**Attitudes and opinions of Greek teachers regarding STEM education**

**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 sample was randomly selected and comprised 90 primary and secondary school teachers from Greek public and private schools. The teachers' participation was voluntary, and the results were analyzed using the programme SPSS.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, teachers’ attitudes, STEM fields, STEM education

# **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, 4]. 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. [5]. 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 [6]. 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 [7]. At the same time, through its interdisciplinary approach, it contributes to the development of 21st century skills such as creativity, critical and innovative thinking [8, 9].

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 [7, 4]. 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 [5]. 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 [10]. 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 [5]. 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 [8]. This type of education is deemed appropriate for both primary and secondary education [4] so understanding teachers’ attitudes and perceptions is essential for the successful implementation of STEM education and for sup porting teachers’ professional development [5, 11]. 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?

# **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 [12]. 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” [12].

One of the methods that prove useful in analysing 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 [13]. 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 participants were randomly selected and the responses to the questionnaire were voluntary. 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.

# **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 [14]. 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 [15]. Therefore, the existence of this type of education at the secondary level is considered vital to the success of its goals.

## 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 [5, 11].

### **Science**

Science is defined as the systems of knowledge that are concerned with the study of the physical world, of behaviour of matter and the universe. Observation, experimentation, and formulation of laws to explain natural phenomena are its core methods [16].

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 [17] and making decisions [5]. At the same time, it is necessary to use relationships that are qualitative, quantitative, spatial and temporal. The use of scientific methods [5, 18] such as comparison and correlation [18] is developed. At the same time, creative thinking is developed and students can embrace scientific values [5].

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 [10]. STEM education can be a powerful ally in this regard.

### **Technolog**y

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 [16]. 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 [15].

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 [17]. It is also directly related to computer science [19]. 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 [20]. 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 [15].

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 [15].

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 [18].

### **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 [16]. Its applications are visible in everyday life; however, its role is not [21]. 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 [18]. In most cases, it is absent from the curricula [21] 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 [18]. 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 [15], engineering being viewed as a real-world context for learning mathematics and science [22]
			* promotion of communication skills enhancement of collaboration among the members of a group
			* providing an entertaining and real-world learning environment [22].
			* It lays the foundations for engagement with technology
			* Helps to motivate students to pursue vocational disciplines related to engineering design [5].

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 [15].

### **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 [16]. 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 CO2 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 [18], which in turn can help students solve problems and face the changes in their everyday life [23]. Developing such mathematical thinking starts from the early school years, even in kindergarten [15], 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 [10]. 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-cantered pedagogies and heavy, demanding curricula [15].

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 [23]. Furthermore, mathematics in STEM education is generally used as a tool to solve problems to the detriment of deeper learning through problem-solving [17].

## 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 The gender of the sample.

|  |  |  |
| --- | --- | --- |
|  | **Frequency** | **Percent** |
| Valid | Male | 18 | 20,0 |
| Female | 72 | 80,0 |
| Total | 90 | 100,0 |

 |

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

Table 2 The age of the sample. |
| Table 3 The education background of sample.

|  |  |  |
| --- | --- | --- |
|  | **Frequency** | **Percent** |
| Valid | First degree/Bachelor’s | 32 | 35,6 |
| Master’s/Doctorate | 58 | 64,4 |
| Total | 90 | 100,0 |

 | Table 4 Years of service of sample.

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

 |
| Table 5 The level in the education system than each one works.

|  |  |  |
| --- | --- | --- |
|  | **Frequency** | **Percent** |
| Valid | Primary | 36 | 40,0 |
| Secondary | 54 | 60,0 |
| Total | 90 | 100,0 |

 |

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

Table 6 The number of samples that work in public and the number that work in privet. |
| Table 7 The specialty of each one.

|  |  |  |
| --- | --- | --- |
|  | **Frequency** | **Percent** |
| Valid | Humanities | 31 | 34,4 |
| Science  | 22 | 24,4 |
| Engineering | 1 | 1,1 |
| Technology | 4 | 4,4 |
| Arts | 3 | 3,3 |
| Other | 8 | 8,9 |
| Total | 69 | 76,7 |
| Missing | System | 21 | 23,3 |
| Total | 90 | 100,0 |

 |

|  |  |  |
| --- | --- | --- |
|  | **Frequency** | **Percent** |
| Valid | Interdisciplinarity | 16 | 17,8 |
| Combination of fields  | 61 | 67,8 |
| Holistic approach  | 13 | 14,4 |
| Total | 90 | 100,0 |

Table 8 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” |

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 9. 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. The results of Chi-Square Tests of above question.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Value** | **df** | **Asymptotic Significance (2-sided)** |
| Pearson Chi-Square | 6,262a | 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 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 | Yes | 62 | 68,9 |
| Maybe | 27 | 30,0 |
| No | 1 | 1,1 |
| Total | 90 | 100,0 |

 | Table 12 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 | Yes | 61 | 67,8 |
| Maybe | 23 | 25,6 |
| No | 6 | 6,7 |
| Total | 90 | 100,0 |

 |
| Table 13 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 | Yes | 83 | 92,2 |
| Maybe | 7 | 7,8 |
| Total | 90 | 100,0 |

 | Table 14 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 | Yes | 69 | 76,7 |
| Maybe | 20 | 22,2 |
| No | 1 | 1,1 |
| Total | 90 | 100,0 |

 |

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

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).

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

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. The results in question: “Do you think you have the knowledge necessary to apply STEM education? A. Yes B. No”

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

Table 16 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 The results of Chi-Square tests.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Value** | **df** | **Asymptotic Significance (2-sided)** | **Exact Sig. (2-sided)** | **Exact Sig. (1-sided)** |
| Pearson Chi-Square | 1,523a | 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. 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 | Training offered at school | 1 | 1,1 |
| Training outside of the school/own initiative | 29 | 32,2 |
| Internet | 22 | 24,4 |
| Bibliography | 5 | 5,6 |
| Acquaintances | 4 | 4,4 |
| No knowledge | 25 | 27,8 |
| Total | 86 | 95,6 |
| 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 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. 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. 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. The results of t-test about independent samples test (EVA-Equal variances assumed, EVNA- Equal variances not assumed)

|  |  |
| --- | --- |
|  | **Levene's Test for Equality of Variances** |
| **t-test for Equality of Means** |
| F | Sig. | t | df | Significance | Mean Difference | Std. Error Difference |
| One-Sided p | Two-Sided p |
| Critical thinking | EVA | ,819 | ,368 | -,770 | 88 | ,222 | ,444 | -,139 | ,180 |
| EVNA |  |  | -,777 | 26,475 | ,222 | ,444 | -,139 | ,179 |
| Problem-solving | EVA | 1,382 | ,243 | -1,032 | 88 | ,153 | ,305 | -,181 | ,175 |
| EVNA |  |  | -,904 | 22,790 | ,188 | ,375 | -,181 | ,200 |
| Leadership | EVA | 1,131 | ,290 | -1,742 | 88 | ,042 | ,085 | -,347 | ,199 |
| EVNA |  |  | -1,584 | 23,571 | ,063 | ,127 | -,347 | ,219 |
| Creativity | EVA | 1,619 | ,207 | -1,409 | 88 | ,081 | ,162 | -,236 | ,168 |
| EVNA |  |  | -1,236 | 22,805 | ,115 | ,229 | -,236 | ,191 |
| Adaptability | EVA | ,901 | ,345 | -,970 | 88 | ,167 | ,335 | -,236 | ,244 |
| EVNA |  |  | -1,090 | 30,838 | ,142 | ,284 | -,236 | ,217 |
| Team spirit | EVA | ,426 | ,516 | -1,156 | 88 | ,125 | ,251 | -,264 | ,228 |
| EVNA |  |  | -1,059 | 23,754 | ,150 | ,300 | -,264 | ,249 |
| Lifelong learning | EVA | 11,203 | ,001 | -1,796 | 88 | ,038 | ,076 | -,444 | ,247 |
| EVNA |  |  | -1,364 | 20,413 | ,094 | ,187 | -,444 | ,326 |
| Entrepreneurial skills | EVA | 5,128 | ,026 | -,728 | 88 | ,234 | ,469 | -,167 | ,229 |
| EVNA |  |  | -,582 | 21,144 | ,284 | ,567 | -,167 | ,287 |
| School equipment | EVA | ,103 | ,749 | 1,012 | 88 | ,157 | ,314 | ,319 | ,316 |
| EVNA |  |  | ,934 | 23,950 | ,180 | ,359 | ,319 | ,342 |
| Preparation time | EVA | 1,562 | ,215 | -,952 | 88 | ,172 | ,344 | -,264 | ,277 |
| EVNA |  |  | -1,116 | 33,113 | ,136 | ,272 | -,264 | ,236 |
| Time spent by students | EVA | ,318 | ,574 | -1,072 | 88 | ,143 | ,287 | -,264 | ,246 |
| EVNA |  |  | -1,142 | 28,439 | ,132 | ,263 | -,264 | ,231 |
| Knowledge fields | EVA | ,146 | ,704 | ,727 | 88 | ,235 | ,469 | ,236 | ,325 |
| EVNA |  |  | ,729 | 26,264 | ,236 | ,472 | ,236 | ,324 |

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. 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 fields | 0-10 | 42 | 2,36 | 1,226 | ,189 |
| 10-30 | 48 | 2,69 | 1,223 | ,177 |

Table 24. The results of t-test about independent samples test. test (EVA-Equal variances assumed, EVNA- Equal variances not assumed)

|  |  |
| --- | --- |
| . | **Levene's Test for Equality of Variances** |
| **t-test for Equality of Means** |
| F | Sig. | t | df | Significance | Mean Difference | Std. Error Difference |
| One-Sided p | Two-Sided p |
| Critical thinking | *EVA* | 1,337 | ,251 | -,720 | 88 | ,237 | ,474 | -,104 | ,145 |
| *EVNA* |  |  | -,723 | 87,620 | ,236 | ,472 | -,104 | ,144 |
| Problem-solving | *EVA* | ,010 | ,920 | -1,298 | 88 | ,099 | ,198 | -,182 | ,140 |
| *EVNA* |  |  | -1,284 | 81,022 | ,101 | ,203 | -,182 | ,141 |
| Leadership | *EVA* | ,060 | ,806 | -,643 | 88 | ,261 | ,522 | -,104 | ,162 |
| *EVNA* |  |  | -,644 | 87,062 | ,261 | ,521 | -,104 | ,162 |
| Creativity | *EVA* | ,338 | ,562 | ,460 | 88 | ,323 | ,646 | ,063 | ,136 |
| *EVNA* |  |  | ,458 | 83,885 | ,324 | ,648 | ,063 | ,137 |
| Adaptability | *EVA* | ,111 | ,739 | ,015 | 88 | ,494 | ,988 | ,003 | ,196 |
| *EVNA* |  |  | ,015 | 85,331 | ,494 | ,988 | ,003 | ,197 |
| Team spirit | *EVA* | ,011 | ,917 | 1,254 | 88 | ,107 | ,213 | ,229 | ,183 |
| *EVNA* |  |  | 1,263 | 87,908 | ,105 | ,210 | ,229 | ,181 |
| Lifelong learning | *EVA* | 1,357 | ,247 | 1,507 | 88 | ,068 | ,135 | ,301 | ,199 |
| *EVNA* |  |  | 1,531 | 87,125 | ,065 | ,129 | ,301 | ,196 |
| Entrepreneurial skills | *EVA* | ,000 | ,996 | ,097 | 88 | ,461 | ,923 | ,018 | ,184 |
| *EVNA* |  |  | ,097 | 87,584 | ,461 | ,923 | ,018 | ,183 |
| School equipment | *EVA* | 6,942 | ,010 | -2,401 | 88 | ,009 | ,018 | -,592 | ,247 |
| *EVNA* |  |  | -2,446 | 86,138 | ,008 | ,016 | -,592 | ,242 |
| Preparation time | *EVA* | 1,249 | ,267 | -1,595 | 88 | ,057 | ,114 | -,351 | ,220 |
| *EVNA* |  |  | -1,616 | 87,725 | ,055 | ,110 | -,351 | ,217 |
| Time spent by students | *EVA* | ,035 | ,852 | -,646 | 88 | ,260 | ,520 | -,128 | ,198 |
| *EVNA* |  |  | -,649 | 87,747 | ,259 | ,518 | -,128 | ,197 |
| Knowledge in fields | *EVA* | ,069 | ,794 | -1,277 | 88 | ,103 | ,205 | -,330 | ,259 |
| *EVNA* |  |  | -1,277 | 86,364 | ,103 | ,205 | -,330 | ,259 |

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. 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 fields | Primary | 36 | 2,64 | 1,150 | ,192 |
| Secondary | 54 | 2,46 | 1,284 | ,175 |

Table 26. The results of t-test about independent samples test. (EVA-Equal variances assumed, EVNA- Equal variances not assumed)

|  |  |
| --- | --- |
|  | **Levene's Test for Equality of Variances** |
| **t-test for Equality of Means** |
| F | Sig. | t | df | Significance | Mean Difference | Std. Error Difference |
| One-Sided p | Two-Sided p |
| Critical thinking | *EVA* | 1,298 | ,258 | ,944 | 88 | ,174 | ,348 | ,139 | ,147 |
| *EVNA* |  |  | ,932 | 71,789 | ,177 | ,354 | ,139 | ,149 |
| Problem-solving | *EVA* | ,638 | ,427 | -,387 | 88 | ,350 | ,700 | -,056 | ,144 |
| *EVNA* |  |  | -,372 | 65,353 | ,355 | ,711 | -,056 | ,149 |
| Leadership | *EVA* | ,545 | ,462 | ,561 | 88 | ,288 | ,577 | ,093 | ,165 |
| *EVNA* |  |  | ,572 | 80,085 | ,285 | ,569 | ,093 | ,162 |
| Creativity | *EVA* | 2,658 | ,107 | ,402 | 88 | ,344 | ,689 | ,056 | ,138 |
| *EVNA* |  |  | ,419 | 84,553 | ,338 | ,676 | ,056 | ,133 |
| Adaptability | *EVA* | ,170 | ,681 | ,510 | 88 | ,306 | ,611 | ,102 | ,200 |
| *EVNA* |  |  | ,514 | 77,117 | ,304 | ,609 | ,102 | ,198 |
| Team spirit | *EVA* | ,010 | ,919 | -1,653 | 88 | ,051 | ,102 | -,306 | ,185 |
| *EVNA* |  |  | -1,600 | 66,715 | ,057 | ,114 | -,306 | ,191 |
| Lifelong learning | *EVA* | 1,324 | ,253 | ,950 | 88 | ,172 | ,345 | ,194 | ,205 |
| *EVNA* |  |  | 1,017 | 87,698 | ,156 | ,312 | ,194 | ,191 |
| Entrepreneurial skills | *EVA* | 2,729 | ,102 | ,544 | 88 | ,294 | ,588 | ,102 | ,187 |
| *EVNA* |  |  | ,572 | 85,880 | ,284 | ,569 | ,102 | ,178 |
| School equipment | *EVA* | ,013 | ,911 | -,143 | 88 | ,443 | ,887 | -,037 | ,259 |
| *EVNA* |  |  | -,144 | 77,072 | ,443 | ,886 | -,037 | ,257 |
| Preparation time | *EVA* | ,161 | ,689 | 1,316 | 88 | ,096 | ,192 | ,296 | ,225 |
| *EVNA* |  |  | 1,288 | 69,696 | ,101 | ,202 | ,296 | ,230 |
| Time spent by students | *EVA* | ,044 | ,834 | ,092 | 88 | ,464 | ,927 | ,019 | ,202 |
| *EVNA* |  |  | ,091 | 73,848 | ,464 | ,928 | ,019 | ,203 |
| Knowledge in all STEM fields | *EVA* | 1,226 | ,271 | ,663 | 88 | ,254 | ,509 | ,176 | ,265 |
| *EVNA* |  |  | ,678 | 80,594 | ,250 | ,500 | ,176 | ,259 |

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. 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 skills  | Non-STEM fields | 42 | 4,07 | ,778 | ,120 |
| 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. The results of t-test about independent samples test. (EVA-Equal variances assumed, EVNA- Equal variances not assumed)

|  |  |
| --- | --- |
|  | **Levene's Test for Equality of Variances** |
| **t-test for Equality of Means** |
| F | Sig. | t | df | Significance | Mean Difference | Std. Error Difference |
| One-Sided p | Two-Sided p |
| Critical thinking | EVA | ,073 | ,789 | -1,452 | 67 | ,076 | ,151 | -,238 | ,164 |
| EVNA |  |  | -1,487 | 59,916 | ,071 | ,142 | -,238 | ,160 |
| Problem-solving | EVA | ,009 | ,925 | -2,776 | 67 | ,004 | ,007 | -,460 | ,166 |
| EVNA |  |  | -2,917 | 63,877 | ,002 | ,005 | -,460 | ,158 |
| Leadership | EVA | ,122 | ,728 | -,133 | 67 | ,447 | ,895 | -,026 | ,199 |
| EVNA |  |  | -,130 | 51,359 | ,449 | ,897 | -,026 | ,204 |
| Creativity | EVA | 2,996 | ,088 | -1,963 | 67 | ,027 | ,054 | -,320 | ,163 |
| EVNA |  |  | -2,066 | 64,061 | ,021 | ,043 | -,320 | ,155 |
| Adaptability | EVA | ,638 | ,427 | -1,754 | 67 | ,042 | ,084 | -,399 | ,228 |
| EVNA |  |  | -1,848 | 64,201 | ,035 | ,069 | -,399 | ,216 |
| Team spirit | EVA | ,918 | ,341 | -2,643 | 67 | ,005 | ,010 | -,556 | ,210 |
| EVNA |  |  | -2,815 | 65,442 | ,003 | ,006 | -,556 | ,197 |
| Lifelong learning | EVA | ,397 | ,531 | ,829 | 67 | ,205 | ,410 | ,206 | ,249 |
| EVNA |  |  | ,796 | 48,211 | ,215 | ,430 | ,206 | ,259 |
| Entrepreneurial skills | EVA | 3,861 | ,054 | 1,494 | 67 | ,070 | ,140 | ,331 | ,221 |
| EVNA |  |  | 1,398 | 43,791 | ,085 | ,169 | ,331 | ,237 |
| School equipment | EVA | 5,351 | ,024 | -,933 | 67 | ,177 | ,354 | -,272 | ,292 |
| EVNA |  |  | -,867 | 42,762 | ,195 | ,391 | -,272 | ,314 |
| Preparation time | EVA | ,902 | ,346 | -2,387 | 67 | ,010 | ,020 | -,540 | ,226 |
| EVNA |  |  | -2,452 | 60,412 | ,009 | ,017 | -,540 | ,220 |
| Time spent by students  | EVA | ,039 | ,845 | -,858 | 67 | ,197 | ,394 | -,196 | ,228 |
| EVNA |  |  | -,879 | 59,832 | ,192 | ,383 | -,196 | ,223 |
| Knowledge in all STEM fields | EVA | 1,998 | ,162 | -4,071 | 67 | <,001 | <,001 | -1,138 | ,279 |
| EVNA |  |  | -3,817 | 44,114 | <,001 | <,001 | -1,138 | ,298 |

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. 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 The results of t-test about independent samples test. (EVA-Equal variances assumed, EVNA- Equal variances not assumed)

|  |  |
| --- | --- |
|  | **Levene's Test for Equality of Variances** |
| **t-test for Equality of Means** |
| F | Sig. | t | df | Significance | Mean Difference | Std. Error Difference |
| One-Sided p | Two-Sided p |
| Critical thinking | *EVA* | ,054 | ,817 | -1,672 | 88 | ,049 | ,098 | -,329 | ,197 |
| *EVNA* |  |  | -1,726 | 18,647 | ,050 | ,101 | -,329 | ,191 |
| Problem-solving | *EVA* | ,035 | ,852 | -1,160 | 88 | ,125 | ,249 | -,224 | ,193 |
| *EVNA* |  |  | -1,178 | 18,375 | ,127 | ,254 | -,224 | ,190 |
| Leadership | *EVA* | ,004 | ,952 | -,716 | 88 | ,238 | ,476 | -,160 | ,223 |
| *EVNA* |  |  | -,648 | 16,785 | ,263 | ,526 | -,160 | ,246 |
| Creativity | *EVA* | 5,789 | ,018 | -1,590 | 88 | ,058 | ,115 | -,293 | ,184 |
| *EVNA* |  |  | -2,004 | 23,627 | ,028 | ,057 | -,293 | ,146 |
| Adaptability | *EVA* | ,633 | ,428 | -,845 | 88 | ,200 | ,400 | -,227 | ,269 |
| *EVNA* |  |  | -1,049 | 23,089 | ,153 | ,305 | -,227 | ,217 |
| Team spirit | *EVA* | ,321 | ,573 | -,015 | 88 | ,494 | ,988 | -,004 | ,254 |
| *EVNA* |  |  | -,014 | 16,871 | ,495 | ,989 | -,004 | ,278 |
| Lifelong learning | *EVA* | 4,058 | ,047 | 1,255 | 88 | ,106 | ,213 | ,346 | ,276 |
| *EVNA* |  |  | ,949 | 15,173 | ,179 | ,357 | ,346 | ,364 |
| Entrepreneurial skills | *EVA* | 1,579 | ,212 | ,512 | 88 | ,305 | ,610 | ,130 | ,253 |
| *EVNA* |  |  | ,399 | 15,376 | ,348 | ,696 | ,130 | ,325 |
| School equipment | *EVA* | 9,318 | ,003 | -2,036 | 88 | ,022 | ,045 | -,697 | ,342 |
| *EVNA* |  |  | -1,551 | 15,220 | ,071 | ,142 | -,697 | ,450 |
| Preparation time | *EVA* | 3,222 | ,076 | -,379 | 88 | ,353 | ,705 | -,117 | ,307 |
| *EVNA* |  |  | -,494 | 24,873 | ,313 | ,625 | -,117 | ,236 |
| Time spent by students | *EVA* | ,070 | ,792 | ,502 | 88 | ,308 | ,617 | ,137 | ,273 |
| *EVNA* |  |  | ,512 | 18,437 | ,307 | ,615 | ,137 | ,268 |
| Knowledge in all STEM fields | *EVA* | ,369 | ,545 | -2,836 | 88 | ,003 | ,006 | -,976 | ,344 |
| *EVNA* |  |  | -2,900 | 18,487 | ,005 | ,009 | -,976 | ,336 |

# **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 [24], 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 [25, 26, 27, 28] 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 [11], 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 [26, 29, 30].

According to the survey referenced in [30], teachers of science in Indonesia generally declared being acquainted with STEM education. However, in a subsequent survey [31] 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 [29] revealed that the majority of the teachers sampled (only) knew what the acronym stands for. The survey referenced in [26] 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 [25, 30, 32, 33]. The survey referenced in [33] 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 [32] 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 [32, 33] followed by team spirit and creativity [32]. Acquiring skills that contribute to the students’ later professional life is deemed the least important in survey [33], whereas it is considered important in survey [31]. Entrepreneurial skills are considered the least important in survey [32]. In survey [31] associating STEM education issues with everyday life is considered meaningful, whereas it is not according to survey [26].

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 [24, 28, 30, 31] 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 [11, 26, 33].
* Difficulty establishing an interdisciplinary relation [26]
* Lack of facilities/resources provided by the school [26, 28, 30, 31]
* Excessive student number per class [26]
* Curriculum structure [26]
* Insufficient knowledge on the teachers’ part [28, 31]
* Mobilization of the administration to ensure appropriate teacher training [31]
* Cultivating students’ interest [28].
* Experiential approach [28].
* Adapting the teaching practice to students’ levels of knowledge [28].
* Safety during experiments [28].

It is worth noting that survey [33] which concerns Vietnam reveals as the least important hurdle the spending required for the acquisition of the necessary equipment. Survey [11] 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 favourable 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 [5].

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.

# **Conclusions**

Similarly to those referenced below [25, 26, 27, 28], 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 [25, 30, 32, 33] 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 [33], 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 [32, 33] 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 [32], occupy the second to last position in the current survey.

As with the surveys [24, 28, 30, 31] 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 [5, 9, 4] .

Disclaimer (Artificial intelligence)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1. Use of DeepL to correct syntactic errors

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