RESEARCH AND EDUCATION COOPERATION EXAMPLE: EDUCATIONAL PACKAGES OF ERIS PROJECT

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One very promising model of learning designs is the model of Research and Education Cooperation activities. The ERIS project proposes exploitation of research results in school practice. ERIS is EU funded project (ERASMUS+) aiming to increase the interest of pupils in lower and upper secondary schools in science, and the choice of a scientific career. Thanks to the development, pilot implementation and dissemination of educational packages and methodological materials, research results will be exploited in the education systems of at least 3 European countries: Poland, Romania and France. ERIS packages are dedicated to various topics, e.g.: glaciers, earthquakes, geomagnetism, meteorology in the Arctic, UV radiation, etc. They use freely available research databases or results published online, which may be analyzed by pupils with the help of instructions prepared by scientists. The packages include materials for teachers to work with pupils during classes or extracurricular activities. They contain worksheets for pupils and guidance for teachers. 30 packages were tested in schools in Poland, Romania and France. The results of evaluation studies are presented and discussed. Teachers found packages interesting and useful for school practice. They found the tasks for pupils rather difficult, as it was a challenge for pupils to apply a new approach, which wasn't taught at schools before. Pupils could not solve tasks in a schematic ways, which they often use when solving typical school exercises, and it might have caused difficulties. However, challenging tasks are developing interest and engagement. ERIS packages and proposed teaching approach may be considered as an efficient way of increasing pupils' interest in science and scientific topics.

Keywords: scientific interest, measurement, secondary school

INTRODUCTION

One very promising model of learning designs is the model of Research and Education Cooperation activities (REC). According to De Haan & Huck (2008) REC stands for a cooperation between at least one research partner (e.g., public or private science or technology research institutes, museums, individual researchers) and at least one educational partner (e.g., schools, individual teachers, pupils or students, teacher education, school authorities). Research and Education Cooperation improves the teaching quality by applying up to date didactic approaches and they raise motivation, performance and ownership of the students in a significant way. To work alongside with the schools may help to attract talented and motivated students (De Haan & Huck, 2008).

According to the recent Report of the European Commission (2015) on *Science Education for Responsible Citizenship* in conducting the process of science education it is vital to promote a culture of scientific thinking and inspire citizens to use evidence-based reasoning for decision making, and to ensure citizens have the confidence, knowledge and skills to participate actively in an increasingly complex scientific and technological world. These objectives of science education could be met among others with the use of educational materials based on scientific databases and observations, as a didactic tool going beyond school routine, and contributing to Research and Education Cooperation.

Currently, researchers conducting projects, financed from public funds, especially within European Commission's programmes, are obliged to disseminate their results and publish them in open access standards (European Commission, 2016). This creates opportunity to increase the attractiveness of science education through the introduction of real scientific results into school practice. To increase pupils' interest in mathematics and natural sciences one should make them aware of the practical importance of science and embed it in the everyday life. Hence, it is important that students in their work use the actual results of tests and measurements.

Even if data are made freely available by professional monitoring institutions, education communities need specific database in relation with pedagogic and didactic aspects: access to the data, illustrate case studies, and select data of interest. Therefore, educational materials based on scientific research results should include not only presentations, videos and descriptions, but should also be based on the latest scientific findings and use analysis of actual measurements and observations. This approach allows students to realize that science has its reference to the practice. However, it requires diligent preparation of good quality, comprehensive teaching materials and educational resources.

ERIS PROJECT

One of the current educational initiatives proposing innovative way of teaching STEM by exploitation of research results in schools is ERIS. It is an EU funded project (ERASMUS+) aiming to increase the interest of pupils in lower and upper secondary schools in STEM, and the choice of a scientific career. Thanks to the development, pilot implementation and dissemination of educational packages, research results will be exploited in the education systems of at least 3 countries: Poland, Romania and France.

The ERIS project is conducted by three institutions: Institute of Geophysics, Polish Academy of Sciences (Poland, leader of the consortium), University of Bucharest (Romania), and Universite de Versailles Saint-Quentin (France). Each consortium partner prepared 10 educational packages in national language and in English and tested them in schools in their countries.

ERIS project is divided into 2 parts: testing phase and dissemination phase. In the testing phase teaching materials in the form of 30 packages in national languages (French, Polish and Romanian) and in English for pupils from lower and upper secondary schools were prepared. National packages were tested in schools in each partner country. Packages in English were tested in partner countries and also outside. We invited European teachers for testing and participating in webinars with scientists. Basing on the results of evaluation studies, packages were adapted to the needs of end-users: teachers and pupils.

In the dissemination phase all interested schools in partner countries, as well as in whole Europe, will have the opportunity to take part in the project for free. They will use prepared packages during their lessons and take part in the webcasts of online lessons conducted by scientist in national languages and in English. Such virtual meetings with scientists will give a closer look at the specificity of scientific work, the measurements and research in the field of mathematics and science. These webinars may also be an inspiration for students and encourage them to continue an independent exploration of science. Moreover, a guide for teachers on the effective exploitation of research results in school with examples of good practice in this area is being prepared.

In addition, in the dissemination phase workshops for teachers are planned, which will increase the level of use of project‘s products among schools that have not participated in the testing phase. The success of these activities will be proved by the use of the product in at least 350 schools across Europe.

Furthermore, the project will contribute to the growth of pupils' ability to search for reliable sources of knowledge, which is important in today's world overloaded with information. Usage of modern technologies and forms of communication (e.g. teleconferencing system that allows pupils to participate in international broadcasts) also positively affects the increase of interest in STEM. Participation in the project will allow schools to exchange experiences and establish Pan-European cooperation. Participation in online lessons and usage of educational resources in English contribute to the increase of students' language skills and expand specialized vocabulary in STEM. It may be very useful for future students of STEM studies, which are crucial for knowledge-based economy of Europe. In the long term, the project will also help to increase the understanding of the language of science and scientific messages.

EDUCATIONAL PACKAGES

In the ERIS project 30 educational packages in English and in three national languages (French, Polish, Romanian) were prepared. National packages were tested in schools in Poland, Romania and France. Each topic was elaborated separately for lower and upper secondary schools. Each package uses different database or set of measurements available online. Each consortium partner selected 5 topics to be presented within educational packages. Each topic was prepared in the form of two separate packages: one for lower and one for upper secondary schools. Each package contains theoretical background and introduction to the topic in the form of presentation, some multimedia and graphics. Additionally, scientists prepared introductory videos with explanations on the topic, which may be broadcasted at the classroom or serve as a preparatory kit for teachers, who are not familiar with the research topic. Practical aspects of conducted research was also presented by scientists – authors of the materials. The important part of each package consists of worksheets with tasks for students, which they may solve, calculate and fill in basing on introduction and available datasets with some necessary guidance from teachers or scientists.

Packages prepared by the Institute of Geophysics PAS

Seismological package **"Physics of earthquakes,"** developed by seismologist Dr. Łukasz Rudziński, allows to learn about seismology, its observations and measurements. It uses interactive seismological Platform for Anthropogenic Seismicity Research (https://tcs.ah-epos.eu/), which enables to see and analyse real seismic signals recorded by seismic networks.

At least several earthquakes occur every day. Usually the source of tremor is rock movement, but not only. Earthquakes can also be associated with volcanism and even can be triggered or induced by human activity. All of them are continuously monitored by very sensible devices called seismometers. Some of them are dedicated to record local and very small tremors which are not felt by human, while another observe strong earthquakes occurred on the other part of the Earth. Seismometers record seismic waves which are next analyzed by seismologists using sophisticated software and knowledge of Earth structures. Investigation of waves enables scientists to indicate time and location of source as well as strength of quakes and its mechanisms. Further studies describe seismic hazard on specific areas. All this information is essential to understand how earthquakes happen and may help in future in earthquakes' forecasting.

The package on **ultraviolet radiation**, developed by Dr. Agnieszka Czerwińska and Jakub Guzikowski, informs, what UV radiation is and what factors influence natural radiation from the Sun. It presents threats and benefits, that UV radiation brings to our health, and how can we assess the danger to our skin phototype from current sun radiation. It uses some portals with meteorological data, as well as Institute's measurements of ozone concentration (http://ozon.igf.edu.pl/). It presents also very useful practical information on how to use sunscreens effectively and how to assess the danger to our skin phototype from current sun radiation. Thanks to the package, which contains also exercises to activate students, one can learn how to use public sources about danger from natural UV radiation. Students may learn what "UV Index" is and how to check its current value (weather forecasts, meteorological data bases, hand-held meters). Furthermore, students learn about skin phototypes classification and its connection with UV Index. They learn also about positive influence of the UV radiation on human's health, such as a vitamin D3 synthesis and phototherapy. The package allows to gain practical knowledge which can be used in everyday life.

Thanks to the package **"Earth's magnetic field,"** developed by Paweł Czubak, students are able to answer questions regarding the influence of geomagnetism on life on Earth. Students learn what the Earth's magnetic field is, define its sources, where the magnetic poles are and discover what actually tourist compass shows and under what conditions it shows falwed measurements. Students get acquainted with the term "magnetic declination" and learn how to calculate declination in a given year on the basis of available data from geomagnetic observatories. Calculations are based, among others, on data from INTERMAGNET, an organization of geomagnetic observatories around the world. Students learn also how to find the maximum and minimum value of the magnetic declination of the day; determine the declination for the date and for certain place; determine the difference between the declination determined from measurements and declination derived from calculator declination.

The educational package **"Glaciers,"** developed by Dr. Jerzy Giżejewski, aims to increase knowledge of the glaciers, beyond standard school textbooks. The package consists of a general part – the introduction of substantive information on glaciers and practical part with worksheets – to be filled in by pupils. General part contains description of glaciers, geographical conditions of their occurrence, presentation of the basic types of glaciers, erosion, transport and accumulation and basic glacial morphology forms. Moreover, it focuses on mass balance of glaciers and glacial karst, glacier motion, calving, surge, glacial erosion, accumulation and fluvio-glacial forms. Practical part of the package includes tasks related to the presentations to be performed by the students. Each exercise allows students to become familiar with the methods of monitoring of various glacial processes and the way of their use. For filling in the worksheets students use sets of measuring data, attached to tasks or obtainable in public free databases e.g. measurements from Hans glacier on Svalbard and data from www.eklima.met.no.

The package **"Meteorological measurements in the Arctic,"** developed by Dr. Tomasz Wawrzyniak, aims to acquaint pupils with the measurements carried out in the meteorological site next to the Polish Polar Station Hornsund on Spitsbergen, and compare them to the current weather in their hometown. The tasks use meteorological databases available online (e.g. http://hornsund.igf.edu.pl/pogoda) and contains additionally some mathematical puzzles.

Packages prepared by the University of Bucharest

The packages **"Elementary particles and fundamental forces,"** developed by Dr. Bogdan Popovici separately for lower and upper secondary schools, focus on notions about the Standard Model of elementary particles and the way it is investigated today in research laboratories. By means of lectures, films and applications scientist presents concepts about particles classifications, conservation laws, particles trajectories and particles decays. The exercises accompanying the lectures are inspired and use resources developed by the educational program International Masterclasses http://physicsmasterclasses.org/, which use data from real experiments and visualization tools made available by researchers in the field. The educational materials present current study on the elementary structure of nature, refined after more than a century of modern researches, which is the following: the matter is made up of two classes of particles, leptons and hadrons which interact with each other by means of four fundamental forces: strong force, electromagnetic force, weak force and gravitational force (except the leptons which don't "feel" the strong force, but only the other three). This set of basic elements and their compounds, which together form the so called Standard Model of elementary particles, allows one to explain the wide range of phenomena we experience from the sub-microscopic scale to the astronomical one and the scale of the evolution of the Universe.

The package **"Wind and waves,"** developed by Dr. Mircea Zus and Dr. Roxana Zus, proposes to investigate the relation between the direction and speed of the wind and wave formation. We review concepts related to wind characteristics with an emphasis on the most relevant factors for the generation of waves. A detailed characterization of wind waves adapted to the level of study (lower or upper secondary schools) is provided. In the upper secondary school, students study notions on mechanical oscillations, allowing a more detailed investigation of wind waves features. Using free online data available on several forecast websites, the lower and upper secondary students will have to make predictions and as a subsequent step, compare their prediction with real data, on the formation and characteristics of the wind waves, such as the wave height in relation with the wind properties, the propagation direction of the wave front taking into account besides the wind, also the specific geographical characteristics, marine currents etc. For a start, the wind waves' formation on the Romanian Black Sea Coast is analysed. Fluid mechanics is an important part of our daily life, bringing contributions in most of the STEM domains. The students need to practically understand the physics behind these complex phenomena.

The package **"Sharing data – chasing earthquakes,"** developed by Dr. Dragos Tataru, makes use of the interest that earthquakes and seismology raise among children at all ages to teach a range of basic science concepts. Moreover, using real-time data available online instead of static information out of a textbook helps to engage students in STEM subjects. That is why a specific tool for accessing Romanian earthquake data has been developed and is freely available. Additionally, 15 recording locations are in schools, consisting in educational seismographs sending real time event base data to the centralizing application. It is a great opportunity for children to use not only real data but local data in their activities. To analyse data students have to understand records, to pick waves time arrival, to locate epicenter, to estimate amplitude. They use specific software dedicated to educational purposes.

By using the package **"Weather – a game between pressure and temperature,"** developed by Dr. Vasile Bercu, students become familiar with concepts of meteorology and weather, but also with different databases containing meteorological information. The data manipulation allows them to check different relations between pressure and temperature. Moreover, using simple materials, available to everyone, they are able to build instruments for measuring temperature and pressure.

The package **"Digital maps and geographical coordinates,"** proposed by Dr. Mircea Bulinski, is combining geography, mathematics, physics and technology integrated into a social and cultural context. Students investigate the geometry of geographical coordinates and how to use the related digital maps to get various type of geographical and socio-cultural information. Concepts related to "Coordinate Reference System" (2D and 3D) and to geographic coordinates (latitude, longitude and height) are reviewed within the package. A theoretical algorithm for measuring distances around the globe is provided (adapted to the level of study – lower or upper secondary schools) and a practical and fun method for measuring latitude and longitude. Also the relations between positions (and distances) on the surface of the globe and a 2D map is discussed related to "conversion systems", in the context of modern technologies that use GPS tracking systems. Some practical applications as: usage of map for location of various places of interest, using information from databases accessible via the Internet to calculate distances and surfaces, finding important administrative or cultural information are included in the package.

Packages prepared by Universite de Versailles Saint-Quentin

The package **"Climate,"** developed by Dr. Slimane Bekki and Dr. Alain Sarkissian, aims at helping students to understand the concept of climate. The general public is familiar with the notion of weather conditions, commonly known as "weather", and weather forecasting on a few days scale. The weather is characterized by several atmospheric parameters of which the best known are the temperature, the wind and the precipitations. The weather can vary greatly from one day to another or from one place to another, even if the two places are close enough. We say that weather is very heterogeneous temporally and spatially. The climate represents meteorological weather but averaged over long periods, typically at least 10 years. The climate is much less heterogeneous than weather, temporally and spatially. On average, we can see several typical climatic zones, strongly dependent on the sunshine: tropical climates to polar climates and temperate climates to medium latitudes. Meteorological observations and models show that the climate has warmed up over the last 5 decades.

The package **"Lidar,"** developed by Dr. Phillippe Keckhut, presents the Light Detection and Ranging (LIDAR) instrument to measure the parameters needed to understand physics and chemistry in the atmosphere. Students get familiar with two important parts in the operation of the Lidar, measuring the distance and measuring the density of what is being measured. The Lidar makes it possible to measure many things in the atmosphere of the Earth but also of other planets: the ozone, the temperature, the dust, the clouds etc. It emits towards the sky a radius Green (or blue, or red or invisible to the eye) and we look at the amount of light that is diffused through the atmosphere. In this way, several properties are deduced at each altitude, following a measurement principle that is described in this package.

The package **"Venus,"** developed by a group of researchers (Dr. Mustapha Meftah, Dr. Slimane Bekki and Dr. Alain Sarkissian), helps to understand some operational parts of a space experiment on real example. It uses SODISM, a kind of camera onboard the satellite Picard in orbit around the Earth, which regularly takes photos of the Sun to study its atmosphere. Pickard is a French satellite dedicated to Solar studies. The package uses images from SODISM, obtained during the transit of Venus (passage of Venus in front of the Sun for an observer on Earth) to explore the peculiarity of the space experiments.

The package **"Mimosa,"** developed by Dr. Alain Hauchecorne and Dr. Alain Sarkissian, allows to understand and predict the dynamics of the wind, vortex and the transport of air masses in the polar stratosphere (high altitude, 12-25 km) by using MIMOSA maps. MIMOSA is a model that follows the movement (dynamics) of the air masses in the stratosphere to study its evolution. Since these air masses do not mix with the air masses from below or above, MIMOSA can follow the evolution of these air masses over several days. In the Arctic, in winter (polar night) the stratosphere in addition to not being able to mix vertically, will be caught in a vortex, the polar vortex that will prevent it from mixing with neighboring air masses to create a polar vortex. The package helps to understand the behavior of this vortex.

The package **"Polar lows,"** developed by Dr. Chantal Claud and Dr. Maxence Rojo, helps to understand polar lows with the use of satellite images. During winter, small cyclones – typically 200 to 600 km in diameter – develop in subarctic regions over areas free of sea ice. The most intense cyclones are called polar lows. These severe storms usually form when polar air is transported over maritime areas. This cold and dry air destabilises the lowest layers of the atmosphere when it arrives over relatively warm waters, creating a polar low. Short-term forecasting of polar lows remains challenging, because they develop very rapidly, in areas with very few observations. The understanding of the formation of polar lows has been substantially improved with the advent of satellite observations. Climate change may potentially affect where and when polar lows will occur in the future.

Polish packages are available on the project website: http://eris-project.eu/index.php/pl/pakiety-edukacyjne/ and may be freely downloaded by teachers.

Romanian, French and English versions of packages will be uploaded to the website by the end of April 2018.

METHODOLOGY OF EVALUATION OF THE PACKAGES

Testing of packages

For each package online lessons were conducted, which supplemented the materials prepared by scientists in advance. During webinars scientists were presenting the materials, videos, animations. Instructions on how to use research databases were also delivered. After lessons teachers and pupils were encouraged to work additionally with worksheets prepared for each package.

National packages were tested in lower and upper secondary schools in partners' countries. Subsequently, English versions of packages were prepared and freely proposed to European secondary schools (not only in partners' countries). Each package was tested by at least 5 groups of students.

Evaluation of packages

In order to assess usefulness of packages in school practice, teachers, who tested them with their pupils were requested to fill in two separate surveys. The data was collected with the use of CAWI Surveys. CAWI (Computer Assisted Web Interviews) research technique is an interview in which participants fill in an online questionnaire or survey received via the Internet (Sharp, Rogers, & Preece, 2002), and is very popular and commonly used method of evaluation.

For each package online lessons were conducted by scientists, who prepared educational materials for packages. After lessons teachers and pupils were encouraged to work additionally with worksheets prepared for each package. Subsequently, they could have filled in the survey dedicated to the materials in the package. This survey contained some statistical questions (type of school, age of pupils, subject taught by a teacher, who participated in testing), four content questions (about importance of the topic, transparency of materials, sufficient explanations and level of difficulty), and two fields for suggestions.

In this paper results from surveys conducted after testing Polish packages in secondary schools in Poland is presented. 20 STEM teachers participated in the testing phase. Each teacher could evaluate up to 5 packages. 32 answers were obtained.

Evaluation of impact of the project

The second step of the evaluation was dedicated to the assessment of the general impact of proposed materials and methods on pupils' skills and interests. This survey was conducted by each partner institution after finishing of testing packages in national languages in Poland, Romania and France. Teachers were requested to assess how many students developed the ability to apply research methods in solving problems in the field of mathematics and natural sciences, and number of students, who developed skills of analytical and synthetic thinking. Moreover, they were also assessing the number of students, whose interest in scientific topics increased. The results of surveys conducted in all 3 countries are presented in the section Results.

RESULTS

Evaluation of Polish packages

The results are based on 32 surveys obtained from teachers from secondary schools in Poland, who tested ERIS packages in Polish (Figure 1). Teachers declared that packages contain important educational materials (definitely yes: 81%, rather yes: 19%). They assessed the materials included in the packages as clear and transparent (definitely clear: 59%, rather clear: 41%). They also found explanations and instructions for the tasks sufficient (definitely sufficient: 59%, rather sufficient: 41%). Teachers assessed materials included in the packages as generally difficult (very difficult: 3%, rather difficult: 56%, rather easy: 41%).

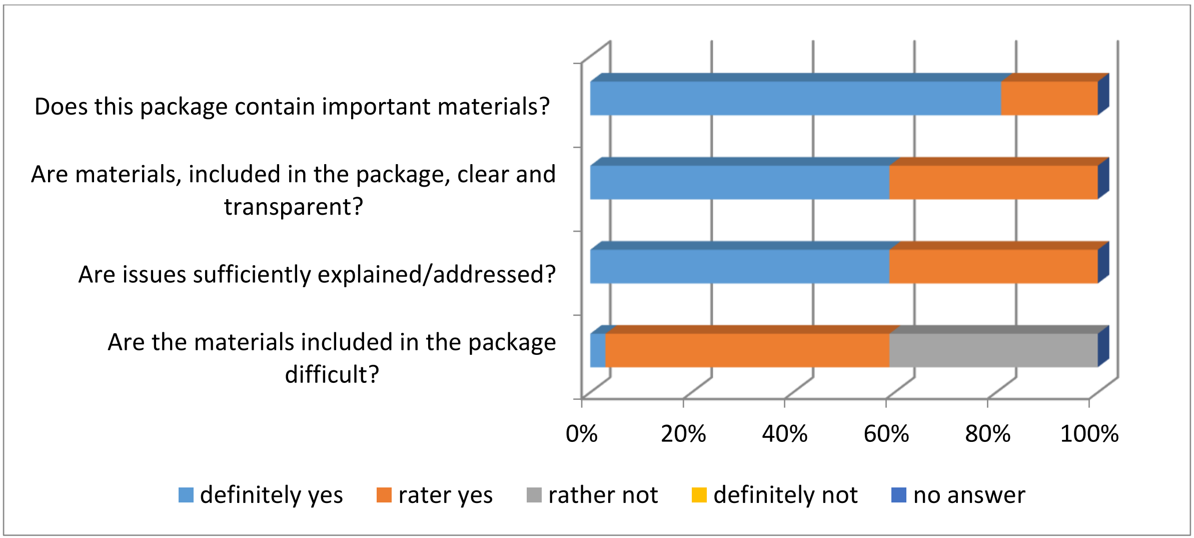

Figure 1. Results of evaluation of packages (Total = 32 answers).

Evaluation of impact of the project

The results are based on 44 surveys obtained from teachers from secondary schools in Poland (18 surveys), Romania (23 surveys) and France (3 surveys), who tested ERIS packages in their national languages. Teachers worked with 44 groups of students. Total number of students who tested the packages was 1054 (356 students from Poland, 631 students from Romania and 67 students from France).

The results from the surveys show that the impact of the project on students' skills and interest in scientific topics is significant. Teachers declared that for 70% of their students, who tested the packages, they observed an increase of the ability to apply research methods in solving problems in the field of mathematics and natural sciences. They assessed that 70% of their students developed skills of analytical and synthetic thinking, with a slight difference between upper and lower secondary schools (result for lower secondary school students is 71%, for upper secondary school students, 69%). Moreover, teachers observed a significant increase in students' interest in scientific topics. They declared that for 72% of their students interest increased. Some differences between younger and older students were observed. Students from lower secondary schools became more interested than those from upper secondary schools (73% compared to 70%). Detailed results are presented in Table 1.

Table 1. Results of evaluation of impact of the project in breakdown into types of schools and countries.

Country	Number of groups testing the packages	Number of students testing the packages	Percentage of students, who developed the ability to apply research methods in solving problems	Percentage of students, who developed the skills of analytical and synthetic thinking	Percentage of students, whose interest in scientific topics increased
			Lower secondary schools		
Poland	12	247	67.6	65.0	62.1
Romania	11	311	69.6	72.9	80.0
France	3	67	79.9	83.0	81.2
Total for 3 countries	26	625	69.9	70.9	73.1
			Upper secondary schools		
Poland	6	109	69.3	69.8	67.3
Romania	12	320	70.6	68.3	70.3
France	0	0	n/a	n/a	n/a
Total for 3 countries	18	429	70.3	68.7	69.6
			Total for the project		
Total for 3 countries	**44**	**1054**	**70.1**	**70.0**	**71.6**

DISCUSSION AND CONCLUSIONS

The results of the evaluation show that teachers generally assessed the packages positively. In some cases more detailed explanations would be appreciated, but for most users materials were complete and sufficiently descriptive. After the evaluation scientists were requested to update their materials, especially worksheets for students and instructions to tasks. They discussed their materials with methodological expert. Moreover, detailed scenarios of lessons proposed for each topic were prepared by the methodological adviser in the project and will be disseminated in the last part of the project duration.

Most teachers found materials rather difficult or difficult (59% of answers). Authors of materials expected that tasks for students might be found difficult. However, the scientific materials and using research databases are demanding and should be something extraordinary and challenging for students. To boost creativity and analytical and synthetic thinking, it is necessary to propose tasks, which are more demanding than normal textbooks' tasks. Calculations were probably not difficult for pupils in terms of their mathematical skills. However, it was a challenge for pupils to apply a new approach, which wasn't taught at schools before. Pupils could not solve tasks in a schematic ways, which they often use when solving typical school exercises, and it might have caused difficulties.

ACKNOWLEDGEMENT

ERIS project has received funding from the European Union's ERASMUS + programme under grant agreement No. 2015-1-PL01-KA201-016622. The content of the document is the sole responsibility of the author and authors of the educational packages and it does not represent the opinion of the European Commission, and the Commission is not responsible for any use that might be made of information contained.

The author of the paper would like to thank to the authors of educational materials for descriptions of packages used in the paper and originally prepared by: Jerzy Giżejewski, Łukasz Rudziński, Agnieszka Czerwińska, Jakub Guzikowski, Tomasz Wawrzyniak, and Paweł Czubak from the Institute of Geophysics, PAS, Poland; Bogdan Popovici, Mircea Zus, Roxana Zus, Vasile Bercu, Dragos Tataru and Mircea Bulinski from University of Bucharest, Romania; Slimane Bekki, Phillippe Keckhut, Mustapha Meftah, Alain Sarkissian, Alain Hauchecorne, Chantal Claud and Maxence Rojo from Universite de Versailles Saint-Quentin, France.

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