f3 was .252, for f1-f4 was .401, for f1-f2 was .501, and for f2-f4 was .576. Furthermore, the HTMT ratio values were below .85, as factors' HTMT ratios ranged from .277 to .783.

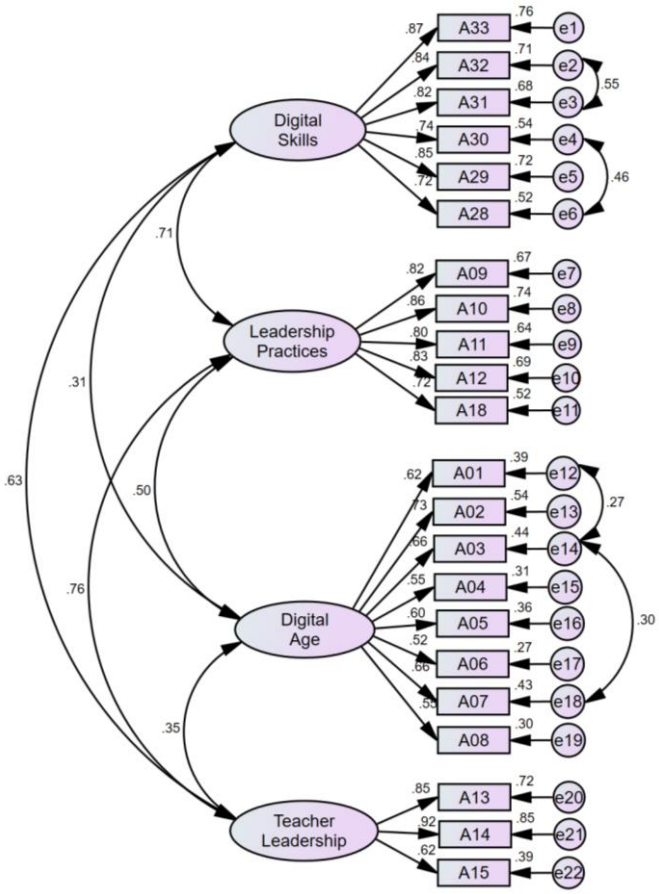

Figure 2. The path diagram of the QDTLP –study 1 dataset

3.2. Results of study 2

3.2.1. Evaluation of normality and outlier assumptions

The normality and outlier assumptions for study 2 data (n=505) evaluated using the same criteria as in study 1 [20], [21], [35]. The skewness values ranged from -0.502 to -1.614, and kurtosis from -0.400 to 4.429. Univariate values that could be marked as outliers were maintained within the study 2 dataset. Moreover, the study 2 dataset was checked for non-typical patterns of values (i.e., the same value in all items) and multivariate outliers, with no combinations found that negatively affected the structure of the model in question.

3.2.2. Confirmatory factor analysis

The revised CFA model of the QDTLP had to be confirmed and in another sample, that was the sample of study 2 [20], [35], [41]. The subsequent CFA process using the ML as estimator, revealed that the revised four-factor CFA model-noted as CFA-2 in Table 1- fits well to the new data, giving the following indices (RMSEA=.063 with a 90% interval of .057 and .069, Chi-square/df ratio (597.683/199=3.003), p<.001, SRMR=.055, CFI=.933, TLI=.922, NNFI=.922, AIC=26689.381, ECVI=1.485, and GFI=.991). These results confirmed the revised CFA model of the QDTLP to a new set of data and were perceived as evidence of a good enough fit of the revised four-factor CFA model to the sample of study 2 as shown in Figure 3.

Sufficient discriminant validity was demonstrated, as estimated factor covariance between factors was .38 for f3-f4, .41 for f1-f3, .55 for f1-f4, .57 for f2-f3, .70 for f1-f2, and .77 for f2-f4, suggested that the latent variables were related, but the correlations were not so high to indicate that they were measuring the same construct. In the same direction, the average variance extracted (AVE) value of each pair of factors appeared greater than or equal to their r^2 [44], [45]; more specifically, the AVE was equal to .583, .588, .329 and .735 for f1, f2, f3, and f4, respectively, while the r^2 for f1-f3 was equal to .167, for f3-f4 was .147, for f2-f3 was .328, for f1-f4 was .298, for f1-f2 was .489, and for f2-f4 was .588. Furthermore, the HTMT ratio values were below .85, as factors' HTMT ratio ranged from .408 to .801.

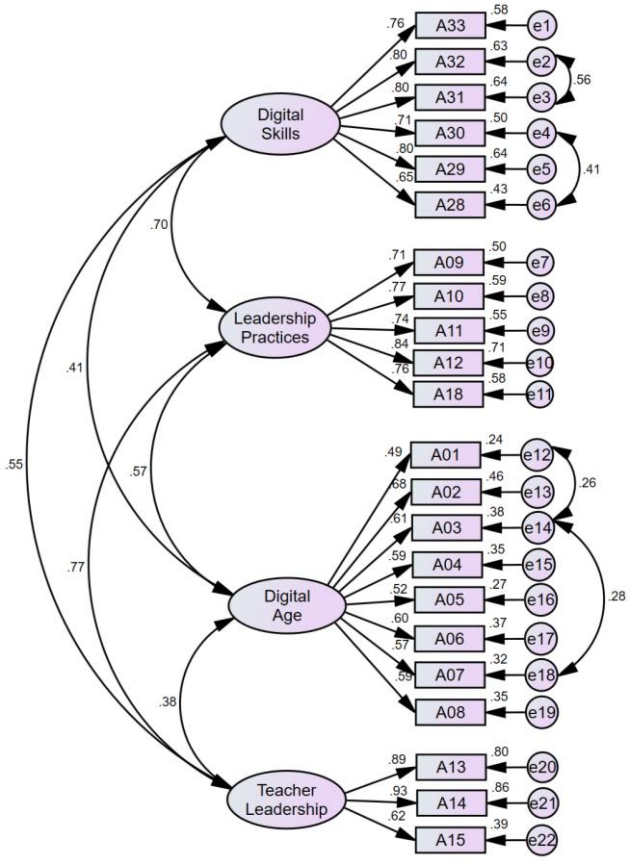

Figure 3. The path diagram of the QDTLP –study 2 dataset

3.3. Reliability of the QDTLP

Reliability analysis of study 1 (*n* =502) resulted an overall Cronbach's alpha equal to .925 with a range of .918 to .926 if an item dropped, and an ICC =.925 (95% CI =.915 to .934). The internal consistency for the 4 factors ranged from very good to excellent levels, according to the criteria [21], [35]. Cronbach's alpha reliability values were .926 for f1, .901 for f2, .832 for f3, and .834 for f4. The item-rest correlation values ranged from .730 to .827 for f1, .671 to .809 for f2, .481 to .663 for f3, and .569 to .789 for f4. The average interitem correlation values were .675 for f1, .646 for f2, .384 for f3, and .622 for f4).

In study 2 (*n* =505) the overall Cronbach's alpha was equal to .919 with a range of .911 to .919 if an item dropped, and an ICC =.919 (95% CI =.908 to .929). The internal consistency for the four factors -and in this case-ranged from very good to excellent [21], [35]. Cronbach's alpha reliability coefficient was .804 for f1, .875 for f2, .898 for f3, and .919 for f4. The item-rest correlation ranged from .426 to .624 for f1, .645 to .764 for f2, .578 to .834 for f3, and .655 to .790 for f4. The average interitem correlation values were .347 for f1, .584 for f2, .646 for f3, and .595 for f4). The results from both studies demonstrated the excellent reliability of QDTLP [21], [35], [46].

3.4. Discussion

The primary objective of this research was to provide evidence for the validity and reliability of the QDTLP, which investigates the perceptions of principals, vice-principals, teachers, and special educational staff for the digital age, and whether -and to what extent- the utilization of digital technologies affects leadership practices in elementary schools. The selection and the development of the questionnaire items were derived by a thorough literature review in the fields of digital technologies and school leadership practices, with a focus on understanding the impact of digital technologies on leadership practices, particularly in terms of promoting innovation, fostering creativity, and driving change. In addition, the questionnaire items were designed to examine the impact of digital technologies on school leadership practices, teachers' active involvement in the decision-making process regarding instructional issues, their capacity to regularly convene and discuss students' learning needs, overcome spatial and temporal constraints, and promote collective leadership practices. Furthermore, the perceptions of school staff about emblematic elements of the digital age, including direct communication, interaction, collaborative action, and

social networking were investigated, providing insights into their effects on learning, participation, collaboration, decision-making, mutual support, and professional development.

The pilot study played an important role in assessing the consistency and reliability of the initial version of the QDTLP. The evaluation focused on ensuring the consistency of the research instrument over time and avoiding potential biases such as recall, learning, or carryover effects. Following the guidelines recommended by several researchers[17], [20], a two-week interval was implemented between the initial test and the retest. The results showed a remarkable level of stability and reliability, as indicated by the overall Cronbach's alpha values in the consistency test and in the consistency retest. The achieved Cronbach's alpha scores above .900 exceeded the accepted literature thresholds [21], [35], providing valuable insight into the ability of the QDTLP to produce results consistently and reliably over time. This provided a robust foundation for the subsequent EFA process.

In study 1, the initial QDTLP version was thoroughly examined to identify the underlying factors, including latent variables. The study included an assessment of the construct validity and reliability of the research instrument. At the end of the EFA process, 23 questionnaire items were grouped into four factors.

The digital skills factor (6 items) emerged as a critical element of the educational environment. The six items in this factor examine the school's commitment to promoting the digital skills of its teachers, supporting their growth, and introducing creative teaching ideas to enrich students' digital skills. In addition, highlight the critical role of the principal in this commitment, by emphasizing his or her ability to use digital technologies in their daily work. Furthermore, emphasize the principal's responsibility for organizing professional development activities that focus on improving the digital skills of the school staff, and encourage teachers' active engagement in these initiatives. The link between leadership roles and digital skills is clear, as teachers in leadership roles demonstrate the skills necessary to perform their roles effectively in the dynamic digital educational environment. This interconnectedness underscores the importance of digital skills as a fundamental component within the school's educational context.

The leadership practices factor (5 items) emerged as a key dimension with a significant impact on the educational landscape. The five items within this factor assess the extent to which digital technologies play a role in the active participation of elementary school teachers in decision-making process on instructional issues. They also examine how these technologies enable regular meetings among teachers to discuss students' learning needs, which contributes significantly to the formation of leadership practices within the elementary school. In addition, the factor examines how the school uses digital technologies to overcome spatiotemporal or other barriers to decision-making process about instructional issues, thereby enhancing its capacity to foster collaborative leadership practices. The use of digital technologies is essential for creating a collaborative and inclusive environment in schools. It enables schools to adapt and respond quickly and efficiently to changes in education. This highlights the transformative impact of digital technologies in shaping and improving school leadership practices.

The digital age factor (8 items) emerged as a transformative force shaping various dimensions of contemporary society. The eight items within this factor collectively assess the extent to which emblematic elements of the digital age, such as interaction, direct communication, social networking, and collaborative action, have become defining characteristics of our era. In addition, the items explore how the transcendence of conventional spatiotemporal boundaries is one of the most dynamic facets of this digital age, enabling unprecedented connectivity and interaction across distances. It also considers how the rapid pace and far-reaching reach of digital innovation have positioned digital technologies as key drivers of progress on a global scale. Importantly, the items also investigate into how digital technologies have redefined important aspects of modern life, directly or indirectly influencing every aspect of modern social reality. This comprehensive examination underscores the profound and far-reaching impact of the digital age on our interconnected and rapidly evolving world. The multiple effects of these technological advances underscore the transformative nature of the digital age in shaping contemporary social dynamics.

The teacher leadership factor (4 items) emerged as an important aspect of elementary school dynamics. The four items within this factor collectively assess the extent to which teachers use digital technologies to share/exchange ideas and collaboratively solve instructional challenges. They also explore the use of digital platforms to share instructional strategies and materials, contributing to a supportive and knowledge-sharing community among educators. Beyond collaboration, the assessment also examines the implementation of digital technologies by teachers to improve the overall quality of the instructional process, demonstrating the transformative capabilities of teacher leadership. In addition, these items highlight the role of digital technologies in facilitating an informal network of communication and collaboration among teachers, underscoring the dynamic and networked nature of teacher leadership in utilizing digital technologies for innovative education in elementary school contexts.

The cumulative variance rate of the four above-mentioned factors, which accounted for 57.4%, highlighted their ability to interpret information effectively from 23 variables [20]. The factor structure

provided a comprehensive framework for understanding intricate connections between digital skills, leadership practices, perceptions of school staff about digital age, and teacher leadership. Our refined survey with streamlined questions and well-defined factors demonstrated strong psychometric properties, denoting heightened effectiveness and accuracy. The methodical elimination of questions and the distinct factor arrangement contributed significantly to the overall validity and reliability of QDTLP.

The CFA process in study 1 and study 2 data provided strong evidence of a good/close fit of the revised four-factor QDTLP model. More specifically, the evaluation of the initially specified CFA model yielded promising results, indicating an acceptable fit. The fit indices, including RMSEA, Chi-square/degrees of freedom ratio, SRMR, CFI, and TLI, all demonstrated values within the acceptable range [21]. The slight modification of the model was deemed necessary, consistent with the recommendations of Harrington [20], to address areas where the initial model exhibited suboptimal fit. The refinement of the CFA model involved introducing residual covariances for specific item pairs (A31-A32, A28-A30, A03-A07, A03-A01) and eliminating item A21. This adjustment led to the development of a revised CFA model (CFA-1r). The subsequent analysis, employing ML as the estimator, revealed notable improvements in fit indices compared to the initial model. Specifically, the RMSEA decreased to .058, the chi-square/degrees of freedom ratio reduced to 2.713, and SRMR reached .050, all indicative of a substantial enhancement in model fit [21].

The robustness of the revised CFA model (CFA-1r) was further assessed in study 2, necessitating a new sample for validation [20], [35], [41]. Utilizing ML as the estimator in this independent dataset, the revised four-factor CFA model (CFA-2) demonstrated commendable fit indices. The RMSEA was .063, the Chi-square/degrees of freedom ratio were 3.003, and other indices, including SRMR, CFI, TLI, NNFI, AIC, ECVI, and GFI, confirmed the robustness and generalizability of the revised model to new data [21], [41]. These results provide strong evidence supporting the validity and applicability of the revised CFA model to the sample of study 2.

The iterative process of model evaluation and refinement, as demonstrated in this research, underscores the importance of methodological rigor in ensuring the appropriateness and generalizability of measurement models. The modifications made to the initially specified CFA model were informed by fit indices and guidelines from several studies [20], [35], [41]. The revised CFA model, refined through expert guidelines, enhanced the QDTLP's credibility and reliability, reinforcing the discourse in the field of digital technologies and school leadership practices.

Furthermore, the reliability analysis indicated that QDTLP reached excellent levels of internal consistency. The consistency in the reliability metrics across both study 1 and study 2 underscores the robustness and stability of the measurements for the QDTLP. The results align seamlessly with established criteria for reliability [35], [41], [46]. The high Cronbach's alpha values and narrow confidence intervals for the ICC further support the trustworthiness and consistency of the QDTLP in assessing the impact of digital technologies on leadership practices in elementary school. The outcomes of this reliability analysis enhance the confidence in the utilization of QDTLP for future research and applications in other educational contexts.

In future research efforts, it is crucial to expand the exploration of the QDTLP to encompass a wider array of educational settings. The insights gained from its initial use in elementary schools establish a basis for its adaptation in various contexts and facilitate a deeper understanding of how digital technologies impact school leadership practices. Future research could investigate the long-lasting effects and viability of detected patterns, illuminating the changing dynamics of digital technologies in school leadership practices. Analyzing the factors that affect digital skills, leadership practices, and staff perspectives about digital age may improve our understanding of the complex interaction within education. Furthermore, the QDTLP can be utilized in cross-cultural contexts throughout the European Union or worldwide to achieve a thorough comprehension of the impact of digital technologies on leadership practices in educational settings.

4. CONCLUSION

This research achieved its primary goal of establishing the validity and reliability of the QDTLP research instrument. The thorough investigation focused on understanding the perceptions of principals, vice principals, teachers, and special educational staff in the digital age and how the use of digital technologies affects leadership practices in elementary schools. The refinement process, informed by literature review and extensive statistical analyses, produced a reliable four-factor model that captures the interrelated dimensions of digital skills, leadership practices, perceptions about digital age, and teacher leadership. The instrument's reliability analysis demonstrated its stability and consistency, surpassing accepted thresholds. The improved model exhibited robust fit in study 1 and study 2 datasets, reinforcing the applicability and generalizability of the model.

The iterative refinement method, underpinned by methodological precision, establishes the QDTLP as a reliable and valid tool for future research in the fields of digital technologies and school leadership practices. This study provides valuable insights into the impact of digital technologies on school leadership

practices and offers a basis for further research and application in different educational contexts in Greece, European Union countries and worldwide. To this end, the QDTLP's final version was translated/adapted from Greek to English, following the translation/adaptation process described in previous section.

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