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University of the Peloponnese, Department of Informatics and Telecommunications,Tripoli, Greece

* Correspondence: peppas@uop.gr

Abstract: STEM education is a means of linking the knowledge acquired at school with the skills that individuals will develop in their working lives. It is precisely because this type of education is gaining ground worldwide that it is considered appropriate to explore the attitudes and opinions of Greek teachers towards STEM education, since they are the ones who will be called upon to implement it. In order to make a change towards this type of education, it seems appropriate to be aware of the obstacles that teachers encounter in their everyday life and to what extent they think that it can contribute. The survey was carried out in the form of a questionnaire with closed questions. The survey showed that teachers consider learning 21st century skills to be important and that they consider themselves ready to use them. They also believe that any knowledge they have acquired has come from their own initiative.

Keywords: STEM education; teachers' opinions; 21st century skills

1. Introduction

STEM education (STEM stands for Science, Technology, Engineering, Mathematics) has emerged from the need for a more substantive approach to teaching Natural Sciences and Mathematics [1], triggered by the changes in the global economy [2], as well as the need to maintain the competitiveness of national economies [3]. Training professionals in STEM fields is a common goal of countries at the international level, as trained workers in these fields can contribute to the economic development of their country and the world. [4]. From 2007 onwards, STEM education is deemed key to achieving knowledge acquisition during the school years and skills acquisition which are necessary for the professions of the future [1].

In 2003, the International Council of Association for Science Education (I.C.A.S.E.) in its Kuching (Malaysia) declaration stresses the need to link STEM education and contemporary issues such as the protection of the environment and sustainability [5]. This declaration signals a tendency of open- ness of science to society / (of an out-ward-looking science, open to society) thus providing new perspectives for this type of education. STEM education is gaining ground in education systems around the world. It is therefore a trend that we cannot ignore. After all, this type of education is associated with a number of benefits for the participating students, such as high participation rates in the educational process, high performance in standardized tests in reading, mathematics and science [6]. At the same time, through its interdisciplinary approach, it contributes to the development of 21st century skills such as creativity, critical and innovative thinking [7].

In any change in the education system, teachers are the first to adapt. One of the key requirements for STEM education to have its positive effects on the cognitive level of students is the professional development of teachers [6]. Research in Saudi Arabia concluded that students are not motivated to pursue STEM careers in the future because their teachers have limited experience in applying this education and are not effective in individual STEM fields [4]. The use of STEM methods was also highlighted, with problems mainly related to teachers' readiness to process and teach in this way. Many misconceptions of teachers themselves about this type of teaching were observed [8]. The

aim of this research is to investigate the attitudes and opinions of Greek teachers towards STEM education, as teachers' perceptions play an important role in the effective implementation of STEM education and in shaping pedagogical practices in the classroom [4]. Through this process, we will be able to investigate whether teachers have positive attitudes towards the implementation of STEM education in their classrooms, which is a pre-requisite for its proper implementation.   Research on schools in the United Arab Emirates shows that schools are biased towards the implementation of STEM education [7]. Understanding teachers' attitudes and perceptions is essential for the successful implementation of STEM education and for sup porting teachers' professional development [4, 9]. The main purpose of this research is to answer the following questions:

1. Do demographic characteristics such as gender, age, years of experience, additional qualifications, the level at which they work, the type of employer and, finally, the subject area in which the participants hold their bachelor's degree influence their attitudes and perceptions towards STEM education?
2. What are the teachers' views on STEM education?
3. How did they acquire their knowledge?
4. Do Greek teachers see the potential for developing 21st century skills through STEM education?
5. What do they consider to be the main obstacles to the implementation of this type of education in the Greek reality?
6. What measures could be taken by policy makers, taking into account the views of teachers, to integrate STEM education into the Greek reality?

2. Materials and Methods

Questionnaires are a basic research tool in various scientific fields that allow the collection of useful data. Questions included can be categorized into two main categories: open-ended or closed-ended. With open-ended questions, respondents can give answers in their own words without any sort of guidance. With closed-ended questions, they are asked to choose among predetermined answers. Open-ended questions usually receive long- form answers and have two main downsides: the time and effort needed to process and compare the answers to get valid results. With closed-ended questions, the answer can be simply a yes or a no or a selection from several answers proposed. They may also propose answers on a scale [10]. The Likert scale is one such type of data collection which can be used concerning attitudes and views. The range of the scale is determined by the researcher who can use rating scales with 5 or 7 points. Answers can range for example from "very dissatisfied" to "very satisfied" or "totally disagree" to "totally agree" [10].

One of the methods that prove useful in analyzing the data collected from a questionnaire is the analysis of variance (ANOVA). This method allows us to establish if there is a statistically significant difference in means of more than two groups of the sample. T-tests are recommended to compare the means of two subgroups [11]. The questionnaire was distributed via email and social media to educators in primary and secondary education and it was open from 1 March 2024 until 31 March of the same year. The aim of the survey was to investigate the attitudes and perceptions of Greek teachers regarding STEM education and ultimately compare the findings with surveys conducted in other countries.

3. Results

Many studies have been carried out, mainly in developed countries, to assess the adequacy of STEM education received by students. There are difficulties in comparing the results of these studies, mainly related to: the different contexts of each country, the different choices made by decision makers regarding STEM education, and the pattern of equal participation of men and women [12]. In each country, STEM education is implemented in a different way, so it seems appropriate to report

on how it is implemented in each country. An interesting point in the studies is that students in developing countries show more interest in STEM careers than their peers in developed countries. While most make the decision to pursue STEM education during their secondary education [13]. Therefore, the existence of this type of education at the secondary level is considered vital to the success of its goals.

3.1. STEM FIELDS

STEM education aims to integrate the four sub-disciplines to ultimately increase students' desire to study the individual disciplines in an effective way [4, 9].

3.2.1. Science

Science is defined as the systems of knowledge that are concerned with the study of the physical world, of behavior of matter and the universe. Observation, experimentation, and formulation of laws to explain natural phenomena are its core methods [14].

At the level of STEM education, science can contribute to the acquisition of skills such as using evidence to test claims, using models and representations to explain phenomena and discover new knowledge [15] and making decisions [4]. At the same time, it is necessary to use relationships that are qualitative, quantitative, spatial and temporal. The use of scientific methods [4, 16] such as comparison and correlation [16] is developed. At the same time, creative thinking is developed and students can embrace scientific values [4].

The way science is taught challenges students to solve complex problems, but most of the time without any connection to applications in their daily lives. This connection can motivate students to engage with the subjects [8]. STEM education can be a powerful ally in this regard.

3.2.1. Technology

Technology is the branch of knowledge concerned with the creation of technical means and their use to deal with everyday life, the environment, and society more broadly [14]. Students' contact with technology has been proved beneficial in that it:

- reinforces their creativity
- reinforces thinking at a larger scale
- facilitates an inter-disciplinary approach of STEM fields
- motivates them to dip into all scientific fields [13].

The concept of technology in STEM education focuses mainly on digital technologies and the fourth industrial revolution, whose pillars are artificial intelligence, engineering, and data processing [15]. It is also directly related to computer science [17]. Information literacy, media literacy and ICT (Information, Communications and Technology) literacy are key 21st century skills relating to technology. STEM education can contribute to their acquisition since it encompasses all these parameters [18]. Technological applications in everyday life can stimulate students' interest and desire to delve into the field and through this proximity motivate them to further pursue studies or careers therein [13].

The hurdles with regard to technology come down to difficulties in navigating and searching for information in digital form as well as in evaluating the reliability of various sources. Limited technological resources in schools is another important challenge [13].

In STEM education, technology constitutes a tool for the optimization and systematization of the creation of products with environmental protection, economic efficiency, and demand as core principles [16].

3.2.2. Engineering

Engineering is the branch that uses knowledge from physics, chemistry, and other sciences and applies them to the construction of all sorts of objects [14]. Its applications are visible in everyday life; however   its role is not [19]. Engineering is well-defined when it comes to the engineering profession and its applications. Whereas the profession of an engineer and its applications are well defined, the same is not true for the discipline of engineering in primary and secondary education [16].   In most cases, it is absent from the curricula [19] and when actually taught as part of STEM education, it is usually limited to a simple creative activity, such as the creation of a design [16]. Engineering can in fact contribute to or achieve the following:

- amelioration of students' achievements
- development of 21st century skills
- enhancement of students' interest in the problem they are asked to solve
- creation of a framework in which mathematics and science can find concrete applications in everyday life [13], engineering being viewed as a real-world context for learning mathematics and science [20]
- promotion of communication skills enhancement of collaboration among the members of a group
- providing an entertaining and real-world learning environment [20].
- It lays the foundations for engagement with technology
- Helps to motivate students to pursue vocational disciplines related to engineering design [4]. Integrating engineering in primary and secondary education is hampered mostly by:

- the lack of resources and equipment required
- negative attitudes of educators who deem the curriculum already over- loaded [13].

3.2.2. Mathematics

Mathematics is a group of sciences including algebra, geometry, calculus, the studying of quantity, numbers, shape, and space, as well as their inter- relationships by using a specialized notation [14]. Mathematics constitutes a connective link among all the other STEM disciplines since it underlies each one of them individually. However, it has not necessarily been given enough attention in STEM education. This discipline can be the source of evidence, and thus foster several 21st century skills [3]. More specifically, mathematics is a useful tool for:

- the creation of formulas and charts that can in turn be used to describe phenomena (e.g. uniform linear motion)
- depicting sizes/figures and trends (e.g. concentration of CO_2 in the atmosphere, percentage of populations living below the poverty line)
- measuring distances and creating shapes and lines to build an engineering design (e.g. a sports car miniature)

Mathematical literacy can contribute not only to the advancement of other STEM branches but also to the development of social sensitivity. The EU funded project MaSDiV (Supporting mathematics and science teachers in addressing diversity and promoting fundamental values) establishes a link between mathematics and science on the one hand and the development of a well-rounded personality and active citizens [3]. Mathematics helps develop logical thinking [16], which in turn can help students solve problems and face the changes in their everyday life [21]. Developing such mathematical thinking starts from the early school years, even in kindergarten [13], which reinforces the view that innovative pedagogical practices like STEM need to be applied early on.

Like with science, traditional mathematics education does not give the students the chance to apply their knowledge in everyday life, and thus demotivates them [8]. STEM education can

contribute to the connection between mathematics and problems of everyday life and help improve students' performances.

In developed countries, we observe a decline in the number of students who decide to pursue studies in mathematics at the end of their secondary education, which is a cause for concern regarding the quality of the education of future professionals, mathematics being foundational for many professions. A general lack of interest for professions related to disciplines taught at school can be attributed to teacher-centered pedagogies and heavy, demanding curricula [13].

Some researchers express concern for the place occupied by mathematics in STEM education, concern that stems from an inadequate emphasis on the role of mathematics in the comprehension of concepts of other disciplines [21]. Furthermore, mathematics in STEM education is generally used as a tool to solve problems to the detriment of deeper learning through problem-solving [15].

3.1. Survey Results

The first part of the survey consists of questions concerning demographic data, such as gender, age, education background of the teachers, years of experience, level of education at which they serve, the type of employer – public or private. For teachers in secondary education, there was an extra question concerning their specialty, according to their first degree.

Ninety educators participated altogether, 72 female, 18 male (Table 1), aged from 23 to 65 (Table 2). Of those, 58 had a master's degree and 32 a first university degree (Table 3). 48 teachers had more than 10 years of prior experience (Table 4), 36 worked in primary education and 54 in secondary education (Table 5). The vast majority (76 respondents) worked at a public school (Table 6). Table 7 shows the field of study of respondents.

Table 1. This table shows the gender of the sample.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	18	20,0	20,0	20,0
	Female	72	80,0	80,0	100,0
	Total	90	100,0	100,0	

Table 2. This table shows the age gap of sample.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	23-40	39	43,3	43,3	43,3
	40-65	51	56,7	56,7	100,0
	Total	90	100,0	100,0	

Table 3. This table shows the education background of sample.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	First degree/Bachelor's	32	35,6	35,6	35,6
	Master's/Doctorate	58	64,4	64,4	100,0
	Total	90	100,0	100,0	

Table 4. This table shows the education background of sample.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-10	42	46,7	46,7	46,7
	10-35	48	53,3	53,3	100,0
	Total	90	100,0	100,0	

Table 5. This table shows the level in the education system than each one works.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Primary	36	40,0	40,0	40,0
	Secondary	54	60,0	60,0	100,0
	Total	90	100,0	100,0	

Table 6. This table shows the number of sample that work in public an the number that work in privet schools.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Public	76	84,4	84,4	84,4
	Private	14	15,6	15,6	100,0
	Total	90	100,0	100,0	

Table 7. This table shows the specialty of each one.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Humanities	31	34,4	44,9	44,9
	Science	22	24,4	31,9	76,8
	Engineering	1	1,1	1,4	78,3
	Technology	4	4,4	5,8	84,1
	Arts	3	3,3	4,3	88,4
	Other	8	8,9	11,6	100,0
	Total	69	76,7	100,0	
Missing	System	21	23,3		
Total		90	100,0		

The second part of the survey comprised closed-ended questions whose aim was to investigate attitudes and knowledge of Greek educators with regard to STEM education. The first question related to what STEM education entails: an interdisciplinary approach to education to solve an everyday life problem (17,8%); a pedagogical approach whose aim is to combine knowledge from various disciplines (67,8%); a holistic approach of an issue (14,4%). It becomes readily apparent that more than half the population surveyed recognizes the need to combine knowledge from different fields (Table 8). Using then a cross tabulation or contingency table, taking into account the level of education at which the educators teach, the SPSS gives the following: the largest per- centage of those whose chose the first (75%) and second (62,3) answer teach in secondary schools. Conversely, the largest percentage of those who chose the third (69,2%) work in primary schools (Table 9). It can thus be concluded that the level of education at which the educators teach impacts their definition of STEM education (Table 10).

Table 8. This table shows the answers in question: "STEM education is: A. an interdisciplinary approach to a problem of everyday life B. a pedagogical approach that combines knowledge from different scientific fields C. A holistic approach to an issue".

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Interdisciplinarity	16	17,8	17,8	17,8
	Combination of fields	61	67,8	67,8	85,6
	Holistic approach	13	14,4	14,4	100,0
	Total	90	100,0	100,0	

Table 9. This table is a cross-tab between the question about what STEM education is and the school that the educator works.

DSF			STEM education is :			Total
			Interdisciplinarity	Combination of fields	Holistic approach	
Level	Primary	Count	4	23	9	36
		Expected Count	6,4	24,4	5,2	36,0
		% within Level	11,1%	63,9%	25,0%	100,0%
		% within STEM education is:	25,0%	37,7%	69,2%	40,0%
		% of Total	4,4%	25,6%	10,0%	40,0%

Secondary	Count	12	38	4	54
	Expected Count	9,6	36,6	7,8	54,0
	% within Level	22,2%	70,4%	7,4%	100,0%
	% within STEM education is:	75,0%	62,3%	30,8%	60,0%
	% of Total	13,3%	42,2%	4,4%	60,0%
Total	Count	16	61	13	90
	Expected Count	16,0	61,0	13,0	90,0
	% within Level	17,8%	67,8%	14,4%	100,0%
	% within STEM education is:	100,0%	100,0%	100,0%	100,0%
	% of Total	17,8%	67,8%	14,4%	100,0%

Table 10. This table shows the results of Chi-Square Tests of above question.

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6,262[a]	2	,044
Likelihood Ratio	6,262	2	,044
Linear-by-Linear Association	5,481	1	,019
N of Valid Cases	90		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 5,20.

The following question sought to investigate the views of the sample concerning the impact of STEM education on the later choice of profession by the students. 68,9% gave a positive answer, 30% answered maybe. Only one respondent gave a negative answer (Table 11). It is safe to say that

educators believe that STEM education and exposure to engineering, science and mathematics are likely to affect future choices.

Table 11. This table shows the results of question: "Do you think that STEM education can contribute to the choice of the future profession of the students involved? A. Yes B. Maybe C. No".

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	62	68,9	68,9	68,9
	Maybe	27	30,0	30,0	98,9
	No	1	1,1	1,1	100,0
	Total	90	100,0	100,0	

Teachers' perception of the applicability of STEM education in all levels of education – from kindergarten to high school – is positive (Table 12).

Table 12. This table shows the results in question:" Do you think that STEM education can be applied at all levels of education (Kindergartens, Elementary, Middle School, High School)? A .Yes B. Maybe C. No".

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	61	67,8	67,8	67,8
	Maybe	23	25,6	25,6	93,3
	No	6	6,7	6,7	100,0
	Total	90	100,0	100,0	

The survey also revealed a positive perception of the association of STEM education with 21st century skills. This question received no negative answer (Table 13).

Table 13. This table shows the results in question: "Is it considered that STEM education can contribute to the development of 21st Century Skills?" A .Yes B. Maybe C. No".

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	83	92,2	92,2	92,2
	Maybe	7	7,8	7,8	100,0
	Total	90	100,0	100,0	

Likewise, educators deem the linking of the problems dealt with in STEM education with everyday life important. (Table 14)

Table 14. This table shows the results in question: "Do you consider it necessary to connect the problem that students deal with in a STEM class with everyday life? A. Yes B Maybe C. No. ".

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	69	76,7	76,7	76,7
	Maybe	20	22,2	22,2	98,9
	No	1	1,1	1,1	100,0
	Total	90	100,0	100,0	

The following question asked educators to evaluate their own knowledge around STEM education. Here, educators appear hesitant. 71,1% of the respondents feel that they do not possess adequate knowledge to apply STEM scenarios (Table 15). The largest percentage of those respondents (64,1%) work in secondary education (Table 16). Conversely, 50% of those who deem themselves capable of applying STEM in their classroom belong to primary education and 50% to secondary education (Table 17).

Table 15. This table shows the results in question: "Do you think you have the knowledge necessary to apply STEM education? A. Yes B. No".

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	26	28,9	28,9	28,9
	No	64	71,1	71,1	100,0
	Total	90	100,0	100,0	

Table 16. This table is a cross-tab between the above question an the level of teaching.

			Possession of required knowledge		Total
			YES	NO	
Level of education	Primary	Count	13	23	36
		Expected Count	10,4	25,6	36,0
		% within Level	36,1%	63,9%	100,0%
		% within Do you possess the required knowledge?	50,0%	35,9%	40,0%
		% of Total	14,4%	25,6%	40,0%

Secondary	Count	13	41	54
	Expected Count	15,6	38,4	54,0
	% within Level	24,1%	75,9%	100,0%
	% within Do you possess the required knowledge?	50,0%	64,1%	60,0%
	% of Total	14,4%	45,6%	60,0%
Total	Count	26	64	90
	Expected Count	26,0	64,0	90,0
	% within Level	28,9%	71,1%	100,0%
	% within Do you possess the required knowledge?	100,0%	100,0%	100,0%
	% of Total	28,9%	71,1%	100,0%

Table 17. This table shows the results of Chi-Square tests.

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1,523[a]	1	,217		
Continuity Correction[b]	,994	1	,319		
Likelihood Ratio	1,507	1	,220		
Fisher's Exact Test				,242	,159
Linear-by-Linear Association	1,507	1	,220		
N of Valid Cases	90				

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 10,40.

b. Computed only for a 2x2 table

The last question has to do with the ways in which teachers became familiarized with STEM education. 27% of the sample declared total ignorance; 32,2% participated in training on their own initiative; 24,4% acquired knowledge through the internet; 5% through bibliography; 4,4% through acquaintances. Only 1,1% of the sample received training via their school. (Table 18)

It is apparent that the vast majority of the respondents acquired knowledge thanks to their own initiatives, either through training or through re- search on the internet or of the bibliography. (Table 18)

Table 18. This table shows the results in question: "How did you gain your knowledge of STEM education?   A. Monitoring of training that took place at the initiative of the school B. Attendance of training/seminar attended on your own initiative (individually) outside the context of the school C. After searching the internet D. Bibliography E. Friends/acquaintances F. I don't have any knowledge".

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Training offered at school	1	1,1	1,2	1,2
	Training outside of the school/own initiative	29	32,2	33,7	34,9
	Internet	22	24,4	25,6	60,5
	Bibliography	5	5,6	5,8	66,3
	Acquaintances	4	4,4	4,7	70,9
	No knowledge	25	27,8	29,1	100,0
	Total	86	95,6	100,0	
Missing	System	4	4,4		
Total		90	100,0		

The third part of the questionnaire comprised eight questions, each of which refers to a different 21st century skill. A Likert scale with 5 levels was used, from 1 corresponding to "not at all" to 5 corresponding to "a lot". The questions aimed to reveal to what extent teachers believe that STEM education can contribute to the development of each of these skills. These skills are ranked as follows (Table 19) from the one to which STEM education can contribute the most to the one it can contribute the least, according to the views of the respondents:

- Creativity
- Problem-solving
- Critical thinking
- Team spirit
- Lifelong learning
- Adaptability
- Entrepreneurial skills
- Leadership skills

Table 19. This table the statistics of Likert scale question: "To what extent do you think that STEM education can contribute to the development of on the part of students to develop each of the following skills.".

		Critical thinking	Problem-solving	Leadership	Creativity	Adaptability	Team spirit	Lifelong learning	Entrepreneurial skills
N	Valid	90	90	90	90	90	90	90	90
	Missing	0	0	0	0	0	0	0	0
Mean		4,22	4,31	3,72	4,47	4,02	4,21	4,08	3,97
Std. Deviation		,683	,664	,765	,640	,924	,868	,951	,867

The fourth and last part of the survey comprised four Linkert scale questions with 5 levels with regard to the degree to which each of the conditions mentioned constituted an obstacle to the implementation of STEM education. The scale went from 1 to 5 (not at all to a lot). According to the data collected (Table 20), the obstacles can be classified in descending order as follows:

- Time that students can spend in order to be able to cope with a STEM subject
- Time teachers need to dedicate to their preparation
- Knowledge in all fields included in STEM
- School equipment/resources.

Table 20. This table the statistics of Likert scale question: "How much of a barrier is each of the following conditions to implementing STEM education in the classroom? To what ex-tent do you think the following conditions affect the implementation of STEM education in the school where you work?".

		School equipment	Preparation time	Time spent by students	Knowledge in all the fields
N	Valid	90	90	90	90
	Missing	0	0	0	0
Mean		2,41	2,54	3,04	2,53
Std. Deviation		1,198	1,051	,935	1,229

Subsequently, t-tests (Independent Samples Tests) were carried out with each skill and each obstacle as the dependent variable, introducing a different independent variable each time.

Gender as the independent variable did not result in a statistically significant difference, as illustrated in the Table 21 and Table 22. We may thus conclude that gender did not affect the educators' answers.

Table 21. This table is group statistics between the extent that STEM education can contribute to the development each one of the skills and the gender of participant.

Group Statistics

.	Gender	N	Mean	Std. Deviation	Std. Error Mean
Critical thinking	Male	18	4,11	,676	,159
	Female	72	4,25	,687	,081
Problem-solving	Male	18	4,17	,786	,185
	Female	72	4,35	,632	,074
Leadership	Male	18	3,44	,856	,202
	Female	72	3,79	,730	,086
Creativity	Male	18	4,28	,752	,177
	Female	72	4,51	,605	,071
Adaptability	Male	18	3,83	,786	,185
	Female	72	4,07	,954	,112
Team spirit	Male	18	4,00	,970	,229
	Female	72	4,26	,839	,099
Lifelong learning	Male	18	3,72	1,320	,311
	Female	72	4,17	,822	,097
Entrepreneurial skills	Male	18	3,83	1,150	,271
	Female	72	4,00	,787	,093
School equipment	Male	18	2,67	1,328	,313
	Female	72	2,35	1,165	,137
Preparation time	Male	18	2,33	,840	,198
	Female	72	2,60	1,096	,129
Time spent by students	Male	18	2,83	,857	,202
	Female	72	3,10	,952	,112

Knowledge in all STEM fields	Male	18	2,72	1,227	,289
	Female	72	2,49	1,233	,145

Table 22. This table shows the results of t-test about independent samples test.

		Levene's Test for Equality of Variances		t-test for Equality of Means								
		F	Sig.	t	df	Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						One-Sided p	Two-Sided p			Lower	Upper
Critical thinking	Equal variances assumed	,819	,368	-,770	88	,222	,444	-,139	,180	-,498	,220
	Equal variances not assumed			-,777	26,475	,222	,444	-,139	,179	-,506	,228
Problem-solving	Equal variances assumed	1,382	,243	-1,032	88	,153	,305	-,181	,175	-,528	,167
	Equal variances not assumed			-,904	22,790	,188	,375	-,181	,200	-,594	,233

		F	Sig.	t	df	Sig. (1-sided)	Sig. (2-sided)	Mean Difference	Std. Error Difference	Lower	Upper
Leadership	Equal variances assumed	1,131	,290	-1,742	88	,042	,085	-,347	,199	-,743	,049
	Equal variances not assumed			-1,584	23,571	,063	,127	-,347	,219	-,800	,106
Creativity	Equal variances assumed	1,619	,207	-1,409	88	,081	,162	-,236	,168	-,569	,097
	Equal variances not assumed			-1,236	22,805	,115	,229	-,236	,191	-,631	,159
Adaptability	Equal variances assumed	,901	,345	-,970	88	,167	,335	-,236	,244	-,720	,248
	Equal variances not assumed			-1,090	30,838	,142	,284	-,236	,217	-,678	,206
Team spirit	Equal variances assumed	,426	,516	-1,156	88	,125	,251	-,264	,228	-,717	,190
	Equal varian			-1,0	23,754	,150	,300	-,264	,249	-,778	,251

		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
	ces not assumed				59						
Lifelong learning	Equal variances assumed	11,203	,001	-1,796	88	,038	,076	-,444	,247	-,936	,047
	Equal variances not assumed			-1,364	20,413	,094	,187	-,444	,326	-1,123	,234
Entrepreneurial skills	Equal variances assumed	5,128	,026	-,728	88	,234	,469	-,167	,229	-,622	,289
	Equal variances not assumed			-,582	21,144	,284	,567	-,167	,287	-,762	,429
School equipment	Equal variances assumed	,103	,749	1,012	88	,157	,314	,319	,316	-,308	,947
	Equal variances not assumed			,934	23,950	,180	,359	,319	,342	-,386	1,025
Preparation time	Equal variances assum	1,562	,215	-,952	88	,172	,344	-,264	,277	-,815	,287

		F	Sig.	t	df	Sig.	Sig.	Mean Diff.	Std. Error	Lower	Upper
	ed										
	Equal variances not assumed			-1,116	33,113	,136	,272	-,264	,236	-,745	,217
Time spent by students	Equal variances assumed	,318	,574	-1,072	88	,143	,287	-,264	,246	-,753	,225
	Equal variances not assumed			-1,142	28,439	,132	,263	-,264	,231	-,737	,209
Knowledge in all STEM fields	Equal variances assumed	,146	,704	,727	88	,235	,469	,236	,325	-,409	,881
	Equal variances not assumed			,729	26,264	,236	,472	,236	,324	-,429	,901

The second t-test used prior teaching experience as the independent variable. The sample was divided into two categories: teachers with less than 10 years of experience and teachers with more than 10. Table 23 and Table 24 reveal a statistically significant difference only with regard to school equipment as a hurdle to the implementation of STEM education. Indeed, teachers with more than ten years of experience consider in-adequate equipment as more of an issue than teachers with less than ten years of experience.

Table 23. This table is group statistics between the extent that STEM education can contribute to the development each one of the skills and the experience of participant.

	Prior experience	N	Mean	Std. Deviation	Std. Error Mean	
Critical thinking	0-10	42	4,17	,660	,102	
	10-30	48	4,27	,707	,102	
Problem-solving	0-10	42	4,21	,717	,111	
	10-30	48	4,40	,610	,088	
Leadership	0-10	42	3,67	,754	,116	
	10-30	48	3,77	,778	,112	
Creativity	0-10	42	4,50	,672	,104	
	10-30	48	4,44	,616	,089	
Adaptability	0-10	42	4,02	,950	,147	
	10-30	48	4,02	,911	,131	
Team spirit	0-10	42	4,33	,816	,126	
	10-30	48	4,10	,905	,131	
Lifelong learning	0-10	42	4,24	,821	,127	
	10-30	48	3,94	1,040	,150	
Entrepreneurial skills	0-10	42	3,98	,841	,130	
	10-30	48	3,96	,898	,130	
School equipment	0-10	42	2,10	,983	,152	
	10-30	48	2,69	1,307	,189	
Preparation time	0-10	42	2,36	,932	,144	
	10-30	48	2,71	1,129	,163	
Time spent by students	0-10	42	2,98	,897	,138	
	10-30	48	3,10	,973	,140	
Knowledge in all STEM	0-10	42	2,36	1,226	,189	

fields						
	10-30		48	2,69	1,223	,177

Table 24. This table shows the results of t-test about independent samples test.

.		Levene's Test for Equality of Variances		t-test for Equality of Means							
		F	Sig.	t	df	Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						One-Sided P	Two-Sided P			Lower	Upper
Critical thinking	Equal variances assumed	1,337	,251	-,720	88	,237	,474	-,104	,145	-,392	,184
	Equal variances not assumed			-,723	87,620	,236	,472	-,104	,144	-,391	,182
Problem-solving	Equal variances assumed	,010	,920	-1,298	88	,099	,198	-,182	,140	-,459	,096
	Equal variances not assumed			-1,284	81,022	,101	,203	-,182	,141	-,463	,100
Leadership	Equal variances assumed	,060	,806	-,643	88	,261	,522	-,104	,162	-,426	,218
	Equal variances not assumed			-,644	87,062	,261	,521	-,104	,162	-,426	,217
Creativity	Equal variances	,338	,562	,460	88	,323	,646	,063	,136	-,207	,332

		F	Sig.	t	df	Sig. (1)	Sig. (2)	Mean Diff.	Std. Error Diff.	Lower	Upper
	assumed										
	Equal variances not assumed			,458	83,885	,324	,648	,063	,137	-,209	,334
Adaptability	Equal variances assumed	,111	,739	,015	88	,494	,988	,003	,196	-,387	,393
	Equal variances not assumed			,015	85,331	,494	,988	,003	,197	-,388	,394
Team spirit	Equal variances assumed	,011	,917	1,254	88	,107	,213	,229	,183	-,134	,592
	Equal variances not assumed			1,263	87,908	,105	,210	,229	,181	-,131	,590
Lifelong learning	Equal variances assumed	1,357	,247	1,507	88	,068	,135	,301	,199	-,096	,697
	Equal variances not assumed			1,531	87,125	,065	,129	,301	,196	-,090	,691
Entrepreneurial skills	Equal variances assumed	,000	,996	,097	88	,461	,923	,018	,184	-,348	,384
	Equal variances not assumed			,097	87,584	,461	,923	,018	,183	-,347	,382
School equipment	Equal variances assumed	6,942	,010	-2,401	88	,009	,018	-,592	,247	-1,082	-,102

		F	Sig.	t	df						
	Equal variances not assumed			-2,446	86,138	,008	,016	-,592	,242	-1,074	-,111
Preparation time	Equal variances assumed	1,249	,267	-1,595	88	,057	,114	-,351	,220	-,789	,086
	Equal variances not assumed			-1,616	87,725	,055	,110	-,351	,217	-,783	,081
Time spent by students	Equal variances assumed	,035	,852	-,646	88	,260	,520	-,128	,198	-,522	,266
	Equal variances not assumed			-,649	87,747	,259	,518	-,128	,197	-,520	,264
Knowledge in all STEM fields	Equal variances assumed	,069	,794	-1,277	88	,103	,205	-,330	,259	-,845	,184
	Equal variances not assumed			-1,277	86,364	,103	,205	-,330	,259	-,845	,184

No significant statistical difference was observed (Table 25) when the level of education at which served the teachers was introduced as the independent variable from the t- test (Table 26).

Table 25. This table is group statistics between the extent that STEM education can con- tribute to the development each one of the skills and the level of education that participant works.

	Level of education	N	Mean	Std. Deviation	Std. Error Mean	
Critical thinking	Primary	36	4,31	,710	,118	
	Secondary	54	4,17	,666	,091	
Problem-solving	Primary	36	4,28	,741	,124	
	Secondary	54	4,33	,614	,084	
Leadership	Primary	36	3,78	,722	,120	
	Secondary	54	3,69	,797	,108	
Creativity	Primary	36	4,50	,561	,093	
	Secondary	54	4,44	,691	,094	
Adaptability	Primary	36	4,08	,906	,151	
	Secondary	54	3,98	,942	,128	
Team spirit	Primary	36	4,03	,941	,157	
	Secondary	54	4,33	,801	,109	
Lifelong learning	Primary	36	4,19	,749	,125	
	Secondary	54	4,00	1,064	,145	
Entrepreneurial skills	Primary	36	4,03	,736	,123	
	Secondary	54	3,93	,949	,129	
School equipment	Primary	36	2,39	1,178	,196	
	Secondary	54	2,43	1,222	,166	
Preparation time	Primary	36	2,72	1,111	,185	
	Secondary	54	2,43	1,002	,136	
Time spent by students	Primary	36	3,06	,955	,159	
	Secondary	54	3,04	,931	,127	
Knowledge in all STEM	Primary	36	2,64	1,150	,192	

fields					
	Secondary	54	2,46	1,284	,175

Table 26. This table shows the results of t-test about independent samples test.

		Levene's Test for Equality of Variances		t-test for Equality of Means							
		F	Sig.	t	df	Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						One-Sided p	Two-Sided p			Lower	Upper
Critical thinking	Equal variances assumed	1,298	,258	,944	88	,174	,348	,139	,147	-,153	,431
	Equal variances not assumed			,932	71,789	,177	,354	,139	,149	-,158	,436
Problem-solving	Equal variances assumed	,638	,427	-,387	88	,350	,700	-,056	,144	-,341	,230
	Equal variances not assumed			-,372	65,353	,355	,711	-,056	,149	-,353	,242
Leadership	Equal variances assumed	,545	,462	,561	88	,288	,577	,093	,165	-,236	,421
	Equal variances not assumed			,572	80,085	,285	,569	,093	,162	-,230	,415
Creativity	Equal variances	2,658	,107	,402	88	,344	,689	,056	,138	-,219	,330

		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
	assumed										
	Equal variances not assumed			,419	84,553	,338	,676	,056	,133	-,208	,319
Adaptability	Equal variances assumed	,170	,681	,510	88	,306	,611	,102	,200	-,295	,499
	Equal variances not assumed			,514	77,117	,304	,609	,102	,198	-,293	,496
Team spirit	Equal variances assumed	,010	,919	-1,653	88	,051	,102	-,306	,185	-,673	,062
	Equal variances not assumed			-1,600	66,715	,057	,114	-,306	,191	-,687	,076
Lifelong learning	Equal variances assumed	1,324	,253	,950	88	,172	,345	,194	,205	-,212	,601
	Equal variances not assumed			1,017	87,698	,156	,312	,194	,191	-,186	,574
Entrepreneurial skills	Equal variances assumed	2,729	,102	,544	88	,294	,588	,102	,187	-,270	,474
	Equal variances not assumed			,572	85,880	,284	,569	,102	,178	-,252	,456
School equipment	Equal variances assumed	,013	,911	-,143	88	,443	,887	-,037	,259	-,552	,478

	Equal variances not assumed			-,144	77,072	,443	,886	-,037	,257	-,549	,475
Preparation time	Equal variances assumed	,161	,689	1,316	88	,096	,192	,296	,225	-,151	,744
	Equal variances not assumed			1,288	69,696	,101	,202	,296	,230	-,162	,755
Time spent by students	Equal variances assumed	,044	,834	,092	88	,464	,927	,019	,202	-,384	,421
	Equal variances not assumed			,091	73,848	,464	,928	,019	,203	-,387	,424
Knowledge in all STEM fields	Equal variances assumed	1,226	,271	,663	88	,254	,509	,176	,265	-,351	,703
	Equal variances not assumed			,678	80,594	,250	,500	,176	,259	-,340	,692

On the contrary, in the t-test where the first university degree of the secondary education teachers was used as the independent variable statistically significant differences were observed (Table 28). The teachers were divided into two categories: those whose degree was in a STEM related field and those with a non-STEM related one.

The statistically significant differences are observed in the following questions:

- To what degree do you believe STEM education contributes to the development of problem-solving skills?
- To what degree do you believe STEM education contributes to the cultivation of team spirit?
- Are you able to dedicate enough time to the preparation of a STEM lesson?
- Are you in possession of the necessary knowledge in all STEM fields to effectively implement STEM education?

The following conclusions have been reached:

- Teachers with a degree in a non-STEM field consider the contribution of STEM education to problem-solving skills and team spirit less important (Table 27).
- Teachers with a degree in a STEM field consider the time for preparation and knowledge in all STEM disciplines as a more significant hurdle than those with a non-STEM related degree (Table 27).

Table 27. This table is group statistics between the extent that STEM education can contribute to the development each one of the skills and the field of the participants' basic degree.

	Specialty	N	Mean	Std. Deviation	Std. Error Mean
Critical thinking	Non-STEM fields	42	4,10	,692	,107
	STEM fields	27	4,33	,620	,119
Problem-solving	Non-STEM fields	42	4,10	,726	,112
	STEM fields	27	4,56	,577	,111
Leadership	Non-STEM fields	42	3,71	,774	,119
	STEM fields	27	3,74	,859	,165
Creativity	Non-STEM fields	42	4,31	,715	,110
	STEM fields	27	4,63	,565	,109
Adaptability	Non-STEM fields	42	3,79	1,001	,154
	STEM fields	27	4,19	,786	,151
Team spirit	Non-STEM fields	42	4,00	,937	,145
	STEM fields	27	4,56	,698	,134
Lifelong learning	Non-STEM fields	42	4,10	,932	,144
	STEM fields	27	3,89	1,121	,216
Entrepreneurial	Non-STEM	42	4,07	,778	,120

skills	fields				
	STEM fields	27	3,74	1,059	,204
School equipment	Non-STEM fields	42	2,36	1,008	,156
	STEM fields	27	2,63	1,418	,273
Preparation time	Non-STEM fields	42	2,24	,958	,148
	STEM fields	27	2,78	,847	,163
Time spent by students	Non-STEM fields	42	2,95	,962	,148
	STEM fields	27	3,15	,864	,166
Knowledge in all STEM fields	Non-STEM fields	42	2,05	,987	,152
	STEM fields	27	3,19	1,331	,256

Table 28. This table shows the results of t-test about independent samples test.

		Levene's Test for Equality of Variances		t-test for Equality of Means							
		F	Sig.	t	df	Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						One-Sided p	Two-Sided p			Lower	Upper
Critical thinking	Equal variances assumed	,073	,789	-1,452	67	,076	,151	-,238	,164	-,565	,089
	Equal			-	59,91	,071	,142	-,238	,160	-,558	,082

	varianc es not assume d			1,48 6 7							
Problem- solving	Equal varianc es assume d	,009	,92 5	- 2,77 6	67	,004	,007	-,460	,166	-,791	-,129
	Equal varianc es not assume d			- 2,91 7	63,87 7	,002	,005	-,460	,158	-,776	-,145
Leadership	Equal varianc es assume d	,122	,72 8	- ,133	67	,447	,895	-,026	,199	-,424	,371
	Equal varianc es not assume d			- ,130	51,35 9	,449	,897	-,026	,204	-,436	,383
Creativity	Equal varianc es assume d	2,99 6	,08 8	- 1,96 3	67	,027	,054	-,320	,163	-,646	,005
	Equal varianc es not assume d			- 2,06 6	64,06 1	,021	,043	-,320	,155	-,630	-,011
Adaptability	Equal varianc es	,638	,42 7	- 1,75 4	67	,042	,084	-,399	,228	-,854	,055
	Equal										

		F	Sig.	t	df	One-sided p	Two-sided p	Mean Difference	Std. Error Difference	Lower	Upper
	Equal variances assumed										
	Equal variances not assumed			-1,848	64,201	,035	,069	-,399	,216	-,831	,032
Team spirit	Equal variances assumed	,918	,341	-2,643	67	,005	,010	-,556	,210	-,975	-,136
	Equal variances not assumed			-2,815	65,442	,003	,006	-,556	,197	-,950	-,161
Lifelong learning	Equal variances assumed	,397	,531	,829	67	,205	,410	,206	,249	-,291	,703
	Equal variances not assumed			,796	48,211	,215	,430	,206	,259	-,315	,728
Entrepreneurial skills	Equal variances assumed	3,861	,054	1,494	67	,070	,140	,331	,221	-,111	,773
	Equal variances not assumed			1,398	43,791	,085	,169	,331	,237	-,146	,808

		F	Sig.	t	df						
School equipment	Equal variances assumed	5,35 1	,02 4	-,933	67	,177	,354	-,272	,292	-,855	,311
	Equal variances not assumed			-,867	42,76 2	,195	,391	-,272	,314	-,906	,361
Preparation time	Equal variances assumed	,902	,34 6	-2,38 7	67	,010	,020	-,540	,226	-,991	-,088
	Equal variances not assumed			-2,45 2	60,41 2	,009	,017	-,540	,220	-,980	-,100
Time spent by students	Equal variances assumed	,039	,84 5	-,858	67	,197	,394	-,196	,228	-,651	,260
	Equal variances not assumed			-,879	59,83 2	,192	,383	-,196	,223	-,642	,250
Knowledge in all STEM fields	Equal variances assumed	1,99 8	,16 2	-4,07 1	67	<,00 1	<,00 1	-1,138	,279	-1,695	-,580
	Equal varianc			-3,81 4	44,11	<,00 1	<,00 1	-1,138	,298	-1,738	-,537

es not		7		
assume				
d				

Table 29 and Table 30 illustrate that working in public or private education results in a statistically significant difference when it comes to the importance of possessing knowledge in all STEM fields. Private school teachers tend to consider it a more severe hurdle in the implementation of STEM education than teachers working in public schools.

Table 29. This table is group statistics between the extent that STEM education can contribute to the development each one of the skills and the kind of school that participant work (public or private).

	Employer	N	Mean	Std. Deviation	Std. Error Mean
Critical thinking	Public	76	4,17	,681	,078
	Private	14	4,50	,650	,174
Problem-solving	Public	76	4,28	,665	,076
	Private	14	4,50	,650	,174
Leadership	Public	76	3,70	,749	,086
	Private	14	3,86	,864	,231
Creativity	Public	76	4,42	,659	,076
	Private	14	4,71	,469	,125
Adaptability	Public	76	3,99	,959	,110
	Private	14	4,21	,699	,187
Team spirit	Public	76	4,21	,853	,098
	Private	14	4,21	,975	,261
Lifelong learning	Public	76	4,13	,869	,100
	Private	14	3,79	1,311	,350
Entrepreneurial skills	Public	76	3,99	,808	,093
	Private	14	3,86	1,167	,312
School equipment	Public	76	2,30	1,083	,124
	Private	14	3,00	1,617	,432
Preparation time	Public	76	2,53	1,101	,126
	Private	14	2,64	,745	,199
Time spent by students	Public	76	3,07	,943	,108
	Private	14	2,93	,917	,245
Knowledge in all STEM fields	Public	76	2,38	1,188	,136
	Private	14	3,36	1,151	,308

Table 30. This table shows the results of t-test about independent samples test.

		Levene's Test for Equality of Variances		t-test for Equality of Means					Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		F	Sig.	t	df	Significance					Lower	Upper
						One-Sided p	Two-Sided p					
Critical thinking	Equal variances assumed	,054	,817	-1,672	88	,049	,098	-,329	,197	-,720	,062
	Equal variances not assumed			-1,726	18,647	,050	,101	-,329	,191	-,728	,070
Problem-solving	Equal variances assumed	,035	,852	-1,160	88	,125	,249	-,224	,193	-,607	,160
	Equal variances not assumed			-1,178	18,375	,127	,254	-,224	,190	-,622	,175
Leadership	Equal variances assumed	,004	,952	-,716	88	,238	,476	-,160	,223	-,603	,283
	Equal variances not assumed			-,648	16,785	,263	,526	-,160	,246	-,680	,361
Creativity	Equal variances assumed	5,789	,018	-1,590	88	,058	,115	-,293	,184	-,660	,073
	Equal variances not assumed			-2,004	23,627	,028	,057	-,293	,146	-,595	,009
Adaptability	Equal variances assumed	,633	,428	-,845	88	,200	,400	-,227	,269	-,762	,307

	Equal variances not assumed			-1,049	23,089	,153	,305	-,227	,217	-,676	,221
Team spirit	Equal variances assumed	,321	,573	-,015	88	,494	,988	-,004	,254	-,508	,501
	Equal variances not assumed			-,014	16,871	,495	,989	-,004	,278	-,591	,584
Lifelong learning	Equal variances assumed	4,058	,047	1,255	88	,106	,213	,346	,276	-,202	,894
	Equal variances not assumed			,949	15,173	,179	,357	,346	,364	-,430	1,122
Entrepreneurial skills	Equal variances assumed	1,579	,212	,512	88	,305	,610	,130	,253	-,373	,633
	Equal variances not assumed			,399	15,376	,348	,696	,130	,325	-,563	,822
School equipment	Equal variances assumed	9,318	,003	-2,036	88	,022	,045	-,697	,342	-1,378	-,017
	Equal variances not assumed			-1,551	15,220	,071	,142	-,697	,450	-1,655	,260
Preparation time	Equal variances assumed	3,222	,076	-,379	88	,353	,705	-,117	,307	-,727	,494
	Equal variances not assumed			-,494	24,873	,313	,625	-,117	,236	-,602	,369
Time spent by students	Equal variances assumed	,070	,792	,502	88	,308	,617	,137	,273	-,406	,680

		F	Sig.	t	df	Sig. (1)	Sig. (2)	Mean Diff.	Std. Error Diff.	Lower	Upper
	Equal variances not assumed			,512	18,437	,307	,615	,137	,268	-,425	,699
Knowledge in all STEM fields	Equal variances assumed	,369	,545	-2,836	88	,003	,006	-,976	,344	-1,659	-,292
	Equal variances not assumed			-2,900	18,487	,005	,009	-,976	,336	-1,681	-,270

4. Discussion

International research has shown that one of the fundamental issues with the application of STEM education in various educational systems is the teachers' lack of knowledge regarding its application. Given that their knowledge on STEM education is directly related to the efficacy of said education and the students' success [22], it is useful to go through the bibliography concerning teachers' perceptions, attitudes, and knowledge. We will then proceed to study the same issues with regard to teachers in the Greek education system. The surveys will be analyzed on the basis of their commonalities.

Those referenced in [23, 24, 25, 26] relating to teachers' views in Constantinople, Saudi-Arabia and Greece reveal that in most part those teachers do not feel capable of applying a STEM pedagogy in their classroom. On the other hand, secondary education teachers in Liberia, according to the results of the survey referenced in [9], deem themselves generally capable of rising to the task.

Another point the results of these surveys have in common is the difficulty concerning engineering. In all surveys where teachers where asked which discipline posed the most challenges, the answer was overwhelmingly engineering [24, 27, 28].

According to the survey referenced in [28], teachers of science in Indonesia generally declared being acquainted with STEM education. However, in a subsequent survey [29] which included teachers of mathematics and science without prior experience, 31% declared not knowing anything about STEM education. A survey conducted in Thailand in 2017 [27] revealed that the majority of the teachers sampled (only) knew what the acronym stands for. The survey referenced in [24] reveals diverging views on STEM education and 21st century skills: the former is considered important while the latter not. In all other surveys teachers consider 21st skills important and make a connection between their acquisition and STEM education [23, 28, 30, 31]. The survey referenced in [31] reveals differing views depending on specialty. Science teachers seem to better grasp the importance of 21st century skills, whereas primary education teachers seem to have the least appreciation com- pared to all other specialties. The survey referenced in [30] revealed that teachers with more experience (more than 10 years) had a more positive perception of 21st century skills.

As for 21st century skills taken individually, problem-solving is ranked first [30, 31] followed by team spirit and creativity [30]. Acquiring skills that contribute to the students' later professional life is deemed the least important in survey [31], whereas it is considered important in survey [29]. Entrepreneurial skills are considered the least important in survey [30]. In survey [29] associating STEM education issues with everyday life is considered meaningful, whereas it is not according to survey [24].

There is also more or less convergence with regard to the ways in which teachers came by STEM education. In most countries, teachers seem to have acquired any knowledge whatsoever on their

own initiative [22, 26, 28, 29] with most of them mentioning the internet as their primary source of information.

Teachers have identified the following barriers and challenges to actually applying a STEM pedagogy in their classroom:

- Lack of time either in the classroom with the students or for preparation [9, 24, 31].
- Difficulty establishing an interdisciplinary relation [24]
- Lack of facilities/resources provided by the school [24, 26, 28, 29]
- Excessive student number per class [24]
- Curriculum structure [24]
- Insufficient knowledge on the teachers' part [26, 29]
- Mobilization of the administration to ensure appropriate teacher training [29]
- Cultivating students' interest [26].
- Experiential approach [26].
- Adapting the teaching practice to students' levels of knowledge [26].
- Safety during experiments [26].

It is worth noting that survey [31] which concerns Vietnam reveals as the least important hurdle the spending required for the acquisition of the necessary equipment. Survey [9] has produced several other noteworthy results: no significant statistical difference was observed in the answers given on the basis of gender, years of experience and level of teachers' education.

Conversely, the type of school – public or private – played a significant role in the answers, with teachers working in the latter being more favorable to the application of STEM pedagogies. A marginally significant difference was found between on the one hand high school teachers and on the other middle school teachers, with the former having a more positive attitude.

There was also a significant statistical difference in the type of school, with private schools scoring higher than public schools. A marginally significant statistical difference was found between those teaching in grammar schools and those teaching in secondary schools, with those teaching in grammar schools scoring higher. Considering the following research findings:

- Teachers acquired their knowledge of STEM education on their own initiative, so they had a personal interest.
- Most of them believe that they can do it if they can implement it.
- They see the lack of preparation time for pupils as a major obstacle.
- Teachers also lack the time to prepare a STEM seminar.
- They believe that STEM education can be applied to all levels of education, starting from primary school. Taking into account the data from the international literature, according to which students can acquire motivation towards the respective professions through their participation in competitions and extracurricular activities [4].

The authors of the article suggest

(1) The participation of students in STEM competitions, a preparation that can be done in the course of Skills Workshops, a course taught from the first to the third year of high school. The aim of the course is to develop 21st century skills, but it is not possible to prepare for a competition during the course.

(2) Changing the Skills Labs course from one lesson to two lessons per week.

(3) The organization of seminars on STEM education by the IEP, which in the past has organized seminars on topics such as differentiated teaching and teacher involvement, has been very

successful. The responses of the teachers in the present research show the positive attitude of the teachers towards STEM education, but also their intention to develop it.

5. Conclusions

Similarly to those referenced below [23, 24, 25, 26], this survey reveals that the majority of the participants feel that they lack the necessary knowledge to apply a STEM pedagogy in their classroom. A comparison between the results of the present survey and other published research reveals several common points. For example, in the surveys referenced in [23, 28, 30, 31] and in the present one STEM education is deemed apt to contribute to the acquisition of 21st century skills. This conclusion has been reached after taking into account the high scores in each question asking whether STEM education can contribute to the development of each skill. Contrary to the result in survey [31], no significant divergence is observed between primary and secondary education teachers with respect to their views on the contribution of STEM education to the development of 21st century skills.

With respect to how these skills were ranked, the results of the current survey are close to those of the surveys [30, 31] as far as the top positions are concerned, which are occupied by problem-solving and creativity. The entrepreneurial skills, which were ranked in the last position according to the survey [30], occupy the second to last position in the current survey.

As with the surveys [22, 26, 28, 29] the present one confirms that any knowledge around STEM education on the teachers' part is acquired due to their own desire and initiative. However, where in previous surveys the internet was cited as the primary source of information, in this one, seminars come first only to be followed by the internet in the second place.

Any attempt to integrate STEM education into the school curriculum, whether through the curriculum or through student participation in activities, must take into account the resources that teachers consider important to support their work [4] .

References

1. J. M. Breiner, C. C. Johnson, S. S. Harkness and C. M. Koehler, "What Is STEM? A Discussion About Conceptions of STEM in Education and Partnerships.," *School Science and Mathematics*, Jan 2012.
2. K. H. C. Kennedy, Y. Yi-Fen and H. Ying-Shao, A Framework for Examining Teachers' Practical Knowledge for STEM Teaching, 2019, Asia-Pacific STEM Teaching Practices.
3. K. Maass, V. Geiger, M. Ariza and M. Goos, "The Role of Mathematics in interdisciplinary STEM education.," *ZDM Mathematics Education*, no. 51, p. 869–884, 2019.
4. M. Alsalamat, "Secondary Stage Science Teachers' Perceptions toward STEM Education in Saudi Arabia.," *Sustainability*, vol. 16, no. 3634, 2024.
5. I. C. O. A. F. S. EDUCATION, "Kuching Declaration on Science and Technology Education," in *Final Proceeding of the WorldConference on Science and Technology Education (WorldSTE2013).*, Kuching, Malaysia, 2013.
6. J. Wieselmann, . G. Roehrig, E. Ring-Whalen and T. Meagher, "Becoming a STEM Focused School District: Administrators' Roles and Experiences.," *Edu. Sci.,* vol. 11, no. 805, 2021.
7. R. Khalil, H. Tairab, A. Qablan, K. Alarab and Y. Mansour, "STEM-Based Curriculum and Creative Thinking in High School Students.," *Educ. Sci.,* vol. 13, no. 1195, 2023.
8. Widya, R. Rifandi and Y. L. Rahmi, "STEM education to fulfil the 21st century demand: a literature review.," *Journal of Physics*, 2019.
9. S. Hackman, D. Zhang and J. He, "Secondary school science teachers' attitudes towards STEM education in Liberia," *INTERNATIONAL JOURNAL OF SCIENCE EDUCATION*, vol. 43, no. 2, pp. 223-246, 2021.
10. H. Tahesdoost, "Measurement and Scaling Techniques in Research Methodology; Survey / Questionnaire Development," *International Journal of Academic Research in Management*, vol. 6, no. 1, pp. 1-5, 2016.
11. B. Paylopoulos, Data Analysis Models, Αθήνα: E.K.P.A. Philisophy Department. , 2008.

12. M. V. Bøe, E. K. Henriksen, T. Lyons and C. Schreiner, "Participation in science and technology: young people's achievement-related choices in late-modern societies," *Studies in Science Education*, vol. 47, no. 1, pp. 37-72, 16 Aug 2011.

13. C. V. McDonald, "STEM Education: A Review of the Contribution of the Disciplines of Science, Technology, Engineering and Mathematics.," *Science Education International*, vol. 27, no. 4, pp. 530-569, 2016.

14. B. Altangerel , R. Tsolmon and O. Khulan , "An Experiment in Applying Differentiated Instruction in STEAM Disciplines," *Eurasian Journal of Educational Research*, pp. 21-37, 2022.

15. R. Tytler, J. Aderson and Y. Li, "STEM Education for the Twenty-First Century.," in *Integrated Approaches to STEM Education: An International Perspective*, Cham, Springer International Publishing, 2020, pp. 21-43.

16. C. Yata, T. Ohtani and M. Isobe, "Conceptual framework of STEM based on Japanese subject principles.," *IJ STEM* Ed, 2020.

17. K. Almazroui, "Project-Based Learning for 21st-Century Skills: An Overview and Case Study of Moral Education in the UAE," *The Social Studies*, vol. 114, no. 3, pp. 125-136, 2023.

18. "Partnership for 21st Century Skills. Framework for 21st Century Learning.," 2019.

19. S. Darwish and M. Darwish, "*Promoting The 'E' In Stem," in 54th International Universities Power Engineering Conference (UPEC)*, Bucharest, 2019.

20. M. El Nagdi, F. Leammukda and G. Roehrig, "Developing identities of STEM teachers at emerging STEM schools.," *IJ STEM*, vol. 5, no. 36, 2018.

21. N. Fitzallen, "STEM Education: What Does Mathematics Have to Offer?," in *Mathematics Education Research Group of Australasia, Paper presented at the Annual Meeting of the Mathematics Education Research Group of Australasia (MERGA)*, 2015.

22. D. Bell, D. Morrison-Love, D. Wooff and et al., "STEM education in the twenty-first century: learning at work—an exploration of design and technology teacher perceptions and practices.," *Int J Technol Des Educ*, vol. 28, pp. 721-737, 2018.

23. H. El-Deghaidy and N. Mansour , "Science Teachers' Perceptions of STEM Education: Possibilities and Challenges," *International Journal of Learning and Teaching*, vol. 1, no. 1, 2015.

24. B. Yildirim and C. Türk, "Opinions of Secondary School Science and Mathematics Teachers on STEM Education," *World Journal on Educational Technology: Current Issues*, vol. 10, no. 1, pp. 52-60, 2018.

25. A. Baltsavias and A. Kyridis, "Preschool Teachers' Perspectives on the Importance of STEM Education in Greek Preschool Education," *Journal of Education and Practice*, vol. 11, no. 14, 2020.

26. M. Ampartzaki, M. Kalogiannakis, S. Papadakis and V. Giannakou, "Perceptions About STEM and the Arts: Teachers', Parents' Professionals' and Artists' Understandings About the Role of Arts in STEM Education. In: Papadakis, S., Kalogiannakis, M. (eds) STEM, Robotics, Mobile Apps in Early Childhood and Primary Education.," Springer, Singapore., 2022.

27. W. Srikoom, D. Hanuscin and C. Faikhamta, "Perceptions of in-service teachers toward teaching STEM in Thailand," *Asia-Pacific Forum on Science Learning and Teaching*, vol. 18, no. 2, p. 1, 2017.

28. A. Permanasari, B. Rubini and O. Nugroho, "STEM Education in Indonesia: Science Teachers' and Students' Perspectives," *Joulnal of Innovation in Educational and Cultural Research*, vol. 2, no. 1, pp. 7-16, 2021.

29. R. Rifandi, Y. L. Rahmi , Widya and E. S. Indrawati, "Pre-service teachers' perception on science, technology,engineering, and mathematics (stem) education," *Journal of Physics: Conference Series*, 2020.

30. K. Lin, Y. Yeh, Y. Hsu, J. Wu, K. Yang and H. Wu, "STEM education goals in the twenty-first century: Teachers' perceptions and experiences.," *Int J Technol Des Educ*, vol. 33, pp. 479-496, 2023.

31. N. Thi To Khuyen, N. Van Bien, Lin P-L, Lin J and Chang C-Y, "Measuring Teachers' Perceptions to Sustain STEM Education Development.," *Sustainability*, vol. 12, no. 4, p. 1531, 2020.

32. Y. Xie, M. Fang and K. Shauman, "STEM Education," *Annual Review of Sociology*, pp. 331-357, Aug 2015.

33. W. T. Tang, "STEM Education Landscape: The Case of Singapore," *Journal of Physics: Conference Series*, vol. 1340, 2019.

34. B. Wahono, P. Lin and C. Chang, "Evidence of STEM enactment effectiveness in Asian student learning outcomes.," *IJ STEM Ed*, p. 36, 7 2020.

35. G. Quan, Tracking STEM Education Development in China: National, Regional, and Local Influences., Springer, 2020.

36. C. Y. Wong and Y. T. Shih, "Enhance STEM Education by Integrating Product Design with Computer-Aided Design Approaches," *Computer-Aided Design & Applications*, vol. 19, no. 4, pp. 694-711, 2022.

37. A. Leung, "Boundary crossing pedagogy in STEM education," *IJ STEM Ed*, vol. 7, no. 15, 2020.

38. R. Farwati, K. Metafisika, I. Sari, D. Sitinjak, D. Solikha and S. Solfarina, "*STEM EDUCATION IMPLEMENTATION IN INDONESIA: A SCOPING REVIEW,"* INTERNATIONAL JOURNAL OF STEM EDUCATION FOR SUSTAINABILITY*, vol. 1, 2021.

39. L. Gonzalez-Perez and M. Ramirez-Montoya, "Components of Education 4.0 in 21st Century Skillw Frameworkw: Systematic Reviw," *Sustainability*, vol. 14, no. 3, p. 1493, 2022.

40. Tang Wee Teo and Tang Wee Teo, Singapore Math and Science Education Innovation, vol. 1, Singapore, 2021.

41. "Delivering STEM skills for the economy.," in *Forty-Seventh Report of Session*, 2017-2019.

42. M. El Nagdi and G. Roehrig, "Reality vs. Expectations of Assessment in STEM Education: An Exploratory Case Study of STEM Schools in Egypt.," *Educ. Sci.*, p. 726, 12 2022.

43. G. Roehrig, H. El-Deghaidy, A. García-Holgado and D. Kansan, "A closer look to STEM education across continents: insights from a multicultural panel discussion," in *IEEE Global Engineering Education Conference (EDUCON)*, Tunis, 2022.

44. C. Sen, Z. S. Ay and S. S. Kiray, "STEM Skills in the 21st Century Education," *Research Highlights in STEM Education*, pp. 81-101, 2018.

45. L. V. Shukshina, L. A. Gegel, M. A. Erofeeva, I. D. Levina, U. Y. Chugaeva and O. D. Nikitin, "STEM and STEAM Education in Russian Education: Conceptual Framework," *EURASIA Journal of Mathematics, Science and Technology Education*, vol. 17, no. 10, 2021.

46. I. DeCoito, "STEM Education in Canada: A Knowledge Synthesis," *Can J Sci Math Techn*, vol. 16, p. 114–128, 2016.

47. R. Milton and O. Daniel Clark, STEM Education in the Brazilian Context: An Ethnomathematical Perspective, 2017.

48. G. O. Pugliese and V. De Macedo Santos, "The connection betwen the PISA and STEM Education movement in Brazil," *Educacao em revista*, 2022.

49. S.E.V., "Special Report: STEM Education," SEV, Athens, 2021.

50. "F.E.K. B/3567," 04/08/2021.

51. "I.E.P," New study programs, 2023. [Online]. Available: http://iep.edu.gr/el/nea-programmata-spoudon-arxiki-selida. [Accessed 19 04 2023].