ERIS: EXPLOITATION OF RESEARCH RESULTS IN SCHOOL PRACTICE - 30 EDUCATIONAL PACKAGES FOR SECONDARY SCHOOLS

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Abstract

ERIS is 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 and methodological materials, research results will be exploited in the education systems of at least 3 European countries: Poland, Romania and France.

The ERIS project is divided into 2 parts: a testing and a dissemination phase. During the testing phase, teaching materials in national languages and in English for pupils in lower and upper secondary schools are being prepared. The packages are tested in selected schools in each partner country. Packages are adapted to the needs of end-users: teachers and pupils, according to the results of evaluation surveys. During the dissemination phase, all participating schools in the partner countries, but also elsewhere in Europe, will have the opportunity to freely participate in the project. They will use the packages during their lessons and take part in the webcasts of online lessons conducted by scientists in the project's national languages and in English. These virtual meetings with scientists will offer the opportunity to get a close view of scientific work, taking measures and doing research in the field of mathematics and science. The meetings are designed to encourage pupils to explore the world of science independently.

30 educational packages (10 per each partner institution) are being developed during the project. They are dedicated to various topics, e.g.: glaciers, earthquakes, geomagnetism, meteorology in the Arctic, UV radiation, ocean waves 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 and/ or extracurricular activities. They contain worksheets for pupils and hints for teachers. In addition, they include multimedia materials (movies, animations). Webcasts of online lessons are complementary to the packages. One package or its part can be used on lessons in several subjects (physics, geography, mathematics, science and others). The amount of materials and worksheets presented in one package will be so vast that teachers may use some parts of materials during one lesson or even a couple of lessons, including the extra classes for interested pupils.

10 packages was tested in Polish schools. The results of 3 surveys conducted by teachers testing the packages are presented and discussed. Teachers found packages interesting and useful for increasing skills of analytical and synthetic thinking and the ability to apply research methods in solving problems. Moreover, ERIS packages and proposed teaching approach may be considered as an efficient way of setting pupils on a path to careers important for economy-based societies, as they help to increase pupils' interest in science and scientific topics.

Keywords: STEM education, research, educational packages, STEM teachers, secondary schools, scientific database, scientific messages

1 INTRODUCTION

One of the main challenges for the education systems in Europe is to increase the low level of basic skills achievement, including math and science. STEM education is often carried out in a schematic manner, regardless actual conditions, and is focused on preparation for external exams instead of real development of skills and interests. Technological development and dissemination of research results, which are obligatory in most projects co-financed with the public funds, contribute to increase availability and open access to research results shared by leading research centers. This allows to increase the attractiveness of science education through the introduction of real scientific results into school practice and to familiarize students with scientific work through contacts with scientists. This

requires diligent preparation of materials and equipping teachers in good quality, comprehensive teaching materials and educational resources, as well as presentation of the benefits of using inquiry-based learning methods and getting familiar with scientific methods of work.
One very promising model of learning designs is the model of Research and Education Cooperation activities (REC) [1]. A 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 [1].

According to the recent Report of the European Commission (EC) – *Science Education for Responsible Citizenship* [2] 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.

1.1 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 and methodological materials, research results will be exploited in the education systems of at least 3 European countries: Poland, Romania and France.

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 are being prepared. Packages are tested in schools in each partner country. Basing on the results of evaluation studies, packages are 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. That meetings can 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. Project website and multimedia application containing teaching materials will be prepared.

In addition, in the dissemination phase conferences 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 will allow pupils to participate in international broadcasts) will also positively affect 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 will 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.

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). In the paper Polish packages, which have been already tested in Polish schools are described and the results of evaluation studies are presented.

2 ERIS PACKAGES

In the ERIS project 30 educational packages in English and in three national languages (French, Polish, Romanian) will be prepared. At the moment 10 Polish packages are developed and were tested in Polish schools. Below you will find information on the topics and content of the packages proposed by researchers from the Institute of Geophysics, Polish Academy of Sciences. Each topic was elaborated separately for lower and upper secondary schools.

2.1 Package "GLACIERS"

The educational package "GLACIERS" aims to increase knowledge of the glaciers, beyond standard school textbooks. The problem of ablation, reducing the area of ice sheets and glaciers, associated with the global climate warming, is a topic constantly present in the media. Therefore significantly increases the interest in the subject. The package consists of a general part – the introduction of substantive information on glaciers and part with worksheets – to be filled in by pupils.

The introductory part includes general description of the glaciers, the geographical conditions of their occurrence, presentation of the basic types, erosion, transport and accumulation and basic glacial morphology forms. It contains also presentations of selected issues such as: mass balance of glaciers, internal drainage system and glacial karst, glacier motion, calving, surge, glacial erosion and accumulation forms. Additionally, animation presenting ablation and accumulation processes is proposed. Second part of the package includes tasks related to the presentations to be performed by pupils. Each exercise allows pupils to become familiar with the methods of monitoring of various glacial processes and the way of their use. Pupils should use sets of measuring data, attached to tasks or obtainable in public free databases, to fill in the worksheets. Familiarizing pupils with the rules of use of the available online scientific databases will be an additional effect of the work with the package.

2.2 Package "PHYSICS OF EARTHQUAKES"

Seismological Package "PHYSICS OF EARTHQUAKES" allow to learn about seismology, its observations and measurements. Seismology is a multidisciplinary science using knowledge from other disciplines, like geology, tectonics, physic and mathematics.

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 analysed by seismologists. Investigation of waves give valuable information on origin time and location of source, as well as strength of quakes and its mechanisms. Further studies describe seismic hazard on specific areas. Using modern interactive seismological Platform: *Platform for Anthropogenic Seismicity Research* (https://tcs.ah-epos.eu/) enables to see and analyse real seismic signals recorded by seismic networks.

2.3 Package "ULTRAVIOLET RADIATION – IS IT ALWAYS AN ENEMY?"

The package "ULTRAVIOLET RADIATION – IS IT ALWAYS AN ENEMY?" informs, what UV radiation is and what factors influence natural radiation from the Sun, what threats and benefits UV radiation brings to our health, how can we prevent danger from overexposure, how should we use sunscreens to let them be the most effective and finally how can we assess the danger to our skin phototype from current sun radiation.

Thanks to the package, which contains also exercises for pupils, one can learn how to use public sources, reporting on natural UV radiation. Pupils may learn what "UV Index" is and how to check its current value (weather forecasts, meteorological data bases, hand-held meters). Furthermore, pupils 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.

2.4 Package "METEOROLOGICAL MEASUREMENT IN THE ARCTIC"

By definition, weather is the temporary state of the atmosphere expressed by certain elements of meteorological and atmospheric phenomena. Weather is extremely important for each of us in every aspect of our lives. Our lives, the economy, agriculture, and transport depend on the air temperature, rainfall and wind. Observations and measurements of the state of the atmosphere are carried out all over the world at a network of meteorological observatories. Collected data, statistics, and knowledge of the laws governing the development of atmospheric processes are used to determine the most likely future weather conditions – weather forecast.

The package 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. Additionally, the package contains several mathematical puzzles.

2.5 Package "EARTH'S MAGNETIC FIELD"

Thanks to this package, pupils are able to answer questions regarding the influence of geomagnetism on life on Earth. Pupils learn what the Earth's magnetic field is, define its sources, localise the magnetic poles and discover what actually tourist compass shows.

Pupils 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, a network of geomagnetic observatories around the world. Pupils learn also how to find the maximum and minimum value of the magnetic declination of the day, how to determine the declination for the date and for certain place, and how to determine the difference between the declination obtained from measurements and declination derived from calculating model.

3 EVALUATION OF THE PROGRAM

As the ERIS project proposes innovative method of connecting research institutions with education system, it was crucial to assess, if the packages are prepared properly and are tailored to the needs of teachers and schools. Therefore, a two-stage evaluation was planned and conducted during and after testing the packages in Polish schools.

3.1 Methodology of evaluation

The data was collected with the use of a CAWI Survey. CAWI (Computer Assisted Web Interviews) research technique is an interview in which participants fill in an online questionnaire or survey received via the Internet. Currently the CAWI method is one of the most popular and fastest-growing research methods [3]. Compared to other methods, with a sense of anonymity and the opportunity to participate in the study at a time convenient for the respondent, it allows to collect more accurate data.

3.2 Evaluation of packages and online lessons

For each package online lesson was conducted, which supplemented the materials prepared by scientists in advance. During webinars scientists were presenting the materials, videos, animations. Research databases were also presented and instructions on how to find data needed for calculations and analysis in worksheets were provided. Pupils might also ask questions concerning conducted research and scientific work. After online lessons teachers had opportunity to work with additional worksheets and presented databases during other lessons or on individual bases (e.g. as homework for pupils). After each lesson teachers were requested to fill in the survey dedicated to the online lesson. This survey contained some statistical questions (type of school, age of pupils, subject), six content questions (dedicated to the content of materials, interest of students in the topic, flow of the lesson, form of presentation, etc.), and two open questions for suggestions. The results of this survey are presented in the subsection 4.1.

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), four content questions (about importance of the topic, transparency of materials, sufficient explanations

and level of difficulty), and two fields for suggestions. The results of this survey are presented in the subsection 4.2.

3.3 Impact assessment

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 last survey was conducted, when schools finished their testing phase. It was not compulsory for teachers to do all the packages with one group of pupils. Therefore, they were indicated in the survey, how many packages each group has tested. Teachers were requested to assess percentage of students, who developed the ability to apply research methods in solving problems in the field of mathematics and natural sciences, and percentage of students, who developed skills of analytical and synthetic thinking. Moreover, they were also assessing percentage of students, whose interest in scientific topics increased. The results of this survey are presented in the subsection 4.3.

4 DISCUSSION

4.1 Online lessons' evaluation

Online lessons were conducted 20 times (two times per package). 10 to 13 groups of pupils per package participated in online lessons dedicated to lower secondary schools' packages. 4 to 6 groups of pupils per package took part in online lessons dedicated to lower secondary schools' packages. After each lesson, teachers received invitation to fill in the survey dedicated to particular lesson. 52 answers were obtained. Teachers were participating in online lessons mainly during geography classes (63%), physics (25%), biology, math or extra classes (12%).

The results of the survey are presented in Fig. 1. Teachers assessed the content of the lesson as well tailored to the age of students (definitely tailored: 58%, rather tailored: 40%, rather not tailored: 2%) and presented in a comprehensible manner (definitely yes: 67%, rather yes: 33%). They also found the lessons interesting (definitely interesting: 65%, rather interesting: 35%), and appreciated that scientists used various materials e.g. presentations, animations, graphics, worksheets (definitely yes: 58%, rather yes: 40%). The pace of work with pupils demands some improvements, as 13% of teachers assessed it as rather not tailored to the age of pupils. It may be caused by the fact, that scientists could not observe the reaction of pupils, as lessons were conducted online, simultaneously for several groups.

The authors of materials did not expect that packages will be dedicated to particular parts of curriculum, as they go beyond the normal school activities and topics. Nevertheless, most teachers found the lessons useful for implementation of school curriculum (definitely useful: 48%, rather useful: 48%, rather not useful: 4%), which increases the chances of packages to be used by many schools in future.

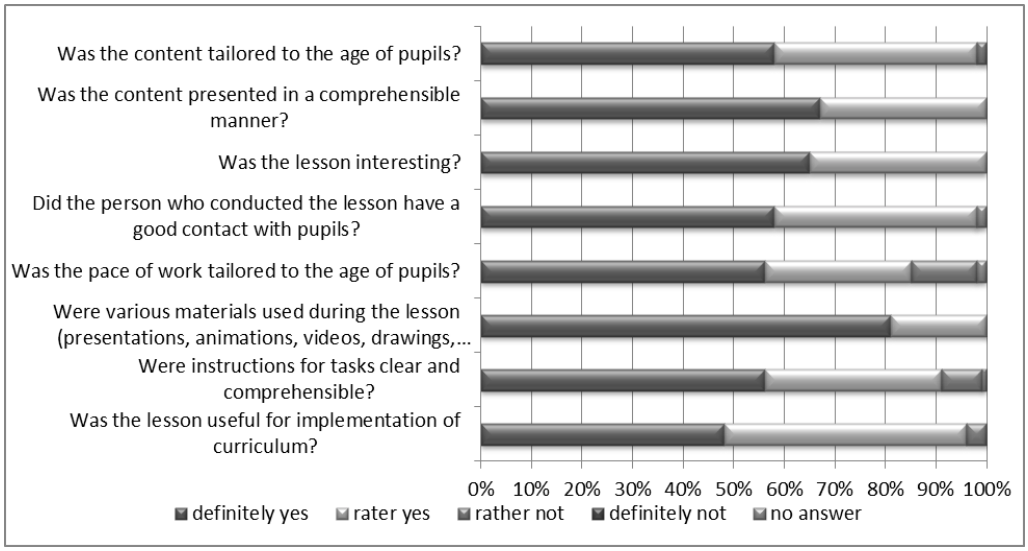

Fig 1. The results of evaluation of online lessons (based on 52 answers).

4.2 Packages' evaluation

Teachers were encouraged to work with their students on additional worksheets after each online lesson and to assess the packages after testing with pupils. 32 answers were obtained. 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%). Authors of materials expected that might be rather difficult. However, the scientific materials and using research databases are demanding and should be something extraordinary and challenging for pupils. To boost creativity and analytical and synthetic thinking it is necessary to propose tasks, which are more difficult and demanding than normal textbooks' tasks. Calculations were probably not difficult for pupils, but a challenge was to apply completely 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 schools exercises, and it might have caused difficulties.

4.3 Results of impact assessment

The general impact assessment survey was filled in by 11 teachers, who tested the packages at 18 groups: 12 groups of lower secondary pupils (with total number of 247 pupils) and 6 groups of upper secondary pupils (with total number of 109 pupils).

As ERIS packages were mainly tested during normal classes (within school curriculum hours), it was not compulsory for teachers to test all the packages. Therefore, the results are presented in four categories, separately for lower and upper secondary schools and for all groups, which tested at least 1 (up to 5) package and for groups, which tested 3 and more packages (up to 5). The results of general impact assessment are presented in the table 1.

Table 1. *Results of the general impact assessment.*

			Percentage of pupils		
Category	Number of groups testing the packages	Number of pupils testing the packages	who developed the ability to apply research methods in solving problems	who developed the skills of analytical and synthetic thinking	whose interest in scientific topics increased
Lower secondary schools, which tested at least 1 package	12	247	68%	65%	62%
Lower secondary schools, which tested at least 3 packages	5	107	74%	72%	68%
Upper secondary schools, which tested at least 1 package	6	109	69%	70%	67%
Upper secondary schools, which tested at least 3 packages	4	73	70%	68%	66%

The results of evaluation studies for ERIS packages reveal very positive impact of proposed method and materials on pupils' competencies: increase of ability to apply research method in solving problems (among more than 68% of pupils) and analytical and synthetic thinking development (among more than 65% of pupils). Teachers found using educational packages based on real scientific data and measurements as effective tool for building pupils' competencies and increasing their interest in science and scientific careers (among more than 62% of pupils).

5 CONCLUSIONS

Educational packages based on real scientific data and measurements are an effective tool for increasing the interest of pupils in science and scientific careers. There is an evidence from evaluation studies for Polish packages that teachers find them interesting and useful for increasing skills of analytical and synthetic thinking and the ability to apply research methods in solving problems. Moreover, teachers declared that thanks to implementation of ERIS packages, interest in scientific topics of over 60% of pupils, who took part in testing activities, increased. Therefore, ERIS packages and proposed teaching approach may be considered as an efficient way of setting pupils on a path to careers important for economy-based societies.

At present, 10 packages in Polish for lower and upper secondary schools are freely available online. Within a year English version of packages, as well as materials from partners' institutions in French and Romanian will be available. For details, please visit: http://eris-project.eu. The website is available in 4 languages (EN, FR, PL, RO).

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