Evaluation of Secondary Teachers' Knowledge and Skills, Regarding the Information and Communication Technologies Utilization, before and after the COVID-19 Era, in Greece

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Abstract

The current wide exploitation of information and communication technologies (I.C.T.) enhances students' ability to further acquire knowledge and skills. In today's era when society is overwhelmed by a multitude of gadgets (laptops, tablets, smart-phones, etc.), students adapt very easily to technologically supported learning environments and learn to utilize I.C.T. It is a fact that during the global pandemic (COVID-19) the I.C.T.'s implementation of modern and asynchronous distance education supported greatly the educational community at all educational levels. The purpose of the study was the detailed evaluation of the knowledge and skills of Greek teachers in the exploitation of I.C.T., and the comparison of their "armamentarium" with those of the pre-COVID-19 era, (where I.C.T.s' tools in teaching were apparently very limited). Stratified sampling was carried out with proportional allocation (Panaretos & Xekalaki, 2000). Subsets of the population were selected which met certain properties. The method was used because there was an uneven population between the geographical prefectures of Greece from where the sample was collected. During the research process, appropriately structured questionnaires of 40 questions were fully completed by 130 teachers. The research questions were searching for: 1) The degree of satisfaction among teachers who used I.C.T. before and after COVID-19 pandemic. 2) The satisfaction rate of teachers towards the educational success of I.C.T.s' tools, before and after COVID-19. With the term "success" we mean the degree of satisfaction with acquiring new knowledge thanks to the use of I.C.T.s' tools in teaching. Following COVID-19 pandemic along with the forced implementation of distance learning, there was an increase in the number of teachers participating in I.C.T. training programs from 18.8% to 38%. The percentage of

teachers who claimed that the quality of the provided education is improving, increased from 53.8% to 68%. Additionally, after the COVID-19 era, the percentage of teachers who were satisfied with the use of I.C.T. in theory courses increased from 47.5% to 64%, while the percentage of teachers who supported the use of I.C.T. in laboratory courses decreased from 60.9% to 51.3%. The percentage of teachers who wished for the existence of e-courses adapted to the students needs improved from 52.5% to 56%. An increase in teachers' gaining satisfaction with school equipment was observed from 46.3% to 60%, while the percentage of schools that enhanced the implementation of I.C.T. techniques also increased from 37.5% to 58%. Teachers' opinion over I.C.T. did not dramatically change after the implementation of distance learning. However, a more positive picture emerges regarding both the degree of satisfaction with the I.C.T. use, integration and implementation tools, as well as the degree of enhancement of students' knowledge from the use of I.C.T.

Keywords

Information and Communication Technologies in Education (I.C.T.), COVID-19, Education, Distance Learning, Teachers' Opinions, Education in Greece, Greece, I.C.T. in Greece, After COVID-19, Before COVID-19, Secondary Schools, Teachers' Knowledge, Teachers' Skills, Pre and Post COVID-19

1. Introduction

Nowadays, we are all living in the era of multiple global crises, but also under extremely rapid technological developments. As it is known, crises, in general, if they are used properly can become a rich source of creativity and constructivism (Arshad, 2020). The current evolution of technology marks the change in the way we think and act. These developments and changes are affecting directly education. Every day, we observe the influence of New Technologies in the field of education. Computers, the internet (World Wide Web) and its pervasiveness do not leave the education sector unaffected. Digital literacy enhances participation in social becoming and the individual's professional development (Zeppos, 2017).

For above reasons, significant investments have been made globally in computing and network infrastructure and equipment for schools, as well as in the development of digital educational materials. However, these investments alone cannot offer the expected benefits to the educational process, without the contribution of parallel supporting actions, especially, with the most important upgrading and modernization of teachers' knowledge and skills (Grestas, 2018).

The success of any educational and information system heavily depends on the total use by the users and their desire to improve themselves. Teachers therefore, need to be aware of the pedagogical and educational advantages offered by the New Technologies, given that: a) the gap that exists in terms of I.C.T. knowledge and b) the non-satisfaction of students, detected with the implementation

of corresponding educational material (Vlassopoulos et al., 2021). Modern research has shown that the greater development of I.C.T., the greater improvement there was in the workplace, (in our study it concerns teaching) but that did not mean there weren't problems (Abubakari, Inusah, & Abdulai, 2023).

The enhancement of e-learning has been a key issue in the implementation of the strategy outlined in the White Paper "Open and Distance Education" since 1995 (Commission, 1995).

In the E.U. the promotion of I.C.T. in education is rapid (Commission, 2022). For example:

• Poland where the NAVOICA platform (website coordinated by the Ministry of Education), has been implemented for years at national policy level, providing access to free M.O.O.C-type e-courses to students (Szyszka, Tomczyk, & Kochanowicz, 2022).

• Ireland with the Classroom 2000 (C2k) has long been providing every school with modern I.C.T. infrastructure, hardware and software required by schools, secure internet access, user help desk, e-learning platform (fronter) and creation of Europe's first cloud education environment. In addition, there is access to a rich pool of learning resources that supports collaboration between schools helping the development skills that equip students for the future (Department of Education, 2016).

Outside the E.U., China in its educational agenda for 2030, has recognized the importance of I.C.T. in education aiming additionally to improve virtual reality in teaching, simulations, and pedagogical techniques (Yang, Guo, & Cui, 2023).

In recent years, the Greek Ministry of Education initiated a systematic effort to train teachers with I.C.T. programs (Institute of Computer Technology and Publications "Diofantos", 2023), at various levels, such as:

• Introductory I.C.T. training.
• Advanced training for the utilization of I.C.T. in teaching.

It is worth mentioning that Greece is 24th in the E.U. in terms of the digital skills of the human resources and 32nd among the 33 O.E.C.D. countries in terms of the percentage of participation of the human resources in training programs (Mastoras, 2022).

2. Objectives and Methods

2.1. Purpose of the Research

The purpose of the present effort was to evaluating the teacher's knowledge and skills in terms of I.C.T. use, utilization and familiarity. Data were collected in 2019/05 (before COVID-19) and 2023/05 (after COVID-19) to compare, in such distinct periods, teachers' knowledge and skills. More specifically, two types of questions contained the questionnaire body, towards secondary school teachers:

A) The satisfaction degree of teachers **using** I.C.T. before and after COVID-19 period (**Question A'**).

B) The satisfaction rate of teachers concerning the educational **success** of I.C.T.s' tools before and after COVID-19 (**Question B'**). With the term "success" we mean the degree of satisfaction with acquiring new knowledge thanks to the

use of I.C.T.s' tools in teaching.

2.2. The Study Sample

A total of 130 teachers participated in the assessment. Specifically, in May 2019, 50 teachers from the prefecture of Attica and 30 teachers from the prefecture of Cyclades, both in Greece, were selected (before the COVID-19 era). In May 2023, 30 teachers from the prefecture of Attica and 20 teachers from the prefecture of Cyclades were selected (after the COVID-19 era). In order to ensure the project reliability and validity, the final sample consisted of a representative and homogeneous number of teachers (general and vocational education).

In our study we used random stratified sampling with a proportional sample size. There was a ratio between the teachers' sample of the strata (layer) and the size of the total teachers' sample. This ratio is equivalent to the ratio of the teachers' population of the strata (layer) to the size of the total population of teachers. As a result, the total sample was a proportional micrograph of the population (Zafeiropoulos, 2010).

In stratified sampling each prefecture corresponded to a different strata (island and mainland). Within the strata there was as little variance as possible (great homogeneity) but between them, there was as much variance as possible (Halikias, Manolesou, & Lalou, 2015).

The stratified sampling design does not impose restrictions on the sampling method from strata to strata, nor on the sample size of each strata (Papageorgiou, 2015).

Independent sampling was performed in each strata. The final sample consisted of all individual samples per strata.

The term "random" does not mean that we randomly selected whoever from the population (Halikias, Manolesou, & Lalou, 2015). We used the equation of proportional allocation so that the population sizes were equivalent to those of the sample (Papageorgiou, 2015).

$$\frac{n_h}{n} = \frac{N_h}{N} \rightarrow n_h = n \cdot \frac{N_h}{N}$$

Specifically:

N: Total population (sum of layers).

N_h: Population size of each layer.

n: Sample size per layer.

n_h: Final sample size.

For example, in the D district of Athens (one of the largest educational districts) there were 2.506 registered teachers, while in the district of the Cyclades prefecture, there were 896 registered teachers (Kordis, 2019). The total population of these two regions amounts (for the 2019-2020 school year) to 3.402 teachers. In advance, we had decided to collect 70 questionnaires before and 70 after the implementation of distance education. According to the proportional distribution equation, we collected 50 questionnaires from the D district of Athens.

$$n_h = n \cdot \frac{N_h}{N} \rightarrow n_h = 70 \times \frac{2506}{3402} \rightarrow n_h = 50$$

19 questionnaires corresponded to the Cyclades prefecture (island area). Because the number of questionnaires was quite small, at least 30 questionnaires were collected (Koutrouvelis, 2000). It is reported that both the number of 50 and the number of 19 questionnaires correspond to a percentage of 2% of the total population of the prefectures.

In addition, the simple size of the proportion equation (Papanastasiou & Papanastasiou, 2014) resulted in a sample proportion of 30 teachers.

$$N = \left(\frac{z}{e}\right)^2 \times p \times (1-p) \rightarrow N = \left(\frac{1.96}{0.05}\right)^2 \times 0.02 \times (1-0.98) = 30$$

Specifically:

N: the sample size.

G: the desired confidence interval.

e: the error rate.

p: the percentage of subjects in a category.

Finally they have collected 50 questionnaires at the beginning and 30 at the end of the survey from the prefecture of Attica. In the Cyclades prefecture, 30 questionnaires were collected at the beginning and 20 at the end of the survey.

2.3. Method

Well designed, comprehensive and targeted questionnaires were used. In terms of structure, the questionnaires consisted of three parts:

- Part 1: demographics (6 questions).
- Part 2: general questions about I.C.T. training (9 questions).
- Part 3: questions regarding satisfaction, followed by the implementation of I.C.T. in the classroom (25 questions).

The process of designing the questionnaire began with the formulation of the research objectives. The collected information was useful for the analysis of the research (Petrakos, 2021).

The questionnaire was constructed according to the following steps (Stathakopoulos, 2005; Siomkos & Mavros, 2008):

a) Preliminary decisions were made (What kind of information would be necessary to collect? From whom would the information be collected? By what method would the information be collected? What measurement scale would be used?).

b) Previous questionnaires were reviewed.

c) Decisions were made regarding the content, the wording, the type of each question, the order of the questions and the structure of the questionnaire.

d) A draft of the questionnaire was prepared.

e) Tested and revised the questionnaire.

f) The questionnaire was finalized.

The questionnaire was checked in terms of (Ouzouni & Nakakis, 2011):

1) Content validity.

2) Construct validity.

3) Regarding test-retest reliability.

1) **Content validity** refers to the extent to which a questionnaire covers the different dimensions of the concept or variable being measured (Spoto, Nucci, Prunetti, & Vicovaro, 2023). The questionnaire variables were representative of the abstract concept measured by the questionnaire.

2) **Construct validity** refers to the extent to which a questionnaire reflects the true theoretical meaning of the concept it measure (Grimm & Widaman 2023). The testing of conceptual construct validity is subjective. For this reason a significant number of studies are required in different countries, populations and at different points in time. However, in this particular study, the control of the validity of the conceptual construct was achieved by the factor analysis at a preliminary stage of the questionnaire.

3) **Test-retest reliability** assesses the degree of correlation of participants' responses to a questionnaire at two different points in time (Verster et al. 2023). Specifically, to assess the test-retest reliability, the questionnaire was completed by the participants in the context of a pilot study. After a period of time, the questionnaire was completed by the same participants with minimal deviations.

Responses were given on a 10-point Likert scale, graded from "1" corresponding to "not at all satisfied" to "10" corresponding to "completely satisfied". The questionnaires time took about 10 minutes to complete.

In the pilot phase, the questionnaires were distributed to 5 secondary school teachers and were completed after the necessary clarifications. Data were collected on Limesurvey and analyzed with SPSS 27.0 (academic license). Initially, descriptive statistical analysis was conducted to depict the demographics and other characteristics of the respondents. Statistical analysis was based on the non-parametric Chi-square and Mann-Whitney test methods. Finally, with Factor Analysis, the variables were reduced to significant "factors" (Siomkos & Vassilikopoulou, 2005), that is, the variables were grouped. The reliability index value (Cronbach's alpha) was satisfactory, $\alpha = 0.783$.

3. Results

The relationship of all satisfaction questions with the answers to the two research questions was statistically studied.

For better reader's understanding, it is presented in Table 1 a detailed calculation example of Table 2 and Table 3.

All statistical results for the two types of questions are presented in Table 2 and Table 3. In Table 1, as well as in Table 2 and Table 3, the responses were first compared in terms of two different variables/questions.

Because the respondents' answers did not cover the entire ten-point scale, their answers were consolidated into three groups: *Little* (scale values 1 - 3), *Enough* (scale values 4 - 6), *Very* (scale values 7 - 10). Responses were compared separately before and after COVID-19 with Chi-squared test. In addition, the median values of overall responses before and after COVID-19, were compared with the Mann-Whitney test. Applying additional 32 similar tables created Table 2, Table 3 for the research questions.

Table 1. Table of frequency distribution of teachers' responses regarding the equipment of their laboratories for I.C.T. and their satisfaction with the use of I.C.T.s' tools during teaching. Most responses indicated a high degree of satisfaction with the utilization (use, integration and implementation) of I.C.T.s' tools, both before and after COVID-19. Comparing the medians of responses before and after COVID-19 with the Mann-Whitney test statistic, which was applied to the 10-point Likert scale, showed a p-value of 0.890. According to that, we concluded that there was no difference between the responses of teachers before and after the COVID-19 era concerning the utilization of I.C.T.s' tools during teaching.

		VAR5 Equipment of the laboratories in I.C.T.						
		Before COVID-19				After COVID-19		
		Little	Enough	Very		Little	Enough	Very	
(Var1) Degree of Satisfaction from the use of I.C.T.s' tools in teaching	Little	5	9	3		2	1	3	
	%	6.3%	11.3%	3.8%	p-Value Chi-Square 0.034	4.0%	2.0%	6.0%	p-Value Chi-Square 0.020
	Enough	2	7	10		1	8	10	
	%	2.5%	8.8%	12.5%		2.0%	16.0%	20.0%	
	Very	4	13	27		0	6	19	
	%	5.0%	16.3%	33.8%		0.0%	12.0%	38.0%	
	Average on a ten-point scale	6.95/10				7.34/10			Mann-Whitney test 0.890

Table 2. Results of the main variables that determine the "degree of satisfaction with the use of I.C.T.s' tools" before and after the pandemic. Where p-value > 0.05 (bold), we accepted the null hypothesis, i.e. there was no relationship between the variables. The Mann-Whitney test was used to compare teachers' responses before and after the COVID-19 period. In Mann-Whitney test values with p-value < 0.05, there was a statistically significant difference, between teachers' responses in the pre and post-COVID-19 period.

		(Var1) Degree of satisfaction with the use, (integration and implementation) of I.C.T.s' tools (130 teachers/100%)								
		Before				After				
Var	Variables of A' Research Question	Little	Enough	Very	Chi-square p-Value	Little	Enough	Very	Chi-square p-Value	Mann-Whitney test p-value
02	Participation in I.C.T. trainings	0.0%	3.8%	17.5%	<0.001	0.0%	14.0%	24.0%	0.039	**0.039**
03	Obtaining an E.C.D.L.	7.5%	21.3%	35.0%	0.003	0.0%	14.0%	34.0%	<0.001	0.078
04	Participation in trainings on Coursera	1.3%	0.0%	7.5%	**0.136**	0.0%	4.0%	4.0%	**0.700**	0.882
05	Knowledge of Wikis	6.3%	13.8%	43.8%	<0.001	0.0%	22.0%	38.0%	<0.001	0.669
06	WiKi construction	1.3%	2.5%	11.3%	**0.085**	0.0%	4.0%	18.0%	0.004	0.311
07	Construction of concept maps (C-map)	0.0%	6.3%	30.0%	<0.001	0.0%	10.0%	34.0%	<0.001	0.380
08	Knowledge about M.O.O.C.	1.3%	0.0%	21.3%	<0.001	0.0%	12.0%	28.0%	0.002	**0.033**
09	Ability to use an interactive whiteboard	11.3%	15.0%	41.3%	**0.092**	8.0%	28.0%	40.0%	**0.470**	0.302
1	Significant degree of satisfaction with the use of I.C.T.s' tools. (Research Question A')	-	-	-	-	-	-	-	-	0.890
2	Significant degree of satisfaction with acquiring new knowledge thanks to the use of I.C.T.s' tools in teaching (Satisfaction with educational success of I.C.T.s' tools) (Research Question B')	10.0%	15.0%	52.5%	<0.001	8.0%	28.0%	48.0%	0.019	0.884

Continued

3	Significant degree of use of I.C.T. during teaching	0.0%	3.8%	38.8%	<0.001	0.0%	10.0%	44.0%	<0.001	0.368
4	Systematic promotion and implementation of I.C.T. from school	3.8%	8.8%	26.3%	0.015	4.0%	20.0%	40.0%	0.009	**0.023**
5	Complete laboratory equipment infrastructure for school I.C.T. use	3.8%	12.5%	33.8%	0.003	6.0%	20.0%	38.0%	0.020	**0.046**
6	Significant degree of satisfaction with the use of I.C.T. in theory courses	3.8%	13.8%	40.0%	0.001	10.0%	20.0%	40.0%	0.118	**0.044**
7	Significant degree of satisfaction with the use of I.C.T. in laboratory courses	4.7%	12.5%	50.0%	<0.001	0.0%	23.1%	38.5%	<0.001	0.433
8	Large number of distance learning course attendance	6.3%	13.8%	41.3%	<0.001	0.0%	30.0%	42.0%	<0.001	0.668
9	High degree of satisfaction with the competence of I.C.T. trainers	6.3%	9.4%	25.0%	**0.491**	0.0%	7.7%	30.8%	0.022	0.594
10	Systematic use of interactive whiteboard	0.0%	1.3%	7.5%	0.020	0.0%	4.0%	12.0%	0.035	0.056
11	Systematic use of simulations (Photodendro, Phet-Coorado)	0.0%	2.5%	15.0%	<0.001	0.0%	6.0%	22.0%	<0.001	**0.049**
12	Significant degree of satisfaction with the construction of Blog	0.0%	1.3%	12.5%	<0.001	0.0%	0.0%	26.0%	<0.001	0.117
13	A significant degree of enhancement of teaching by the use of tablets and mobile phones	6.3%	10.0%	30.0%	**0.057**	0.0%	12.0%	28.0%	<0.001	0.835
14	Significant use of I.C.T.s' tools for students' evaluation	0.0%	1.3%	11.3%	<0.001	0.0%	6.0%	18.0%	<0.001	**0.025**
15	Significant use of I.C.T.s' tools for presenting material	0.0%	1.3%	13.8%	<0.001	0.0%	4.0%	12.0%	<0.001	0.328
16	Significant use of I.C.T.s' tools for organizing and managing the classroom	0.0%	1.3%	7.5%	<0.001	0.0%	0.0%	4.0%	0.008	0.953
17	Considerable exploitation of digital learning environments	0.0%	2.5%	12.5%	<0.001	0.0%	4.0%	4.0%	**0.104**	0.288
18	Important use of I.C.T.s' tools to create interactive lessons with images and videos	0.0%	0.0%	6.3%	<0.001	0.0%	4.0%	12.0%	0.030	0.868
19	Significant degree of enhancement of teaching by the use of an electronic learning platform	8.8%	12.5%	28.7%	**0.318**	2.0%	26.0%	34.0%	**0.153**	**0.040**
20	Significant degree of exploitation of online teaching class	1.3%	6.3%	8.8%	0.040	2.0%	10.0%	20.0%	<0.001	**<0.001**

Continued

21	Significant degree of course creation on an electronic platform such as: Moodle, E-CLASS, EDMONDO,	0.0%	8.8%	23.8%	<0.001	2.0%	12.0%	40.0%	<0.001	**<0.001**
22	Great desire to join programs to create an electronic learning platform	8.8%	11.3%	21.3%	**0.378**	4.0%	20.0%	44.0%	<0.001	**0.013**
23	Great desire to acquire an e-course that will be adapted to the needs of the students	10.0%	15.0%	37.5%	**0.212**	6.0%	18.0%	36.0%	**0.115**	0.865
24	Creation of a significant number of virtual distance learning rooms (B.B.C., Webex)	1.3%	2.5%	15.0%	0.030	0.0%	4.0%	24.0%	<0.001	0.569
25	Significant degree of enhancement of the quality of the teaching provided in Adult Education	8.8%	15.0%	36.3%	**0.070**	10.0%	26.0%	38.0%	**0.261**	0.081

Table 3. Results of the main variables that determine the "degree of satisfaction with the acquisition of new knowledge (educational success) thanks to the use of I.C.T.s' tools" (during teaching before and after the pandemic). Where the p-value > 0.05 (bold) is presented, we accepted the null hypothesis, i.e., there was no relationship between the variables.

		(Var2) Degree of satisfaction with acquiring new knowledge thanks to the use of I.C.T.s' tools in teaching (130 teachers/100%)							
		Before				After			
Var	Variables of B' Research Question	Little	Enough	Very	p-Value	Little	Enough	Very	p-Value
02	Participation in I.C.T. trainings	0.0%	2.5%	18.8%	0.139	0.0%	0.0%	38.0%	<0.001
03	Obtaining an E.C.D.L.	1.3%	8.8%	53.8%	**0.139**	0.0%	8.0%	40.0%	<0.001
04	Participation in trainings on Coursera	1.3%	1.3%	6.3%	**0.642**	0.0%	0.0%	8.0%	**0.066**
05	Knowledge of Wikis	1.3%	11.3%	51.2%	**0.380**	0.0%	4.0%	56.0%	0.039
06	WiKi construction	0.0%	1.3%	13.8%	**0.089**	0.0%	0.0%	22.0%	0.007
07	Construction of concept maps (C-map)	0.0%	3.8%	32.5%	0.021	0.0%	0.0%	44.0%	<0.001
08	Knowledge about M.O.O.C.	0.0%	2.5%	20.0%	**0.102**	0.0%	0.0%	40.0%	<0.001
09	Ability to use an interactive whiteboard	0.0%	13.8%	53.8%	**0.406**	0.0%	8.0%	68.0%	**0.129**
1	Significant degree of satisfaction with the use of I.C.T.s' tools. (Research Question A')	0.0%	2.5%	52.5%	<0.001		2.0%	48.0%	0.019
2	Significant degree of satisfaction with acquiring new knowledge thanks to the use of I.C.T.s' tools in teaching (Satisfaction with educational success of I.C.T.s' tools) (Research Question B')	-	-	-	-	-	-	-	-
3	Significant degree of use of I.C.T. during teaching	0.0%	2.5%	40.0%	<0.001	0.0%	4.0%	50.0%	**0.07**
4	Systematic promotion and implementation of I.C.T. from school	0.0%	1.3%	37.5%	<0.001	0.0%	6.0%	58.0%	<0.001
5	Complete laboratory equipment infrastructure for school I.C.T. use	0.0%	3.8%	46.3%	<0.001	0.0%	4.0%	60.0%	<0.001
6	Significant degree of satisfaction with the use of I.C.T. in theory courses	0.0%	10.0%	47.5%	<0.001	0.0%	6.0%	64.0%	**0.068**

Continued

7	Significant degree of satisfaction with the use of I.C.T. in laboratory courses	0.0%	6.3%	60.9%	0.003	0.0%	10.3%	51.3%	**0.961**
8	Large number of distance learning course attendance	1.3%	5.0%	55.0%	<0.001	0.0%	10.0%	62.0%	**0.518**
9	High degree of satisfaction with the competence of I.C.T. trainers	1.6%	6.3%	32.8%	**0.829**	0.0%	2.6%	35.9%	**0.218**
10	Systematic use of interactive whiteboard	0.0%	0.0%	8.8%	**0.173**	0.0%	0.0%	16.0%	**0.090**
11	Systematic use of simulations (Photodendro, Phet-Coorado)	0.0%	3.8%	13.8%	**0.132**	0.0%	2.0%	26.0%	**0.063**
12	Significant degree of satisfaction with the construction of Blog	0.0%	0.0%	13.8%	0.002	0.0%	0.0%	26.0%	**0.164**
13	A significant degree of enhancement of teaching by the use of tablets and mobile phones	1.3%	1.3%	43.8%	0.002	0.0%	2.0%	38.0%	0.033
14	Significant use of I.C.T.s' tools for students' evaluation	0.0%	1.3%	11.3%	0.031	0.0%	24.0%	24.0%	0.002
15	Significant use of I.C.T.s' tools for presenting material	0.0%	1.3%	13.8%	0.002	0.0%	0.0%	16.0%	**0.090**
16	Significant use of I.C.T.s' tools for organizing and managing the classroom	0.0%	1.3%	7.5%	0.031	0.0%	0.0%	4.0%	**0.708**
17	Considerable exploitation of digital learning environments	0.0%	1.3%	13.8%	0.006	0.0%	0.0%	8.0%	**0.093**
18	Important use of I.C.T.s' tools to create interactive lessons with images and videos	0.0%	0.0%	6.3%	**0.086**	0.0%	2.0%	14.0%	**0.897**
19	Significant degree of enhancement of teaching by the use of an electronic learning platform	1.3%	6.3%	42.5%	0.028	0.0%	6.0%	26.0%	**0.366**
20	Significant degree of exploitation of online teaching class	0.0%	1.3%	15.0%	**0.065**	0.0%	6.0%	26.0%	**0.563**
21	Significant degree of course creation on an electronic platform such as: Moodle, E-CLASS, EDMONDO	0.0%	2.5%	30.0%	0.007	0.0%	4.0%	50.0%	0.041
22	Great desire to join programs to create an electronic learning platform	1.3%	2.5%	37.5%	0.003	0.0%	2.0%	66.0%	0.002
23	Great desire to acquire an e-course that will be adapted to the needs of the students	1.3%	8.8%	52.5%	0.048	0.0%	4.0%	56.0%	0.021
24	Creation of a significant number of virtual distance learning rooms (B.B.C., Webex)	0.0%	0.0%	18.8%	0.026	0.0%	2.0%	26.0%	**0.170**
25	Significant degree of enhancement of the quality of the teaching provided in Adult Education	1.3%	5.0%	53.8%	<0.001	0.0%	6.0%	68.0%	0.046

For a better interpretation of Table 2 and Table 3, all the questions of both research questions were grouped into seven "factors" by applying the factor analysis method to reduce the number of variables (related to I.C.T.) to a smaller number of significant factors. The technique of clustering variables uses as a criterion correlations between variables. From the analysis, it was found that the variables included in the seven factors (components) of the factor analysis explain 59.6% of the total variance (a satisfactory rate for the exported factors). This fact in combi-

nation with the high value (0.6) of the variables in the Extraction—Communalities table of the Factor Analysis and the high value of the Kaiser Meyer Olkin statistical criterion (0.738) make the following factors useful and reliable.

The following tables concern the significant factors and compare the data from the pre and post COVID-19 era. Data came from Table 2 and Table 3. Extensively the factors concerned:

1*st factor: general I.C.T. knowledge* (Table 4).

Teachers' I.C.T. knowledge improved after COVID-19 during the implementation of distance learning. This improvement was directly related to the extent to which the teachers utilized (used, integrated and applied) I.C.T.s' tools in their teaching. The enhancement of students' knowledge from the use of I.C.T. directly related to the knowledge gained by teachers after COVID-19.

2*nd factor: Application of various I.C.T.* (Table 5).

Table 4. Regarding the General Knowledge of Teachers in I.C.T. (Factor 1 of the Factor Analysis).

Question A': The percentage of teachers' satisfaction with the use (integration and implementation) of I.C.T. before and after COVID-19 (Table 1)	Question B': The percentage of teachers' satisfaction with the educational success of I.C.T.s' tools before and after COVID-19 (Table 2)
43.8% were aware of wikis (Var05) versus **38%** after COVID-19, ($p < 0.001$)	**51.2%** were aware of wikis (Var05) versus **56%** after COVID-19, ($p < 0.001$)
30% constructed concept maps (Var07) versus **34%** post-COVID-19, ($p < 0.001$)	**32.5%** constructed concept maps (Var07) versus **44%** post-COVID-19, ($p < 0.001$)
21.3% gained knowledge around Massive Open Online Courses (M.O.O.C.) (Var08) versus **28%** post-COVID-19, ($p < 0.001$)	**20%** gained knowledge around Massive Open Online Courses (M.O.O.C.) (Var08) versus **40%** post-COVID-19, ($p = 0.002$)
12.5% engaged in Blog construction (Var12) versus **26%** post-COVID-19, ($p < 0.001$)	**13.8%** engaged in Blog construction (Var12) versus **26%** post-COVID-19, ($p < 0.001$)
41.3% have attended significant number of distance learning courses (Var8) versus **42%**, ($p < 0.001$)	**55%** have attended significant number of distance learning courses (Var8) versus **62%**, ($p < 0.001$)

Table 5. Implementation of Various I.C.T.s' tools during the Lesson (Factor 2 of the Factor Analysis).

Question A': The percentage of teachers' satisfaction with the use (integration and implementation) of I.C.T. before and after COVID-19 (Table 1)	Question B': The percentage of teachers' satisfaction with the educational success of I.C.T.s' tools before and after COVID-19 (Table 2)
7.5% used class organization and management tools (Additio, ClassDojo) (Var 16) versus **4%** post-COVID-19	**7.5%** used class organization and management tools (Additio, ClassDojo) (Var 16) versus **4%** post-COVID-19
13.8% systematically presented their educational material using I.C.T.s' tools (Padlet, InsertLearning, Educreations) (Var15) versus **12%** after COVID-19.	**13.8%** systematically presented their educational material using I.C.T.s' tools (Padlet, InsertLearning, Educreations) (Var15) versus **16%** after COVID-19
11% of teachers used student assessment tools (H5P, Kahoot, Quizlet, Hotpotatos) (Var14) versus **18%** post-COVID-19	**11.3%** of teachers used student assessment tools (H5P, Kahoot, Quizlet, Hotpotatos) (Var14) versus **24%** post-COVID-19
6.3% engaged in implementing tools to create interactive courses and build visuals and videos for the course (Tinklink, EDpuzzle) (Var18) versus **12%** post-COVID-19	**6.3%** engaged in implementing tools to create interactive courses and build visuals and videos for the course (Tinklink, EDpuzzle) (Var18) versus **14%** post-COVID-19
12.5% took advantage of digital learning environments (Var17) versus **4%** post-COVID-19	**13%** took advantage of digital learning environments (Var17) versus **8%** post-COVID-19

There were no statistically significant differences in teachers' responses before and after COVID-19 according to Mann-Whitney test. A variety of I.C.T.s' tools were not implemented after the COVID-19 era. An exception was the use of I.C.T.s' tools for the evaluation of the students ($p = 0.025$).

3rd factor: *Creation of on-line/interactive courses to enhance education* (Table 6).

Statistically significant difference (positively spaced) was observed in the post-COVID-19 era, in terms of: a) participation in e-course creation programs on learning platforms ($p = 0.002$) and b) the opinion that teaching is significantly enhanced by the use an e-learning platform ($p = 0.040$). The satisfaction from the utilization (use, integration and application) of I.C.T.s' tools was directly related to the creation of online and interactive courses. The enhancement of students' knowledge thanks to I.C.T.s is directly related to the creation of electronic and interactive courses and the improvement of the quality of education.

4th factor: *School equipment with I.C.T.* (Table 7).

Schools' I.C.T. equipment significantly improved in the post-COVID-19 era ($p = 0.046$). Also, there was an increase in the number of schools that promoted and implemented I.C.T. practices ($p = 0.023$). These improvements were directly related to the extent to which teachers utilized I.C.T.s' tools in their teaching (Table 1). The enhancement of students' knowledge from the use of I.C.T. was directly related to the degree to which schools were equipped with I.C.T. An improvement in teachers' interactive whiteboard skills was observed in the post-COVID-19 era.

Table 6. Creation of Online/Interactive Courses to Enhance the Quality of Education (Factor 3 of the Factor Analysis).

Question A': The percentage of teachers' satisfaction with the use (integration and implementation) of I.C.T. before and after COVID-19 (Table 1)	Question B': The percentage of teachers' satisfaction with the educational success of I.C.T.s' tools before and after COVID-19 (Table 2)
21.3% wanted to join e-course creation programs on e-learning platforms (Var22) versus **44%** post-COVID-19	**37.5%** wanted to join e-course creation programs on e-learning platforms (Var22) versus **66%** post-COVID-19
37.5% wished to acquire an e-course that would be adjusted to the needs of students (Var23) versus **36%** post-COVID-19	**52.5%** wished to acquire an e-course that would be adjusted to the needs of students (Var23) versus **56%** post-COVID-19
28.7% claimed that teaching is enhanced by the use of an e-learning platform (Var19) versus **34%** post-COVID-19	**42.5%** claimed that teaching is enhanced by the use of an e-learning platform (Var19) versus **26%** post-COVID-19

Table 7. School Equipment with I.C.T. (Factor 4 of the Factor Analysis).

Question A': The percentage of teachers' satisfaction with the use (integration and implementation) of I.C.T. before and after COVID-19 (Table 1)	Question B': The percentage of teachers' satisfaction with the educational success of I.C.T.s' tools before and after COVID-19 (Table 2)
26.3% of teachers considered that the school they work in promoted and applied I.C.T. practices (Var4) versus **40%** after COVID-19	το **37.5%** of teachers considered that the school they work in promoted and applied I.C.T. practices (Var4) versus **58%** after COVID-19
33.8% were very satisfied with the infrastructure of the laboratory equipment for I.C.T. use in their school (Var5) versus **38%** post-COVID-19	**46.3%** were very satisfied with the infrastructure of laboratory equipment for I.C.T. use in their school (Var5) versus **60%** post-COVID-19
41.3% reported having interactive whiteboard skills (Var09) compared to **40%** after COVID-19	**53.8%** reported having interactive whiteboard skills (Var09) compared to **68%** after COVID-19

5th factor. Utilization of on-line learning platform (M.O.O.C.) (Table 8).

There was a statistically significant difference in teachers' responses with the percentages being improved in the post-COVID-19 era regarding the utilization of e-learning platforms regarding the use of an electronic classroom ($p = 0.001$) and the creation of lessons on an electronic platform ($p = 0.001$). The use of e-learning platforms (M.O.O.C.) was directly related to the satisfaction with the utilization of I.C.T. as well as to the enhancement students' knowledge.

6th factor. Utilization of the Pan-Hellenic Learning Objects Repository (Table 9).

There was a statistically significant difference in the responses of the teachers with the percentages being improved in the post-COVID-19 era regarding the utilization of the PanHellenic repository of learning objects $p = 0.049$. The use of the Greek repository of learning objects is directly related to both the satisfaction from the utilization (use, integration and application) of I.C.T.s' tools and the strengthening of students' knowledge.

7th factor. Teachers' opinions on improving the quality of teaching in courses (*theoretical and laboratory*) *using I.C.T.* (Table 10)

There were no statistically significant differences regarding teachers' opinions on improving the quality of teaching in courses (theory/practical courses) using I.C.T. However, there is a slight improvement regarding the quality of teaching thanks to I.C.T.s ($p = 0.081$). The quality of teaching is directly related to the satisfaction from the use of I.C.T.s' tools and the strengthening of students' knowledge from the use of I.C.T. After the COVID-19, there was both a significant increase in the number of teachers who believed that I.C.T.s were ideal for theory courses and a decrease in teachers who believed that I.C.T.s were ideal for laboratory courses.

Table 8. Utilization of e-Learning Platforms (M.O.O.C.) (Factor 5 of the Factor Analysis).

Question A': The percentage of teachers' satisfaction with the use (integration and implementation) of I.C.T. before and after COVID-19 (Table 1)	Question B': The percentage of teachers' satisfaction with the educational success of I.C.T.s' tools before and after COVID-19 (Table 2)
8.8% regularly used the online classroom (Var20) compared to **20%** after COVID-19	**15%** regularly used the online classroom (Var20) compared to **26%** after COVID-19
23.8% indicated that they created several courses on an online platform such as: MOODLE, E-CLASS, EDMONDO (Var21) compared to **40%** after COVID-19	**30%** indicated that they created several courses on an online platform such as: MOODLE, E-CLASS, EDMONDO (Var21) compared to **50%** after COVID-19

Table 9. Utilization of the PanHellenic Repository of Learning Objects (Factor 6 of the Factor Analysis).

Question A': The percentage of teachers' satisfaction with the use (integration and implementation) of I.C.T. before and after COVID-19 (Table 1)	Question B': The percentage of teachers' satisfaction with the educational success of I.C.T.s' tools before and after COVID-19 (Table 2)
15% of teachers had used simulations (Photodendro, Phet-Coorado) of the pan-Hellenic repository of learning objects in the context of virtual laboratories (Var11) versus **22%** post-COVID-19	**13.8%** of teachers had used simulations (Photodendro, Phet-Coorado) of the pan-Hellenic repository of learning objects in the context of virtual laboratories (Var11) versus **26%** post-COVID-19

Table 10. Teachers' Opinions on Improving the Quality of Teaching in Courses (Theoretical and Laboratory) Using I.C.T. (Factor 7 of the Factor Analysis).

Question A': The percentage of teachers' satisfaction with the use (integration and implementation) of I.C.T. before and after COVID-19 (Table 1)	Question B': The percentage of teachers' satisfaction with the educational success of I.C.T.s' tools before and after COVID-19 (Table 2)
52.5% considered that the students' knowledge was significantly enhanced by the use of I.C.T. (Var2) compared to **48%** after COVID-19	-
40% of teachers both before and after COVID-19 believed that the use of I.C.T. was ideal in theory courses (Var6)	**47.5%** of teachers before COVID-19 believed that the use of I.C.T. was ideal in theory courses (Var6), versus **64%** post-COVID-19
50% thought I.C.T. was suitable for laboratory courses (Var7) versus **38.5%** post-COVID-19	**60.9%** thought I.C.T. was suitable for laboratory courses (Var7) versus **51.3%** post-COVID-19
38.8% of teachers systematically used I.C.T. in their teaching after the end of the program (Var3) compared to **44%** after COVID-19	**40%** of teachers systematically used I.C.T. in their teaching after the end of the program (Var3) compared to **50%** after COVID-19
36.3% claimed that with the implementation of I.C.T. the quality of the provided teaching was improved, the same is applied to adult education (Var25)	**53.8%** claimed that with the implementation of I.C.T. the quality of the provided teaching was improved, the same is applied to adult education (Var25)

The interpretation of the results of both two questions was based on the grouped variables. The following variables (questions) they were not interpreted, because they were not included in any factor, which means that their answers did not significantly affect the overall interpretations of the research questions.

- VAR 10 Use of interactive table.
- VAR 06 WiKi Construction.
- VAR 9 Suitability of I.C.T. trainers.
- VAR 24 Creation of a virtual room for teleconferencing (B.B.C., Webex).
- VAR 03 Acquisition of E.C.D.L.
- VAR 13 Enhancing teaching using tablets and mobile phones.

4. Conclusion-Suggestions for Further Improvement of I.C.T. Use

Teachers' opinions on I.C.T. did not demonstrate very significant changes (as might be expected) (Gulbahar & Guven, 2008; Giavrimis et al., 2010) after the implementation of distance learning, due to COVID-19 special conditions. However, a careful observation of their responses revealed a more positive view concerning both the degree of satisfaction gained, with the utilization (use, integration and application) of I.C.T.s' tools and the degree of its enhancement of students' knowledge (Table 10).

Obviously, after the pandemic and the forced implementation of distance learning, teachers understood their shortcomings in terms of I.C.T. (Table 4). Therefore, a significant increase in participation in I.C.T. seminars was observed. Teachers maintained their initial opinion that I.C.T. is ideal for teaching

theory, but not for laboratory (practical) courses (Table 10). They further understood the importance of using simulations to reinforce theory materials, but mainly virtual laboratory courses (Table 9). In addition, after COVID-19 the use of e-learning platforms gained ground (Table 6), applied in combination with conventional teaching. The desire of teachers to create e-courses increased, after their understanding of M.O.O.C. importance, in education (Table 8), while schools the same promoted I.C.T. implementation, along with strengthening their I.C.T. infrastructure (Table 7). I.C.T.'s tools related to classroom management and the presentation of educational materials showed little interest compared to student assessment tools and the creation of interactive e-courses (both pre- and post-COVID-19 era) (Table 5).

Moral Ethics

Present research project was approved (with registration number 12/27-05-2019) by the Ethics Committee of the University of Western Attica, in Athens, Greece.

Author's Statement

I hereby declare that academic ethics are observed, supporting the rigorous style of study.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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