SCHOOLS STUDY EARTHQUAKES

Guide of Good Practice

Erasmus+

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1. Introduction

“Schools Study Earthquakes” (SSE) – ID code: 2015-1-EL01-KA201-013966, is a project developed in the framework of Erasmus+ programme - K2 Key Action “Cooperation for Innovation and the Exchange of Good Practices”. The project started in September 2015 and will finish in August 2017 involving six different organizations from five different European countries. It focuses on the study in the reality of classroom practice of a physical phenomenon with great societal impact and proposes pedagogical practices based on inquiry-based methods that are more effective in science education. The objective of this combination is on one hand to increase youngsters’ interest in science, on how science is made and how it affects every-day life, and on the other to stimulate teachers’ motivation on up-taking innovative teaching methods, subjects and practices to enrich and renew the science curriculum. SSE project also provides increased opportunities for cooperation and collaboration between schools across different areas and countries and encourage relationships between stakeholders of both formal and informal education.

This guide would resume the main steps covered by the project from its beginning as well as the most significant results gathered so far, and then represents a reference point to the teachers in physics and science, as well as to everybody who would exploit the educational resources developed in the framework of SSE. The guide is divided into three main parts: the first part briefly outlines the general features of the project, the members of the consortium and the main educational products developed in its framework; the second outlines the most significant actions carried out and the results achieved in its implementation phases in each country; the third part is a report describing in detail the evaluation process and the related results gathered by each partner organization.

1.1. General

Science and education play a key role in everybody’s life. Thanks to scientific and technological advances that many aspects of our life, such as entertainment and health, have improved dramatically over the last twenty years. Scientific discoveries have already changed and will continue to change our life styles with some profound effects on society. The world has never been so complex, and understanding what is happening, knowing how to choose and use technology, and gaining an understanding of scientific facts help to make informed decisions. Over the years scientific and technological discoveries have increasingly shaped our daily lives, it is also fair to say that people can influence the work of scientists and engineers by taking decisions that will have an impact on future social structures and environmental choices. Thus, the publication The Next Generation Science Standards, developed by 26 American states, reads: “Science is also a key to the United States’ ability to continue to innovate, retain the role of leader of the global economy and create future employment opportunities[1]”.

If Europe intends to make technological advances as well, improve the quality of life of its citizens and compete at the global level, its students must have a solid scientific education in preparation for their university studies and careers. On the contrary, however, the percentage of scientific graduates is falling. “The resulting lack of skills in these sectors is now perceived as a threat for the current economies, based on technology and science. Therefore, the majority of European countries have taken the increase in the number of graduate students in math, science and technology as one of their priorities (Eurydice-EACEA, 2012)”. All the measures that may help to increase students’ motivation to learn about science, math and technology are necessary actions to take. Yet few of these countries have developed national strategies to elevate the scientific profile and are instead continuing to endorse non-systemic programs and initiatives.

The enhancement of teachers’ competences is also regarded as a key factor in the strategies that can be deployed in order to strengthen scientific education. And the enhancement of teachers’ training is among the first actions taken by those European countries that pursue a national strategic framework aimed at the promotion of scientific education. In Europe, education authorities provide specific and constant training activities for teachers. “School partnership, associations, science centres and similar institutions contribute to teachers’ informal training” (ibid.). In most of these countries, the knowledge and ability to teach scientific courses are considered to be the most important skills in teacher training.

1. Achieve, Inc. on behalf of the Twenty-six States and Partners that collaborated on the NGSS (2O13).

School associations in partnership with universities, research institutes, museums and science centres are widespread in Europe. This cooperation can be extremely diverse - in terms of the partners involved, the way they are structured and the geographical areas they cover - however they all pursue at least one of the following objectives: promoting scientific culture, understanding what science is for, strengthening scientific education, increasing work in the scientific field. “The science centres share one or more of the afore-mentioned objectives and contribute towards the improvement of scientific education by providing students with activities that go beyond those usually offered in schools. Two thirds of the European countries under review declare to have scientific centres at the national level” (EurydiceEACEA, 2011).

But how do we teach science in school? Almost anywhere in Europe, science is taught as a complementary subject throughout primary school education. However, in most countries this approach only lasts until the first two years of lower secondary education. Afterwards, science education is divided in different subjects like biology, chemistry and physics. Moreover, while most European countries recommend that scientific education should be put in context and in relation to contemporary society and its issues, traditional teaching methods are still prevailing. Therefore, traditional teaching can be combined with active and participatory approaches based on inquiry processes (IBSE, Inquiry-Based Science Education) aimed to make science teaching and learning more effective.

Starting from the statements exposed above, the SSE project assumes a significant value also considering the heterogeneous features of its partner organizations whose activities range from research in Geophysics and Science Education, to formal and non-formal education, communication and dissemination in science, etc. This wide range of expertise has represented an advantage to ensure the best development of the actions expected by the project.

1.2. Non-formal education in seismology

Since the 1990s, the widespread availability of ICTs has implicated the development of several projects aimed at the non-formal teaching of seismology. These projects were mainly based on the sharing in network of seismic data detected by digitally controlled seismographs, usually located in schools establishments. Below are mentioned some of these projects, many of which are still underway thanks to the positive feedback they have received in the school world: "P.E.P.P." and "Seismographs in Schools" in the US; "Sismos à l'école" in France; "UK School Seismology" in the United Kingdom; "Seismology in Schools" in Ireland; "Edu-Seis" and "Sismoscholar" in Italy.

In this regard, it is worth highlighting some of the reasons which, in our opinion, are the source of this success: firstly, the disquieting suggestion that a natural phenomenon such as an earthquake exercises on the public opinion and the consequential widespread desire to deepen the rational knowledge about them; moreover the so-called "transversal" aspect of the subject on a variety of disciplines ranging from Earth's sciences to the mechanics of elastic bodies, then passing on the disciplines related to the technology of seismic devices (mechanical, electromagnetic, electronics), finally reaching issues of more explicit social interest such as civil protection and seismic prevention. These aspects entail the employment of different competences highlighting therefore the effective educational value of this subject. Finally seismic data acquired in digital format and distributed on the internet are real experimental data and can be studied qualitatively and quantitatively by students and teachers with a positive didactic relapse analogous to that derived from any laboratory activity that involves the direct development of real experimental experiences such as the reproduction of a chemical reaction in the respect of the right stoichiometric proportions, or of a mechanical experiment using appropriate execution and measurement procedures.

In this context the Erasmus+ project "Schools Study Earthquakes" is characterized by significant advantageous features due to both the experience already gathered from the projects described above and the fact that it is the first one involving as partners all organizations coming from countries of south-eastern Europe, each of them characterized by a remarkable seismic risk .

Moreover the features of partner organizations are heterogeneous ranging their missions from research in Geophysics and Science Education, to formal and non-formal education, communication and dissemination in science, etc. This wide range of expertise has represented an advantage to ensure the best development of the actions expected by the project.

2. General features

2.1. Consortium of partners

The SSE consortium is composed by six different partners coming respectively from Greece, Cyprus, Bulgaria, Turkey and Italy. Since the beginning of the project the consortium has established a management strategy in order to assure in-time delivery of best-quality project outcomes according to the work plan and within budget, effectively addressing any organizational and operational issues that may arise, and maintaining a close coordination with the European Commission.

Partners have continuously provided their input to all project phases, which have culminated the necessary cross-links between theory and practice and improve the quality assurance of the work agenda. As Project Coordinator, the National Observatory of the Athens has provided a hub for advice, contact and guidance as required, sharing insights and knowledge with all the consortium partners. The coordinator has, thus, monitored closely the progress of each deliverable in general and the work of each Project Activity in particular, overseeing and supporting the activities involved in the whole project.

Below are listed the partners of the consortium and are described their main tasks in the in the framework of the project:

National Observatory of Athens, Greece (NOA)

The National Observatory of Athens (NOA) - the project coordinator - was established in 1842 by the Vienna-based national benefactor George Sinas. It carries out state-of-the-art basic and applied research in collaboration with other world-leading research centers. The activities of NOA are organized in 3 institutes staffed with high quality scientific, research and technical personnel: the Institute of Astronomy, Astrophysics, Space Applications and Remote Sensing, the Institute of Environmental Research and Sustainable Development, and the Institute of Geodynamics. NOA's research activities are focused on the terrestrial interior, the atmospheric environment and Space, from the interplanetary medium to the astronomical Universe. Basic and applied research is conducted by using observational data from hundreds of ground based stations and several modern space probes. The Centre, with its rich scientific outcomes and activities, is linked to entrepreneurship, culture, education and the popularization of science. NOA offers critical social services, such as a daily monitoring of seismicity and issuing earthquake alerts to the Greek State Authorities on a 24/7 basis, weather forecasting, forest fires monitoring, ionospheric activity recording, continuation of a 150 years long climatic dataset and operation of one of the largest European telescopes. It also provides the national gate to the European Space Agency. The research centre has also an important contribution to public outreach via its popular visitor's centers at Penteli, Thission and the Geoastrophysics Museum. The Institute of Geodynamics (I.G) is one of the oldest Institutes in Greece operating continuously since 1893. In 1897 the first seismograph was installed in Athens and in 1899 the first seismic network started to operate. Since then, systematic and detailed seismic observations started for the region extending from 34B° to 42B° N and 19B° to 30B° E. The location of the Head Office of I.G is on the hill of Nymphs, opposite to Acropolis, at the center of Athens. It is the main center in Greece, for the continuous monitor of the seismicity of the country and reporting to national and international authorities. Moreover Institute's aim is the study and research in the fields of: seismology, physics of the earth›s interior, geophysics, plate tectonics, volcanology and geothermy, neotectonics, tsunamis, seismotectonics and Engineering Seismology. Main tasks of I.G are collection and processing of various seismological - geophysical parameters, the elaboration of research projects and relevant studies, the training and services provided to third bodies. The contribution of I.G to the Higher Education is also strong. A lot of undergraduate, postgraduate and PhD theses have been carried out at the Institute. I.G collaborates with Universities and Research Centers in Greece and abroad in order to carry out scientific research on various seismological and geophysical themes. The I.G operates around the clock, 365 days a year and has also a crucial mission to inform the Government, the General Secretariat of Civil Protection, the Earthquake Planning and Protection Organization (E.P.P.O) and the Public about the seismic activity of Greece.

Ellinogermaniki Agogi, Greece (EA)

Ellinogermaniki Agogi (EA) is an educational organization of private law, officially recognized by the Greek state. It is an institutional member of EDEN (European Distance Education Network), of STEDE (Science Teacher Education Development in Europe) network and of ECSITE (European Network of Science Centres and Museums) network. EA was the first Greek educational organization, which applied Open Distance Learning in secondary level education in the year of 1993. Since 1998, the organization has established a devoted department, the Research and Development (R&D) Department for the design, development and implementation of the research activities in education, expanding the collaboration with Universities and pedagogical Institutions across Europe. The R&D Department acts as interface between the pedagogical research, the technological innovation and the school community. The work of the R&D department which currently employs 18 full time researchers (10 with PhD, 8 at MSc level) focuses on the following areas: a) the development of methodologies and empirical research to investigate processes of learning and knowledge acquisition in various subject-matter areas (physics, mathematics, biology, history, etc); b) the collaboration with computer science departments and artificial intelligence labs for the development of computational models and AI learning systems; c) the collaboration with Universities and private companies for the development and testing of educational software; and d) the design of technology supported learning environments.

During the last years the R&D department has coordinated and supported the participation of EA in more than 100 European (eContent-Plus, ICT-PSP, SiS and e-Infrastructures in FP7; ICT in FP6; IST in FP5; LLP-ACT, Socrates, Leonardo da Vinci) and National projects. In most of them, the main role of the research group is the design of technology-enhanced educational and learning activities, development of innovative teaching methodologies and practices in science education, the implementation of the proposed activities in real school environments at national and international level, the organisation of international summer courses for science teacher trainings. EA is the leading partner for the implementation in schools the largescale FP7 projects "Inspiring Science Education", "Global Online Science Labs for Inquiry Learning at School", "Ark of Inquiry: Inquiry Awards for Youth over Europe" which involve thousands of secondary education schools from various countries around Europe.

University of Cyprus, Department of Education, Cyprus (UCY)

The Research in Science and Technology Education Group (ReSciTEG) of the University of Cyprus conducts a co-ordinated program of research, curriculum development and instruction. The group includes faculty, research associates, post-doctoral students and graduate students (both at the Master's and PhD level). The director of ReSciTEG is Dr. Zacharias C. Zacharia. The ReSciTEG members have a lot of experience with designing STEM oriented curriculum and with designing and implementing online inquiry oriented environments for science teaching and learning purposes. Additionally, the ReSciTEG members have a lot of experience with evaluating skills related to the cognitive and affective domain. The group is taking a leadership role in the efforts of the Ministry of Education of Cyprus to implement its eLearning strategy through a series of projects including topics such as designing multimedia environments for science teaching and learning. ReSciTEG's work has received continuous financial support over the years from the Cyprus Research Promotion Foundation and theEuropean Commission (through various programs e.g., IST, Science and Society, FP 7). Finally, the ReSciTEG members have published papers related to all these research projects in many major journals (e.g., Science, Cognition and Instruction, Learning and Instruction, Journal of Research in Science Teaching).

Bahcesehir Eğitim Kurumları Anonim Şirketi, Turkey (BEKAS)

BEKAS was founded with the mission of providing of the highest and most contemporary education, while always holding dear the principle of equality of opportunity began providing education at its site in the Istanbul suburb of BahΓ§eΕџehir. BEKAS decided to expand operations to incorporate educational activities in the Anatolian part of Turkey. BahΓ§eΕџehir Collages with its painstakingly-developed corporate structure, both in its existing schools and those that it will open in future, endeavours to provide the same high quality of education in keeping with its well-established quality standards. To ensure uniformity of high standards necessitates involving both administrators and teachers at each stage of the decision-making process as well as cooperating closely with our affiliated institutions to obtain support with regard to key related issues. BahΓ§eΕџehir College, that in cooperation with BJK College, provides high-quality education at its 42 kindergartens, 27 primary schools, 16 high schools and 4 science museums at 25 different provinces, aims to increase the number of schools to 150 within the next three years and so reach a total of 350 schools on three continents by 2023, consequently ensuring a position for itself as one of the world'slargest, most successful and respected educational institutions. Our target is to provide an education of the highest quality, delivered in state-of-the art well-equipped educational environments by a highly-educated and informed, enlightened, contemporary-minded and dynamic educational personnel all sharing the same vision that places priority on the importance of the acquisition of knowledge and encourages values of research-mindedness, entrepreneurship and individual interaction and incentive and personal creativity. The research personnel for this project in the school have strong university research background and European project experiences. The science courses in the school are taught using Inquiry Based Science Education methods. The design of the science laboratory in the school gives students freedom to conduct their experiments using open and guided inquiry. BEKAS is a partner of Ark of Inquiry Project which is supported by FP7 of European Union.

Fondazione Idis - Città della Scienza, Italy (IDIS)

Fondazione Idis represents a system of excellence in non-formal education in Italy: public engagement in science, innovation in science education and the development of innovative teaching methods are the core of its mission. Fondazione Idis is officially commissioned by the Italian Ministry of Education as training body in science education. Città della Scienza is the science centre of Fondazione Idis and hosts in its spaces permanent and temporary exhibitions reserved to relevant scientific subjects. The most of these exhibitions endorse an interactive and "hands-on" approach, and are developed in partnership with research organizations or other museums and science centres. In 2015 about 100.000 peoples have visited the spaces of Città della Scienza and the 70% of them were pupils of all levels. Città della Scienza is member of the board ECSITE - the European Network of Science Centres and Museums – and of ASTC – the Association of Science – Technology Centers. Since its origins Città della Scienza has been customary in carrying out non-formal educational activities in basic sciences (such as physics, biology, biotechnology, Earth science, etc.) intended for pupils from primary to high school. In the last years these educational initiatives have been extended to other subjects as robotics, coding, digital fabrication, health education and nutrition. Facilities includes 8 laboratories equipped for science and multimedia activities, a web TV, as well as an extensive system of IT services (cloud computing and Microsoft Learning Room) and the D.RE.A.M. FabLab also seated in Città della Scienza. Actually about 1.000 non-formal educational activities per school year are carried out in the laboratories of Città della Scienza involving about 25.000 school pupils. Moreover Città della Scienza proposes training activities in non-formal education in science intended for school teachers of all levels.

National Research Network Association, Bulgaria (NRNA)

The Bulgarian National Research Network Association (NRN Association or NRNA) is registered under the Bulgarian Law as a non-for-profit legal entity carrying out activities to public benefit. Among its founding members are the biggest universities in Bulgaria, Bulgarian Academy of Sciences, Ministry of Transport and Communications and ICT Development Agency. At present the organization comprises 25 academic members, as well as the Ministry of Education and Science, where is registered the official address of operation and associations' headquarters. The Association achieves its objectives by the following means: Building up and maintenance of virtual spaces (Internet portals) for idea and information exchange among the users of the research networks, as well as between broad social groups that use the new information and communication technologies; Support and participation in projects and initiatives for the development of the information technologies in Bulgaria and abroad; Organization of information workshops and trainings for different social groups, including distance learning; Supporting the education and qualification of pupils, students and specialists, working in the field of the information technologies; Technological, administrative and financial optimization of the connections of Bulgarian organizations and individuals of the scientific, information and cultural spheres to the research networks; Provision of support to schools and educational institutions that offer ICT training; Organization of educational seminars, conferences, symposiums, exhibitions and other public events dedicated on the promotion of advanced information technologies and multimedia information services; Consulting on technological solutions on ICT Projects, as well as participation in national and international initiatives aiming at the ICT development in the European countries.

2.2. Materials for teachers

Several supporting materials have been developed under the guidance and collaboration of the partners of the consortium to better address the educational contents of SSE, as well as to allow the teachers to independently adopt, adapt and implement the educational approach of the project.

Pedagogical Framework

This first intellectual output of SSE represents a tool aimed to better address the educational contents of the implementation phase. It is an essential part of the project as it is laying out the theoretical and practical background with respect to conceptualization and development of the learning system. The Department of Education of the University of Cyprus has taken on the role of coordinator for its accomplishment given considering its particular expertise in science education and related research.

As first step, by the end of 2015, under the guidance of UCY each partner has made an investigation about the teaching of Earth's science in primary and secondary education according with the school curricula of the national education system in its country. By reviewing the information provided by representative organizations from each country, the consortium has underlined the significance and importance of an inquiry-oriented perspective and approach to the educational subject, this in order to better fit the educational proposal of SSE in the framework of the school curricula in science. Moreover, the pedagogical framework suggests some guidelines to make teachers able to better implement with their classes the proposed lesson plans and in relation to the other educational opportunities offered by SSE, as well as to make these activities more appealing and engaging for students. The final version of the Pedagogical Framework was finished by February 2016.

Implementation Guide

Also this intellectual output was developed under the coordination of the Department of Education of UCY with thematic contributions of the other partners, and was delivered by April 2016. The aim of this output has been the realization of a guide for the participating teachers through which they will be supported on how to implement the teaching materials (e.g., educational scenarios, lesson plans, etc.) and related equipment (e.g., digital seismographs, data analysis software, etc.) in their teaching practice.

The Implementation Guide is divided in three main parts:

- the overall application, providing general information to better implement SSE's contents in schools or to exploit them;
- the educational intervention – this part have seen the participation of all partners who have developed the scripts of some illustrative lesson plans to be implemented in the schools;
- the evaluation of the project – BEKAS has developed two questionnaires aimed to evaluate how students involved in SSE project face with education in science at school and how teachers in science and physics use to carry out their teaching activity. Both the questionnaires have been reported in the Implementation Guide. The criteria adopted to develop these evaluation tools are described in detail in chapter Evaluation.

2.3. Seismic network

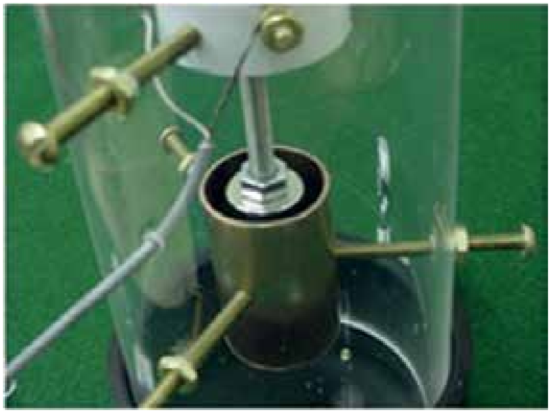
One of the most significant goals achieved in this project is the establishment and operation of an educational seismic network. In the framework of past educational projects in seismology other seismic networks - having their seismometers installed mainly in schools - have been created around the World and Europe. However, we have to note and emphasize the fact that the network established in the framework of SSE is the first one involving countries of south-eastern Europe, each of them marked out by a remarkable seismic activity and risk. As first step, the project coordinator has chosen the most suitable devices to achieve this task considering several practical issues like low price, reliability, educational effectiveness, simplicity in use, etc. The chosen device is the TC1 electromagnetic seismometers developed specifically for educational purposes. Beyond the features mentioned above, these devices can be easily managed by common PCs and by open source software specifically designed for educational use.

A TC1 sensor

TC1 seismometer

The TC1 is a simple vertical seismometer ideated and developed by the American engineer Ted Channel. The version VIII utilized for SSE's seismic network reflects the latest set of modifications since the first version in 2005. It is very "Kid" friendly and it is made mainly by everyday materials like a toy slinky spring, magnets, and a coil. The entire seismic system is composed of this sensor, a pc computer, and software. It consists of a mass made by a big screw and some applied magnets hanging from the spring and oscillating into the coil in case of ground motion. The electric currency induced in the coil by the motion of the magnets is converted in digital signal by an Arduino mainboard.

The natural oscillation period of the system composed by the spring and the mass is less than one second, but a dumper made by a cupper cylinder by mean of the so called "Lenz's effect" makes the sensor able to effectively oscillate in a wider range of frequencies.



Particular of the magnets oscillating respectively inside the coil (left) and inside the dumper (right)

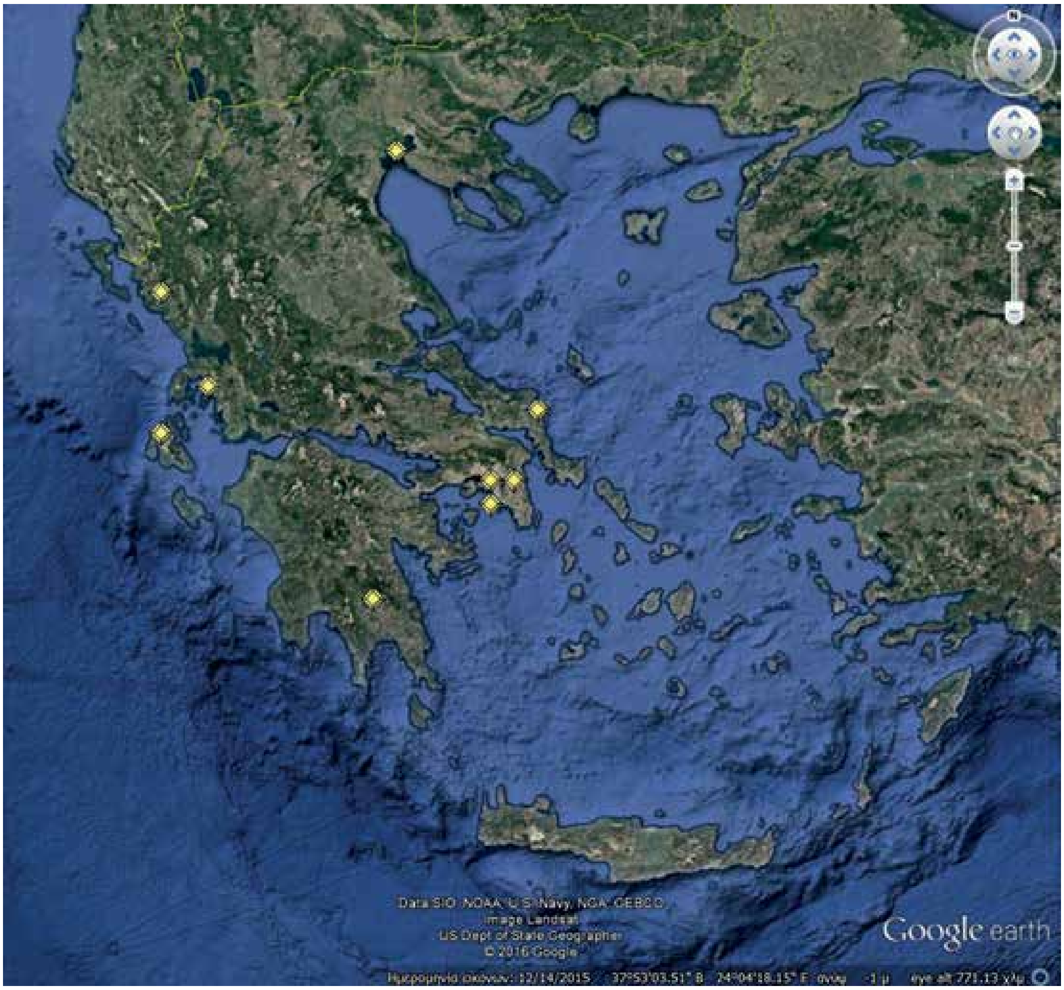
So this sensor does a remarkable job of detecting and recording the vibration caused by earthquakes, small and large, from near and far. On the other hand, it is simple, cheap, and easy to understand and maintain.

Hence NOA has purchased 10 seismometers and on June 2016 has provided each partner of the project with two of them to be hosted and installed in schools.

The data gathered by the seismometers have been made available to all partners as well as to teachers and their students involved in the project by means of a sharing software. All the raw data gathered by the seismic station are also publicly available on the web site of the project (http://sse-project.eu/?m=7).

A TC1 seismometer installed in the premises of Ellinogermaniki Agogi in Athens

The schools in Naples where the travelling TC1 seismometer has been installed during school year 2016/2017

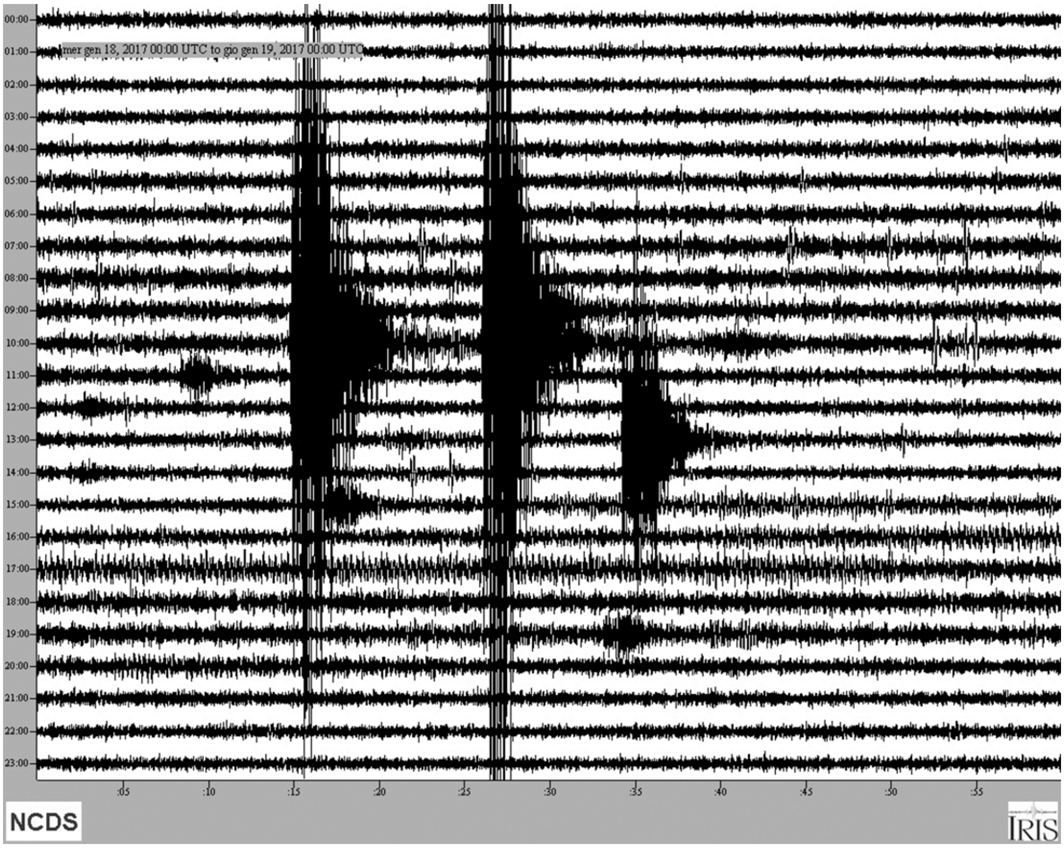


The network of TC1 seismometers installed in Greece by EA and NOA

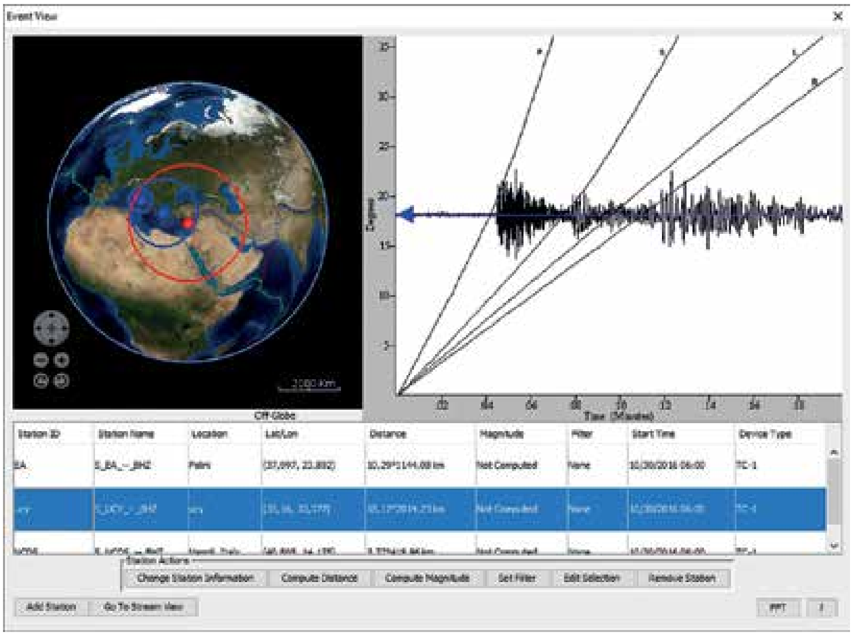
The jAmaSeis software is utilized to manage and administer the seismometers of the SSE network, as it has been mainly developed for educational purposes and is compatible for data acquisition of TC1 seismometers.

jAmaSeis software

jAmaSeis facilitates the study of seismological concepts in school through introductory undergraduate classrooms. Users can obtain and display seismic data in real-time from either a local instrument or from remote stations. Users can also filter data, fit a seismogram to travel time curves, triangulate event epicenters on a globe, estimate event magnitudes, and generate images showing seismograms and corresponding calculations. Users accomplish these tasks through an interface designed specifically for educational use.



Example of a helicorder showing the seismic activity detected on January 18th 2017 by the TC1 seismometer installed in Città della Scienza in Naples. This kind of interface allows also low skilled students and teachers to get an immediate perception of the seismic activity occurring in their location in real time.



The location of the epicentre of the earthquakes Magnitude 6.5 occurred in central Italy on October 30th 2016 fulfilled exploiting the data gathered by the seismic stations installed respectively in Naples, in Athens and in Nicosia

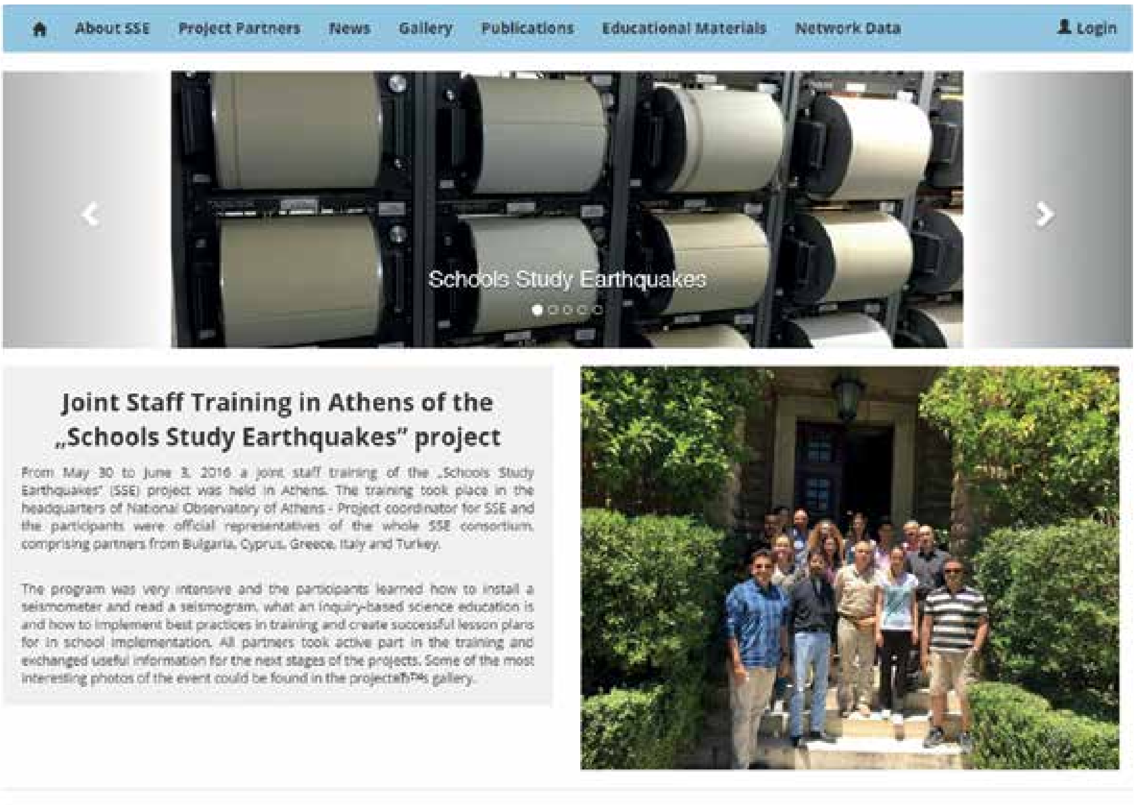
2.4. Project web site and platform

The website portal of the Schools Study Earthquakes project is located at http://sse-project.eu/ and is designed to serve the basic needs of the project partners regarding the publicity of the project, uploading network data gathered by the SSE ground stations for school usage, news, publications and educational materials. There is a special Gallery section designed to serve as photo archive of the project as well as digital repository that could host various outputs created throughout the project by the partners and their collaboration.

The portal is created and maintained by the National Research Network Association and it also hosts the profiles of all project partners and description of their major achievements (http://sse-project.eu/?m=3). All project participants have their unique login names and passwords and could create and maintain various resources within the portal site and there is a complete tracking of all activities and credentials for various directories.

On the long run we intend to maintain the portal even after the project formal end and keep the information and educational materials for future school use and source of data for teachers and students who are interested in seismology and earthquakes.

The Community Support Environment for the SSE project is based on the Adobe Connect web conferencing application and is also provided by the National Research Network Association - Bulgaria. Adobe Connect is a web conferencing application that enables teachers to deliver engaging audio, video, and interactive content in an online



The home page of SSE's website

virtual classroom. Classes may be taught live (synchronous presentation) or offered on-demand (asynchronous presentation). Constant access for partners and associated schools to the Collaboration tool is provided through the link http://adobeconnect.mon.bg/sse/. The virtual room is configured according to the project needs and the rights and roles of the participants could be re-configured on the fly each time depending on the concrete event (project meeting, online session, schools demonstration etc.). A comprehensive user guide was also developed by SSE as intellectual output entitled "Collaborative Learning and Support Environment".

There is a core group of individuals (project partners) that are configured with their real names and roles, while most visitors (like participating teachers) could be either configured on a weekly basis or invited before the event (they could visit the link above and be accepted as guest by the meeting host whoever he is at the concrete occasion). Adobe Connect is primarily used as a synchronous teaching tool, meaning that participants are simultaneously connected and can interact with each other in real time. However, unattended persistent virtual rooms can also be used to hold course materials for on-demand retrieval by students while recorded live sessions could be used at later stage by anyone that has the shared link from the meeting host, not to mention the opportunity to upload the videos to popular video portals such as YouTube, VBox7 etc.

3. Implementation in schools

Each partner involved in the project developed several lesson plans and educational activities aimed to non-formal education in earthquakes and seismology. The contents of these lesson plans are described in detail in the intellectual output entitled "Implementation Guide". One of the most significant expected steps of SSE has been the implementation of these activities. According to the project proposal submitted in 2015: "*10 schools of secondary education per participating partner country (total 50 schools) will be involved in the educational activities of the project. In each school at least 2 science teachers per school to be actively participating (total 50 x 2 = 100 teachers) with about 20 students per teacher (total 100x20=2000 students)*".

In general, the involvement of the schools has been articulated in two consecutive steps:

- Initial and follow-up training meetings and workshops aimed to let the involved science teachers to be able to carry out the lesson plans with their classes;
- The actual implementation of lesson plan in science classroom settings, carried out by the participant teachers in collaboration with the SSE partners in each country.

Moreover each partner organization has undertaken several dissemination actions aimed to promote the contents and the results of the project at national and international levels.

The following subsections describe the implementation of the lesson plans as well as the dissemination actions undertaken in each country.

3.1. Greece (Ellinogermaniki Agogi)

3.1.1. Introduction and methodology

Greece, and in general Europe, needs its youth to be skillful in and enthusiastic for science and also regard it as potential future career field in order to guarantee innovation, competiveness and prosperity in long-term. To ensure this, initiatives are needed that engage students in interesting and motivating science experiences within the standard science curriculum or complementary to it. In this context the "Schools Study Earthquakes" Erasmus+ project (SSE) focuses on the study of earthquake, a physical phenomenon with great societal impact, and proposes pedagogical practices based on inquiry-based methods that are more effective in science education. The general project's approach is to offer to teachers and their students a well-organised set of guides, supporting materials and ready-to-use example lesson plans for in-school implementation. Furthermore, teachers are supported and guided to adopt, develop and implement their educational scenarios, share them with other colleagues and build a wider community of practitioners that promotes the best practices and experiences across country.

Of particular concern was how schools and science teachers can be approached initially and then be further engaged in implementing the project's proposed activities in their classrooms. A well-designed, detailed, clear and systematic work plan and implementation scheme and strategy was laid in order to achieve this and realize an effective and successful dissemination and diffusion of innovative science teaching methods and practices across schools in Greece. Two complementary main methods of approach were devised, a. top-down method of approach and b. bottom-up method of approach. These deployed methods of approach proved successful, as can be seen by the quantitative and qualitative results reached which are discussed in the next sections.

Top-down method of approach: In this approach we use official channels of communication to approach and invite teachers or science principals of schools to project activities such as introductory seminars, induction and training workshops etc. In this case we contact the district's school counsellor or regional bureau of education or other equivalent authority and inform them about the project. An introductory-informational event is initially arranged and teachers from the region are invited officially to attend. Teachers who are interested further in applying the SSE related activities and methodology in their science classroom are given further guidance and support material with educational content (i.e. classroom scenarios or lesson plans) to start with. If needed additional events to provide hands-on training and practicing are organised. In this respect introductory and focused workshops or seminars for teachers are organised in collaboration with the network of Laboratory Centers of Natural Sciences (EKFE in Greek, ΕΚΦΕ-Εργαστηριακά Κέντρα Φυσικών Επιστήμων) in Attica-Nea Filadelfia, Lakonia-Sparti, Western Greece-Kefalonia-Arta. Also, a wider dissemination event and related implementation actions, i.e. national thematic educational contest for schools, is communicated officially to all schools of secondary education from the Ministry of Education of Greece. Further details regarding these actions are presented in the next sections.

Bottom-up method of approach: In this case we organize in EA informational events and practice workshops contacting and inviting directly science teachers from schools in the local area of Attica or with whom we have collaborated in the past in the framework of other European or national projects in the field of education, school innovation etc. In this respect not only these already known teachers are directly informed about the project, but also through them their network of colleagues. Within the context of this approach lies the category of teachers and schools that were winners of educational contests organized by EA in the framework of large-scale European projects, such as "Inspiring Science Education" and "Open Discovery Space". The prize of reward was the installation of an educational seismometer in their schools and their inclusion in the SSE network.

Deploying simultaneously the above complementary methods we achieve a highly effective and sustainable implementation and dissemination of the project's objectives, outcomes, methods and practices to a wider audience of schools, teachers and students in Greece. We discuss the main results in the following sections.

3.1.2. Implementation and dissemination of activities in schools across Greece

The implementation of the SSE project in Greece took place in two main phases covering the two consecutive school years of 2015-16 and 2016-17. The effort during the first phase was primarily focused on informing and engaging teachers across the country. With the completion of the relevant guides for teachers (i.e. intellectual outputs "Pedagogical Framework", "Implementation Guide" and "Seismology Handbook") and the installation of the educational seismometers a country-wide network of schools is formed. Teachers therein gradually implement the SSE proposed lesson plans or adopt and develop their own educational activities or/and utilizing the data recorded with their school seismometer or other devices of the installed network. In parallel, seminars and training workshops for novice or experienced teachers are organized in schools or in EKFE in collaboration with the school counsellor or regional bureau of education or other local authority, such as the municipality, to facilitate and maximize both the dissemination and sustainable impact of the project. In most cases events in school sites, and in particular the installation of the educational seismometer, are also accompanied or followed-up by relevant educational activities for students which are conducted by EA and NOA staff. Further to these actions, a thematic educational contest, entitled "Build your own seismograph", is launched at national level in 2017 as a major dissemination event to attract further the interest of the community of schools, teachers and students across Greece.

In recognition of the significance of the project objectives and activities in Greece and the neighbour countries, SSE received an honourable distinction by the state according to which the **Schools Study Earthquakes activities are under the Auspices of H.E. the President of the Hellenic Republic (**Το πρόγραμμα «Τα Σχολεία Μελετούν Τους Σεισμούς» τελεί υπό την Αιγίδα της Α**.**Ε**.** του Προέδρου της Δημοκρατίας**)**

In the following we discuss and highlight the main categories of actions, their importance and outcomes, namely: training of teachers, activities for students or/and installation of educational seismometers in schools and educational contest.

3.1.3. Training of teachers

The SSE project greatly encompasses teachers' training needs in a pragmatic way by developing and offering them a comprehensive set of guides, with balanced mix of theory and practice in order to enrich their capacity to uptake innovative teaching methodologies and practices. Teachers are key players in the renewal of education and, among other methods, their active involvement and participation in innovative projects, networks and trainings allows them to improve the quality of their teaching, supports their motivation and stimulates their morale which then is passed to students and learners and have long-term implications for the individuals and for the society.

In the framework of SSE a series of induction and hands-on training seminars were organized for science teachers of schools in Greece. The objectives are to introduce teachers to the project and its general concept, to offer practice sessions where they will familiarize themselves with the pedagogical framework and educational activities and further to practice themselves in using the hardware and software tools in order to be able to exploit its potential in full in their classrooms. The following training events were organized:

- in Marathon in July 2016 as part of the international training programme Inspiring Science Education and Developing Geospatial Thinking Skills with 12 attendee teachers from Greece
- in EA in November 2016 as part of the conference "Open School for an Open Society",

24 teachers from Greece participated in the workshops

- in EA in Jan 2017 as part of the "STEM Youth" initiative (Εργαστήρια STEM EMpowering Youth στην Περιφέρεια: Καινοτομία στην τοπική κοινωνία), 20 teachers from schools in remote areas or islands around the country participated in day-long workshops
- in EKFE Neas Filadelfias in February 2017, 17 teachers from schools of the local area and of Eastern Attica participated
- in EKFE Lakonias/Sparti in February 2017, 23 teachers from schools of the region participated
- in Igoumenitsa and Kefalonia in March 2017, in collaboration with the region's school counsellor and bureau of education, about 20 teachers participated
- in Marathon in July 2017 as part of the "Scientix" initiative and the training of its ambassadors, 11 teachers from Greece participated

Figure 1. Highlight from a teacher training workshop organized in EKFE Lakonias in Sparti.

In total 127 teachers from schools around Greece were trained comprehensively about all aspects of the SSE project including its pedagogical approach, its support materials, guides and proposed educational activities. Figure 1 shows a highlight of such workshop, in particular the one organized in EKFE Lakonias in Sparti.

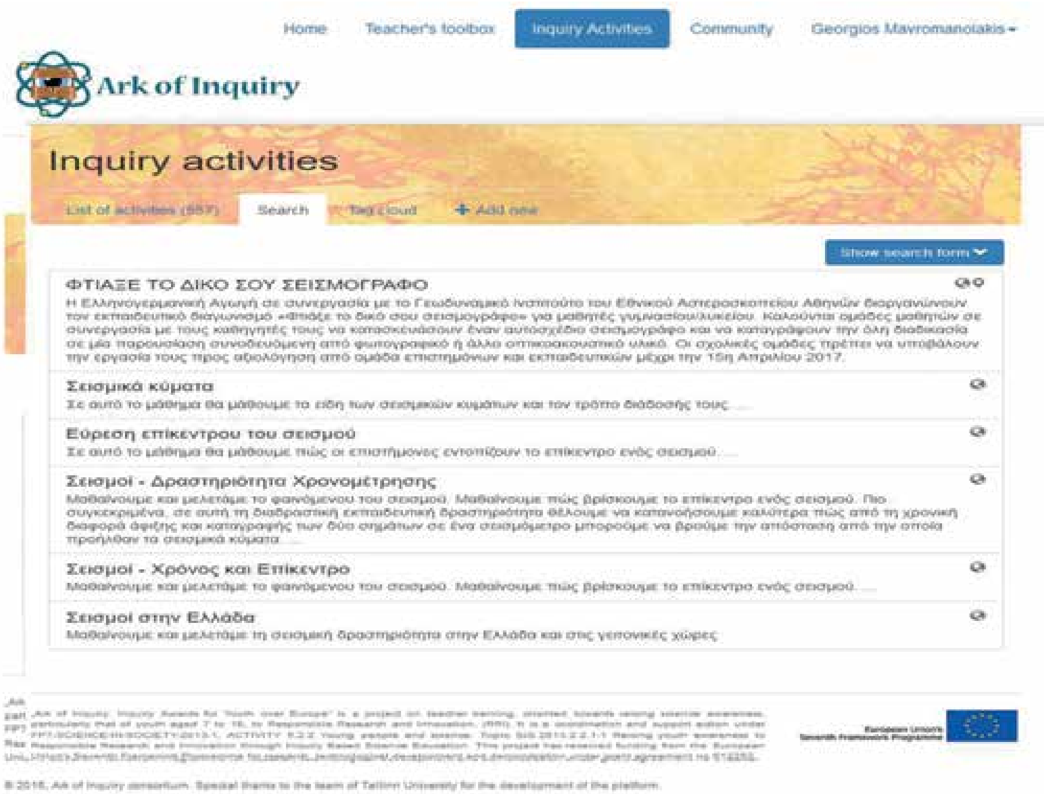


Figure 2. Screenshot of the "Ark of Inquiry" portal showing some of the inquiry activities related to the study of earthquakes in Greek language.

In most occasions the workshops were organized in properly equipped and networked computer labs where participant teachers practiced directly the interactive activities/lesson plans of the project (fig.3). It should be noted that the interactive lesson plans and proposed classroom implementation activities related to the study of earthquakes are also uploaded in the dedicated portal/repository of online educational resources of the European project "Ark of Inquiry". They are in English and in Greek and can be utilized by a large number of science teachers from Greece and from more than 15 countries around Europe that participate in the piloting and large-scale implementation phases of the project. Below, fig.2, is a screenshot of the "Ark of Inquiry" portal that shows some of the uploaded activities in Greek language.

3.1.4. Activities for school students

In this category fall all activities which involve participation of primary or secondary school students and which are organized or conducted by EA or/and NOA in the framework of the project. These include lectures, in-classroom or in-school activities, demonstration and practice workshops of using a seismometer and the data recorded, discussion of protection measures and actions in case of an earthquake etc. (Under this category falls also the installation of an educational seismometer in a school which is accompanied by relevant presentations and activities for students and teachers. For better clarity this is discussed in a separate subsection below.)

- EA and NOA participated in the 1st Summer School of Physics organized by the Municipality of Argostoli in Kefalonia island, which is one of the regions of Greece with the highest seismicity in the country and the whole Mediterranean area. The summer school was held in June 2016 and was attended by about 50 advanced high school students from 12 schools of the local area and islands. Staff members of EA and NOA conducted lectures, for students and the general public, about seismology, demonstrated the operation and analysis of seismometers and gave workshops with interactive educational activities.
- Similar week-long summer school for advanced students is also organized in summer 2017 in Lefkada island in collaboration with the regional school counsellor and the local educational and municipal authorities.
- In June 2017 EA is organizing a science summer camp for primary school students, with about 40 participants, where hands-on workshops related to earthquakes are included.
- Throughout the duration of the project, and specifically during the installation of educational seismometers in 8 school sites across

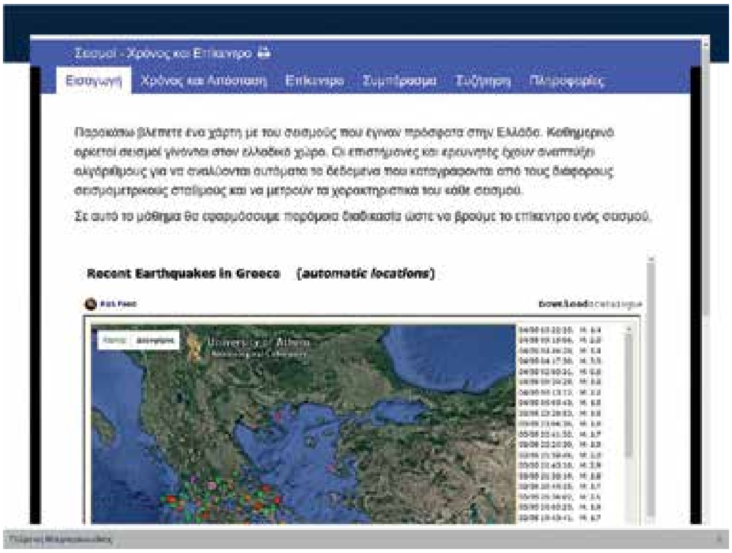


Figure 3. Example of an online interactive lesson plan in Greek. Students are guided to follow the various inquiry stages to acquire content and concept knowledge on how earthquakes are located and to practice themselves the finding of the epicenter of an earthquake by analyzing seismograms.

the country, as listed below, about 16 teachers and 179 students attended the lectures, presentations and related activities that were given by EA and/or NOA on each occasion.

In total 319 students from 33 schools across the country participated in the comprehensive educational activities that EA and NOA organized or participated in the framework of SSE.

Figure 4. Highlight of lecture to high school students in Avlonari after/during the installation of an educational seismometer on site.

Figure 5. Highlight of in-classroom educational activity where high school students work with an interactive lesson plan and learn to find and locate the epicenter of an earthquake.

3.1.5. Network of educational seismometers in Greece

In the following table, tab.1, are listed the schools where educational seismometers of type TC1 are installed. The last column gives an estimate of the total number of teachers and students that participated in the relevant educational activities accompanying the installation of a seismometer in school. As can be seen on the map, depicted in figure 6 below, a wide network is established that is well-covering the main seismogenic areas of Greece. The seismometers are in continuous operation and record minor and major earthquake events at local and regional level (characteristic highlights of recorded seismograms are depicted in fig.7 and 8).

Table 1: List of schools in Greece where educational seismometers are installed in the framework of the SSE project. Last two columns indicate the number of teachers and students participating in relevant educational activities

Name of School	Όνομα Σχολείου	Number of Teachers	Number of Students
Gymnasium and Lyceum of Ellinogermaniki Agogi	Γυμνάσιο και Λύκειο Ελληνογερμανικής Αγωγής, Παλλήνη Αττικής	3	37
Evangeliki School of Smyrna	ΓΕΛ Ευαγγελική Σχολή Σμύρνης, Νέα Σμύρνη Αττικής	2	13
Special Gymnasium of Thessaloniki	Δημόσιο Ειδικό Γυμνάσιο Θεσσαλονίκης	2	20
3rd Gymnasium of Igoumenitsa	3ο Γυμνάσιο Ηγουμενίτσας	1	23
2nd Lyceum of Sparti	2ο Γενικό Λύκειο Σπάρτης	3	15
Lyceum of Avlonari	Λύκειο Αυλωναρίου	2	35
Lyceum-Gymnasium of Agnanton Arta	Γυμνάσιο - Λύκειο Αγνάντων Άρτας	1	15
1st Lyceum of Argostoli	1ο Λύκειο Αργοστολίου Κεφαλλονιάς	2	21

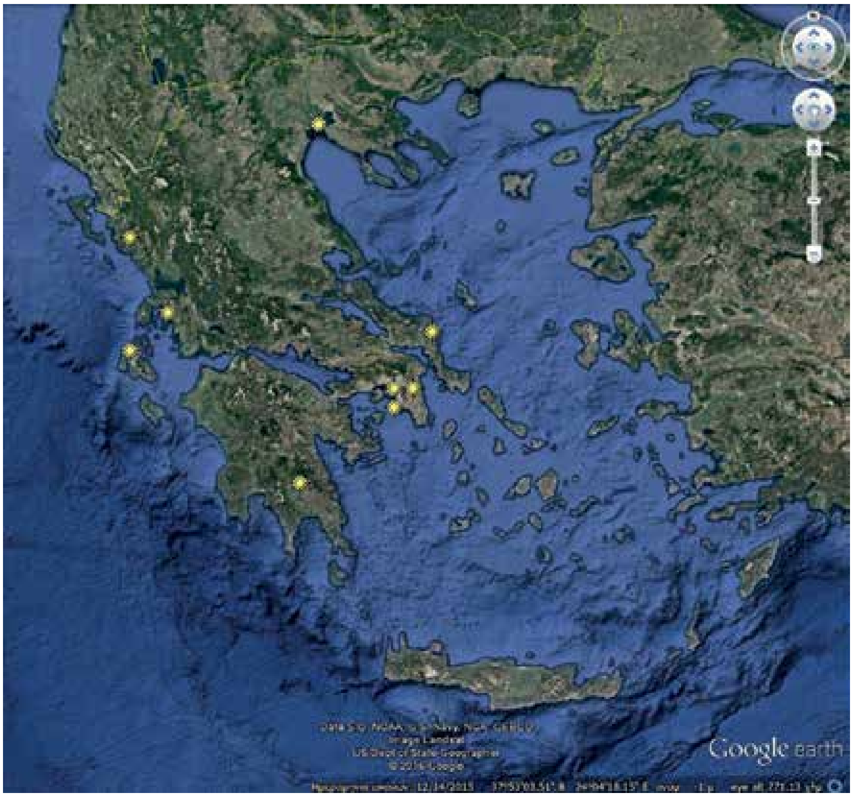


Figure 6. Map of Greece showing the location of schools where educational seismometers are installed.

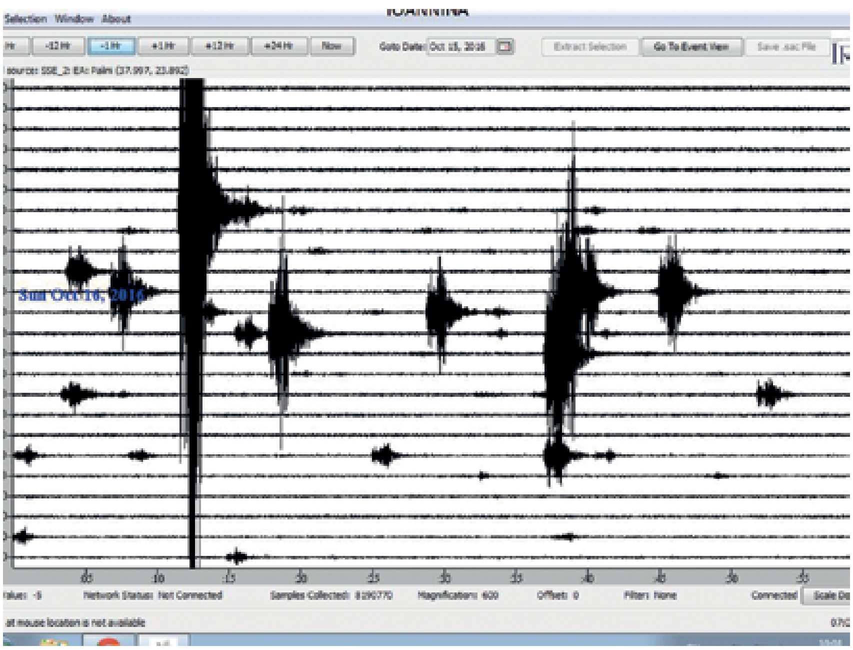


Figure 7. Characteristic example of typical recording from an educational seismometer installed in school. It shows the series of earthquakes occurred in Ioannina region in October 2016 and as clearly recorded by the seismometer located in EA in Pallini Attica.

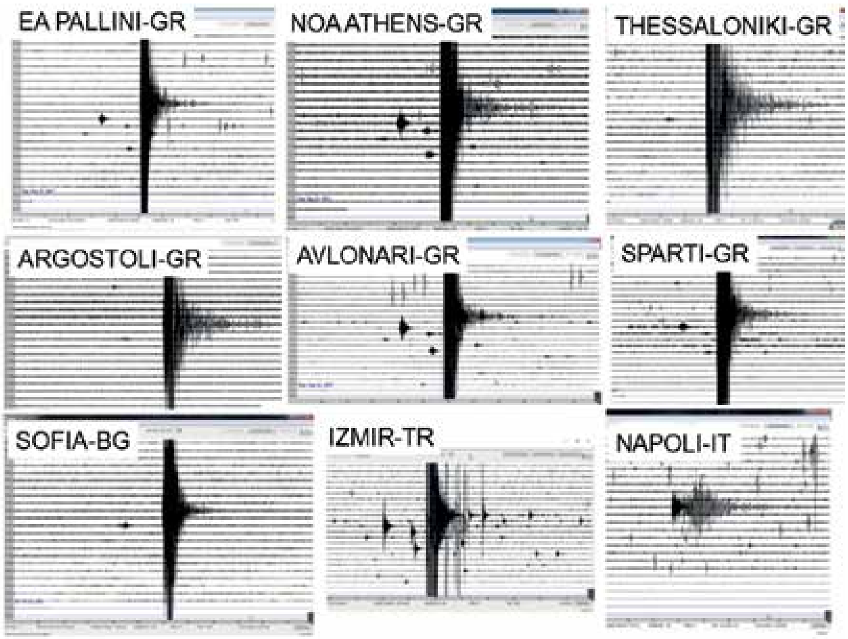


Figure 8. Highlight example of the recording of a major earthquake in Lesvos island in June 2017 by the network of educational seismometers in various school sites in Greece and in other partner countries of the SSE project.

3.1.6. National thematic educational contest "Build your own seismograph"

In order to disseminate and promote further the objectives, practices and outcomes of the SSE project in the school community of Greece, EA in collaboration with NOA organize a thematic educational contest which run at national level (fig.9). Eligible to participate are student teams of secondary, both general and vocational, education. The main goal or challenge of each team is to build a seismograph, to elaborate on the principles of operation, to document the whole procedure, and finally to make a comprehensive presentation of their study, work and construction. The evaluation criteria include:

- Overall quality and completeness of work
- Scientific correctness
- Incorporation of audiovisual material created by students
- Emphasis in inquiry-based science learning, problem solving, creativity and collaboration
- Inclusion of students of social or economic disadvantage and/or special needs
- Emphasis in promoting awareness within the school or local community of measures of civic protection and precautionary actions in case of an earthquake event

The contest is communicated officially to all schools of secondary education from the Ministry of Education of Greece (fig.10 below shows the official announcement document). Although it run for a relatively short period (starting date on 1 March and closing on 15 April 2017) the contest quickly attracted the interest of schools across the country. In total 25 teams with the participation of 147 students and 39 teachers/supervisors submitted qualifying materials. The full list of participant schools are tabulated in table 2. Fig.11 shows a map indicating the location of each school, as can be seen participation is from both urban and rural or remote areas of the country. Also it should be emphasized the fact that among the participants are both vocational schools and schools of students of special needs along with gymnasiums and lyceums of general education.

An evaluation committee from EA and NOA assessed all submitted entries and accompanying materials of each school team and listed the final contest winners. The winner student teams and their teachers/supervisors were then invited to receive a commemorative symbolic certificate and more importantly to present their work and demonstrate their seismograph in a ceremony that was hosted at NOA in a historic building on 5 May 2017 (fig.12). The event was

Figure 9. Screenshot of the website containing all information related to the thematic educational contest for schools "Build your own seismograph – Φτιάξε το δικό σου σεισμογράφο"

ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ, ΕΡΕΥΝΑΣ ΚΑΙ ΘΡΗΣΚΕΥΜΑΤΩΝ

ΓΕΝΙΚΗ ΔΙΕΥΘΥΝΣΗ ΣΠΟΥΔΩΝ Π/ΘΜΙΑΣ ΚΑΙ Δ/ΘΜΙΑΣ ΕΚΠΑΙΔΕΥΣΗΣ
ΔΙΕΥΘΥΝΣΗ ΣΠΟΥΔΩΝ, ΠΡΟΓΡΑΜΜΑΤΩΝ ΚΑΙ ΟΡΓΑΝΩΣΗΣ Δ/ΘΜΙΑΣ ΕΚΠΑΙΔΕΥΣΗΣ
ΤΜΗΜΑ Γ΄ - ΜΑΘΗΤΙΚΗΣ ΜΕΡΙΜΝΑΣ ΚΑΙ ΣΧΟΛΙΚΗΣ ΖΩΗΣ

ΔΙΕΥΘΥΝΣΗ ΕΠΑΓΓΕΛΜΑΤΙΚΗΣ ΕΚΠΑΙΔΕΥΣΗΣ
ΤΜΗΜΑ Β΄ - ΜΑΘΗΤΙΚΗΣ ΜΕΡΙΜΝΑΣ ΚΑΙ ΣΧΟΛΙΚΗΣ ΖΩΗΣ

ΑΥΤΟΤΕΛΕΣ ΤΜΗΜΑ ΥΠΟΣΤΗΡΙΞΗΣ ΝΕΩΝ ΤΕΧΝΟΛΟΓΙΩΝ ΚΑΙ ΚΑΙΝΟΤΟΜΙΑΣ

Georgios Mavromanolakis

Βαθμός Ασφαλείας:
Να διατηρηθεί μέχρι:
Βαθμ. Προτερ.: ΕΞ. ΕΠΕΙΓΟΝ

Μαρούσι, 20/03/2017
Αριθμ. Πρωτ.: Φ15/47737/Δ2

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ΠΡΟΣ:
1. Περιφερειακές Διευθύνσεις Π.Ε. & Δ.Ε. της χώρας, Έδρες τους
2. Γραφεία Σχολικών Συμβούλων Δ.Ε. (μέσω των Περιφερειακών Διευθύνσεων Π.Ε. & Δ.Ε. της χώρας)
3. Διευθύνσεις Δ.Ε. της χώρας, Έδρες τους
4. Γυμνάσια, ΓΕ.Λ. και ΕΠΑ.Λ. Δημόσια και Ιδιωτικά της χώρας (μέσω των Δ/νσεων Δ.Ε. της χώρας)

ΚΟΙΝ: Δρ. Γεώργιο Μαυρομανωλάκη
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ΘΕΜΑ: «Έγκριση Εκπαιδευτικού Διαγωνισμού «Φτιάξε το δικό σου σεισμογράφο» σχολικού έτους 2016-2017».

Σχετικά έγγραφα: τα με αρ. πρ. 37240/Δ2/06-03-2017 και 35420/ΓΔ4/03-03-2017 εισερχόμενα έγγραφα του ΥΠ.Π.Ε.Θ.

Σας ενημερώνουμε ότι στο πλαίσιο του ευρωπαϊκού προγράμματος Erasmus+ «Schools Study Earthquakes» (κωδικός έγκρισης 2015-1-EL01- KA201-013966) και του ευρωπαϊκού έργου «Ark of Inquiry» (Grant agreement no: 612252), η Ελληνογερμανική Αγωγή και το Γεωδυναμικό Ινστιτούτο του Εθνικού Αστεροσκοπείου Αθηνών διοργανώνουν τον εκπαιδευτικό διαγωνισμό **«Φτιάξε το δικό σου σεισμογράφο»** για μαθητές Γυμνασίου και Λυκείου. Καλούνται ομάδες μαθητών σε συνεργασία με τους καθηγητές τους να κατασκευάσουν έναν αυτοσχέδιο σεισμογράφο και να καταγράψουν την όλη διαδικασία σε μία παρουσίαση συνοδευόμενη από φωτογραφικό ή άλλο οπτικοακουστικό υλικό. Οι

realized with the partial support of the "Ark of Inquiry" project. The ceremony resembles the function of a real scientific conference were different groups of researchers, scientists or engineers present their work and discuss their findings, exchange ideas and experiences towards acquiring and advancing knowledge or providing solutions to problems and challenges. In this way, and throughout their preparation and work in the framework of the contest, students experience a comprehensive practical understanding of how science and technology advance, increase their interest in related subjects and are motivated to consider them as potential career paths.

All guidelines, documents/announcements and final winner teams' submitted materials are publicly accessible at http://seismografos.ea.gr/

Figure 10. Official announcement of the thematic educational contest that was communicated to all secondary schools by the Ministry of Education of Greece

Table 2: List of schools from which student teams entered the contest

Name of School or Educational Institution	Όνομα Σχολείου ή Εκπαιδευτικού Φορέα	**Number of Teachers**	**Number of Students**
Gymnasium of Skado Naxos	Γυμνάσιο Σκαδού Νάξου	1	13
1st Gymnasium of Triandria	1ο Γυμνάσιο Τριανδρίας Θεσσαλονίκης	2	10
Gymnasium of Agria	Γυμνάσιο Αγριάς	1	3
Lyceum of Evageliki School Smyrnis	Πρότυπο Γενικό Λύκειο Ευαγγελικής Σχολής Σμύρνης	1	13
University of Thessaly, Educational Group "Talos" for secondary school students	Πανεπιστήμιο Θεσσαλίας, Εκπαιδευτική ομάδα «Τάλως» για μαθητές Γυμνασίου/Λυκείου	4	10
Experimental School of University of Athens	Πειραματικό Σχολείο Πανεπιστημίου Αθηνών	2	6
Gymnasium and Lyceum of Alonnisos	Γυμνάσιο - Λυκειακές Τάξεις Αλοννήσου	1	3
2nd Lyceum of Sparti	2ο Γ.Ε.Λ. Σπάρτης	2	4
Gymnasium of Rafina	Γυμνάσιο Ραφήνας	3	7
1st Gymnasium of Tripoli	1ο Γυμνάσιο Τρίπολης	1	3
5th Gymnasium of Irakleio Attiki	5ο Γυμνάσιο Ηρακλείου Αττικής	1	8
Intercultural Gymnasium of Evosmos	Διαπολιτισμικό Γυμνάσιο Ευόσμου	1	7
Special School of Panorama for deaf students	Ειδικό Λύκειο Κωφών και Βαρήκοων Πανοράματος	2	5
1st Gymnasium of Corfu	1ο Γυμνάσιο Κέρκυρας	1	5
1st Vocational School of Didymoteicho	1ο ΕΠΑ.Λ. Διδυμοτείχου	3	12
Gymnasium of Antirrio	Γυμνάσιο Αντιρρίου	4	16
1st Vocational School of Komotini	1ο ΕΠΑ.Λ. Κομοτηνής	3	10
Music School of Chania	Μουσικό Σχολείο Χανίων	3	15

Figure 11. Map of Greece indicating the location of each school from which teams of students entered the thematic educational contest. Participation is from both main urban, peripheral and rural or remote areas of the country.

Figure 12. Group photo of the participants in the ceremony hosted at the National Observatory of Athens.

3.1.7. Summary and key indicators

In summary, throughout the implementation phases of the project in Greece, EA in collaboration with NOA organized and conducted series of implementation and dissemination activities for teachers and students reaching a large audience across the country. Following an overall implementation plan and inclusive strategy, schools, teachers and students are engaged in the study of earthquakes which is turned into a central focus point to facilitate inquiry-based approaches of science teaching and learning. Furthermore, a country-wide network of educational seismometers installed in schools is established and is in constant operation recording earthquakes in the region.

A constant and wide uptake was realized laying the foundations for successful sustainability and broader impact that continues well after the official end of the project. Below are listed the main key indicators and actions that are highlighting the quantitative and qualitative results achieved in Greece.

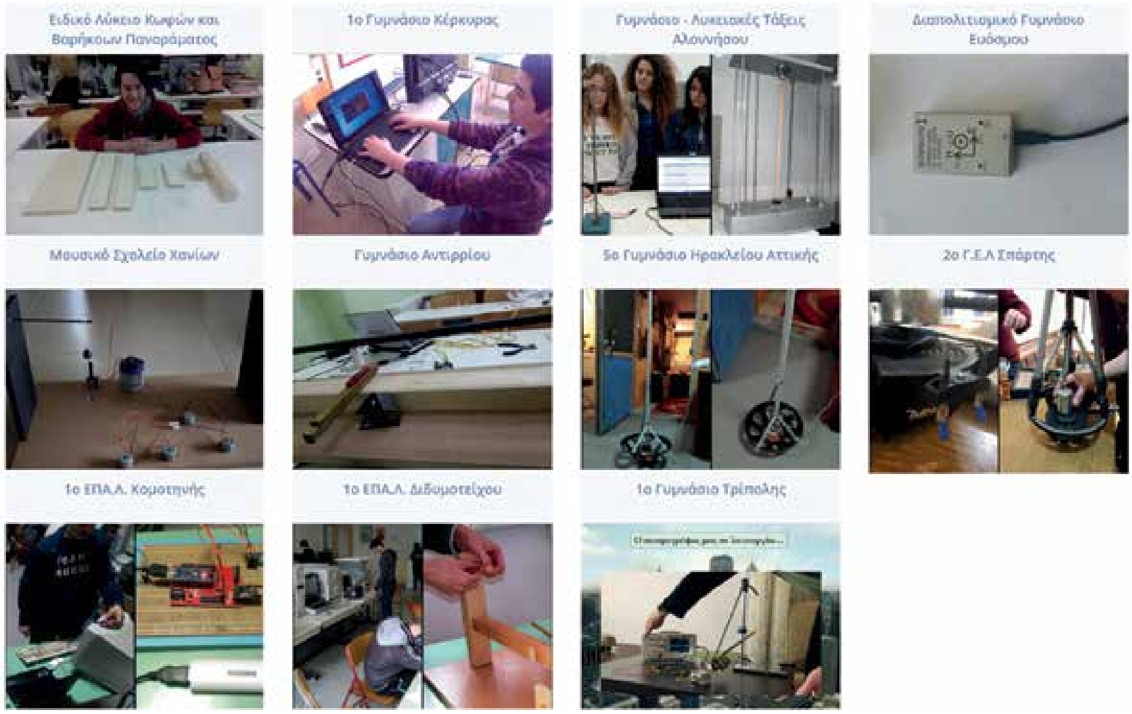


Figure 13. Online folders at the website of the contest containing the material submitted by the winner teams of students.

- 127 teachers attended the training workshops organized in the framework of the SSE project.
- 319 students from 33 schools across the country participated in the educational activities that we organized.
- 25 school teams with the participation of 147 students and 39 teachers/supervisors submitted qualifying materials for entering the national thematic educational contest "Build your own seismograph" that we organized in the framework of the SSE project.
- 8 educational seismometers are installed in school sites across Greece establishing an actual and operational network that is recording continuously earthquake events in the region.
- Organization with high success, in terms of participation, quality of entries, level of engagement and publicity, of a national thematic educational contest for schools, entitled "Build your own seismograph", that is planned to be repeated in the following school years.
- Organization of a week-long thematic summer school on the study of earthquakes (held in Lefkada island in summer 2017) for advanced secondary school students and in collaboration with local educational and municipal authorities that is planned to be repeated in different locations and regions in the following years.
- The SSE Erasmus+ project developed, realized and established synergies with major large-scale European initiatives on education and school innovation that are co-funded by the Seventh Framework Programme, namely "Open Discovery Space", "Inspiring Science Education" and "Ark of Inquiry".
- In recognition of the significance of the project objectives and activities in Greece and the neighbour countries, SSE received an honourable distinction by the state according to which **the Schools Study Earthquakes activities are under the Auspices of H.E. the President of the Hellenic Republic (**Το πρόγραμμα «Τα Σχολεία Μελετούν Τους Σεισμούς» τελεί υπό την Αιγίδα της Α**.**Ε**.** του Προέδρου της Δημοκρατίας**).**

3.2. Turkey (Bahcesehir Eğitim Kurumları Anonim Şirketi)

Introduction:
The aim of this report is to show how participating teachers from primary, secondary and high schools in Turkey implemented an educational scenario, lesson plan or activity related to earthquakes in their classes.

Table 1. Statistical Information about the SSE-Project in Turkey

Numbers	
Number of Schools	9 Schools + 1 Science Museum + 1 University
Number of Teachers	24
Number of Students	538 Students + 105 University Students

In Turkey, Earth Science concepts are being taught starting from grade 3 till grade 12 the end of high school. The learning modules we applied in our classes reinforced the following standards present in Turkey's National Curriculum: the shape and layer by layer structure of the Earth, the properties of these layers, the natural phenomenon of earthquakes, and tsunamis as results of earthquakes. How to be ready before, during and after an earthquake. So our teachers were familiar with this STEM context already. Our educational approach was Inquiry based Science Education (IBSE), and we also applied Engineering Design Process (EDP) therefore Maths, Science, Engineering and Technology were practiced during our lesson plans. 21st century requirements are directly correlated with STEM education. Almost all the qualities the future's generation should have, have been practiced during our lesson activities. The modules support 21st century requirements in the name of problem solving, creativity, group studies, collaboration. The teachers (Physics, Geography, Science, Social studies) decided which group of students they were going to work with according to their age and prior knowledge in the field and prepared their alternative activities accordingly.

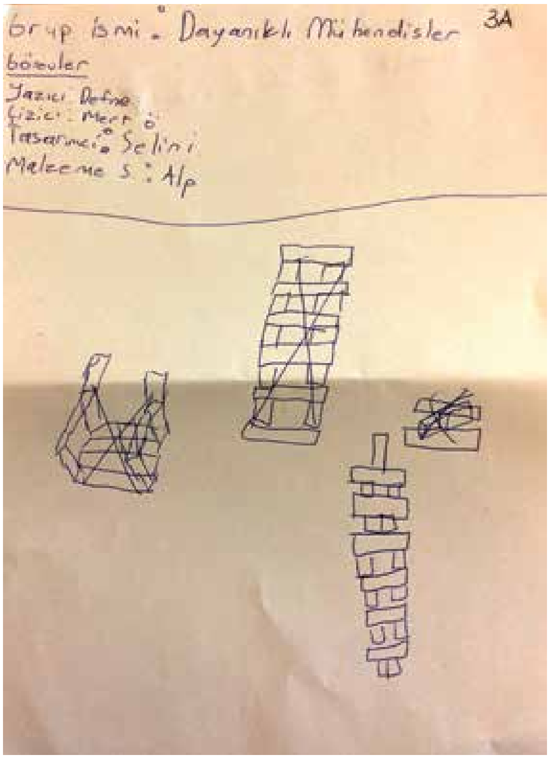
3.2.1. Preparation
There was a training session as an introduction at the same day the seismometer was installed to a school and support materials in the form of alternate lesson plans and activities and also a detailed presentation summarizing the earthquake basics were given to the interested teachers. Teachers in Turkey have either used the lesson plans we've supplied or made their own activities. A paper questionnaire was applied to both the students and teachers to assess the impact of the project before and after the application of lesson plans.

Seismograph was installed and basic info about its working principals explained.

3.2.2. Implementation
In primary school, the national standards cover the basics such as the shape and structure of the Earth and a very preliminary introduction to results of these. With the primary school students in Turkey, we had an introduction to "Earthquake Engineering". This learning module which can be applied between 6-8 weeks depending on the depth of one's studies, teaches the basics of earthquakes, civil engineering in which one can specialize in earthquakes and the building codes which are the rules to abide by if one wants to create earthquake resistant buildings.

Step one in this process was the students to learn to work in groups. For them to determine their weaknesses and strengths, we asked them to build the highest tower they can using wooden bricks. This process allows for the students to assign appropriate roles to everyone in the group. There are: students responsible for materials, students who draw the design ideas / write the results and also students who makes this design come to life.

Once we observed cooperation among the students, the next step was to have an introduction to earthquake basics. We placed a kiosk in the main school corridor where the actual measurement from the seismograph installed @ the basement could be observed. Mentioning the seismic activity, they have been seeing



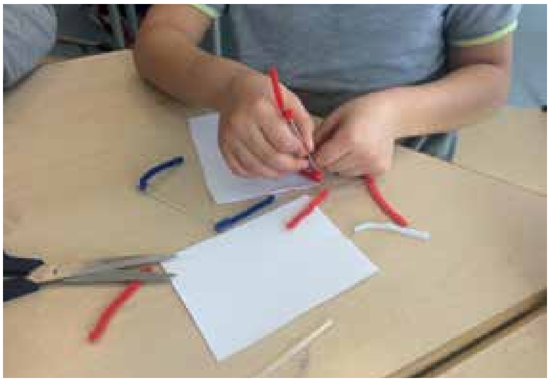
on the kiosk in the main hall, we talked about their experiences about earthquakes.

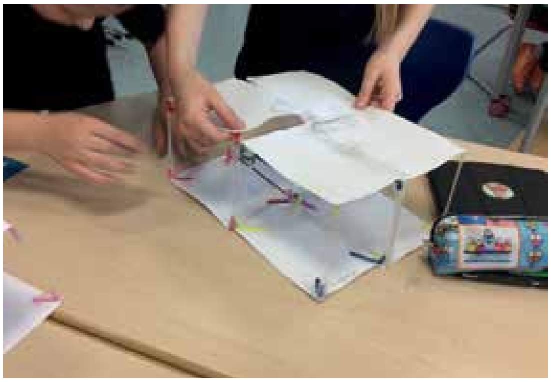
We made a presentation about earthquakes and the destruction caused by some of the most influential ones that happened in Turkey in the past. A short trip to the basement to see the earthquake measurement device, the seismograph, was one of the highlights of this step of our studies as the students came to contact with an actual real-time measurement device and saw the earthquake data and asked questions about the interpretation of this data.

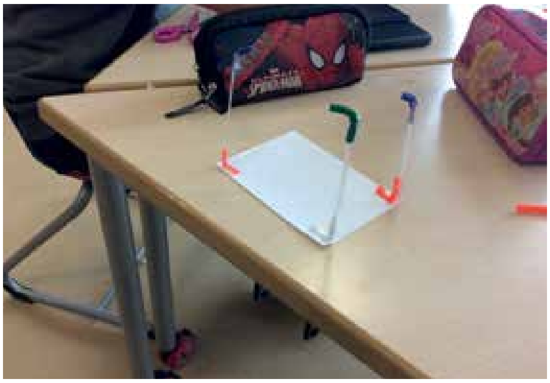
We talked about seismology, seismic waves, seismograph and Earth's structure in detail, and the students also learned about scale and measurement of earthquakes. The teachers and the students had a training about how to act before, during and after an earthquake in the conference hall by a professional search and rescue team.

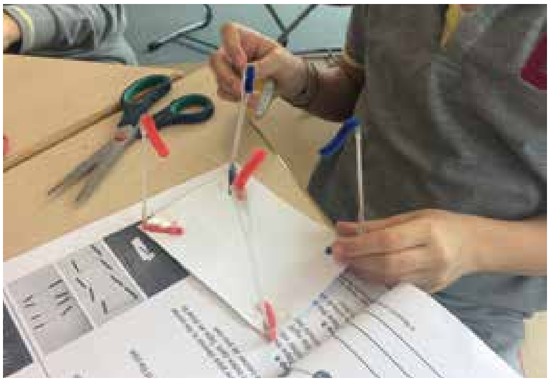
There was a drill, where the students applied their new-gained knowledge during the earthquake signal in class and also during the evacuation after the signal was over.

As the students had already become eager to discover the properties of an earthquake resistant structure, the following steps were applied enthusiastically. Our students built building units, then they formed structures with these



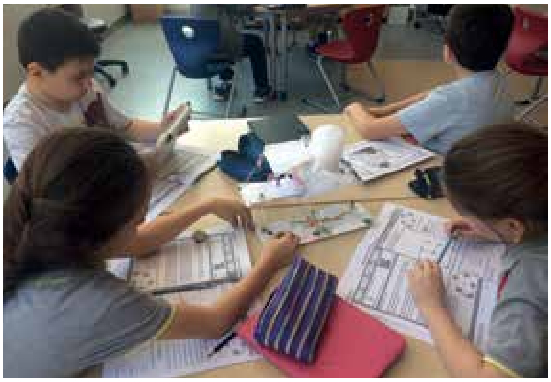






units. The structures were tested on a shake-table that imitated actual earthquakes with a Richter-like scale of different magnitudes.

Our students observed the kind of damage that could result from an earthquake so the next step was to try to improve our buildings and write building codes for a more earthquake resistant structure. The overall experience was very satisfactory. Not only the students learned a lot of new things about earthquakes but also they had hands on experience on a real time data measuring device and they practiced 3D thinking, problem solving and collaboration during their engineering designs of earthquake resistant buildings. At the end of our studies, a lot of students were interested in getting a job in a STEM field and they became very compassionate about the infrastructure of a city and how the structures inside of it were built.



In secondary school, the national standards about Earth Science become more detailed. The properties of Earth's layers are mentioned in depth the movement of tectonic plates, boundaries, continental drift and also the results such as earthquakes and tsunamis are explained thoroughly. The location of an earthquake, the focus, the epicenter, aftershocks, s waves, p waves and surface waves and Richter scale are explained. In addition to the activities applied in primary level, in secondary schools to increase the level of engagement in students during class time, we started with a video about virtual reality glasses: a new technology that lets one to experience an earthquake as if it is happening right now and allows one to become used to the alarming situation.

After watching the video and having a discussion about how to act during earthquakes, our students worked in groups and created an online Padlet page where they shared their questions about earthquakes, what they wanted to learn and what interested them the most about this concept.

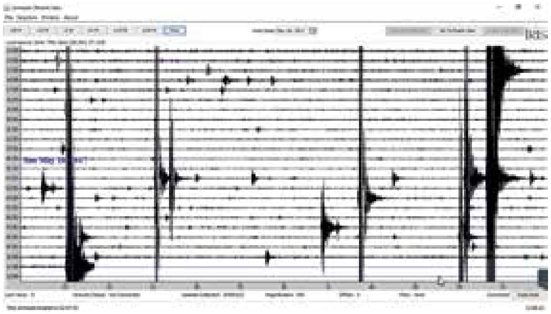
They made their own Earthquake Bags and presented what was inside during class time to their friends and they also prepared presentations about the most destructive earthquakes in Turkey.

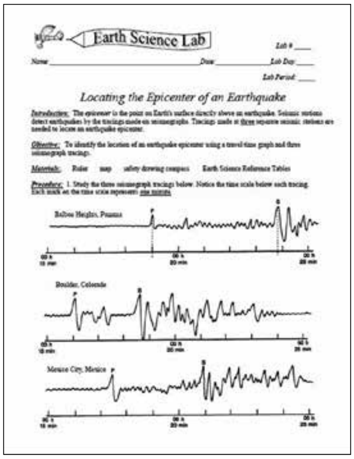
An activity involving the seismic waves (s, p and surface waves) was applied and students' knowledge of these concepts were reinforced with real time seismograph data interpretation. The working principle of the seismograph was explained and the effect of seismic waves during an earthquake was mentioned.

The secondary school teachers also wrote their own lesson plans. One of these plans was about the Pangea: one major continent made up of all the ones that exist now. There was also some interdisciplinary activities where Social Studies teachers and Science teachers got together and talked about different aspects (related to their own field) of earthquakes with their students. The end product of this study was earthquake brochures prepared by our students.

In high schools, geography and physics teachers teach about Earth Science. In physics the types of seismic waves the reasons behind their formation and their effect are the main focus points. In geography, drift theory, tectonic plate boundaries and Turkey's tectonic structure are studied.

The high school teachers in Turkey, in addition to secondary school activities, talked in more detail about the installation and working prin-




Earth Science Lab

Lab # ____

Name ____ Date ____ Lab Day ____

Lab Period ____

Locating the Epicenter of an Earthquake

Introduction: The epicenter is the point on Earth's surface directly above an earthquake. Seismic stations detect earthquakes by the tracings made on seismographs. Tracings made at three separate seismic stations are needed to locate an earthquake epicenter.

Objective: To identify the location of an earthquake epicenter using a travel-time graph and three seismograph tracings.

Materials: Ruler map safety drawing compass Earth Science Reference Tables

Procedure: 1. Study the three seismograph tracings below. Notice the time scale below each tracing. Each mark on the time scale represents one minute.

Balboa Heights, Panama

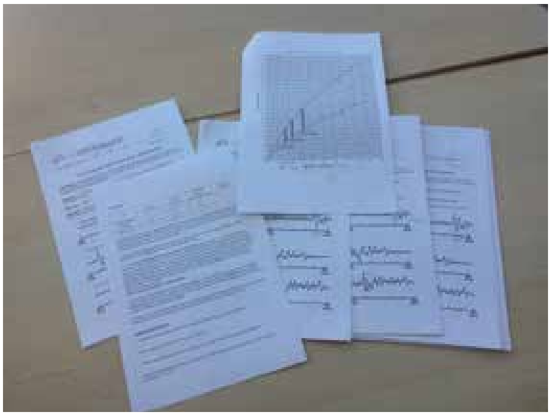
Boulder, Colorado

Mexico City, Mexico

ciples of a seismograph. Recent earthquakes in Turkey measured by the main seismograph has been shown to engage students in the reality of this phenomenon.

In the classroom, we used a worksheet to show how to make data analysis from data obtained from a seismograph. The waveform and how the distance of the epicenter to the earthquake location can be calculated has also been shown online.

Teacher Professional Development Seminars



3.2.3. Teacher professional development seminars

Two different teacher professional development seminars were conducted in Turkey. One of them was related to inquiry-based science education and its implementation in the classroom settings.

Two days – seminar for IBSE implemented in Turkey.

During IBSE teacher professional development seminar.

The second phase of the teacher Professional Development seminar was related to Earthquakes, Seismometers, how to use educational seismometers in the schools. All of the trainings were conducted in the Bornova Bahcesehir College because of the modern infrastructure of the school, modern science laboratories etc.

During Earthquake teacher professional development seminar. A group of teachers work on the seismometers

3.2.4. Participation of Dokuz Eylul University

The SSE project activities are now a part of Instructional Technologies and Material Design course of Dokuz Eylul University, Faculty of Education, Department of Science Education. This course is given to 3rd grade of pre-service science teachers in Izmir. More than 100 Pre-service science teachers used SSE-seismometer and obtained data as their part of course task. (Responsible person: Prof.Dr.Bulent Cavas; Number of university students participated to the SSE project implementation: 105 Pre-service science teachers; Dates of training meetings carried out: 4 meetings, 8-15-22 March 2017).

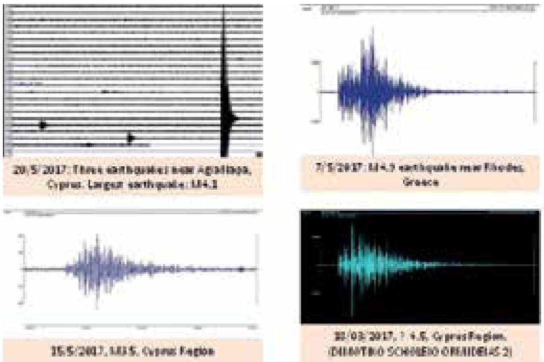
3.3. Cyprus (University of Cyprus)

3.3.1. Use of educational seismometers

In Cyprus, one seismometer was successfully installed and operated in the premises of the University of Cyprus for the duration of the project.

The room in which the seismometer was installed and operated.

The seismometer recorded various small and significant seismic events. Some examples are presented in the images below. All the seismometer recordings were uploaded on the SSE database and significant seismic recordings were also uploaded in the "Research in Science and Technology Education Group (ReSciTEG)" facebook page (https://www.facebook.com/ReSciTEG/?ref=-bookmarks).



Examples of seismic events recorded by the educational seismometer installed in the University of Cyprus.

The second seismometer was used for training purposes, dissemination events and installations in schools during teachers' implementations. Three schools hosted the seismometer for minimum one week and implemented lessons with the use of the seismometer: (1) GYMNASIO ARCHIEPISKOPOU MAKARIOU III – PLATY, (2) DIMOTIKO SCHOLEIO ORMIDEIAS 2 and (3) GYMNASIO AGIAS PARASKEVIS GEROSKIPOU).

Students visiting the seismometer during a school break.

Teachers from additional six schools also implemented 1-2 lessons with the use of the seismometer (e.g. presentation of the seismometer, modeling seismic waves, observing seismograms) in one or more classes of their school. For example, the students "created" small earthquakes by dropping objects or jumping near the seismometer, discussed about the recording of the seismometer and what they need to do for the amplitude of the largest wave to be smaller/bigger (e.g. if they drop something near the seismometer will the recording change? How? If they drop something with less force?). Through these kind of hands-on activities students were able to understand how a seismometer operates and the difference between magnitude and intensity of an earthquake. Some of those lessons were implemented with support from the Cypriot partner (e.g. school visits, co-teaching, design of lesson plans).

An activity example concerning the use of a seismometer implemented in the school DIMOTIKO SCHOLEIO LYKAVITTOU (KA).

An activity example (modeling of seismic waves) with the use of the seismometer implemented in the school DIMOTIKO SCHOLEIO ORMIDEIAS 2.

3.3.2. Development of curriculum materials

Curriculum materials titled "Learning about earthquakes" were developed in Greek. These materials aimed to:

(i) assist teachers in the planning and implementation of inquiry activities for the concept of earthquakes

(ii) support teachers' meaningful implementation of the curriculum materials

(iii) scaffold the procedure followed for installing and monitoring the seismometer

The curriculum materials included paper and pencil worksheets, a teacher guide and Go-lab inquiry learning spaces. Support and guidance concerning the use of these materials was provided to teachers during the professional development course and during their school implementations.

Inquiry Learning Space example published on the Go-lab platform as part of the curriculum materials provided to teachers. The lesson is accessible in this link: https://goo.gl/igcwj4.

The front cover and a paper and pencil worksheet example of the curriculum materials provided to teachers.

3.3.3. Professional development course

The professional development course concerning the SSE project lasted three days (three hours each day) and it was held on the 3rd, 5th and 7th of October 2016 in the afternoon in the University of Cyprus. An open invitation was sent to elementary and middle school teachers regarding the SSE project with the permission and assistance of science inspectors and consultants of the Ministry of Education and Culture of Cyprus. Twenty-one teachers responded to the call, eleven middle school geography teachers and ten elementary school science teachers. The content of the course was situated in practice and teachers were active participants in the process. The design of the professional development course was based on current literature that relates to teachers' Pedagogical Content Knowledge (PCK). The activities of the professional development course for each day are listed in Table 1 below:

Table 1.
The activities embedded in each day of the professional learning course for the SSE project

Day	Activities
1	1. Black box activity (http://arkportal.ut.ee/#/inq_act/442) 2. Presentation and elaboration of the inquiry-based learning framework 3. Inquiry – based learning within the concept of earthquakes: Go – Lab Inquiry Learning Space example (tectonic plates)
2	1. Presentation and discussion of basic concepts (earthquake, tectonic plates, seismic waves, seismogram, epicenter, magnitude etc.) 2. TC-1 Vertical seismometer 3. Activities (paper and pencil work sheets): a. Locating the epicenter of an earthquake by using three seismograms b. Finding the magnitude of an earthquake
3	1. Activities with the use of computer-based tools a. Seismogram 2K, Google Earth Pro – locating the epicenter of an earthquake b. WinQuake – finding the magnitude of an earthquake 2. Discussion about students' alternative ideas about earthquakes and relevant concepts 3. Discussion about the objectives of the project 4. Discussion about the school implementations

Day 1 included three activities that aimed in introducing the theoretical framework of the SSE project (see Intellectual Output 1: Pedagogical Framework) to the participating teachers. The teachers in the first group activity had to decide and describe, based on data, what could be the mechanism inside a black box. This process followed by the teachers corresponds to the scientific procedure of scientists when investigating a phenomenon and it is the desired inquiry experience and process that can be implemented in a science lesson to facilitate students understanding. During the rest of the activities of Day 1, teachers were engaged in discussions about the framework and a lesson example concerning the tectonic plates' boundaries and their relation to earthquakes developed in the Go-lab platform (www.golabz.eu) was presented.

Day 2 aimed in familiarizing teachers with the curriculum materials and content knowledge regarding the concept of earthquakes (e.g. definition and characteristics of earthquakes, seismic waves, seismic parameters). The seismometer was also presented, as well as real-time recordings of that instrument. The activities that followed were part of the curriculum materials provided to the teachers as a form of support for their implementations in schools. During these activities, the teachers in groups with the use of paper and pencil worksheets located the epicenter and calculated the magnitude of an earthquake.

The final day (Day 3) included four activities. In the first group activity, the teachers were involved in similar activities as Day 2, but this time with the use of various computer software (WinQuake, SeisGram2K and Google Earth Pro) in order to get familiar with the curriculum materials, with the software and with the use of seismometer recordings. The second activity included a presentation regarding the alternative ideas of elementary and middle school students to make teachers aware of the existence of these ideas and of the necessity of including them in the learning process. The rest of Day 3 was spent in discussion concerning the school implementations.

Examples of the activities and presentations during the professional development course.

3.3.4. School implementations

The twenty-one teachers participating in the professional development course were obligated to implement at least one lesson concerning the concept of earthquakes in their school. Of course, 87% of participating teachers had little or no experience teaching the concept of earthquakes and thus, some teachers expressed having low self-confidence in their teaching. Thus, all the teachers had the opportunity to choose one of two levels of support they wished to have during their school implementations based on their needs:

1. Provision of the curriculum materials and the opportunity to install the seismometer in their school.
2. Provision of the curriculum materials, the opportunity to install the seismometer in their school, on-going cooperation and support and classroom visits by members of the UCY research group.

All the SSE schools are presented in Table 2 below. The teachers' schools that selected the second level of support are presented with bold in the table. Overall, minimum 500 students participated in activities concerning the concept of earthquakes.

Table 2.
The primary and middle schools in which lessons concerning the concept of earthquakes were implemented by the SSE teachers

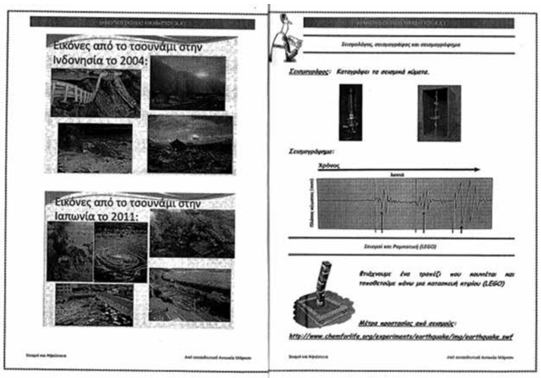
Primary schools	Middle schools
• **DIMOTIKO SCHOLEIO LYKAVITTOU (KA)** • **DIMOTIKO SCHOLEIO LYKAVITTOU (KB)** • DIMOTIKO SCHOLEIO KAMPION - ETHNOMARTYRA KYPRIANOU • **DIMOTIKO SCHOLEIO ORMIDEIAS 2** • DIMOTIKO SCHOLEIO PYRGON • DIMOTIKO SCHOLEIO DALIOU 2 • **DIMOTIKO SCHOLEIO DEFTERAS PANO** • **DIMOTIKO SCHOLEIO PALOURIOTISSAS 1 (KB)** • DIMOTIKO SCHOLEIO AGLANTZIAS 6 • DIMOTIKO SCHOLEIO ALAMPRAS	• GYMNASIO KONSTANTINOUPOLEOS • GYMNASIO PARALIMNIOU • **GYMNASIO ARCHIEPISKOPOU MAKARIOU III – PLATY** • GYMNASIO ARCHANGELOU LAKATAMEIAS • **GYMNASIO AGIAS PARASKEVIS GEROSKIPOU** • GYMNASIO PALOURIOTISSAS & GYMNASIO DIANELLOU KAI THEODOTOU (2 different schools, same teacher) • **GYMNASIO LINOPETRAS** & GYMNASIO NEAPOLIS (2 different schools, same teacher) • GYMNASIO APOSTOLOU PAVLOU • GYMNASIO KLHROU • **PERIFEREIAKO GYMNASIO KITIOU** • PERIFEREIAKO GYMNASIO PERA CHORIOU - NISOU

Students model seismic waves and observe the recording of the seismometer.

3.3.5. Examples of school implementations

DIMOTIKO SCHOLEIO LYKAVITTOU (KA): The science teacher of this school implemented three 80 min lessons in two classes and one 40min lesson in five classes. The teacher developed the materials and implemented lessons concerning various concepts related to earthquakes, for example tectonic plates movement and boundaries, volcanoes and seismograms. The teacher then shared the materials and experienced gained with the rest of the teachers.

One lesson in each class was dedicated in activities related to the seismometer (with support from the UCY research group). During this lesson, students had the opportunity to model seismic waves and observe seismograms and real-time data of the seismometer installed in the University of Cyprus.



A paper and pencil worksheet example of the materials developed by the teacher based on the curriculum materials provided to all the teachers during the professional development course.

The science teacher of the school showcases the model of a volcano she created for presenting it to her students.

DIMOTIKO SCHOLEIO LYKAVITTOU (KB): The science teacher implemented five lessons (80min each) in a 6th grade class concerning tectonic plates and seismic waves. The first three lessons were implemented with the use of an inquiry learning space in the Go-lab platform which was part of the curriculum materials provided to the teachers during the professional development course. During these lessons, the students worked in pairs on a computer and investigated the elevation profile of the tectonic plates boundaries in relation to their type of movement and the occurrence of earthquakes. The last two lessons were devoted in investigating these concepts further with the use of analogical models and the introduction to the concept of seismic waves. The students developed a lot of interest in the concept of earthquakes and also decided (on their own initiative) to participate in a schools' science festival (Uclan science festival) in which they presented to other schools and visitors of the festival the seismometer and models they created about tectonic plates boundaries and seismic waves.

Students presenting their models and overall work to other schools and students in the Uclan science festival.

Students using analogical models to represent the propagation of seismic waves during their last lesson about the concept of earthquakes.

DIMOTIKO SCHOLEIO ORMIDEIAS 2: The science teacher implemented five lessons (80min each) in two 5th grade classes. These lessons concerned the concept of tectonic plates and seismology in general (what is the science of seismology, what do seismologists do, what a seismometer is and how it works etc.). The seismometer was also installed in the school for a week. An earthquake occurred during that time and thus, the teacher had the opportunity to include activities concerning real-time seismic data in her lessons (e.g. searching in databases information about that earthquake and seismograms from seismological stations).

GYMNASIO ARCHIEPISKOPOU MAKARIOU III – PLATY: The geography teacher of this school decided to implement one lesson each week in five 8th grade classes for six weeks (30 lessons in total). The main concepts and ideas taught each week are shown in the Table 3 below. His lessons and the concepts he decided to teach were based on the curriculum materials provided during the professional development course.

Students modeling the seismic waves and observing the real-time recording of the seismometer.

Table 3. *The main concepts and ideas chosen by the teacher for each week*		
No. of week	**Main concept**	**Main ideas**
1	Tectonic plates	The theory of tectonic plates
2	Tectonic plates	Tectonic plates boundaries and movement (transformed, divergent, convergent).
3	Intensity	Definition of intensity Differentiation from magnitude Mercalli scale
4	Epicenter and seismic waves	The process of locating the epicenter of earthquakes. What are seismic waves, their characteristics and their propagation in Earth's inner layers.
5	Seismometer	How a seismometer works
6	Revision of the concepts taught during the prior lessons to prepare for the upcoming test regarding the concept of earthquakes.	

Two models (inner layers of the Earth and a volcano) developed by the students as part of their non-mandatory assignment.

The seismometer was also installed in the school for one week and different group of students each time visited the seismometer during their breaks. The teacher also arranged a visit to a seismological station at the end of his implementations. Furthermore, the teacher decided to assign to students (non-mandatory assignment) the development of a model concerning a concept related to earthquakes. Two models which were developed by students are presented in the pictures beneath.

3.3.6.Lessons learned

The majority of students who had the opportunity to get involved in the SSE project developed interest and eagerness to learn about the concept of earthquakes and therefore, a lot of SSE teachers devoted more lessons to teach the concept than they had first planned. Through this process, students learnt about concepts that they do not always have the opportunity to learn about, such as seismology, the inner layers of the Earth, tectonic plates, magnitude/intensity of earthquakes, epicenter of earthquakes etc. The meaningful implementation of the seismometer in the lessons was also a success with students, as well as with the teachers, and a lot of schools organized 40 or 80 minutes lessons for classes that did not actively participate in the SSE project so that they can also see and use the instrument. Due to the impact of the SSE project, the majority of the SSE teachers expressed their eagerness to participate in the project the next school year. Furthermore, due to other dissemination events, a lot of teachers from other schools also expressed their willingness to participate in the project.

Of course, based on literature and overall classroom observations, students held a lot of misconceptions about concepts related to earthquakes (e.g., earthquakes are a result of human activity, volcanoes eruptions are the only cause of earthquakes, earthquakes occur only in countries with warm climate, continents and tectonic plates are the same things, tectonic plates are really deep into the Earth, tectonic plates do not move) and thus, due to time restrictions based on the Cypriot educational curriculum, if a teacher could teach four lessons about the concept of earthquakes, addressing these misconceptions was a priority. Thus, in a lot of teachers' cases there was not enough time available for students to adequately process seismic data. For example, some teachers did not have enough time for teaching and implementing the process of locating the epicenter of an earthquake. Also, because of the limited or lack of access to technology, geography teachers especially did not have a lot of opportunities to implement activities concerning the analysis of seismic data with the use of computer software or the installation of the seismometer.

3.3.7. Other dissemination events

The Cypriot partners will participate or have already participated in six events and conferences (local and international) related to the SSE project. During these dissemination events, additional teachers, schools, students and communities were informed about the SSE project's goals and activities. A list of those events and a brief description of each event is provided below:

- Participation to the 2nd National Conference of Physics and Teaching of Physics: "Physics in the modern world" (4-5 February 2017): A twenty-minute presentation in Greek concerning the SSE project and activities related to the concept of earthquakes titled "Η Διδασκαλία των Σεισμών στη Δευτεροβάθμια Εκπαίδευση με τη Χρήση Τεχνολογικών Εργαλείων". The participants of this conference were mostly science teachers from secondary and primary education.
- Participation to the 10th Greek National Conference of Physical Sciences and Technology in Education (7 – 9 April 2017): A two-hour workshop in Greek titled "Μαθαίνοντας για τους σεισμούς: Δραστηριότητες και διδακτικές πρακτικές για τη μελέτη σεισμολογικών φαινομένων" was implemented concerning activities about the concept of earthquakes. Teacher-students mostly attended the workshop.
- Participation in the interactive exhibition of the Mediterranean Science Festival in Limassol, Cyprus (27-30 April 2017): During the first two days, numerous schools of all school levels visited the booth and participated in small activities with the use of the seismometer. During the last two days, mostly families attended the interactive exhibition and also participated in similar activities.

Moments of the interactive exhibition during the

Mediterranean Science Festival.

- Implementation of activities concerning the concept of earthquakes in a Cypriot summer school ("Καλοκαιρινό Σχολείο Φυσικής") in which upper secondary education students participate (4 July 2017).
- Participation in the ESERA conference in Dublin, Ireland (21-25 August 2017): Twenty-minute presentation in English with the title: "Lessons learned from examining the PCK of a novice Teacher". The study presented in this conference was conducted in the context of the SSE project and it was part of the thesis of a M.A. student of the University of Cyprus. The purpose and main findings of the study are presented in the last point of the dissemination events list.
- Participation in the interactive exhibition in the Researchers Evening 2017 in Cyprus (29 September 2017): Information about the educational seismometer and the SSE project will be provided to the visitors.
- A M.A. student of the University of Cyprus conducted her thesis titled "The Development of Pedagogical Content Knowledge and its Effect on Enactment: A Beginning Geography Teacher's Case" in the context of the SSE project. The purpose of this study was to examine in what extent the Pedagogical Content Knowledge (PCK) for the teaching of earthquakes of a beginning secondary geography teacher was developed (or not) during his enactment of a series of lessons related to earthquakes in a period of six weeks in five classroom contexts. The PCK model of Magnusson, Krajcik and Borko (1999) served as the theoretical underpinning of this study. Curriculum materials, researcher's feedback and a short-term professional development course served as forms of support for the teacher. Each week, the teacher implemented the same lesson in each one of the five classes (30 lessons in total). The data of the study consisted of an initial open-ended interview, semi-structured interviews prior to every week's lessons, post semi-structured interviews for each lesson, non-participant observations and the teacher's initial and revised lesson plans based on the researcher's feedback. The data were analyzed using explanation building and time-series analysis techniques. Based on the findings, it appeared that the teacher's PCK for the teaching of earthquakes was very limited. His orientation towards science, which significantly affected his instructional decision-making, was incongruent with inquiry-oriented teaching. Evidence from his implementations demonstrated that his knowledge on action (about instructional strategies) was developed, but his knowledge in action (use of that knowledge) was not developed in the same extent. As a result, his enactment impeded students' development of conceptual understanding about earthquakes. Additionally, it was found that teacher's unsophisticated beliefs about teaching and learning affected his teaching orientations, as he switched from student-centered approaches that preached to follow in his initial implementations to transmissive teaching that was more compatible with his "comfort zone". Despite appearing aware of students' difficulties during interviewing him, he never attempted to structure his lesson designs or implementations around students' ideas and used time as the constraint to account for this failure. As the teacher moved towards his "comfort zone", the recommendations for revising his developed curriculum materials provided by the researcher were becoming an increasing necessity, since they were not aligned with his beliefs and instructional decisions. This case study reinforces the necessity for beginning secondary teachers' participation in long-term professional development programs through which their PCK for both the teaching of specific science domains and approaching science teaching through inquiry can be fostered and enhanced.

3.4. Italy (Fondazione Idis – Città della Scienza)

As already said in a previous chapter, Fondazione Idis – Città della Scienza includes among its most significant goals the promotion of scientific and technological culture and the widespread public engagement in science.

Hence since its birth Fondazione Idis established strong relationships with schools at all levels in order to develop innovative educational tools and experiences in non-formal science education. Indeed Fondazione Idis attended numerous projects in science education both at both national and international level as leader or in partnership with other organizations. Moreover Fondazione Idis has founded in 1996 Città della Scienza, the first science centre established in Italy. Hence the implementation of the educational contents developed in the framework of SSE has represented a natural strengthening of the educational mission Fondazione Idis - Città della Scienza.

3.4.1. Network of educational seismometers

As well as to the other partners of the projects, the National Observatory of the Athens has delivered to Fondazione Idis two TC1 seismometers helpful finalized to the educational tasks of the projects.

On July 2016 one of them has been installed - and it is still working- in Città della Scienza.

Starting from January 2017 up to now, the second seismometer has been installed in three different schools helpful to house it in their laboratory rooms:

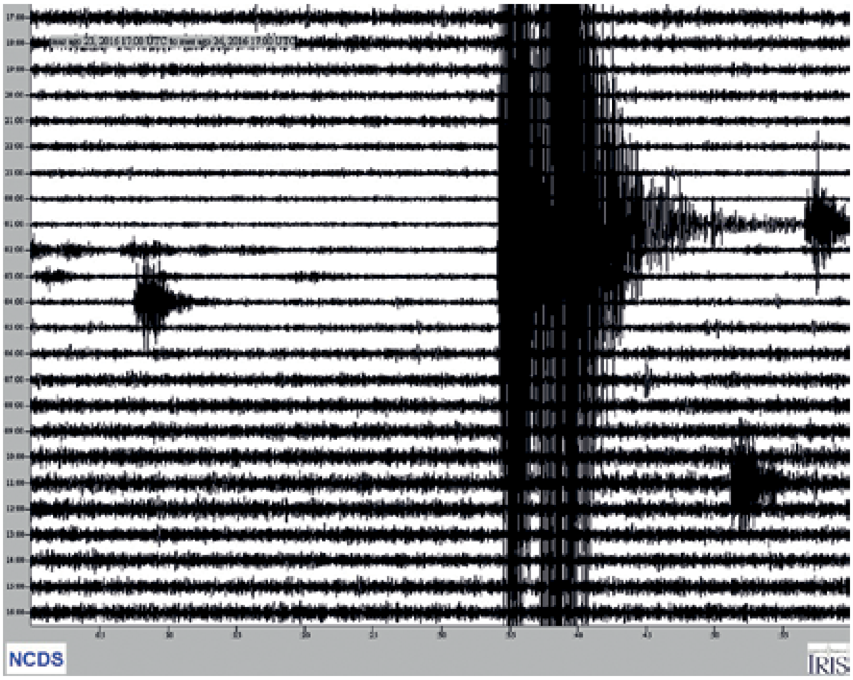
- from 18/01/2017 to 9/03/2017, Liceo Scientifico Statale Arturo Labriola of Naples;
- from 9/03/2017 to 21/04/2017, Liceo Scientifico Statale Elio Vittorini of Naples;
- from 21/04/2017, Liceo Scientifico Statale Galileo Galilei of Naples.

These seismometers have gathered several useful data and in particular the shocks produced by the strong earthquakes that have affected central Italy on August and October 2016, and on January 2017.

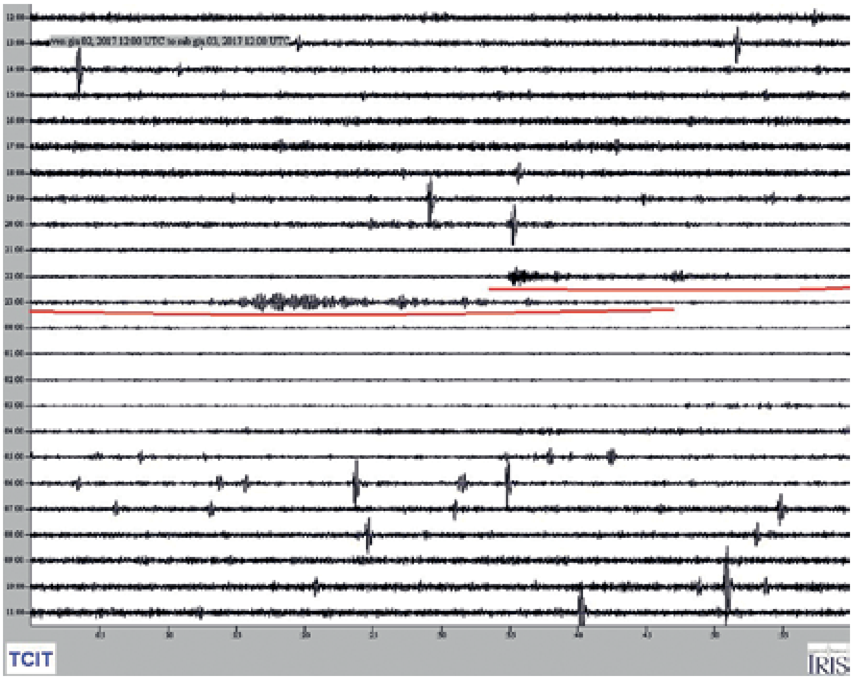
During both the teachers training meetings and the implementation of the lesson plans (see below), the beneficiaries has been trained in the use Jamaseis' software in order to be able to download and elaborate independently seismic data from the seismometers temporarily hosted in their schools.

TC1 seismometer installed in the headquarter of Città della Scienza

The schools in Naples where the travelling TC1 seismometer has been installed during school year 2016/2017



The main earthquake and the aftershocks occurred on August 24th 2016 destroying the towns of Amatrice and Accumoli in central Italy. The shocks have been recorded by the TC1 seismometer installed in Città della Scienza



An earthquake M 6.5 occurred on June 2nd 2017 in Aleutian Islands recorded by the TC1 seismometer while this device was installed in the headquarter of Lyceum Galileo Galilei in Naples

3.4.2. Phase of implementation

The implementation phase of SSE in Italy has begun during school year 2015-16 with some actions following the significant phases represented by the recognition about the teaching of Earth's science in school (01, Pedagogical Framework) and the development of the first lesson plan by the end of 2015.

This lesson has been presented to a party of science teachers in the framework of an aimed training meeting held on April 5th 2016 (this meeting is described more in deep in the subchapter about teachers' training).

Moreover the wider activities of the project to be implemented during school year 2016-17 have been presented in the framework of two relevant events (respectively a science fair and a school fair both held on October 2016, see dissemination paragraphs) and briefly during some thematic scientific seminars aimed to high schools held in Città della Scienza on spring 2016. All these actions have been aimed to promote SSE among the schools to involve them the implementations phase.

The training meeting held in Città della Scienza on April 5th 2016

The location of the science fair Futuro Remoto where the activities of SSE have been presented on October 2016

3.4.2.1. Teachers' training

In the framework of SSE several training meeting have been organized for science teachers in Italy. The objectives were to introduce teachers to the project and its general concept, and let them became able to carry out the lesson plans specifically with their classes as well as to manage the TC1 seismometer if it was installed in their school or exploit the data gathered by these devices or available in the database of SSE's website to develop independently further educational experiences.

Overall five teachers' training meetings have been carried out by Fondazione Idis everyone taking place in Città della Scienza:

5/04/2016 – as already said above, this meeting was organized to both present the activities of the project and introduce the teachers to the educational contents developed so far. The meeting was carried out by Luigi Cerri from Fondazione Idis as trainer and it was attended by six teachers coming from both secondary, high and vocational schools;

15/11/2016 – this training has been carried out in the framework of the second project meeting held in Naples from 14^{th} to 15^{th} November taking advantage of the presence of two experts coming respectively from NOA (Gerasimos Chouliaras, research manager in geophysics) and from EA (Georgios Mavromanolakis, project manager expert in educational issues). The meeting has been attended by 29 Italian teachers working in high, vocational and secondary schools.

The meeting has been focused on the general contents of the project (educational contents of the web based platform; use of the educational seismometers of the SSE's network; implementation of the data gathered by the seismic network; etc.);

13/02/2017 - this meeting has been focused on the contents of the first lesson plan, the one then carried out by the teachers with their classes.

A teachers training meeting held on November 15^{th} 2016 in the framework of the second project meeting in Città della Scienza in Naples.

Also this meeting has been carried out by Luigi as trainer and it has been attended by 16 teachers coming respectively from high schools (10 teachers in physics or in science from scientific high schools), vocational schools (5 teachers) and secondary schools (one teacher);

Two different moments of the teachers training meeting held on February 13th 2017 in Città della Scienza.

6/03/2017 – As the previous one, also this meeting has been focused on the contents of the first lesson plan and it has been carried out by Luigi Cerri. This meeting has been attended by six teachers in physics coming from scientific high schools.

6/04/2017 – this training meeting has been carried out in the framework of A Scuola di Scienza a promotional event organized by De Agostini – one of the main Italian school books publishers – aimed to science teachers held in Città della Scienza. One of these sessions have been focused on SSE and its lesson plans. This meeting is also mentioned in a further paragraph among the dissemination actions.

3.4.2.2. Implementation in schools

The lesson plans carried out in Italy during the school year 2016/2017 have involved 20 classes, respectively 16 of them from scientific lyceums and 4 from vocational schools.

We have to remind that one of the lesson plans developed by the Italian partner in the framework of SSE from 2016 has become parts of its usual educational offer and then available to every school class that would to carry out it. Indeed some of the lessons of the implementation phase have been carried out in the headquarters of the schools if there were available laboratories or, better, ICT classrooms, while others have been carried out in the educational laboratories of Città della Scienza.

In particular, all the classes involved in the implementation phase have attended the lesson plan about the localization of the epicenter of an earthquakes developed by the end of 2015. This lesson presents several advantageous features like for instance the opportunity for the students to work in team to achieve a common result, to exploit ICTs, open source software and scientific data freely available on the web.

The lesson has always been introduced to the students illustrating them some general topics like triangulation, the propagation of seismic waves, the general features of a waveform and the working of a seismometer. Regarding this last point, its explanation has been supported showing directly a TC1 seismometer, its main components and its working. All the students attending the lesson plan expressed a positive

The localization of the epicenter of a teleseism on Google Earth Pro starting from real waveforms

A lesson plan held on January 17th 2017 in the laboratory of chemistry of Liceo Scientifico Labriola in Naples (left) and a lesso plan held on March 9th 2017 in an ICT laboratory in Città della Scienza with a class of Liceo Scientifico Caccioppoli of Naples (right)

feedback attributable to their direct involvement in the operative phase, the discovering of some real phenomena that aren't usually faced in deep during the curricular lessons in science or the opportunity of exploit ICTS in an innovative educational way.

All the lesson plans with classes have been carried out with the support of an expert from Fondazione Idis having often not the teachers in science or in physics a specific background in Earth's science.

The table below resumes all the lesson plans carried out with some additional information

School	Date	Class	Degree	Number of students
Liceo Scientifico Statale Arturo Labriola di Napoli	17/02/2017	IV B	12th	21
	14/03/2017	III I	11th	15
	14/03/2017	IV G	12th	12
	3/05/2017	IV D	12th	17
Liceo Scientifico Statale Elio Vittorini di Napoli	17/03/2017	IV A	12th	17
	22/03/2017	V H	13th	17
Liceo Scientifico Statale Renato Caccioppoli di Napoli	9/03/2017	IV	12th	15
	9/03/2017	V	13th	23
Liceo Antonio Fogazzaro di Vicenza	22/03/2017	IV CU (scientific address)	12th	23
	22/03/2017	V CA (artistic address)	13th	14
Liceo Scientifico Statale Giuseppe Mercalli di Napoli	31/03/2017	V I	13th	19
Istituto Superiore Ninfo di Sessa Aurunca	31/03/2017	IV BT Lab	12th	21
Liceo Scientifico Ettore Majorana di Sessa Aurunca	31/03/2017	III E	11th	20
Liceo Scientifico Statale L. B. Alberti di Minturno	6/04/2017	V E	13th	24
	6/04/2017	V F	13th	21
Istituto Nautico Duca degli Abruzzi di Napoli	8/04/2017	I C	9th	13
	8/04/2017	I G	9th	21
Liceo Scientifico Statale Galileo Galilei di Napoli	17/05/2017	V I	13th	7
	5/06/2017	III A	11th	18
	5/06/2017	III B	11th	13
Total number of students attending the lesson plans				351

3.4.3. Dissemination

In order to promote the activities carried out in framework of Schools Study Earthquakes, Fondazione Idis has communicated and disseminated the project results to educational authorities, science societies, schools and citizens in the framework of various events held at local, national and European level. As already said in this guide, one of the main task of Fondazione Idis is communication and public engagement in science hence it has exploited some of its usual institutional activities to disseminate also the activities developed in the framework of SSE.

The location of Futuro Remoto 2016

Futuro Remoto 2016

Futuro Remoto is one of the most important science fair held every year in Italy organized by Fondazione Idis since 1987. From 2015 Futuro Remoto is held in one of the main squares of Naples. The edition 2016 has lasted from October 7th to 10th 2016. The activities of SSE have been presented to the visitors in a corner set up by the Educational Department of Città della Scienza.

3GIORNIPERLASCUOLA - Smart Education & Technology Days

It is a school fair held every year in Città della Scienza under the patronage of the Italian Ministry of Education and aimed to teachers, educators and all the stakeholders operating in education such as publishing company, lab equipment producers, etc. On October 21st 2016 a session has been held where the lesson plan developed in Italy in the framework of SSE has been exploited with a group of teachers attending the fair.

9.30-11.00
AULA AVIOAERO
LIVING LAB: FARE DIDATTICA IN MANIERA INNOVATIVA NEL MONDO DELLE SCIENZE E DELLA TECNOLOGIA: L'ESPERIENZA DEL CORSO DI ALTA FORMAZIONE DI EHEALTHNET S.C.A.R.L.
Intervengono Annalisa Capano, Caterina Ferrara, Immacolata Rosano, Claudia Volpicelli

9.30-11.00
AULA SAMSUNG
WORKSHOP DI SISMOLOGIA DAL PROGETTO ERASMUS PLUS
A cura di Luigi Cerri, Città della Scienza

52

Sergio Roncelli, Delegato CONI Napoli
Tecnica e pedagogia teatrale: costruire una passione
Michele Monetta, Direttore ICRA Project e Docente dell'Accademia Nazionale di Arte Drammatica "Silvio D'Amico" di Roma
Educare all'arte: lo strumento musicale nell'offerta formativa della scuola secondaria
Enzo Amato, Presidente Associazione Musicale Domenico Scarlatti
Presentazione del Premio Isolimpia - Edizione nazionale 2017
Mauro Biancaccio, Presidente del Comitato Organizzativo di Isolimpia

53

9.30-11.00
AULA B
LA PAROLA ALLE SCUOLE
ESPERIENZE DI APPRENDIMENTO COOPERATIVO
Modera Serena Criscuolo, Città della Scienza
Interventi
Dal demonio all'acquasanta, lo

APPROCCI INNOVATIVI PER L'APPRENDIMENTO E L'ORGANIZZAZIONE SCOLASTICA
Modera Flora Di Martino, Città della Scienza
Interventi

9.30-11.00
FABLAB PICCOLI
LA PAROLA ALLE SCUOLE

The page of the program of Smart Education & Technology Days 2016 where is reported the workshop on the activities of SSE

A Scuola di Scienza – on April 6th 2017 the company De Agostini – one of the main Italian school books publishers – organized an event of training meetings aimed to science teachers held in Città della Scienza. One of these sessions have been focused on SSE and its lesson plans.

The poster of A Scuola di Scienza 2017. The red ellipse highlights the workshop about the contents of SSE

ECSITE Annual Conference 2017 - ECSITE is the European Network of Science Centres and Museums and Fondazione Idis is member of the board, its governing body. Every year the annual conference of ECSITE is held in a different European town and the edition 2017 will take place from June 15th to 17th in Natural History Museum of Porto (PT). A representative of Fondazione Idis presented a poster related to SSE during a showcase on June 16th in the framework of the conference.

Throughout the implementation phase of the project in Italy, Fondazione Idis has organized and carried out several activities aimed to teachers and students mainly, but not only, on a local level. The educational activities proposed to this beneficiaries has been characterized by an inquiry based approach strengthen by the exploitation of real data also gathered by scientific devices like the seismometers of SSE's network. Moreover the contents of the project have been widely promoted in the course of several events addressed not just to the stakeholders of the world of education but also to a larger number of people.

Below are synthetically resumed some numerical results of the implementation phase carried out in Italy:

- one of the seismometers gathered by Fondazione Idis has been installed in its headquarter Città della Scienza from July 2016 and it is still working collecting scientific data useful for the projects' purposed. The second one has been installed for limited periods in three different scientific high schools in the course of school year 2016-17;
- 5 teachers training meetings have been carried out attended by a total of 60 people. Many of these teachers attended also two or more meetings then the teachers involved in the training meetings have been 33. In the course of the meeting 27 questionnaires filled by the attending teachers have been collected. The results of these questionnaires are described in detail in the evaluation report (see below);
- 20 lesson plans have been carried out involving 20 classes of 9 high and vocational schools having their both in Campania and in other regions of Italy. In total 350 student attended the lesson plans in Italy. In the course of the meeting 350 pre and 151 post questionnaires filled by the students have been collected. The results of these questionnaires are described in detail in the evaluation report (see below);
- The activities and the contents of SSE have been disseminated in the course of 5 events held at both local and European level.

3.5. Bulgaria (National Research Network Association)

In the framework of SSE, NRNA has developed two lesson plans, as follows:

- **Proper behavior in an earthquake situation**

Primary school - 2nd grade (7-8 years old)

- **How to find the epicenter of an earthquake, using modern information technology**

Secondary school - 9th-10th grade (15-16 years old)

Due to the necessity for achieving a higher level of comprehension, relation with IBL methodology and scientific understanding within the respective schools, only the second lesson plan has been chosen to be implemented and teachers involved were mainly those, teaching Physics to 9th and 10th grade students – teachers' profiles follow in the table below:

School ID	No	Teaching subjects	Teaching classes
603058	1	Physics and Astronomy, Class hour	7, 9, 11, 12
603058	2	Mathematics, Physics and Astronomy, Class hour	8, 10, 11, 12
603077	3	Mathematics, Physics and Astronomy, Class hour	6, 8, 10, 12
603077	4	Physics and Astronomy, Class hour	7, 8, 9, 11
1690346	5	Physics and Astronomy, Man and Nature, Class hour	6, 7, 9, 10, 11, 12
1690346	6	Physics and Astronomy, Class hour	8, 9, 10, 12
2202002	7	Physics and Astronomy, English Language, Traffic Safety, Class hour	5, 7, 10
2202002	8	Physics and Astronomy, Class hour	7, 9, 10, 11, 12
2204018	9	Physics and Astronomy, Class hour	10, 12
2204018	10	Physics and Astronomy, Man and Nature	5, 7, 9
2204018	11	Physics and Astronomy, Class hour	7, 11
2204091	12	Physics and Astronomy, Class hour	9, 10, 11
2204091	13	Physics and Astronomy, Chemistry and Environmental Protection	9, 11, 12
2205119	14	Physics and Astronomy	7, 10, 11
2205119	15	Physics and Astronomy, Chemistry and Environmental Protection, Class hour	9, 10, 11, 12
2209051	16	Physics and Astronomy	10, 11, 12
2209051	17	Physics and Astronomy, Informatics, Information Technology	5, 7, 9, 10
2309991	18	Physics and Astronomy, Class hour	8, 10
2309991	19	Physics and Astronomy, Activities by Interest, Self-Training	9, 10, 11, 12
2841532	20	Physics and Astronomy, Man and Nature	5, 7, 8, 9, 10, 11
2841532	21	Mathematics, Traffic Safety, Class hour	6, 9, 10

3.5.1. Teachers' trainings

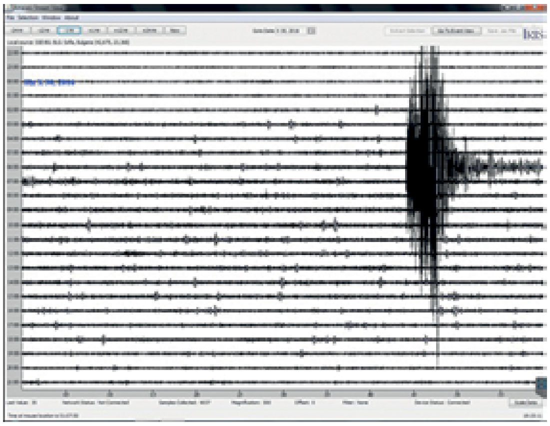
Concerning the teachers' trainings, three special trainings and few promotional events have been carried out within the second half of the school year 2016-2017:

– **a live training in a Physics lab at 51th Secondary school „Elisavetha Bagryana" in Sofia in early March (9th)** – actually this is the location of the second seismometer, that was given by the National Observatory of Athens to the Bulgarian educational community (the first is located in the Laboratory of Telematics in the Institute of Mathematics building, which is right in the heart of the Bulgarian Academy of Science campus)

Training involved the school principal Mr. Asen Alexandrov, two teachers in Physics and members of the school Physics Activity Group, which is very active in school competitions and national Olympiads in Physics and Astronomy. Training included but was not limited to setting up seismometer and configuring jAmaSeis software, using the SSE Project .sac database, the adjustment

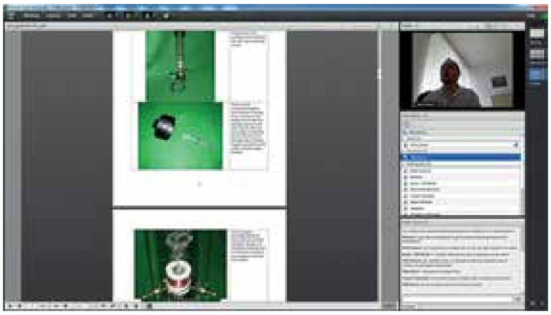
of S and P curves, finding the real distance between the earthquake epicentre and the seismic station as well as finding the epicentre of the earthquake using publicly available sources (understanding the principle of triangulation and the necessity of using at least three different seismograms from different sources of the same event).

The group discussed the seriousness of earthquakes and seismograms from specific events (like the serious earthquake in Italy from October 2016) were analysed (see the diagram below) using the data from the Bulgarian SSE station, located in the Academy of Science.

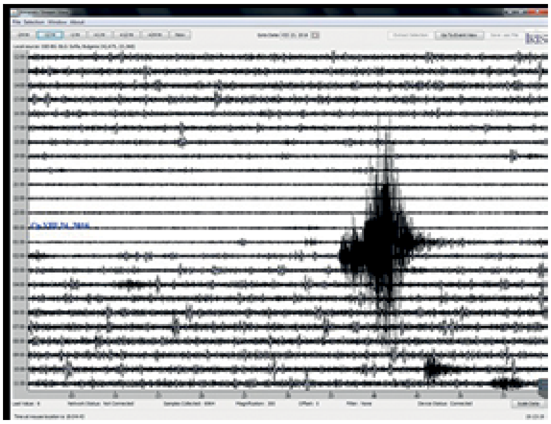


– an online training a week later (March 16th), including 19 teachers from 9 different schools, half of them outside Sofia**:**

The training happened in two shifts (morning and afternoon session, because some of the teachers had classes) and included specific knowledge for teachers how to use the virtual training facility of the Bulgarian SSE Project partner (NRNA), some theoretical fundament of using and adjustment of seismometers (as far as only one device is available for training purposes and it is not viable to move it round the country), the availability of the SSE project web site and the existing network data - seismic database (.sac files). A live connection was established with BAS and the seismometer installed there and basic explanation of the lesson plan, created by the BG team for location of earthquake epicenter was made, giving ground to questions from teachers how to better integrate this specific topics into 9th and 10th grade curricula.

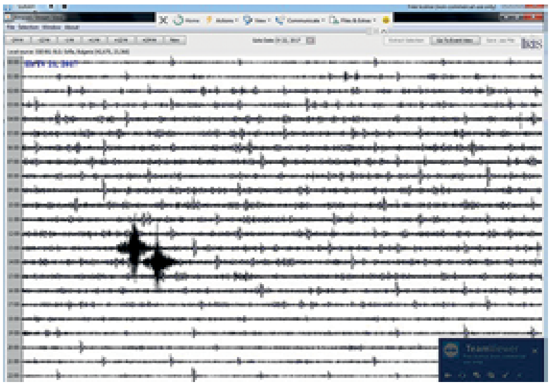


The members of the project team (Orlin Kouzov and Phillip Ivanov) assured the teachers that the web site of the project (sse-project.eu) and the network database will be available for further investigation even after the formal project end. They were confident that there will be useful resources to work with regarding seismic waves and accumulated knowledge base from all the project partners and the created network of participating schools. Some useful links and resources were sent to all teachers, including snapshots from earthquakes recorded by the Bulgarian SSE ground station.



- another live training happened in late April (28th) in the headquarters of the Laboratory of Telematics at BAS Campus in Sofia, including 7 teachers in Mathematics and Physics from four schools – all from Sofia:

The training session was carried out by Assoc. Prof. Radoslav Yoshinov – Director of the Laboratory of Telematics and member of the Bulgarian SSE project team. The participants were shown the working seismometer in the basement of the building and after that they discussed the principles of the seismometers and opportunities for the students to work in real scientific environment. Prof. Yoshinov showed real data from the recent earthquakes in Turkey and the teachers expressed their belief that such experimental setting could raise kids interest towards the subject and linking the mathematical equations with live events could be the key for the long term development of scientific culture and research interest in the younger generation.



3.5.2. Implementation of the lesson plans

The implementation of the lesson plan took place for about two months (from mid March till mid May) involving students from 9th and 10th grade in 10 Bulgarian schools. For a number of logistical and administrative reasons in most schools the proposed lesson plan was squeezed to one school hour and there was no real practice with seismometer, as there is only one device available in the whole country. However the teachers explained the principle and illustrated the lesson with materials they prepared after the teachers' trainings. In some of the cases (like Pravets and Straldzha) the lessons were supported by live connection to the virtual project classroom (http://adobeconnect.mon.bg/sse), maintained by the Bulgarian project team and the NRNA experts explained how to use the existing SSE network and resources from the project website, available at sse-project.eu.

The involved schools, some of their profiles and vision and participating classes were, as follows:

Secondary School "Hristo Botev" – Vratsa

Technologies play a leading role in the school environment. The school management is paying particular attention to the development and integration of traditional teaching practices with the use of technology and innovation. According to the school principal that helps building the necessary skills that will ensure the success of young people in modern society based on knowledge.

Project participation: two teachers with two classes – one 9th grade (23 students) and one 10th grade (25 students)

Secondary school "St. Cyril and St. Methodius" - Kozloduy

The school staff is targeting school development into a constantly learning and developing organization, capable of acting in accordance with changes of the modern society. E-learning, as part of the educational experience of their students, along with using ICT as means of communication and qualification of the staff, are among the key factors for the achievement of this aim. It is the quick access to up-to-date information, the tools it gives for increasing the students' motivation and exchange of experience and ideas, that makes e-learning the perfect means of bringing about the vision. Research and innovation are among the key factors for achieving successful results.

Project participation: two teachers with two classes – one 9th grade (21 students) and one 10th grade (26 students)

High School of Mathematics „Academician Kiril Popov" - Plovdiv

As one of the leading school of Mathematics and Informatics in the country HSM strives to enable the use of ICT in every lesson and throughout the school day. It was among the first schools implementing mobile technology in the classroom and developing and adapting suitable educational resources. Most teachers are trained to work with electronic resources and have substantial methodological preparation for their creation.

Project participation: two teachers with two classes – one 9th grade (25 students) and one 10th grade (24 students)

Secondary school "Academician Emilian Stanev" - Sofia

The school has been consolidating its position of an educational institution with an interesting school life and a lot of work on national and international projects. It tries to be unique because of several reasons – the musical school bell, the songs of which are chosen by the students themselves; the video intercom system, which is used by the parents who come to collect their children at the end of the school day; the electronic card entry, which provides a secure environment and safety for the students; the fact that almost 70% of the classrooms have been equipped with multimedia projectors and computers… The whole process of acquiring knowledge is organised with the idea of inquiry-based and project-based learning and the school has already successfully participated in other innovative projects like Open Discovery Space, Inspiring Science Education, E-STEP.

Project participation: two teachers with two classes – both 10th grade (45 students altogether)

18th Secondary School "William Gladstone" – Sofia

The school has traditions in e-learning and innovative teaching practices. It has around 150 teachers and more than 2300 students. They use to send their teachers to various trainings and developing educational content is the most important components in their school environment. Although relatively static in fact the e-content is subject to continuous improvement, expansion and development and adding relevant and up-to-date scientific data and scientific research practices are very important for the school development.

Project participation: three teachers with three classes – two 9th grade (26 students each) and one 10th grade (25 students)

91st German Language School "Prof. Konstantin Galabov" - Sofia

One of the leading Bulgarian schools with many prize winners of national Olympiads in Bulgarian language, Mathematics, Informatics and Physics. For obvious reasons it has strong foreign language profile and participates in many international projects with schools all across Europe. One of the Physics teachers there developed an innovative educational scenario and won an incentive reward for his participation in Inspiring Science Education project.

Project participation: two teachers with two classes – one 9th grade (24 students) and one 10th grade (23 students)

119 Secondary School "Academician Michail Arnaudov" - Sofia

The school aims to establish unified school environment with educational resources, accessible for all of the students and teachers. Teachers support innovation and implementing new teaching practices in the classroom and projects like SSE has its natural supporters there. The school team cooperates actively with the parents and some of the teachers took part in the E-STEP project, facilitating such collaboration through the use of social networks. Working in teams is a general practice in the school and it is common to see a teacher and group of students working together for various educational initiatives.

Project participation: two teachers with two classes – one 9th grade (22 students) and one 10th grade (23 students)

51 Secondary School „Elisavetha Bagryana“ - Sofia

The staff vision is a creation of a competitive school, in which students can shape their national and universal virtues and can prepare for their personal and social development. A place where teachers can enhance their professional skills and become a team of highly responsible individuals exhibiting tolerance, concern and respect for human dignity, using creative and critical thinking in the implementation of innovative teaching practices to promote the young people as worthy citizen of Bulgaria and the world.

Project participation: two teachers with four classes – two 9th grade (53 students altogether) and two 10th grade (55 students altogether)

Vocational High School of Computer Technologies and Systems - Pravets

The school has a strong technological background and is closely related to the Technical University of Sofia. The Director of the school has several awards for excellent management and was invited as part of the advisory team that drafted the Roadmap for the implementation of the national ICT in Education Strategy.

The school has one of the best teaching staff in engineering and sciences and the highly motivated individuals work for a number of innovative initiatives like paperless workflow, e-learning etc.

Project participation: two teachers with two classes – one 9th grade (24 students) and one 10th grade (23 students)

Secondary school "Peyo Kracholov Yavorov"– Straldzha

The school is affirmed as a competitive Central School which aims to form students' national and universal virtues in their preparation for successful socialization and realization. It achieves this by providing an optimum material and technical foundation, a highly qual-

ified teaching staff and implementation of advanced teaching techniques. The school practice is implementation of innovative methods in teaching and learning process, as open classes at school at a municipal and regional level, students annual participation in Olympiads and competitions from the national school activities calendar of the Ministry of Education and Science. In recent years their students have won prizes in all mentioned levels.

Project participation: two teachers with two classes – two 9th grade (41 students altogether)

Additional examples of good practices in Bulgaria

As the school, where the testing seismometer was given (51 Secondary School „Elisavetha Bagryana" - Sofia), is very active in science teaching, the SSE project team decided to arrange a special open hour for smaller kids and Mr. Peter Kokarchev, who is a teacher in Physics and Informatics for 5,7,9 and 10th grades assisted in organising such event for the 7th grade kids on May 23rd. There was a big interest in installation and working with seismometer and understanding its principle so we intend to multiply the event in the beginning of the next school year.

3.6. Summary of implementation in schools across countries

Apart from the original objectives of SSE, several additional actions have been undertaken strengthening the educational and informative effects of the project. In total 85 schools of all levels participated in SSE across the partner countries involving 2200 students in the educational activities, and 230 teachers at all levels attended the training seminars and workshops. Further to this, 39 teachers and their schools and students participated in the educational contest "Build your own seismograph" which was organized in Greece and 105 perspective pre-service teachers involved in SSE in Dokuz Eylul University in Turkey.

Regarding the seismic network, it has to be considered the fact that in each country the seismometers provided by NOA to the other partners have been hosted in several different schools in each country and that EA has purchased and installed in schools in Greece 7 additional devices to strength the network. Presently the SSE network consists of 16 operational educational seismometers.

Therefore the implementation phase of SSE has fully achieved - and even largely surpassed - its expected targets and tasks. Further indications about the educational impact of SSE can be gathered from the evaluation process considering that during the implementation phase have been collected evaluation questionnaires filled in by 679 students and 130 teachers from 51 different schools. The evaluation process and its results are discussed in the next chapter.

4. Evaluation

4.1. Introduction

4.1.1. Key features of Schools Study Earthquakes

The main purpose of educational systems is acquisition of knowledge. One of the most effective ways to achieve this is by triggering learners' interest. Consequently, this triggering becomes a need. This need is addressed in various ways nowadays. For example, a lot of effort is put into implementing instructional techniques, like innovative lesson plans, seminars, lectures from scientists etc. Furthermore, cutting-edge technological means can be employed (i.e smartboards, lab kits, simulation software, 3D printers etc) to make the learning process more attractive to the pupils. In natural sciences, it is observed that students become enthusiastic and respond better during the learning process when experimental techniques, through both physical and/or virtual means, are employed.

Seismology is fundamental for understanding our dynamic planet, as it plays a vital role in monitoring both human-made and natural seismogenic events. Appreciating and understanding seismology's scientific and societal relevance requires knowledge of geology and physics, often coupled with elements of civil engineering, environmental sciences, official state policy, geography and geo-engineering as well as other scientific disciplines. Seismology is thus an engaging and quantitative science exhibiting a number of inherent links to wider areas of science but also to society.

Seismology in school education can promote scientific literacy at all levels but its benefits go far wider than simply providing scientific knowledge about this everyday natural phenomenon. It provides the basis for informed action to protect lives and property on local, regional, and national levels. As such, the SSE project and proposed approach will not only contribute to providing high-level educational material to teachers and their students but will also highlight aspects of civil protection, citizenship, civil responsibility and cooperation. Teachers and students of the participating schools, as part of their involvement, will consider matters connected to the societal impact of this natural phenomenon and will be asked to produce material that can be used in outreach programs for public awareness.

The large societal impact of earthquakes in the participating countries along with the increased awareness of the participating students and teachers will significantly contribute to meaningful collaboration between the participating schools in both national and international levels. The SSE project will take advantage of the opportunity provided and will strengthen these connections through the use of ICT tools on the project website to establish a tight-knit network of schools across the participating countries. Apart from the proposed benefits of the SSE approach in terms of promoting scientific literacy, civil responsibility and transnational cooperation, the project has set another very important aim, to assist students in developing skills in problem analysis and solution formulation. In order to achieve this, students need to be exposed to real-world problems so that they learn to develop, evaluate and select solutions. Seismology can be safely considered a domain of science that offers this particular real-world setting that will both motivate and improve students' problem solving skills, both individual as well as collaborative. Teachers also need to be prepared to look at the real world, particularly the world that students live in order to appeal to the affective domain in problem solving (willingness and persistence), but also to the cognitive domain by aiding skill transfer across contexts.

4.1.2. Evaluation objectives

In order to assess and analyze the impact of SSE, the following actions were conducted as part of the evaluation work:

– develop an evaluation and quality plan
– design evaluation instruments and materials
– collect data from school environments and incorporate feedback from ongoing evaluation processes
– collect data and analyse summative evaluation results and produce recommendations for further development.

4.1.3. Methodology

The SSE project used two different questionnaires to assess impact on participant students and teachers. One of the questionnaires is regarding the students' perception about their science classes. With this questionnaire, it is intended to collect data from students about perception of their science classes, like their motivation for science at school, their self confidence in their own abilities in science at school, what they get out of science at school, their perception of the necessity of science education etc. It is a well-known issue that aspects like self-confidence, attitudes, interest and motivation are key factors associated with teaching and learning of science in formal and informal education.

The pre and post responses from students that collected from Greece, Cyprus, Italy, Bulgaria and Turkey shed light on how students' perceptions about their science classes change from the project activities. In order to collect data from students, ROSE Project's questionnaire, "my science classes" was used. ROSE (Relevance of Science Education) is an international comparative research project meant to shed light on factors of importance to the learning of science and technology (S&T) – as perceived by the learners. Key international research institutions and individuals work jointly on the development of theoretical perspectives, research instruments, data collection and analysis. The questionnaire used in SSE project includes 16 items, each with a 4-point Likert scale from "Disagree" to "Agree" (Schreiner, Sjøberg, 2004). The questionnaire can be found at the Appendix I.

The second questionnaire is designed to collect data from teachers. It seems that there is a need to clarify teachers' preferences related to their use of inquiry-based science education in the classroom. For a science teacher to enact teaching science as inquiry, the teacher is required to develop approaches that situate learning in authentic problems, model actions of scientists in guiding and facilitating students to make sense of data, and support students in developing their personal understandings of science concepts (Crawford, 2007). The complexity of teaching science as inquiry in a K-12 school setting, and the demands on a teacher to take on a myriad of roles, may be important reasons why this kind of teaching is so rare (Crawford, 2007).

The main aim of using this questionnaire is to determine science teachers' usage of inquiry-based science education in their classroom before and after project's implementation phase. The data which collected from science teachers is expected to give further insights for designing and re-constructing better teaching strategies and learning environment orientations. The instrument consists of two parts. The first part, which consists 4 questions, focuses on the demographic information about science teachers including gender, grade level, teaching subject and length of science teaching experience. The second part of the questionnaire includes 27 items. The subjects were asked to respond using a five-point scale (from almost never to almost always). The score 1 represented the option "almost never" while score 5 on the scale represented the category "almost always". All of the items were positively written. The questionnaire can be found at the Appendix II (Cavas, Holbrook, Kask, Rannikmae, 2013).

4.1.4. Participants

The study consists of data collected from 679 students who enroll in private and state schools and their 130 science teachers from 5 partner countries: Greece, Italy, Turkey, Cyprus and Bulgaria. The statistics of data collected per country are presented in Table 1 below.

Table 1. Descriptive Statistics for Number of students, teachers and schools participated to the evaluation study.

	Number of Students	Number of Teachers	Number of Schools
Greece – Ellinogermaniki Agogi	87	41	18
Cyprus - University of Cyprus	83	21	4
Turkey – Bahcesehir Egitim Kurumları Anonim Sirketi	180	20	10
Italy - Cittadellascienze	151	27	9
Bulgaria - National Research Network Association	178	21	10
Total	679	130	51

When examined the Table above, totally 130 teachers and 679 students from 51 schools participated to the evaluation study. The data was collected mostly from of the Turkish (180), Bulgarian (178) and Italian students (151). 41 teachers from Greece as the biggest participated teachers was participated to this study.

SSE TC1 seismometer in the Buca Middle School.

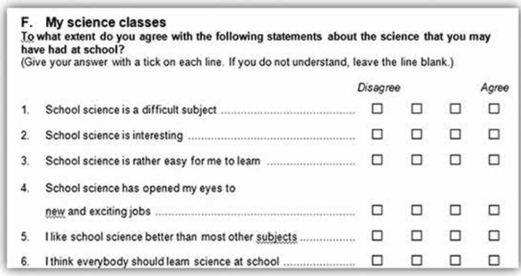
4.2. General overview of findings

4.2.1. My science classes

"My science classes" is part of Relevance of Science Education (ROSE) project master questionnaire. It includes 16 items each with a 4-point Liker scale from Disagree to Agree. The questionnaire begins with an explanation about the instruction to fill in the questionnaire:

To what extent do you agree with the following statements about the science that you may have had at school?
(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

As it indicated in the methodology section, the main aim of this questionnaire is to give an overview about students' perception of their science classes, like their motivation for science at school, their self-confidence in their own abilities in science at school, what they get out of science at school, their perception of the necessity of science education etc. It is a well-known issue that aspects like self-confidence, attitudes, interest and motivation are key factors associated with teaching and learning of science in formal and informal education.


F. My science classes
To what extent do you agree with the following statements about the science that you may have had at school?
(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

		Disagree			Agree
1.	School science is a difficult subject	☐	☐	☐	☐
2.	School science is interesting	☐	☐	☐	☐
3.	School science is rather easy for me to learn	☐	☐	☐	☐
4.	School science has opened my eyes to new and exciting jobs	☐	☐	☐	☐
5.	I like school science better than most other subjects	☐	☐	☐	☐
6.	I think everybody should learn science at school	☐	☐	☐	☐

First 6 items are presented in the figure above.

"My science classes" questionnaire was implemented using pre-post test design. The basic premise behind the pretest–posttest design involves obtaining a pretest measure of the outcome of interest prior to administering some treatment, followed by a posttest on the same measure after treatment occurs. Pretest–posttest designs are employed in both experimental and quasi-experimental research and can be used with or without control groups. For example, quasi-experimental pretest–posttest designs may or may not include control groups, whereas experimental pretest–posttest designs must include control groups. Furthermore, despite the versatility of the pretest–posttest designs, in general, they still have limitations, including threats to internal validity. Although such threats are of particular concern for quasi-experimental pretest–posttest designs, experimental pretest–posttest designs also contain threats to internal validity (Salkind, 2010).

The findings are presented in the country based figures below:

4.2.1.1. Findings from Turkey

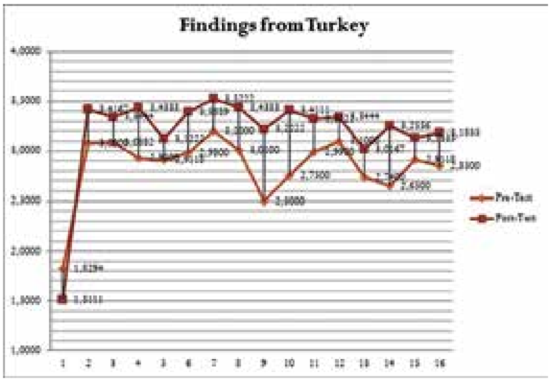


Figure. The mean values of each item in the questionnaire namely "my science classes" from Turkey

The figure above presents mean values of each item in the questionnaire namely "my science classes".
it is easily seen from the figure that the items;
4. School science has opened my eyes to new and exciting jobs
9. School science has made me more critical and sceptical
10. School science has increased my curiosity about things we cannot yet explain
14. I would like to become a scientist
have the most significant differences when pre- and post-test mean values compared.

Table 1. Pre- and Post-test scores

Item No	Pre-Test	Post-Test	Difference
1. School science is a difficult subject	1,8294	1,5111	-0,3183
2. School science is interesting	3,0800	3,4167	0,3367
3. School science is rather easy for me to learn	3,0882	3,3444	0,2562
4. School science has opened my eyes to new and exciting jobs	2,9300	3,4333	0,5033
5. I like school science better than most other subjects	2,9118	3,1222	0,2105
6. I think everybody should learn science at school	2,9800	3,3889	0,4089
7. The things that I learn in science at school will be helpful in my everyday life	3,2000	3,5222	0,3222
8. I think that the science I learn at school will improve my career chances	3,0100	3,4333	0,4233
9. School science has made me more critical and sceptical	2,5000	3,2222	0,7222
10. School science has increased my curiosity about things we cannot yet explain	2,7500	3,4111	0,6611
11. School science has increased my appreciation of nature	2,9900	3,3222	0,3322
12. School science has shown me the importance of science for our way of living	3,1000	3,3444	0,2444
13. School science has taught me how to take better care of my health	2,7400	3,0167	0,2767
14. I would like to become a scientist	2,6500	3,2556	0,6056
15. I would like to have as much science as possible at school	2,9118	3,1333	0,2216
16. I would like to get a job in technology	2,8500	3,1833	0,3333

When the findings analysed and looked through, students' perception of their science classes, like their motivation for science at school, their self confidence in their own abilities in science at school, what they get out of science at school, their perception of the necessity of science education etc. , were dramatically increased when the pre and post test mean values compared. It seems that the educational approach using in this study increased students' perception toward their teaching and learning environments.

The difference in the item related to becoming a scientist as a career is 0,61 and this difference is one of the big difference among other items. It is believed that students' collection of real data from seismometers as scientist increased students' future academic careers decision on science and technology.

4.2.1.2. Findings from Greece

The figure above presents mean values of each item in the questionnaire namely "my science classes" from Greece.

The figure presented above includes feedback for each items. According to the figure, the items "10. School science has increased my curiosity about things we cannot yet explain" and "14. I would like to become a scientist" have the most significant differences when pre- and post-test mean values compared. However, there is no differences in some items; "7. The things that I learn in science at school will be helpful in my everyday life" and "8. I think that the science I learn at school will improve my career chances"

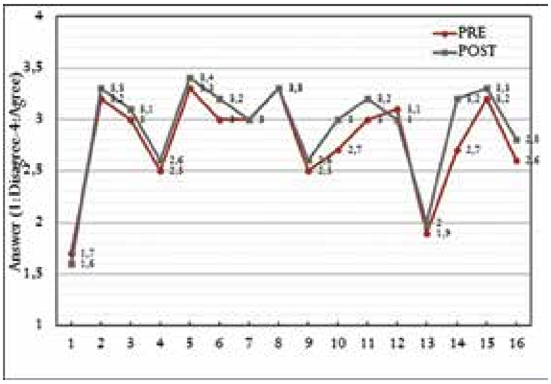


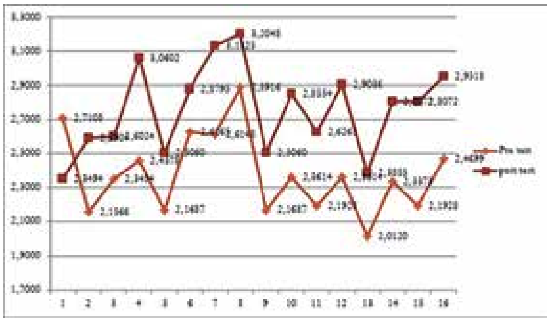
Table 2. Pre- and Post-test scores

Item No	Pre-Test	Post-Test	Difference
1. School science is a difficult subject	1,7	1,6	-0,1
2. School science is interesting	3,2	3,3	0,1
3. School science is rather easy for me to learn	3,0	3,1	0,1
4. School science has opened my eyes to new and exciting jobs	2,5	2,6	0,1
5. I like school science better than most other subjects	3,3	3,4	0,1
6. I think everybody should learn science at school	3,0	3,2	0,2
7. The things that I learn in science at school will be helpful in my everyday life	3,0	3,0	0
8. I think that the science I learn at school will improve my career chances	3,3	3,3	0
9. School science has made me more critical and sceptical	2,5	2,6	0,1
10. School science has increased my curiosity about things we cannot yet explain	2,7	3,0	0,3
11. School science has increased my appreciation of nature	3,0	3,2	0,2
12. School science has shown me the importance of science for our way of living	3,1	3,0	-0,1
13. School science has taught me how to take better care of my health	1,9	2,0	0,1
14. I would like to become a scientist	2,7	3,2	0,5
15. I would like to have as much science as possible at school	3,2	3,3	0,1
16. I would like to get a job in technology	2,6	2,8	0,2

When the Table 2 is analyzed, it seems that the items "10. School science has increased my curiosity about things we cannot yet explain (0,3)" and "14. I would like to become a scientist (0,5)" have the most significant differences.

However, the item "12. School science has shown me the importance of science for our way of living" has turned into negative mean value of -0,1. It can be interpreted that the project approach could not change the Greek students' perception regarding the importance of science for the way of living.

4.2.1.3. Findings from Cyprus



The figure above presents mean values of each item in the questionnaire namely "my science classes" from Cyprus.

According to Figure presented above, there are significant differences between pre and post test scores.

Especially two items; "15. I would like to have as much science as possible at school" and "4. School science has opened my eyes to new and exciting jobs" have most significant differences among the other items.

Table 3. Pre- and Post-test scores

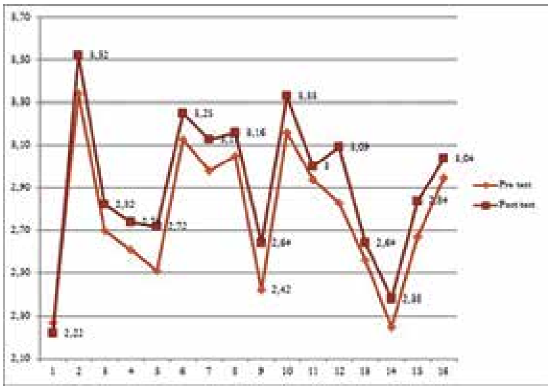
Item No	Pre-Test	Post-Test	Difference
1. School science is a difficult subject	2,7108	2,3494	-0,3614
2. School science is interesting	2,1566	2,5904	0,4337
3. School science is rather easy for me to learn	2,3494	2,6024	0,2530
4. School science has opened my eyes to new and exciting jobs	2,4578	3,0602	0,6024
5. I like school science better than most other subjects	2,1687	2,5060	0,3373
6. I think everybody should learn science at school	2,6265	2,8795	0,2530
7. The things that I learn in science at school will be helpful in my everyday life	2,6145	3,1325	0,5181
8. I think that the science I learn at school will improve my career chances	2,8916	3,2048	0,3133
9. School science has made me more critical and sceptical	2,1687	2,5060	0,3373
10. School science has increased my curiosity about things we cannot yet explain	2,3614	2,8554	0,4940
11. School science has increased my appreciation of nature	2,1928	2,6265	0,4337
12. School science has shown me the importance of science for our way of living	2,3614	2,9036	0,5422
13. School science has taught me how to take better care of my health	2,0120	2,3855	0,3735
14. I would like to become a scientist	2,3373	2,8072	0,4699
15. I would like to have as much science as possible at school	2,1928	2,8072	0,6145
16. I would like to get a job in technology	2,4699	2,9518	0,4819

Table 3 presents findings from Cyprus. According to Table 3 presented above, all items have positive difference when compared pre and post test mean values compared.

Especially items highlighted yellow, “4. School science has opened my eyes to new and exciting jobs”, “7. The things that I learn in science at school will be helpful in my everyday life”, “10. School science has increased my curiosity about things we cannot yet explain”, “12. School science has shown me the importance of science for our way of living”, “14. I would like to become a scientist”, “15. I would like to have as much science as possible at school” and “16. I would like to get a job in technology” have most differences.

This situation indicates that the implementation of school study earthquakes has great effects on the students’ perception regarding their science classroom.

4.2.1.4. Findings from Italy



The figure above presents mean values of each item in the questionnaire namely “my science classes” from Italy.

According to Figure presented above, only 3 items have significant difference mean value between pre and post questionnaire scores and these items are: “5. I like school science better than most other subjects”, “9. School science has made me more critical and skeptical” and “12. School science has shown me the importance of science for our way of living”.

According to the figure, the mean values of item “1. School science is a difficult subject” and “9. School science has made me more critical and skeptical” lower than 2,5 which is neutral perception line.

Table 4. Pre- and Post-test scores

	Pre-Test	Post-Test	Difference
1. School science is a difficult subject	2,27	2,22	-0,05
2. School science is interesting	3,34	3,52	0,18
3. School science is rather easy for me to learn	2,70	2,82	0,12
4. School science has opened my eyes to new and exciting jobs	2,61	2,74	0,13
5. I like school science better than most other subjects	2,51	2,72	0,21
6. I think everybody should learn science at school	3,13	3,25	0,12
7. The things that I learn in science at school will be helpful in my everyday life	2,98	3,13	0,15
8. I think that the science I learn at school will improve my career chances	3,05	3,16	0,11
9. School science has made me more critical and sceptical	2,42	2,64	0,22
10. School science has increased my curiosity about things we cannot yet explain	3,16	3,33	0,17
11. School science has increased my appreciation of nature	2,94	3,00	0,06
12. School science has shown me the importance of science for our way of living	2,83	3,09	0,26
13. School science has taught me how to take better care of my health	2,56	2,64	0,08
14. I would like to become a scientist	2,25	2,38	0,13
15. I would like to have as much science as possible at school	2,67	2,84	0,17
16. I would like to get a job in technology	2,95	3,04	0,09

4.2.1.5. Findings from Bulgaria

The figure above presents mean values of each item in the questionnaire namely “my science classes” from Bulgaria.

According to Figure presented above, most items’ mean value are around 2,7 line which means that Bulgarian students have positive perceptions towards their science teaching and learning environments.

When pre and post test scores compared, it is seen that there are significant differences in items 3, 5, 6, 8 and 11.

Table 5 presents more detailed analyses about Bulgarian students’ responds toward “my science classes” questionnaire which is given in following page.

Table 5. Pre and post test scores

Item No	Pre-Test	Post-Test	Difference
1. School science is a difficult subject	2,4679	2,3539	-0,1140
2. School science is interesting	3,0413	3,2640	0,2227
3. School science is rather easy for me to learn	2,4633	2,8764	0,4131
4. School science has opened my eyes to new and exciting jobs	3,3807	3,4663	0,0856
5. I like school science better than most other subjects	2,6514	3,0112	0,3598
6. I think everybody should learn science at school	2,8211	3,1292	0,3081
7. The things that I learn in science at school will be helpful in my everyday life	2,9862	3,1798	0,1936
8. I think that the science I learn at school will improve my career chances	2,8349	3,1124	0,2775
9. School science has made me more critical and sceptical	2,9771	3,1910	0,2139
10. School science has increased my curiosity about things we cannot yet explain	3,0229	3,2584	0,2355
11. School science has increased my appreciation of nature	3,0138	3,2978	0,2840
12. School science has shown me the importance of science for our way of living	3,4633	3,4944	0,0311
13. School science has taught me how to take better care of my health	2,9954	3,1404	0,1450
14. I would like to become a scientist	2,9037	3,0618	0,1581
15. I would like to have as much science as possible at school	3,0826	3,2303	0,1477
16. I would like to get a job in technology	2,9679	3,2135	0,2456

Table 5 presents findings from "my science classes" questionnaire which is implemented to 178 students in Bulgaria. According to the Analysis, most positive perceived items were "3. School science is rather easy for me to learn", "5. I like school science better than most other subjects", 6. I think everybody should learn science at school, "11. School science has increased my appreciation of nature", and "8. I think that the science I learn at school will improve my career chances".

Science Teachers discuss SSE Projects

4.2.2. Teachers' use of inquiry-based science education

In order to obtain data related to science teachers' IBSE usage in their classroom, a questionnaire, developed by Cavas et al (2013) was used and attached as Appendix II. The first part of the questionnaire, which consist 4 questions, focuses on the demographic information about science teachers including gender, grade level, teaching subject and length of science teaching experience. The second part of the questionnaire includes 27 items. The subjects were asked to respond using a five-point scale (from almost never to almost always). The score 1 represented the option "almost never" while score 5 on the scale represented the category "almost always". All of the items were positively written.

Seven inquiry stages (identifying and posing appropriate scientifically oriented questions; Making prediction / Developing hypothesis; Designing and conducting investigations; Identifying Variables; Collecting data; Analyzing data to develop patterns; Communicating and connecting explanation), whereby each of levels was described on three levels of the inquiry teaching (structured, guided and open).

1. Identifying and posing appropriate scientifically oriented questions — This category focuses on the extent to which teachers are responsible for identifying and posing appropriate scientifically oriented.

2. Contextualizing research questions in current literature/resources — This category focuses on the extent to which teachers are responsible for contextualizing research questions in current literature/resources. What is difference between 1 and 2???

3. Making prediction / Developing hypothesis — This category focuses on the extent to which teachers are responsible for making prediction / developing hypothesis

4. Designing and conducting investigations — This category focuses on the extent to which teachers are responsible for designing procedures for conducting investigations.

5. Identifying Variables — This category focuses on the extent to which teachers are responsible for identifying variables

6. Collecting data — This category focuses on the extent to which teachers are responsible for data collection during investigations.

7. Analysing data to develop patterns — This category focuses on the extent to which teachers are responsible for analysing data to develop patterns.

8. Communicating and connecting explanation (Drawing conslusions) — This category focuses on the extent to which teachers are responsible for Communicating and connecting explanation.

9. Socio-scientific Issues — This category focuses on the extent to which teachers use socio-scientific issues in their classroom

There are several instruments were designed to determine teachers' usage of inquiry in the classroom. However, in general, these instruments are designed using logic and stages of scientific inquiry. Instrument, developed in current study, based on 7 stages of scientific inquiry and described three levels of teaching each stages.

Table 6. The dimensions of the questionnaire.

First dimension "Stages of scientific inquiry"	Second dimension "Levels of inquiry"	
1. Identifying and posing appropriate scientifically oriented questions	Structured	*I supply scientific questions to be answered by my students*
	Guided	*My students and I discuss and create scientific questions together which my students then attempt to answer*
	Open	*My students are given opportunities to create scientific questions as part of teaching*
2. Contextualizing research questions in current literature/ resources	Structured	*I provide my students with the relevant literature and other resources to develop their plans for investigations*
	Guided	*I guide my students to think about the relevant literature and other resources they need to find to develop their investigations*
	Open	*My students find related literature and resources by themselves to develop their investigations*
3. Making prediction / Developing hypothesis	Structured	*I help my students to develop hypotheses about the solution to a scientific problem*
	Guided	*I provide my students with a hypothesis which the students test through investigations*
	Open	*My students are given opportunities to develop their own hypotheses aligned with scientific questions*
4. Designing and conducting investigations	Structured	*I give my students step-by-step instructions so that they can conduct investigations*
	Guided	*I guide my students to plan investigation procedures*
	Open	*My students design their own procedures for undertaking studies*
5. Identifying Variables	Structured	*I tell my students the variables they need to control in undertaking their investigations*
	Guided	*I guide my students on identifying the variables to be controlled in an investigation*
	Open	*My students identify the variables that they need to control in carrying out investigations*
6. Collecting data	Structured	*I give my students step-by-step instructions for obtaining data/making observations*
	Guided	*I guide my students on how to collect data to solve a scientific problem*
	Open	*My students determine which data to collect for their investigations*
7. Analysing data to develop patterns	Structured	*I undertake to interpret the data collected by my students and ask them to make a record*
	Guided	*I guide my students to develop conclusions to scientific evidence*
	Open	*My students use data to develop patterns and draw conclusions by themselves*
8. Communicating and connecting explanation (Drawing conslusions)	Structured	*I give my students step by step instructions to allow them to develop conclusions from their investigations*
	Guided	*I guide my students to use experimental data to explore patterns leading to conclusions*
	Open	*My students develop their own conclusions from their investigations*
9. Socio-scientific Issues	Structured	*I provide guidelines for students to relate the results of their investigations to make decisions about socio-scientific issues*
	Guided	*I guide my students to consider their scientific results when making decisions on socio-scientific issues*
	Open	*My students propose and use scientific evidence to evaluate risks such as those related to environmental or health related issues*

The data was collected from 130 science teachers who agreed to participate to the Schools Study Earthquake project. The descriptive properties of the teachers who participated to evaluation study of SSE project presented Table 7.

Table 7. Characteristics of the participants from partner countries (TR: TURKEY; GR:GREECE; CY:CYPRUS, IT:ITALY, BG:BULGARIA)

	TR	GR	CY	IT	BG
Gender					
Male	5	24	5	4	3
Female	15	17	16	23	18
Grade level					
6	15	5	10	1	3
7	12	5	7	1	10
8	13	5	11	1	6
9	5	5	11	8	13
10	5	23	0	14	14
11	5	23	0	15	13
12	5	21	0	16	1
13	0	21	0	20	0
Teaching subject					
Primary science	15	0	10	0	0
Informatics	0	5	0	0	0
Mathematics	0	2	0	0	0
Geography	0	22	11	0	0
Physics	2	27	0	8	21
Chemistry	2	14	0	16	0
Biology	1	0	0	18	0
Teaching experience					
1-5	2	1	7	1	0
6-10	4	3	2	3	1
11-15	7	8	3	4	2
16-20	5	24	5	4	9
20- +	2	5	4	15	9

According to the Table 7, most of the teachers were female from the partner countries. Regarding the Grade level, teachers who are working from 6 to 13th grade level are participants of this evaluation study. Almost from all STEM subjects were the teaching subject of the teachers who participated to the study.

When the teaching experiences of teachers analysed, it seems that most of the teachers have 16-20 years teaching experiences on STEM subjects.

Table 8. Mean scores and Standard Deviation for items related to Structured Inquiry

Items – related to Structured Inquiry	TR	GR	CY	IT	BG
3. I give my students step by step instructions to allow them to develop conclusions from their investigations	3,90	4,00	3,61	3,89	3,81
6. I give my students step-by-step instructions so that they can conduct investigations	4,25	4,10	3,05	3,50	4,38
15. I tell my students the variables they need to control in undertaking their investigations	4,00	3,60	2,62	3,85	4,05
16. I provide my students with the relevant literature and other resources to develop their plans for investigations	4,20	3,80	2,90	3,70	4,43
18. I give my students step-by-step instructions for obtaining data/making observations	3,95	4,2	3,05	3,67	3,76
19. I provide my students with a hypothesis which the students test through investigations	4,00	4,00	3,00	3,67	4,19
21. I undertake to interpret the data collected by my students and ask them to make a record	4,05	3,10	2,67	3,33	3,67
24. I supply scientific questions to be answered by my students	3,95	3,50	3,14	4,26	3,90
27. I provide guidelines for students to relate the results of their investigations to make decisions about socio-scientific issues	3,85	3,90	3,24	3,59	4,00
Mean	4,01	3,80	3,03	3,72	4,02

Table 9. Mean scores and Standard Deviation for items related to Guided Inquiry

Items – related to Guided Inquiry	TR	GR	CY	IT	BG
1. I guide my students to use experimental data to explore patterns leading to conclusions	4,80	4,70	3,57	3,74	3,95
2. My students and I discuss and create scientific questions together which my students then attempt to answer	4,65	3,80	2,81	4,22	4,10
4. I guide my students to consider their scientific results when making decisions on socio-scientific issues	4,55	4,00	3,38	4,04	3,86
7. I guide my students on identifying the variables to be controlled in an investigation	4,10	3,90	2,71	3,46	3,81
8. I help my students to develop hypotheses about the solution to a scientific problem	4,30	3,60	2,76	4,00	4,10
9. I guide my students to think about the relevant literature and other resources they need to find to develop their investigations	4,45	4,00	3,10	3,62	4,05
14. I guide my students on how to collect data to solve a scientific problem	4,35	4,60	3,43	4,04	3,95
22. I guide my students to plan investigation procedures	4,55	4,70	2,86	3,42	4,10
23. I guide my students to develop conclusions to scientific evidence	4,45	4,50	3,14	3,88	4,00
Mean	4,45	4,20	3,08	3,82	3,99

Table 10. Mean scores and Standard Deviation for items related to Open Inquiry

Items – related to Open Inquiry	TR	GR	CY	IT	BG
5. My students use data to develop patterns and draw conclusions by themselves	4,20	3,6	3,10	2,81	3,86
10. My students design their own procedures for undertaking studies	3,95	3,4	3,00	2,59	3,48
11. My students develop their own conclusions from their investigations	4,50	4	3,19	3,00	3,71
12. My students determine which data to collect for their investigations	3,85	3,5	2,57	3,04	3,57
13. My students propose and use scientific evidence to evaluate risks such as those related to environmental or health related issues	4,10	3	3,00	3,11	3,48
17. My students are given opportunities to develop their own hypotheses aligned with scientific questions	4,00	4	2,95	3,37	3,95
20. My students are given opportunities to create scientific questions as part of teaching	4,35	3,8	2,71	4,07	3,95
25. My students find related literature and resources by themselves to develop their investigations	3,60	4,6	3,19	2,85	3,19
26. My students identify the variables that they need to control in carrying out investigations	3,80	3,5	3,05	2,63	3,29
Mean	4,04	3,71	2,97	3,05	3,60

When the Table 8, 9 and 10 analyzed, Turkish, Greek and Italian teachers use mostly guided inquiry in their teaching and learning environments.

It is clear from Tables that Cypriot teachers use structured, guided and open Inquiry all together in classrooms in Cyprus.

Bulgarian teachers use mostly structured and guided inquiry when they implement earthquakes concepts during the project lifetime.

4.3. Main conclusion

The SSE project and its implementations were the first innovative and educational approach in South Eastern European Countries' schools to collect real earthquake data in real time. According to the results obtained from data, students' perception about their teaching and learning environment positively changed after SSE project implementations. In addition to positive changes in students' perception, the teachers' usage of inquiry based science education in classrooms changed after teachers' professional development courses. As a general remark, SSE project's educational approach was a highly effective model for teaching subjects related to earthquakes to secondary school level students. The approach can be used and implemented to change teachers' IBSE usage in their classrooms.

5 – Summary and outlook

Throughout the implementation of the project in Greece, Cyprus, Bulgaria, Turkey and Italy, partners organized and conducted series of implementation and dissemination activities for teachers and students reaching a large audience across each country. Following an overall implementation plan and inclusive strategy, schools, teachers and students are engaged in the study of earthquakes which is turned into a central focus point to facilitate inquiry-based approaches of science teaching and learning. The table below summarizes the results in each country. As can be seen all target indicators with respect to total number of teachers, schools and students were exceeded (226 teachers, 85 schools and 2136 students) as compared to the corresponding figures in the submitted and granted proposal (100 teachers, 50 schools and 2000 students).

Furthermore, a region-wide network of educational seismometers installed in schools is established and is in constant operation recording earthquakes in the area. It should be noted that 18 TC1 seismometers are now in operation, almost double in number compared to what was proposed and budgeted in the proposal as submitted in 2015.

A constant and wide uptake of the project was realized laying the foundations for successful sustainability and broader impact that continues well after the official end of the project in August 2017. Below are listed some selected key actions and achievements that are highlighting the quantitative and qualitative results of the project.

Country	Number of teachers in training events	Number of schools in implementation phase	Number of students in educational activities
Greece (EA)	127	33	319
Turkey (BEKAS)	24	9	538
Cyprus (UCY)	21	24	400
Italy (IDIS)	33	9	351
Bulgaria (NRNA)	21	10	528
Total	**226**	85	2136

- Ellinogermaniki Agogi and the National Observatory of Athens organized with high success, in terms of participation, quality of entries, level of engagement and publicity, a national thematic educational contest for schools, entitled “Build your own seismograph”. The contest is planned to be repeated in the following school years.

- EA and NOA organized and conducted week-long thematic summer schools on the study of earthquakes for teachers and advanced secondary school students and in collaboration with local educational and municipal authorities. These were held in Kefalonia and in Lefkada islands (this region of Greece has the highest seismicity in the country and the whole Mediterranean area) in summer 2016 and 2017, respectively. Similar summer schools are planned to be organized in different locations and regions in the following years.

- University of Cyprus, Department of Education, organized and conducted teacher professional development course based on the pedagogical approach and content of the SSE project. The course was realized with the permission and assistance of science inspectors and consultants of the Ministry of Education and Culture of Cyprus and will be repeated in the following years for pre-service and in-service science teachers

- In the context of the SSE project, a post-graduate student of the University of Cyprus conducted her master thesis titled “The Development of Pedagogical Content Knowledge and its Effect on Enactment: A Beginning Geography Teacher’s Case”. The purpose of this study was to examine to what extent the Pedagogical Content Knowledge (PCK) for the teaching of earthquakes of a beginning secondary geography teacher was developed, or not, during his enactment of a series of related in-classroom lesson plans.

- The approach, content and activities of the SSE project are now part of the Instructional Technologies and Material Design course of the Department of Science Education of Dokuz Eylul University in Turkey. The course was for pre-service science teachers and is expected to be repeated in the following academic year.

- Partner IDIS in Italy, apart from the original objectives of SSE, undertook several additional actions to strengthen the educational and informative impact of the project to school communities and the general public. Città della Scienza’s science center and museum in Naples, under the patronage of the Italian Ministry of Education, exploited several of its annual high-profile institutional activities, public fairs and outreach exhibitions to disseminate the educational activities and outcomes developed in the framework of the project.

- Furthermore, the SSE Erasmus+ project developed, realized and established synergies with major large-scale European initiatives on education and school innovation that are co-funded by the Seventh Framework Programme, namely “Open Discovery Space”, “Inspiring Science Education” and “Ark of Inquiry”.

- **In recognition of the significance of the project objectives and activities in Greece and the neighbour countries, SSE received a notable and honourable distinction by the state according to which the Schools Study Earthquakes activities are under the Auspices of H.E. the President of the Hellenic Republic (Το πρόγραμμα «Τα Σχολεία Μελετούν Τους Σεισμούς» τελεί υπό την Αιγίδα της Α.Ε. του Προέδρου της Δημοκρατίας).**

Appendix I

My science classes
To what extent do you agree with the following statements about the science that you may have had at school?
(Give your answer with a tick on each line. If you do not understand, leave the line blank.)

	Agree			Disagree
1. School science is a difficult subject	☐	☐	☐	☐
2. School science is interesting	☐	☐	☐	☐
3. School science is rather easy for me to learn	☐	☐	☐	☐
4. School science has opened my eyes to new and exciting jobs	☐	☐	☐	☐
5. I like school science better than most other subjects	☐	☐	☐	☐
6. I think everybody should learn science at school	☐	☐	☐	☐
7. The things that I learn in science at school will be helpful i n my everyday life	☐	☐	☐	☐
8. I think that the science I learn at school will improve my career chances	☐	☐	☐	☐
9. School science has made me more critical and sceptical	☐	☐	☐	☐
10. School science has increased my curiosity about things we cannot yet explain	☐	☐	☐	☐
11. School science has increased my appreciation of nature	☐	☐	☐	☐
12. School science has shown me the importance of science for our way of living	☐	☐	☐	☐
13. School science has taught me how to take better care of my health	☐	☐	☐	☐
14. I would like to become a scientist	☐	☐	☐	☐
15. I would like to have as much science as possible at school	☐	☐	☐	☐
16. I would like to get a job in technology	☐	☐	☐	☐

Appendix II

You don't do this everyday...

Please help us to improve teacher pre and in service teacher programs and students' learning in science and technology by filling this questionnaire. Teachers put emphasis on different aspects of students learning. This questionnaire seeks to establish current teacher preferences in the teaching of science subjects at a particular grade level and also the teachers' perceptions of students' expectations. Please can you answer the questions which are very crucial for us to understand your preferences. It will take you approximately 15 minutes to complete this survey. Please note that we will keep your response confidential and the results will be used only scientific purposes. If you have any question regarding this questionnaire, you can contact us using details at the end of this letter. Thanks for your help in advance.

Part A: About you

Gender	Female ◯	Male ◯					
Grade level of your teaching	6th ◯	7th ◯	8th ◯	9th ◯	10th ◯	11th ◯	12th ◯
Teaching subject	Physics ◯	Chemistry ◯	Biology ◯	Primary science ◯			
Teaching experience	1-5 years ◯	6-10 years ◯	11-15 years ◯	15-20 years ◯	More than 20 years ◯		

Part B. About your teaching preferences

Please select the response that best describes your teaching with respect to the grade and the subject indicated in Part A section

ABOUT YOUR TEACHING	**Almost never**			**Almost always**	
1. I guide my students to use experimental data to explore patterns leading to conclusions	①	②	③	④	⑤
2. My students and I discuss and create scientific questions together which my students then attempt to answer	①	②	③	④	⑤

3. I give my students step by step instructions to allow them to develop conclusions from their investigations	①	②	③	④	⑤
4. I guide my students to consider their scientific results when making decisions on socio-scientific issues	①	②	③	④	⑤
5. My students use data to develop patterns and draw conclusions by themselves	①	②	③	④	⑤
6. I give my students step-by-step instructions so that they can conduct investigations	①	②	③	④	⑤
7. I guide my students on identifying the variables to be controlled in an investigation	①	②	③	④	⑤
8. I help my students to develop hypotheses about the solution to a scientific problem	①	②	③	④	⑤
9. I guide my students to think about the relevant literature and other resources they need to find to develop their investigations	①	②	③	④	⑤
10. My students design their own procedures for undertaking studies	①	②	③	④	⑤
11. My students develop their own conclusions from their investigations	①	②	③	④	⑤
12. My students determine which data to collect for their investigations	①	②	③	④	⑤
13. My students propose and use scientific evidence to evaluate risks such as those related to environmental or health related issues	①	②	③	④	⑤
14. I guide my students on how to collect data to solve a scientific problem	①	②	③	④	⑤
15. I tell my students the variables they need to control in undertaking their investigations	①	②	③	④	⑤
16. I provide my students with the relevant literature and other resources to develop their plans for investigations	①	②	③	④	⑤
17. My students are given opportunities to develop their own hypotheses aligned with scientific questions	①	②	③	④	⑤
18. I give my students step-by-step instructions for obtaining data/making observations	①	②	③	④	⑤
19. I provide my students with a hypothesis which the students test through investigations	①	②	③	④	⑤
20. My students are given opportunities to create scientific questions as part of teaching	①	②	③	④	⑤
21. I undertake to interpret the data collected by my students and ask them to make a record	①	②	③	④	⑤
22. I guide my students to plan investigation procedures	①	②	③	④	⑤
23. I guide my students to develop conclusions to scientific evidence	①	②	③	④	⑤
24. I supply scientific questions to be answered by my students	①	②	③	④	⑤
25. My students find related literature and resources by themselves to develop their investigations	①	②	③	④	⑤
26. My students identify the variables that they need to control in carrying out investigations	①	②	③	④	⑤
27. I provide guidelines for students to relate the results of their investigations to make decisions about socio-scientific issues	①	②	③	④	⑤

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