Promoting STEM Content Epistemology in Technology Enhanced Collaborative Learning Environments

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Abstract

The exploitation of a technologically supported learning environment is proposed so that teachers gain a deeper understanding of STEM content. They become familiarized with the STEM methodology as well as realize its added value in education. In the context of the present study, a distance learning program (e-course) was developed to train teachers in the STEM teaching methodology. Sixteen (16) teachers of Primary and Secondary sectors of education participated in the program through the Edmodo collaborative platform. For its implementation, the Cognitive Apprenticeship model, a model of effective training in STEM methodology, was used in combination with the Jigsaw Collaborative Strategy. The experimental process in a technologically supported learning environment was conducted in the context of problem-based learning which exploits collaboration in a wide range of activities. The method of quantitative analysis was applied for the collection of data. The results of the teachers' evaluation, with a questionnaire as a measuring tool, have indicated that their involvement in STEM activities in an electronically appropriately designed environment that supports their active participation and the exploratory learning process can greatly enhance literacy in STEM and the collaborative skills of learners.

Introduction

The development of Technology and Science makes it imperative to provide lifelong teacher education aiming at the application of innovative teaching techniques and the use of modern digital tools in order to enable the teacher to meet the requirements of the 21st century. In this context, STEM (Science, Technology, Engineering and Mathematics) training can become a new way of organizing teaching which has been linked with the "integrated" teaching of Science, Technology, Engineering and Mathematics as a unit and as a coherent entity (Breiner, Johnson, Harkness & Koelher , 2012 · Morrison, 2006 · Morrison & Bartlett, 2009 · Vasquez, Sneider, & Comer, 2013) with no distinction between them. It is an interdisciplinary and integrated approach related to the incorporation of the content and abilities of the four distinct STEM fields (The Technology Teacher, 2009 · Journal of STEM Teacher Education, 2014) in teaching and an innovative approach to the design of school curricula. The teaching of Mathematics, Physics and Engineering trains trainees in scientific processes and skills, emphasizing exploration-based learning (Spyrou, 2014), promotes the implementation of the integrated STEM education and is linked to the development of modern economics and the creation of new vacancies.

Education oriented to STEM subject areas aims to prepare trainees for the needs of the 21st century by developing effective communication and teamwork skills enabling them to explore global issues and devise solutions to real-world problems (Pacific Policy Research Center, 2010; Partnership for 21st Century Skills , 2009·Trilling & Fadel, 2009) and additionally to be inventive and creative. The core of STEM philosophy is the development of skills such as adaptability, problem solving, creativity, collaboration, teamwork, critical thinking, learning and innovation skills, and the generalization of knowledge in real environments. According to the Council of Advisors on Science and Technology (PCAST, 2010), one of the major objectives of STEM training is to place particular emphasis on learners' STEM literacy. Furthermore, it enables them to use the content of the STEM subject areas effectively, in order to explore and respond to real-world questions by cultivating communication and collaboration skills (Maryland State Department of Education, 2012). STEM literacy includes Science and Technology literacy as well as literacy in Engineering and Mathematics. Science literacy refers to a person's scientific knowledge and his ability to use it to acquire new knowledge (OECD, 2006). The ability to use this knowledge and its related processes enables trainees to understand the real world and think up solutions. Literacy in Technology refers to the knowledge of technology and the ability to understand, evaluate and use it. Literacy in Engineering refers to knowledge concerning design and construction processes and its integration into the teaching objects as well as the problem solving process. Literacy in Mathematics refers to the ability to understand the science of mathematics and to use the mathematical knowledge to work out problems that arise daily in different situations.

A key feature of STEM learning is the emphasis on teamwork. STEM training integrates teamwork into problem solving (The Partnership for 21st Century Learning, 2015) and fosters collaboration contributing to the improvement of learning.

These skills are particularly useful in our days, so that individuals can face realistic problems in an energetic and reflective way in order to assume the responsibility of their learning process. Working in problem-solving groups contributes to the autonomous way of learning, to developing critical thinking, cultivating communication skills, improving interpersonal relationships, and implementing new knowledge and cognitive strategies. Trainees working together, in a collaborative learning context, maintain their personal autonomy although they are interested in improving their learning achievements both in individual and in collective level (Jonson & Jonson, 1993). By developing their collaboration skills, they ensure the right conditions for a lifelong learning and future professional development (Geijsel & VanderBerg 2002 Sleegers, Toole & Louis, 2002 · Zwart, 2007).

Creating collaborative learning environments helps prepare learners for the needs of modern times through the improvement of their thinking skills, problem solving and knowledge retention (Stohlmann, Moore & Roehrig, 2012). For the development of the 21st century skills, which is a goal of STEM education, learning environments that apply innovative pedagogical approaches are required. These environments promote the redistribution of knowledge, the elaboration of activities that helps learners think scientifically, the development of critical thinking and metacognition as well as the interdisciplinary-interscientific approach to knowledge (Petropoulou, Kasimati & Retalis, 2015).

Modern technology development offers the opportunity to use technologically supported learning environments that most effectively support the teaching of teachers on STEM methodology in order to create the appropriate conditions for the promotion of their autonomy, knowledge creation and the development of metacognitive skills (Parscal, 2006). Thus creates an opportunity to experiment with new teaching methods and approaches and to implement innovative actions, which include problem-based learning activities, virtual learning communities, and exploratory software linked to authentic learning (Kasimati & Papageorgiou, 2013).

Also through problem solving, they can promote research and self-directed learning of learners. Moreover, with integrated STEM teaching, they can create a learning environment that allows the interdisciplinary approach of knowledge, which contributes to the development of cognitive and emotional traits and skills of trainees and to the qualitative upgrading of education (Kasimati, 2006). The creation of a collaborative learning environment favors the achievement of the STEM objectives referred to the development of the scientific literacy of learners and their preparation for the needs of the 21st century. By integrating the four fields into one, it implements innovative pedagogical techniques, linking the new knowledge to the real world and promoting exploratory learning.

Collaborative learning strategies in contexts with technology support provide the opportunity for communication, collaboration and interaction among trainees by providing them with the necessary tools to make knowledge their own (Veskoukis & Retalis, 1999). The Jigsaw Strategy is considered as one of the most popular and effective strategies. This strategy supports the interaction and co-operation of people through the formation of various groups (original and expert). It includes 5 steps: the formation of initial groups, the assignment of specialized roles, the formation of expert groups, discussion on how to present specialized knowledge and the presentation of specialized knowledge to the original groups. The above strategy strengthens trainees' interest in active learning and reinforces their learning and metacognitive skills (Amador & Mederer, 2013· Hanza & Berger, 2007). Through cooperative processes, trainees work together, discuss and make decisions about the completion of the task they have undertaken, that is for the completion of the puzzle, in the same way as in an assembling game. They have the opportunity to specialize in a subject or to come to know its aspects in depth, something that would be difficult for each one to take on himself (Dell'Olio & Donk, 2007). In order to achieve the common objectives, it is necessary all members of each group to become involved. According to the Jigsaw strategy, trainees working in groups of 4 people (general and expert groups) study a lot of information in order to solve a problem they have in common (Petropoulou, 2011). The issues under consideration are authentic issues of the real world, divided into individual thematic units in order to penetrate them in depth, which is an aim of STEM education.

To support adult education programs in electronic learning environments, educational models exploiting digital systems are used (Looi & Tan, 1998 · Parscal, 2006), such as the Cognitive Apprenticeship model, which is likely the most effective teaching model. The Cognitive Apprenticeship Model implemented in conjunction with the Jigsaw Collaborative Strategy in the present study is based on the principles of social constructivism. According to this model, learning is best achieved through interaction (mentoring and support) with peers or people with more knowledge and creates the conditions for active learning (Colins, Brown & Newman, 1989). Due to this, it is widely used in electronic learning environments (electronic education platforms) for adult training (Looi & Tan, 1998).

STEM training can be applied to Learning Management environments (LMS - Learning Management Systems), as for example with the development of the Edmodo platform, which supports collaborative and student-centered methods (Thien, 2013). Edmodo has a user-friendly environment in which the construction of knowledge is cooperatively built by trainees and they can work at their own pace of learning, developing communication and critical thinking skills in a familiar and safe environment (Holland & Muilenburg, 2011). It is one of the

most popular LMS systems built for educational purposes and effectively supports distance learning (Kongchan,, 2013). It promotes communication and interaction among trainees, enabling them to take advantage of a variety of distance learning tools (of both synchronous and asynchronous learning). It supports the creation of virtual classes, where a variety of educational approaches and theories can be implemented within the framework of a constructive approach. Within the Edmodo environment, trainees interact and work together, building common learning experiences and acquiring new knowledge. Its interactive educational environment is intimate and friendly because it displays its functions in a similar way as the Facebook social networking environment does. The easy-to-use communication tools and assessment tools (quiz / portfolio) provided allow the interaction between the trainer and trainees aiming to familiarize themselves with the new learning materials and build new knowledge and skills in accordance with the principles of the constructive learning or approach. The use of the Edmodo learning platform, due to its interactive character, is also offered for personalized distance learning and is considered a safe educational tool for the application of collaborative teaching in distance learning approaches (Thien, 2013).

Purpose of the Study

The aim of the study is to deepen teachers' understanding of the STEM content with the support of an electronic environment and the exploitation of collaborative strategies, their familiarization with the STEM methodology and help them understand the added value of STEM in education.

The research questions of the present research paper are the following:

1. Can STEM-oriented education within an electronically-supported learning environment in conjunction with the Jigsaw Collaborative Strategy enhance trainees' Science and Technology literacy as well as their literacy in Engineering and Mathematics?
2. Can STEM-oriented education in an electronically supported learning environment in conjunction with the Jigsaw Collaborative Strategy strengthen the collaborative skills of trainees?

Research methodology
Participants

For the research purposes, sampling, which is characterized as non-probable, was used. The sample could be described as a sample of convenience or a sample of judgment (purposeful). Specifically, the necessary prerequisites for the participation of teachers in the research study were their training in A level ICT, English knowledge, to have a computer and internet connection, as well as familiarization with the Facebook social network, which has an interface environment similar to the Edmodo environment. The choice of the specific sampling (purposeful, convenient) allows the participation of people who are eager and available for a study (Creswell, 2011) to collect data in order to respond to research questions. Sixteen (16) Primary and Secondary Education teachers of various specialties participated in this survey in the framework of a training program for the implementation of STEM methodology. However, this sample, since it is not subject to the laws of probability but based on specific criteria, is not considered representative and does not allow generalizations.

Procedure –Stages of the research

The participating teachers in the experimental process with the support of a technologically supported learning environment (i.e. the Edmodo platform) communicated with each other and with the trainer asynchronously or in real time. Using the tools offered by the Edmodo Collaborative Learning Platform, they worked as active researchers following the principles and steps of the Jigsaw Collaborative Strategy for a period of about a month, having an active role in the educational process (Constantino, 2002). The Jigsaw Collaborative Strategy was applied in conjunction with the Cognitive apprenticeship model.

In the first part of the experimental process, the participating teachers after creating accounts at www.edmodo.com, using their password, enter the software after they have been informed through their personal email from the trainer about the distance program STEM "Methodology – benefits". Concerns about what STEM is and what the benefits of displaying videos and images in the Edmodo digital class are set.

This stage is followed by the completion of a questionnaire so as to have an initial - diagnostic evaluation of the level of their knowledge in STEM. They are then invited to an online search, study (individual and group) and sharing additional learning material on STEM with other members in order to build new knowledge autonomously. They are provided with supporting material in their "Files" and are assigned the project titled "What in their opinion, the STEM benefits for students are".

The teaching scenario through which STEM activities have been implemented is "Meteorological data - Record of measurements ".To carry it out, special emphasis was placed on the design of online courses about group problem solving, based on the principles of active and collaborative learning, which is also a key feature of STEM training. The "problem-based learning" teaching method was followed and the 6 steps of the Savery & Duffy model (1996) were adopted in combination with the Wood model (2003) (Problem identification - Analysis of the problem - Gathering of information-Synthesis-Publication of the results-Reflection). The research process implemented online in a series of modules included the adoption of the Jigsaw strategy, coupled with the training model of cognitive apprenticeship, on which the STEM methodology was based. The first phase of Cognitive apprenticeship (standardization / modeling) was carried out with the provision of information material so that subsequently trainees have the knowledge to work on their own. The second phase of Cognitive apprenticeship (guiding) was associated with the initial four-person grouping (first step of the

Jigsaw Strategy) and the step related to the assignment of a specialized role (second step of the Jigsaw Strategy). The phase of practice with a decreasing guidance by the trainer was applied to all 5 steps of the Jigsaw strategy. That is individualized help and descending guidance to trainees was offered by the trainer, who has a consultative and collaborative role. Trainees were able to communicate with the trainer during the teaching process with the aim to overcome their difficulties and were encouraged to think and act by recalling knowledge and experiences from the real world. The fourth and fifth steps of the Jigsaw Strategy were applied during the support and attenuation process (scaffolding method) as well as during the exploration phase, which concerned the study of the learning material, the exchange of views, the formulation of hypotheses, the setting of objectives and the collaboration on the way of presenting the specialized knowledge and its presentation to their groups. During the reflection phase they were asked to evaluate the educational process in the STEM methodology, in the technologically supported electronic environment and to express their experiences and feelings. In particular, the procedure followed was divided into three phases as follows:

First Phase

The trainees, after discussion and through Skype communication, create 4 groups, consisting of 4 people each (Jigsaw strategy) and they appoint a coordinator for each group (see **Figure 1**). The teacher then posters supporting material divided into sub-modules on the wall of the digital class to allow teachers to take on different aspects of the subject by coming in contact with each STEM branch not only working individually but also interacting with their group members. This material also includes the thematic sections of the Geography e-book of the first grade of High School and the Geography of the fifth class of Primary School. The 4 members of each group proceed to the in-depth knowledge of each part of the subject: a) Temperature/humidity b) Solar radiation c) Rain d) Light and then interacting in the context of collaborative climate the group's overall work is postered in the digital classroom.
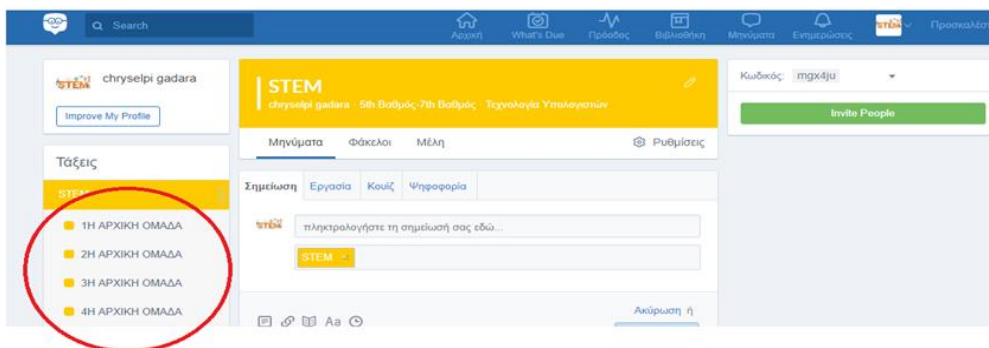

Figure 1. The initial Edmondo groups

Second Phase

In the next phase new expert groups are formed (see **Figure 2**). They are made up of members of the initial groups that have the same role and process the same module. Each member is invited to exchange information and views with his group members about the under examination meteorological element (temperature/humidity, solar radiation, rain, light) that had been studied in his initial group and about the measuring instruments of element. He is also invited to analyze the meteorological phenomenon and its significance for weather forecasting, to make measurements using sensors (with the help of the Arduino program) and then his group is invited to complete the presentation of the specialized knowledge in his initial group in a PowerPoint form. The deepening of their knowledge in the subject after finding additional material and through the discussion and exchange of information intends to teach the subject to their initial group.

After this, he will work collaboratively with the other members in order to take measurements of the meteorological element. He has studied it for over a specific 4-days period, through the Arduino computing platform, after having studied the available information material and the instructions given to him about the use of Arduino and its connection to the sensors of the most important meteorological parameters. A similar sensor will be used to perform the experimental measurements.
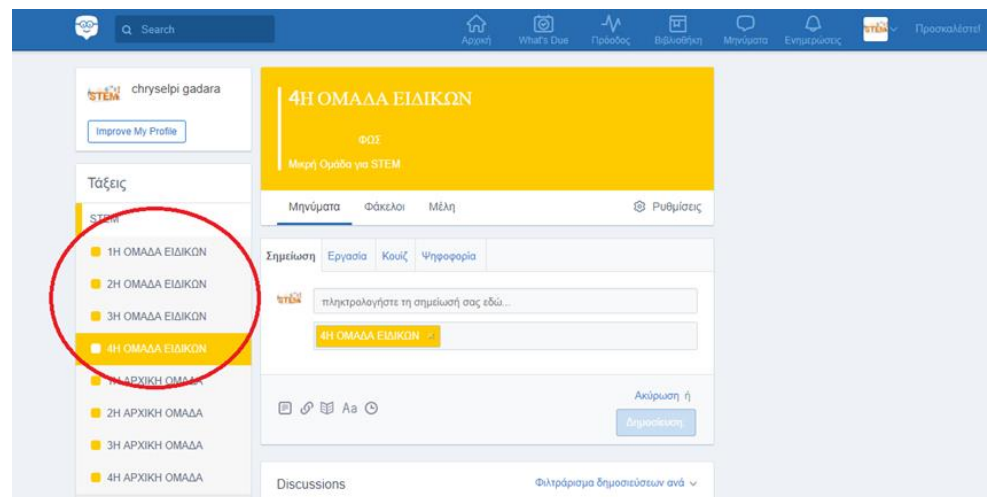

Figure 2. Experts groups' formation on the Edmodo platform

Finally, brainstorming and a discussion about how to present the new specialized knowledge to his initial group are followed within the experts group he belongs to.

There is discussion and exchange of views on the subject under consideration and they move on to the next stage of the implementation of measurements of the meteorological data using Arduino. They are provided with appropriate information about the sensors to be used and about the way of measuring the meteorological data and each group undertakes the connection to the sensor of the natural-size it had studied and the recording of measurements.

Third Phase

At this stage, under the instruction of the trainee, the presentation and analysis of this knowledge follows in the synthesis groups and answers are given to questions and queries formulated by the members of their groups. Online meetings are being conducted on Skype by the trainees themselves in order to evaluate the collaborative process (Dell & Donk, 2007). Diagrams are formed with the data collected and these data are correlated with the weather reports of the specific time intervals. Column tables containing meteorological data measurements and measurements of the official meteorological station of the area are formed in order to test their reliability and the weather prevailing on the days of recording the measurements is recorded. In this way, trainees are involved in learning activities involving STEM applications and its components (Engineering, Technology, Science and Mathematics).

Finally, there is a reflection on the process and the STEM activities in which they were involved, in order to provide appropriate feedback. Their views are shown in the evaluation form of the teaching process provided on-line by the trainer and in the final questionnaire they are asked to complete so that the research questions are answered.

Materials and methods

In the present paper, the questionnaire method (quantitative survey) was used for the data collection so that it responds to the purpose of the research and the possibilities for it to be conducted by the researcher (Vamvoukas, 2010· Creswell, 2011). This method was chosen because it allows participants to choose from a wide range of views and perceptions and includes short questions, clear and understandable and is offered for statistical analysis (Vamvoukas 2010· Makrakis 1997). For the sake of validity and reliability, the questionnaire was granted for pilot implementation to 2 school headmasters and 1 school counselor and the necessary corrections and modifications were made to improve it (Javeau, 1996). The participating teachers through an online form completed the questionnaires.

The questionnaire consisted of 32 close-ended questions (structured response) grouped into four thematic sections with the five-tiered Likert-type scale, which were based on the study of literature and our research questions (Creswell, 2011).

The thematic areas included in the questionnaire concerned the enhancement of literacy in Science, Technology, Engineering and Mathematics, using the STEM methodology and enhancing the collaborative skills of trainees.

More specifically, the initial section includes demographics questions (gender, age, studies, sector of education). The questions of the second section concern the exploration of the degree of familiarization and understanding of the STEM content in the distance learning program in an electronic learning environment. The questionnaire is then divided into two additional sections in order to provide answers to the research questions. The third section contains questions, which explore the degree of reinforcement of literacy in Science, Technology, Mathematics and Engineering, while the fourth section consists of questions that relate to the extent of the enhancement of collaborative skills through STEM methodology in the electronic learning environment.

The measurement of STEM literacy is constituted by 4 factors that are related to literacy in Science (Scientific literacy), Technology (Technological literacy), Mathematics and Engineering, in line with the objectives STEM education (Maryland State Department of Education, 2012). For the measurement of cooperation skills, the following three sub-dimensions (Thomson & Perry, 2006) are under consideration: The social dimension. It is related to the degree of the trainees' participation in the group, with the participation of each member in the collective decisions and the degree of support to the group beyond the tasks assigned to them. The individual dimension. It relates to each member's behavior in the group and the degree of responsiveness to his / her obligations to complete the group's work. Organization and Management. It is related to the members' involvement in defining the goals of the group, allocating group responsibilities and defining their roles within it.

Survey results

For the data processing, charting, and hypothesis statistical tests the SPSS 23.0 (64-bit) statistical packet and Excel 2016 (64-bit) for the Windows operating system were used.

Survey restrictions

The size of the sample was limited and related to specific geographical areas. The sample of the survey is convenient or opportunistic, since it included teachers to whom there was easy accessibility by the researcher and therefore does not allow generalizations (Cohen, Manion & Morrison, 2008). As a result, the survey data cannot be generalized, and we consider another research necessary and useful. This new research will involve a larger number of participants and will not be limited to the use of the quantitative tool of the questionnaire, but will also use qualitative data collection methods for the investigation of the issue (Bird, Hammersley, Gomm & Woods, 1999).

Descriptive statistical analysis

Demographics

The results of the survey refer to a sample of 16 teachers of Primary and Secondary Education, 6 men and 10 women. In particular, the composition of the sample is as in **Table 1** below:

Table 1. Participants' gender

Gender	Frequency f_i	Percentage %
Male	6	37.5%
Female	10	62.5%
Total:	16	100.0%

The distribution of the different age groups to which the participants belong shown in **Table 2**:

Table 2. Participants' age groups

Age	Frequency f_i	Percentage %
Up to 30	4	25.0%
31-40	3	18.8%
41-50	5	31.3%
Over 50	4	25.0%
Total:	16	100.0%

Participants' studies shown in **Table 3** below:

Table 3. Participants' educational level

Education	Frequency f_i	Percentage %
University Education	7	43.8%
Technological Education	1	6.3%
Second Degree	1	6.3%
Postgraduate Degree	7	43.8%
Total:	16	100.0%

Finally, **Table 4** shows the level of education in which the participants serve:

Table 4. Participants' occupation

Education level	Frequency f_i	Percentage %
Primary education sector	9	56.3%
Secondary education sector	7	43.7%
Total:	16	100.0%

Analysis of results

Understanding – becoming familiarized with the STEM content

As far as the degree of understanding the STEM content is concerned, it is found that the majority (more than 50%) of the respondents in the sample replied that they understood the STEM content 'much' after the end of the didactic intervention. A percentage of 31.25% said they understood STEM 'very much' and a small percentage (12.5%) answered 'enough' (see **Diagram 1**).
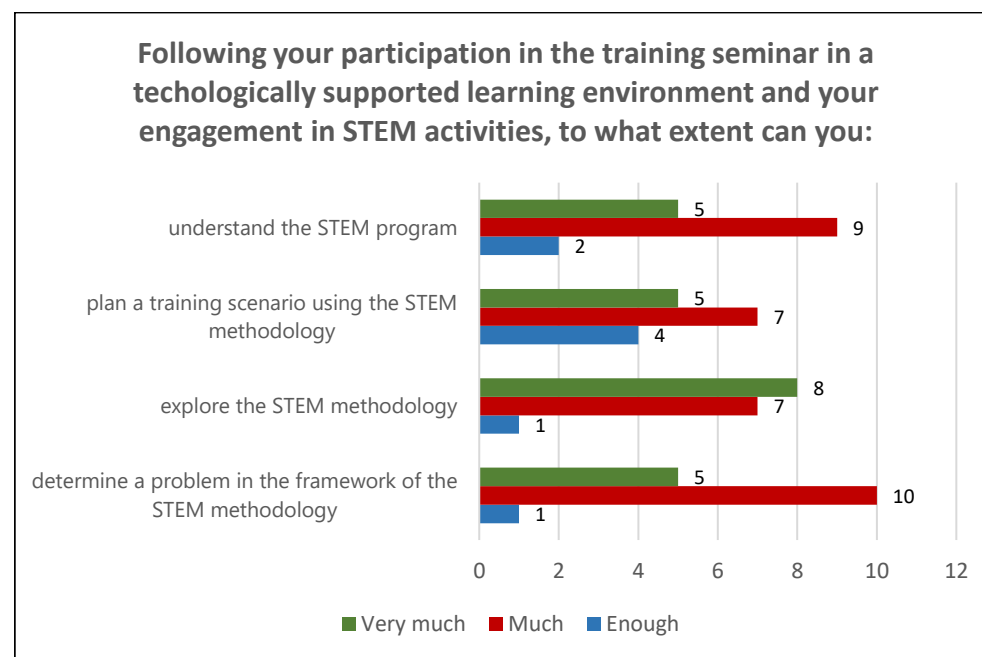

Diagram 1. Degree of understanding the STEM content

Findings regarding the analysis of the first research question, "Does the use of the STEM methodology in an electronically supported learning environment develop the trainees' Scientific and Technological literacy as well as literacy in Engineering and Mathematics?", are given below.

The following results were obtained from the processing of the questionnaires regarding the degree of reinforcement of the scientific literacy of the trainees (**Diagram 2**): a) The majority (62.5%) of the survey respondents believes that using the STEM methodology can greatly assist

trainees in investigating. b) The highest percentage (68.8%) considers that using the STEM methodology can greatly help trainees understand the scientific ideas. c) The vast majority (62.5%) believe it can help them to carry out experiments with the appropriate scientific tools for understanding the world. d) The highest percentage (68.8%) considers that using the STEM methodology can much help learners to use scientific terminology. e) 37.5% of the respondents in the sample believe that it can much help trainees to know the use of scientific methods. f) 50% of the participants consider that using the STEM methodology can much help learners to use scientific knowledge to understand and influence the physical world.

The bibliographic references (Kermani & Aldemir, 2015) are verified according to their responses, whereby the creation of a science-focused curriculum contributes to positive changes in the trainees' learning. With the STEM program, according to the literature, the trainees become scientifically-mathematically-technologically literate and acquire the ability of effective communication (Maryland State Department of Education, 2012). Trainers with appropriate practices can help trainees make connections between past knowledge and the new concepts introduced (Mantzicopoulos et al., 2009), thus increasing their interest in science, which can hardly be changed during adulthood (Archer, DeWitt, Osborne, Dillon, Willis, & Wong (2010)) and achieving their learning goals.

As far as the degree of support of the Technological literacy of trainees (see **Diagram 3**) is concerned, it is noted that: a) 43.8% of the respondents believe that the use of the STEM methodology can help to strengthen the trainees' ability to know and understand the development of technology and its affection to the world. b) The largest percentage of the respondents, 43.8% think that it can greatly help to increase the trainees' ability to solve everyday life problems using technology. c) The majority of them (50%) think that it can enhance the ability to understand the technological tools and their operation very much. d) 43.8% says that it can help a lot in developing the right technological tools. According to the research data, an environment with high quality programs (such as STEM programs) emphasizing student-centered teaching promotes learning in Technology and other sciences (Kermani & Aldemir, 2015).

Regarding literacy in Mathematics: a) 37.5% of the sample considers that using the STEM methodology can help trainees understand the science of Mathematics and generalize problem solving, and in other cases. b) The largest percentage (56.3%) stated that it could greatly help learners to use Mathematical thinking and to communicate ideas in an organized and methodical way. c) 37.5% thinks it can enhance the ability of trainees to use mathematical knowledge to solve problems in different situations. The literature confirms the importance of STEM in the development of literacy in Mathematics. According to bibliographic references, special emphasis ought to be given on STEM education, if children are problem solvers that are constantly evolving, and their experiences at an early age are important for the formation of their brain (Sripada, 2012).
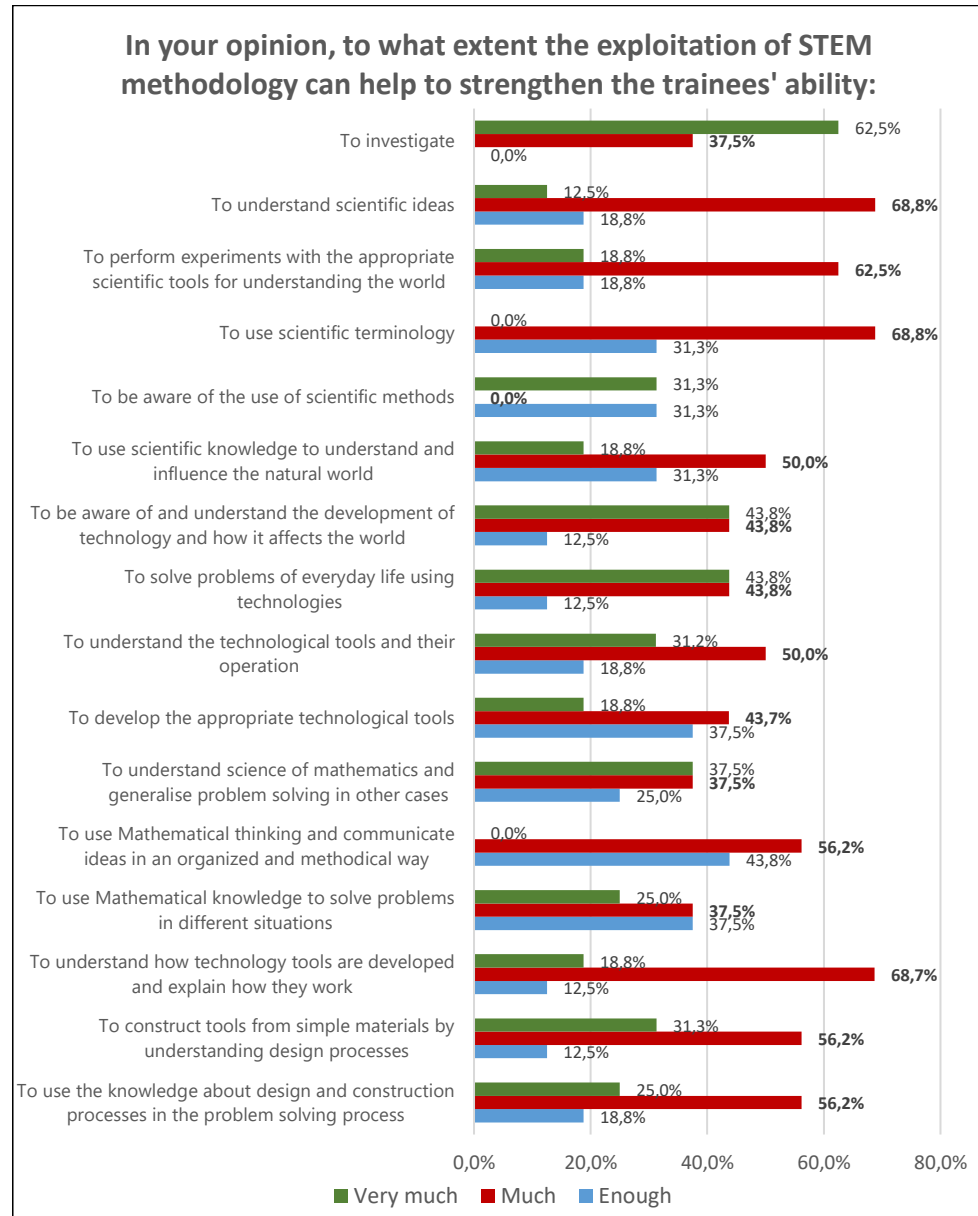

Diagram 2. Degree of reinforcement of the scientific literacy of the trainees

To what extent, in your opinion, the STEM methodology can help trainees:
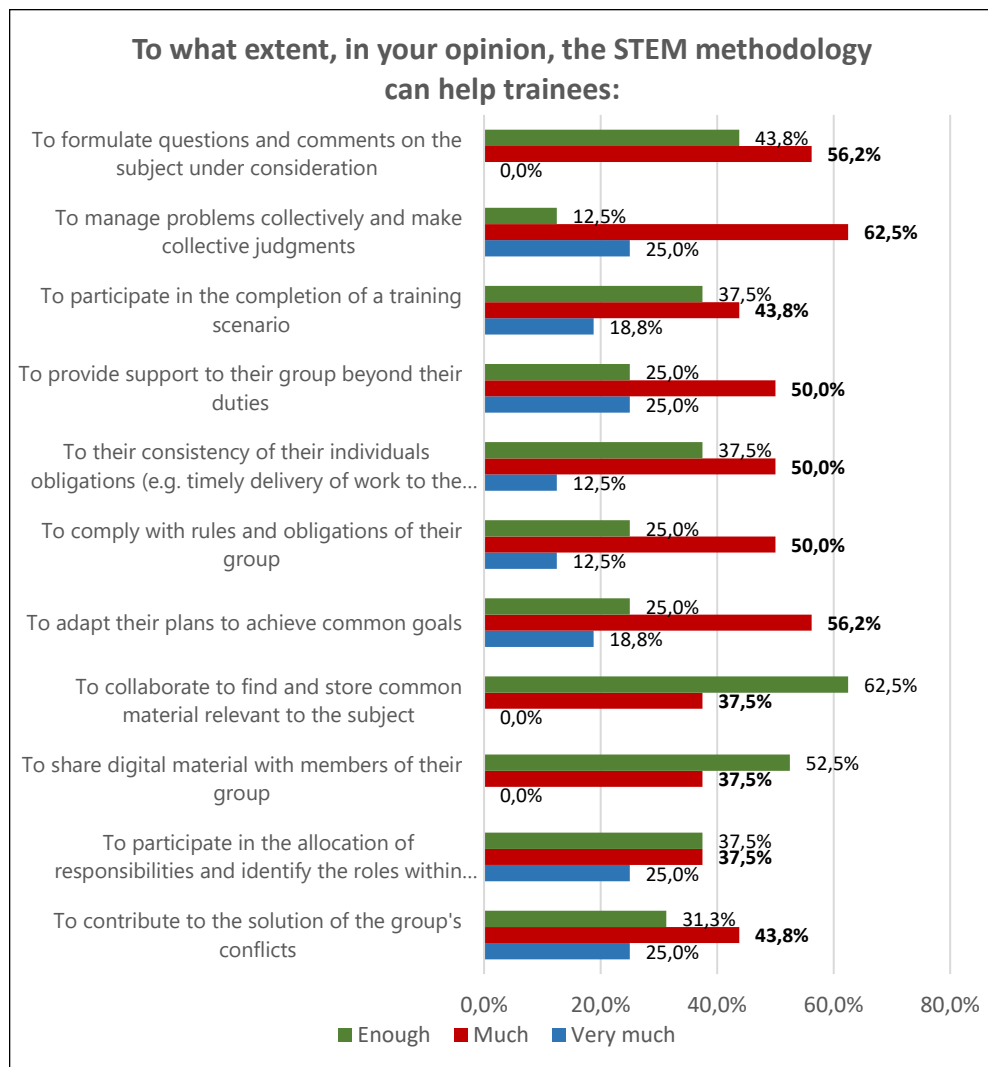

Diagram 3. Degree of support of the Technological literacy of trainees

As for the degree of amplification of literacy in Engineering: a) The overwhelming majority (68.8%) of the respondents who completed the questionnaire believe that using the STEM methodology can much enhance the ability of trainees to understand how technology tools are developed and explain how they work. b) The largest percentage (56.3%) thinks it can help a

lot towards constructing tools from simple materials by understanding design processes. c) The majority (56.3%) of the sample respondents considers that using the STEM methodology can enhance the ability of trainees to use knowledge related to design and construction processes in the problem solving process. It is noted that there is agreement with the bibliography as for the enhancement of literacy in Engineering through STEM programs. According to the research data, it is necessary for the literacy in engineering the teachers to know how to integrate engineering into the educational process, since it is very important to start from the stage of the first years of the trainees (Bagiati & Evangelou, 2009).

As far as the second research question is concerned, i.e. "to what extent the use of the STEM methodology in an electronically supported learning environment in conjunction with the Jigsaw Collaborative Strategy can enhance the collaborative skills of learners", according to the views of the participating teachers, it has a positive impact on the dimensions of cooperation, namely social and individual as Organization and Management. More specifically, with regard to the social dimension of cooperation, the overwhelming majority considers that using the STEM methodology in an electronically supported learning environment coupled with the Jigsaw Collaborative Strategy can greatly enhance the ability to externalize thoughts to the extent of participating in group discussions and in collective decision-making. As confirmed by bibliographic references, through collaborative learning, trainees share experiences and develop all kinds of skills (Efthimiadou, 2011). Through discussion and exchange of ideas, the possibility of finding the most appropriate solution increases, learning is promoted as individuals review their personal beliefs and promote the group's bonds (Arapoglou, 2010). Knowledge is built through argumentation, exchange of ideas and discussions in collaborative environments-in a social environment (Comis, 2004). Collective decisions are more advantageous as members participate equally in finding the most appropriate solutions. Trainees extend their knowledge through interactiion with their group members who have the role of cognitive resources, more willingly responding to any difficult situations or problems (Wilson, Ludwig-Hardman, Thornam & Dunlap, 2004).

As for the individual dimension of collaboration, from the given answers it is noted that the highest percentage believes that using the STEM methodology in an electronically supported learning environment in combination with the Jigsaw Collaborative Strategy can greatly enhance the trainees' ability to participate in the completion of the individual project and the adaptation of their plans to the achievement of common objectives. It is confirmed that there is agreement with the literature that through collaborative learning the members of a group complete their individual work and participate effectively in group work, resulting in a better achievement of their learning goals (Tsay & Brady, 2010).

As far as the third dimension of co-operation (organization and management) is concerned, it is clear that the majority of participants believe that the use of the STEM methodology in an

electronically supported learning environment coupled with the Jigsaw Collaborative Strategy can enhance the trainees' ability to a very large extent in participating in the allocation of responsibilities and the definition of roles within the group, resolution of conflicts and consistency in their individual obligations. The distinction and distribution of roles and a number of other factors influence the efficiency of collaborative activities according to the literature (Kampourakis, 2006). Collaborative learning strategies enhance cooperative interaction among group members and provide facilities for the sharing - dissemination of knowledge (Lipponen, 2002). By adopting the STEM methodology, trainees' development and the development of their cooperative skills are enhanced, while communication and learning outcomes are facilitated (Yakman, 2012).

The analysis of the results reveals that the involvement of trainees in STEM activities in a technologically supported learning environment coupled with collaborative strategies enhances communication and interaction among them. It increases their involvement in the learning process, reinforces their literacy in the STEM fields and strengthens their collaborative skills.

According to the literature, the acquisition of skills in the four STEM fields by young trainees contributes decisively to their integration into organized education programs (Rallis & Kassotakis, 2012) and to the cultivation of key skills such as problem solving.

Cronbach' alpha reliability test

Cronbach's a-factor is a well-known and widely used indicator of the credibility of the intrinsic coherence of the questionnaire. It calculates the correlation of each questionnaire item with any other element of the questionnaire (Cozby & Bates, in Panagiotakopoulos & Sarris, 2015).

In the present study, the confidence index of the scale was very high (Cronbach's α = 0.95), as shown in **Table 5** below.

Table 5. Cronbach's alpha

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.954	.955	32

The t-test criterion

The purpose of inferential statistics was to evaluate the survey data (variables, sample, measurement scales), to investigate the relationships between independent and dependent variables and to draw conclusions by selecting the appropriate statistical criteria (Panagiotakopoulos & Sarris, 2015). These criteria concerned a) the number of research cases b) the number of variables (independent and dependent) c) the level of measurement used and is also influenced by the number of samples (sub-groups) and whether they are dependent or independent (Cohenetal., 2007). Samples are considered independent when there is no relation to each other, as for example in the case of sex.

Since in the present study each individual participates only in a gender-based group (either in the male or female group) and at the education sector (either in the Primary or Secondary sector of education) to which he belongs, the criterion t-test was used for independent samples.

In applying the t-test criterion, the p (p-value) was calculated and compared to the statistical significance level in order to derive the appropriate conclusions as described below. More specifically, the following steps were followed (Emvalotis, Katsis & Sideridis, 2006):

1. Checking the regularity of data (a precondition for control t)
2. Determining the initial (zero) case (that there is no difference between the population average and the default value) and the corresponding alternative case.
3. Definition of significance level.
4. Performing control t
5. Finding the value p
6. Comparison of the value p with the materiality level

In the present study the significance level was set at 5% and therefore for a p value of less than 0.05 the zero hypothesis H0, whereas for p> 0,05 the alternative hypothesis H1 should be accepted and rejected.

The t-test was applied to all sub-questions of the three questions and the validity of the zero case for the responses of the two independent gender groups (men and women) and the level of education to which they belong (Primary or Secondary sector of education).

As can be seen from these results, the p value in all cases is greater than the significance level (p> 0.05) and therefore the zero hypothesis H0 is accepted. Therefore, we can say that there is no statistically significant difference in the responses between men and women. Similarly, there appears to be no statistically significant differentiation of responses depending on the sector of education to which the respondents belong.

Certainly, the small size of the sample must be highlighted and therefore the disputed question of the regularity of the data, and consequently the conclusions drawn from the selection of the relevant criteria (parametric and non-parametric criteria), their application, as well as of their generalization.

Conclusions - Discussion

With the present study, it was attempted to train teachers in STEM methodology through a technologically supported learning environment. The design, development and implementation

of this scenario was based on the Cognitive apprenticeship model in conjunction with the Jigsaw Collaborative Strategy, so that the participants become acquainted and familiar with the STEM methodology and obtain a deeper understanding of STEM while building on innovative collaborative strategies. On the one hand, the gap in the bibliography on the implementation of STEM activities in education was filled and on the other hand, the extent to which STEM education contributes to the enhancement of literacy in Science, Technology, Mathematics and Engineering as well as the development of cooperative skills was explored.

The conclusions from this study are:

- With the participation of teachers in a STEM methodology in an e-learning environment, a deeper understanding of STEM content and familiarization with the STEM methodology was achieved. In their view, teachers were able to become familiar with and understand the STEM program, design an educational scenario by using the STEM methodology, explore the STEM methodology and delineate a problem in the context of STEM methodology.
- Teachers involved in STEM activities related to Science, Technology, Mathematics and Engineering researched, tested and solved problems by acquiring STEM skills. The data that emerged from the analysis of the answers of the trainees to the questionnaire questions showed that the exploitation of the STEM methodology significantly reinforces:
  - literacy in Science
  - literacy in Technology
  - literacy in Mechanics
  - literacy in Mathematics
- During the experimental process in a technologically supported learning environment based on problem-based learning, teachers, with the implementation of Jigsaw Collaborative Strategy, gathered and shared material, discussed and exchanged ideas and opinions, interacting with their group members in their initial groups as well as in the experts groups. Working individually and in groups, they have created a collaborative climate in order to achieve the objectives of the educational scenario and developed their collaborative skills, consisting of the social dimension, the individual and the organization-management. More specifically, according to their views, their engagement in STEM activities has helped in (a) participation in group discussions, collective problem management and collective decision-making, (b) consistency in respecting the rules and individual obligations of the group and (c) their involvement in the allocation of responsibilities and the definition of roles within the group.

From the answers that emerged it appears that using the STEM methodology in an electronically supported learning environment with the Gnostic apprenticeship model combined with collaborative learning can enhance the ability for scientific, technological literacy and literacy in Mathematics and Engineering. In addition, it can enhance the collaborative skills of trainees.

Therefore, education in STEM methodology is seen as an imperative of the modern age, since it responds to the constantly changing needs of society and the labor market. The design of courses based on the four components of STEM is a teaching proposal to enhance innovation, creativity and problem solving, which are among the major skills that modern and future people need to cultivate.

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