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Space Schools Programme

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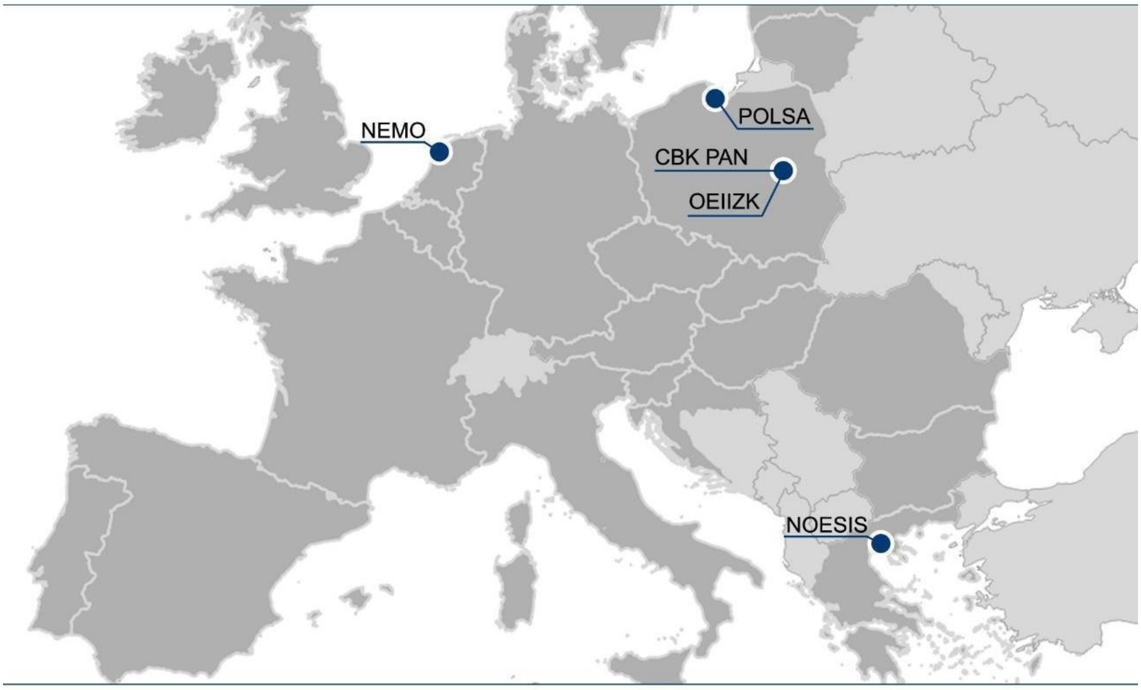
PROJECT PARTNERS

Organization	Acronym	Country
Space Research Centre Polish Academy of Sciences	CBK PAN	Poland
Computer Assisted Education and Information Technology Centre	OEIiZK	Poland
Polish Space Agency	POLSA	Poland
NEMO Science Museum	NEMO	The Netherlands
Thessaloníki Science Center & Technology Museum	NOESIS	Greece



Future Space Project Partners Map

GENERAL PROGRAM OVERVIEW

1. INTRODUCTION - SPACE SCIENCES AT SCHOOLS

Astronomy and space science are two sides o the same coin. The first one considerably contributed to the development of science, it shaped the lives of all civilizations and it also started the most important social changes. Space research is an interdisciplinary field, which combines the elements of physics, astronomy and Earth sciences and their applications by a research methodology, which uses space techniques. Today astronomy allows to get into more and more distant areas of the Universe and it offers possibilities to do even more groundbreaking discoveries than in the previous centuries. On the other hand the applications, which have a direct influence on the quality of our life, are quite often the effects of the development of space research. The most common applications in effect of the two sciences combination are:

- ✓ sensitive electromagnetic spectrum detectors - most of them use the phenomenon of the aperture synthesis, the most common ones are the CCD detectors working in the visible scope, as well as in infrared and in ultraviolet. These days every smartphone has a built-in CCD matrix, which allows to make photos. It is also worth to enumerate detectors used in medicine: in the X-ray and gamma equipment, in computer tomography or resonance and the ones, which enhance our safety in the airports. Astronomy did not contribute to their existence, but their perfect sensitivity and imaging possibilities are the effect of works carried out for the needs of astronomy and space research;
- ✓ digital picture processing methods are the effect of the use of CCD matrix in astronomy - these days teledetection methods are used to track global climate changes or, more broadly, the natural environment from the Earth orbit: deforesting, drought or forest fire, and the consequences of the same, like migrations;
- ✓ navigation systems (Galileo, GPS, Glonass, Beidou) – are examples of model applications of astronomic methods of positioning, time markers and space research. Today it is difficult to imagine the world without navigation services in cars or smartphones;
- ✓ defense systems watching satellites - generally speaking they are telescopes working in various ranges of electromagnetic spectrum, using technologies as well as equipment used in astronomy for the first time;
- ✓ star atmosphere models - they are used in early warning systems against atomic attack;
- ✓ imaging quality improvement method - developed in 1977 for the needs of radioastronomy has been used in the implementations of wireless WLAN networks to reduce radio signals interferences. Thanks to this it is possible to create networks of higher and higher speeds of data transmission;
- ✓ Gas chromatograph in a similar version to that in Martian rovers - at first meant to examine the composition of the planet atmosphere, was also applied at airports as a detector of drugs and explosive materials.

Of course, this is only a selection of technologies present in our daily life, which originated or were improved thanks to the astronomic knowledge or space research. It is worth to remember that both sciences have much more to offer than only innovations and technology transfer. Both astronomy and space research operate in the meeting point of natural and exact sciences; the first are easy to connect with social sciences and humanities, which gives an exceptional perspective: both sciences may provide a new context to the already known problems and their solutions. And this as the Copernican revolution showed - may result in a fundamental change of the method of perception of our surrounding reality. The features perfectly predestine both astronomy and space research to be used in school education, which allows to show also their added value, which is the effect of their interdisciplinary nature. A connection between astronomy and philosophy may also be a good example. Among others, it lets us:

- touch upon fundamental problems, which are very important for every young person, concerning the issue of existence and cognition;
- show the scientific and social effects of attachment to dogma in the historical context, lack of freedom of speaking and lack of unconstrained possibilities to express views;

- Astronomy allows to introduce the scientific method of learning the world, based on information falsification, criticism and skepticism. In the western teaching systems the method was simplified and is commonly used during classes. It allows students not only to understand the discussed problem or phenomenon better, but most of all, it shows the universal method how to verify information. it is particularly important in the era of information flood;

- Astronomy and space research boost not only young minds - there are still many universal questions with no answers: What will be the future of the Universe? Are we alone in the Universe? Are there more Universes? Thanks to its universality, it is easier for astronomy to arouse interest, which may turn into an interesting hobby, the effect of which often is paving the way for the development of STEM (science, technology, engineering, mathematics).

- Astronomy and space research provide immense possibilities to involve youths in so called citizen science. The instruments at space missions, but also telescopes on Earth, generate huge amounts of data, too huge to view in a short time by a small number of professionals. Some of these data are provided to public with simple tools and instructions what patterns we are looking for. Thanks to this many students all over the world, also in Poland, are co-authors of scientific work and discoveries of new planetoids, new stars and supernovas, beyond solar planets etc.

- Astronomy and space research allow to explain and to show the examples of many concepts present in physics, geography or (to a smaller extent) biology such as, for example: electromagnetic spectrum, radiation, Doppler effect, gravitation or even the relativity theory etc. Learning the basics of astronomy will let young people understand better and faster the material, with which they will deal with at other classes in natural sciences;

- Space research changed the quality of our life. Satellites let us not only communicate better and faster and offer simpler navigation tools. They also let us see the changes on Earth from another perspective. Thanks to them we can track deforesting, we can observe and foresee migrations, or examine other changes both on the surface of our planet, as well as underground, in seas and oceans and forecast their influence on fauna and flora, also on us, in the nearest months and years. Space research also is a technological support for many basic research.

- Both astronomy and space research are fields, in which one of the most important elements is a constant international cooperation. Developing a big telescope or sending a space mission is extremely costly, so many institutions in various countries need to cooperate. That is why it is important to know the *lingua franca* of the 21st century: the English language.

It is easy to indicate the areas, where astronomy and space research influence considerably and change our lives, but it is very difficult to measure this influence and to show this dependence in a quantitative way. We realize that there is a correlation between an investment in the research and the social and economic growth, however only some of the research may be measured (for example: the investment value versus the percentage of employment in the innovative sectors). A relatively long period of the investment's return is a major problem. However we know that this dependence is evident: wherever the regions or countries invest in the innovative sectors and wherever the corruption ratio is small, not only the population wellbeing growth is visible in the time span, but also a better social awareness, culture thriving, the average lifespan increase etc.

In the 21st century the world is becoming more and more interrelated and competitive, the scope of knowledge and technology extends, just as the number of work positions, in which the knowledge and understanding of scientific and technological aspects is important. It shows the core of the process of modern education: the essence should be not only providing knowledge and information, which is easy to get today from other sources. The sense of education is working with young people on the understanding of knowledge and data, and showing mutual dependencies and consequences of actions, as well as learning a respective choice of sources of information.

Scientific education is necessary to:

- ✓ promote the culture of scientific thinking and to inspire young people to make decisions based on evidence, contrary to the values and thinking processes, which are less reliable and which are based on subjective evaluations, convictions or feelings;

- ✓ ensure knowledge and skills necessary to find oneself and to participate actively in a more and more complex scientific and technological world;
- ✓ develop competencies concerning problem solving and referring to the process of creating innovations and skills of analytical and critical thinking - they are necessary to have satisfying, socially responsible and involving life, promoting solidarity on the national, European and global level;
- ✓ inspire students of every age and of various possibilities to aspire to scientific career and innovative sectors, in which they may be creative and fulfilled;
- ✓ enable the employers to find properly qualified employees and to promote an innovative, general European environment, in which companies and other interested entities all over the world will want to invest and cooperate;
- ✓ enable an active and responsible participation in public scientific communication, debates and making decisions as an active involvement of citizens of Europe in challenges that the humankind is now facing.

We give you the Space Schools Programme – helpful tool for interdisciplinary teaching of nature and science. Most of the content of the program corresponds to the current (as of 2022) physics curriculum for secondary schools in Poland. We took care to develop particular subjects between at least several subjects and to connect them thematically with astronomic issues and space research. It was our ambition to provide support, which linked the issues of physics, geography, partially also biology and contain elements or references to chemistry, IT or mathematics. We wanted at least some of those classes to be prepared and carried out both at geography, physics (classes devoted to the global challenges of the 21st century are a good example here), as well as IT, possibly assuming cooperation of such classes teachers. Thanks to this the students see the potential of combining knowledge and information of two or more fields of science and the teachers will have the opportunity to extend their knowledge.

A crucial part of the Programme is a module devoted to young people's development: STEM studies and potential career paths in the space sector. What we believe is particularly important is the indication that not only the graduates of engineering and science studies may find a job in the space industry. The sector is also looking for specialists in the area of social sciences, biology, medicine, economics etc.

The Programme also presents western European methods of implementing the scientific methodology during classes and methods of involving youths during classes. They allow to make the classes much more attractive and focus the students' attention on the issue discussed during the lessons, which in effect increases its understanding and is reflected in study results.

2. General Assumptions of the Programme

2.1 Introduction to the issue of space for the needs of STEM classes

The main assumption of the Space Schools Programme is to enrich the completion of the content of teaching STEM classes by introducing the space issue for the needs of classes in secondary schools.

STEM standing for *Science, Technology, Engineering, Mathematics* has been present in education for several years. It is connected with intense actions carried out to improve the teaching of science and technical issues, because it has been known for a long time that teaching in these areas is the gear of progress, economic growth and wellbeing. The STEM Programmes are very popular thanks to interesting topics, modern tools, resources and educational aids, interactive teaching methods. They give an opportunity to arouse and develop students' interest in natural sciences, which often leads to studying engineering and science.

Introducing the space subject at the educational classes does not change the detailed content of teaching mathematics and natural sciences specified by the teaching program for secondary schools, but it adds to the methods of their completion. Certain matters in the teaching program of physics, geography or IT may be realized in an interesting manner, based on real, current examples in the space sector. The detailed themes and proposed content were described in chapter "Programme content - thematic modules".

2.2 Module-based Programme Structure

The Programme is made of several independent parts - thematic modules split into groups:

Every module contains a detailed scenario of classes and materials for the student and for the teacher, such as: multimedia presentations, instructions for programs, experiment descriptions, working cards, thematic quizzes. Every module may be realized separately, because it does not refer to the content in other modules. The teacher chooses a respective module or modules and decides how to realize it, but the methods and conditions of realizing the Programme in partnering countries will differ considerably. More information in the B part, in chapter "Conditions and Methods of Program Completion."

2.3 Role of the ICT

Information and communication technologies are well grounded in education and the period of pandemics is a big lesson for teachers and students concerning the use of technologies in remote teaching. The ICT role in education is growing, but there are two wings, which may be distinguished: informative and constructive one, already discussed by Seymont Papert[1]. Papert's considerations were the subject of many projects and analyses leading to the search of new

[1] S. Papert, *What is Logo? Who needs it?* [in:] Logo Philosophy and Implementation, Logo Computers Inc., 1999

methods of using ICT, which bring educational profits - they provide an added value[2]. A huge, still growing number of ICT tools makes the teacher choose among them and decide how to use them. The same tool may be used in many ways and it may have a different role in the education process. The SAMR Model may be helpful[3] (Figure 1) developed by Ph.D. Ruben Puentedura. He distinguishes between four levels of technology integration in education:

- **S**ubstitution - this Technology is used to do tasks without the functionality change
- **A**ugmentation - this Technology facilitates doing tasks and solving basic problems
- **M**odification - this Technology enables doing the tasks, which were impossible to do earlier
- **R**edefinition - this Technology creates tasks and allows to solve problems, which did not exist earlier

The first two levels **improve** the traditional methods of doing tasks, technology accelerates access to information and facilitates solving problems. On higher levels there is a **transformation** of education: ICT enables doing tasks, which were impossible to do in a traditional way and allows to create and realize new tasks, which did not exist earlier.

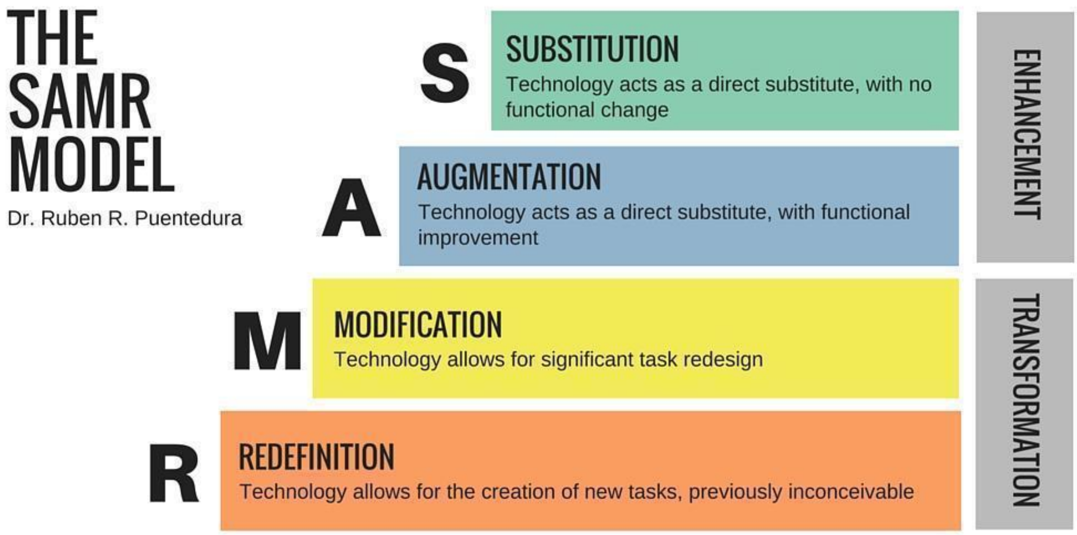


Figure 1. SAMR Model Source: By Lefflerd - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=47961924

ICT tools proposed when running classes under the Space Schools Programme, may be ascribed to various levels of the SAMR Model. The following mind map (Figure 2) illustrates this example:

[2] J. Dunin-Borkowski and others, *Czy TI jest dla nas czyli rzecz o wartości dodanej*, Meritum nr 7/2007
[3] https://edunews.pl/badania-i-debaty/badania/2736-model-samr-czyli-o-technologii-w-nauczaniu

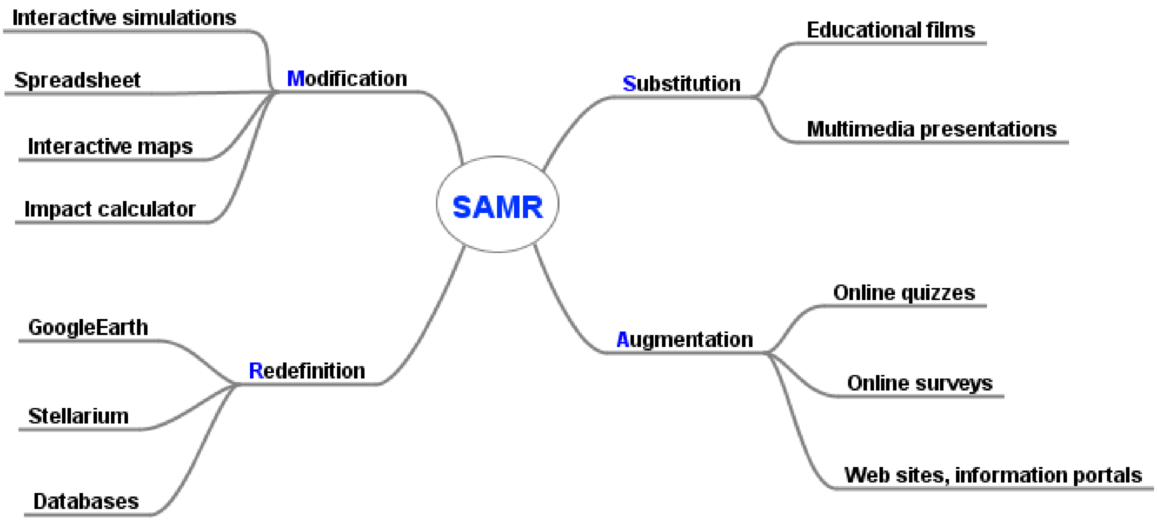


Figure 2. ICT Tools versus SAMR Model

Let us note that the ICT tools ascribed to basic levels (S, A) are commonly used when teaching various subjects. On the other hand the tools ascribed to higher levels (M, R) are used mainly in the STEM education.

3. General Aims of the Programme

3.1 Development of competencies and the students' key skills

The recommendation of the European Parliament and Council of 2018[4] specifies eight key competencies:

1) Literacy competence,,
2) Multilingual competence, ,
3) Mathematical competence and competence in science, technology and engineering, g,
4) Digital competence ,
5) Personal, social and learning to learn competence ,
6) Citizenship competence, ,
7) Entrepreneurship competence ,
8) Cultural awareness and expression competence .

Key competencies are developed for the whole life, everywhere and all the time, on every level of education. In the Space Schools Programme it was marked in every class scenario, which competencies are developed when realizing a given module. All scenarios assume a development of competencies in the scope of understanding and creating information (K1), mathematical competencies and competencies in the scope of natural sciences, technology and engineering (K3), digital competencies (K4), personal ones, social ones and learning competencies (K5). In many scenarios there are references also to materials in English (besides

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01)

the Polish sources). The use of such materials has a positive influence on the development of students' competencies in the scope of multilingualism (K2).

The common aspect of all key competencies are skills, which are developed in the Space Schools Programme, such as: critical thinking, creativity, problem solving, team work, communication and negotiation skills.

The passage of the recommendation of the EP and EU Council quoted below emphasizes the weight of all key competencies and related skills[5].

All key competencies are believed to be equally important; every one of them adds to a successful life in the society. The competencies may be applied in many various contexts and combinations. Their scopes are interrelated: aspects, which are necessary in one field support competencies in the other. Such skills as critical thinking, problem solving, team work, communication and negotiation skills, analytical skills, creativity and intercultural skills are common for all key competencies.

3.2 Indicating the possibilities of professional development and education

An important aim of the Programme is to indicate to students the possibility of professional training and development in the space sector by showing examples of professions and various career paths in the areas, which are available only for STEM specialists, but also for lawyers or social sciences graduates.

A catalogue was prepared for the project: SPACE SCIENCE & INDUSTRY ORIENTED ACADEMIC DEGREES AND COURSES IN EUROPE, which contains a list of current study directions at European schools and specialist courses connected with space subject.

The purpose of the catalogue is not to cover the whole spectre of higher studies and scientific institutions connected with cosmic space research, but rather paying attention to the most distinguished ones and focused only on preparing to the work in the sector right after the graduation. It is important to be aware that the basic knowledge and skills, which are potentially necessary and desirable both by the most prominent players and the promising startups, may be gained elsewhere. It concerns not only STEM, but also a much wider scope, including medicine, psychology, project management or logistics.

The catalogue contains descriptions of courses and basic practical information, which is valuable for potential candidates and students. However it should be remembered that teaching programs, rules and schedules must not be static in the changing environment and that is why the information contained in the catalogue should be treated only as reference and a starting point for further verification. If anybody really considers applying for any of the above presented directions or courses, they should visit a corresponding website and consult directly the school or the institution responsible for the recruitment process.

Interviews were made with people (Role models), who achieved a success in various professions connected with space. More information in chapter "Professions in the space sector - interviews with experts."

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01)

4. PROGRAMME CONTENT - THEMATIC MODULES

The Programme content was split into six groups. Every group contains thematic modules made of materials for the student and for the teacher. They are: lesson scenarios, multimedia presentations, program instructions, experiment descriptions, student worksheets, thematic quizzes. All proposed classes are interdisciplinary, the scenarios contain references to the current curriculum for secondary schools. The description below presents the issues contained in particular groups.

I. Astronomy

The topics of proposed scenarios are very broad. They are, among others: measurements of distances in the Universe (on the example of the Orion constellation), astronomic instruments, chosen issues concerning the Solar System (remote weighing of the planets, watching the Sun), Super-Earths and searching for life and the problem of light contamination.

II. Near Space exploration

The scenarios concern the programs of exploring the Moon and cosmic mining as well as the issue of cosmic debris and threats coming from natural objects, or objects, which were created by our civilization. This part also includes scenarios related to space missions, i.e. related to the conditions on Mars and the design of the space base on this planet, as well as the planning of a scientific space mission.

III. Earth observations

Earth observations are very important for recognizing and monitoring the environmental issues, such as contamination, fire, floods, climate changes. The use of satellite data enables the analysis of time and space changes of various phenomena. For example during the classes devoted to the issue of greenhouse effect, global warming and CO_2 emission, students will look for a correlation between natural and economic phenomena and the CO_2 emission in various geographical regions.

IV. Space missions – interviews with experts

A separate part consists of interviews with experts of various specialties: planetary geologist, analog astronaut, R&D engineer, human resources specialist, etc. They show various career paths in the space industry and the fact that not only engineers and STEM specialists can find themselves in the space industry. The interviews in the form of videos and podcasts were made available on the project website, YouTube channel and other project media.

5. ICT TOOLS SUPPORTING THE PROGRAMME COMPLETION

The completion of the Programme content needs the application of many ICT tools described in the table below. The lesson scenarios and additional materials contain information how to use the tools during education classes. Many of the tools are applications, which support classes provided in the classroom and online with the use of asynchronous platforms or real time communicators. It is recommended that the teachers of natural sciences should cooperate with IT teachers.

Name	Description and purpose of use, websites
Educational films "Astronarium"	Polish TV program cycle "Astronarium" presenting the recent space research. All episodes (more than 100) are available at the Astronarium channel at Youtube with English language subtitles. Examples of episodes, which are used in the subject modules as an introduction to classes or a part of a flipped learning: NEO - Near Earth Objects - Astronarium episode 62 - https://youtu.be/wumQv2vGEjs - Astronarium odc. 62 Solar activity - Astronarium episode 6 - https://youtu.be/w2HTtxL6ugw - Astronarium odc. 6 The Sun surface - Astronarium episode 96 - https://youtu.be/w0RXfUi7h2c Looking for Earth analogue planet - Astronarium episode 89 - https://www.youtube.com/watch?v=9WbQoJpKyvA
Stellarium	Free of charge planetarium software enabling watching the sky in 3D. The software may be downloaded for various operating systems. http://www.stellarium.org/pl On-line version - https://stellarium-web.org/
GoogleEarth (Moon, Mars, Sky)	The program in the GoogleEarth Pro version enables watching the sky, the Moon and the Mars surfaces. It contains many films and photos, such as the gallery of photos of the sky from various telescopes and satellites, films and photos of the Apollo mission on the Moon. The installation version of the program for various operating systems - https://www.google.com/earth/download/ge/agree.html
Calculators	A calculator example to calculate one's own carbon footprint - http://ziemianarozdrozu.pl/apps/online/pl/kalkulator.html A collision calculator (asteroid with the Earth, Mars, Moon surface) - Impact calculator http://down2earth.eu/impact_calculator/planet.html?lang=en-US
Maps and animations	Data from the OCO-2 mission, CO_2 concentration in the atmosphere in various periods, for example: August 16 - September 22, 2015 - http://www.euanmearns.com/wp-content/uploads/2015/10/v3-08-16-2015-09-22-2015.png Annual average - http://www.euanmearns.com/wp-content/uploads/2015/10/annualchopped.png

	Interactive maps: – Plants greening- https://earthobservatory.nasa.gov/global-maps/MOD_NDVI_M – Forest fire - https://earthobservatory.nasa.gov/global-maps/MOD14A1_M_FIRE – Moon interactive map: - http://quickmap.lroc.asu.edu/ Stuff in space - Realtime 3d map of objects in Earth orbit, visualized using WebGL - http://stuffin.space/
Earth Impact Effects Program	https://impact.ese.ic.ac.uk/ImpactEarth/ImpactEffects/
ISS transit finder	Enables searching the ISS passage (International Space Station) https://transit-finder.com/
Astronomical services	The Internet websites containing the recent astronomical findings, images of objects in the Universe NASA, ESA websites - https://www.nasa.gov/ http://www.esa.int/spaceinimages/Images Current information on “space weather” https://spaceweather.com/ Satellites in the sky, visible flying forecasts, ISS visualization - https://www.heavens-above.com/
PhET - Interactive simulations of physical phenomena	Interactive simulations of many phenomena and physical processes and virtual experiences in various fields of physics, elaborated at the University of Colorado. They are applied in teaching physics in many countries, most of them is translated into Polish. https://phet.colorado.edu Simulations translated into Polish https://phet.colorado.edu/en/simulations/translated/pl
Database	The Exoplanet Orbit Database:http://exoplanets.org/table
Popular science articles online	Popular sciences articles in the Polish and in the English language, for example: https://mlodytechnik.pl/technika/30108-wykapana-ziemia https://www.nature.com/articles/d41586-018-07107-4 (popular science perspective of the Moon bases)
Interactive online quizzes - for example Kahoot	Preparing scenarios by the authors as an introduction or summary of classes and making them attractive, introducing the competitive element – https://kahoot.com/
Interactive board-Padlet	Interactive board for cooperation and sharing resources and tools to realize specific tasks and subjects – https://padlet.com/
Mind maps	Applications to create mind maps - graphic imaging of notes, information structures in the form of various schemes, images For example: FreeMind – free program for downloading, installation version – http://freemind.sourceforge.net/wiki/index.php/Download
Remote teaching tools	Internet asynchronous platforms: Moodle, G-Suite Google, Microsoft Office 365; Communication tools for real time meetings: ZOOM, Teams, Cisco Webex, Google Meet, Skype

6. TEACHING METHODS

The assumption of the Space Schools Programme is the application of **active teaching methods**, where the student is in the centre of attention and the teacher plays the role of the teaching process organizer, advisor, leader. They constitute a contradiction of the providing methods, in which a lecture is a dominant form and the student is a passive participant of classes - knowledge recipient.

The basic condition of the teaching effectiveness is the student's interest in the classes, awareness of his or her own responsibility for gaining knowledge and suitability of skills shaped in social and professional life. It is supported by teaching methods, in which **group work** dominates to develop such skills as creativity, cooperation when doing common tasks, the sense of responsibility, negotiation and communication skills. Every student may complete the tasks he or she likes and fulfill various roles in a group and learn from others.

The prepared lesson scenarios limit the lecture to an indispensable minimum, various classes are proposed with the use of information and communication technologies, without which it would be impossible to complete many subjects. Certain scenarios assume the application of a project method and others a flipped lesson. It is also possible to run classes or their parts with the use of the IBSE method.

The Project Method requires a long lasting cooperation of students with the use of a planned task or several tasks. It may be suitable when completing the Space Schools Programme in the form of interdisciplinary classes for interested students.

The project is a task, which occurs in a specific time, which requires various activities, developed by the students independently, but under the teacher's supervision and based on an earlier prepared plan. The purpose of the project is to teach solving authentic problems and to concentrate of the issues, which arouse students' interest. The general substantial framework of the project is specified by the teacher. He or she prepares a list of topics, determines the skills that the students should gain and develop and presents concepts, which are to be developed in action. Students choose tasks, on which they want to work, they decide individually about the methods of completing a given subject, they formulate a problem, they interpret it, analyze and solve. It is worth emphasizing that a teacher may leave freedom to his or her students in making the discussed issue more precise. He or she may also propose a more narrow topic - then he or she allows for a choice among various possibilities to develop the topic. When applying the project method - various technology and communication tools are helpful: tools supporting problem solving and analysis, carrying out experiments, simulations, tools for presentation or communication and cooperation in a group.

Flipped learning method (also referred to as advanced learning) may apply both during interdisciplinary classes as well as in case of including Programme elements in the subject classes. Students prepare for lessons (at home) in a given subject with the use of sources indicated by the teacher. For example: they watch the indicated movie, they read a recommended article, they do experiments on their own and watch the sky in their vicinity. A lesson is used to put the students' information in order, to verify the data they have and using them in practical, engaging tasks. The teacher may design such a lesson based on a film he or she chooses at youtube (we recommend, among others, the Astronarium channel), with the use of a free service: https://ed.ted.com/. After finding a corresponding movie he or she adds questions and hints for the discussion and additional materials in a given subject. After sharing the lesson with students he or she may follow their progress. It is perfect during teaching both in classroom and in online teaching.

The **IBSE (Inquire Based Science Education),** method is extremely important when teaching maths and science and it is recommended by the European Commission in the so called Rocard Report (2007) entitled *Science Education Now: A Renewed Pedagogy for the Future of Europe*[6]. This method, based on scientists' work is based on looking for answers and solving problems with various methods, with a particular focus on the experimental method. Contrary to the providing way of sharing scientific knowledge, facts, definitions and issues, IBSE is based on developing attitudes and research competencies and on supporting the students' independence.

When running classes with the IBSE method, the five stage model is often applied 5E[7] [8] (Figure 3.), the name of which comes from the first letters of the names of subsequent stages:

1. Engage - the teacher's task is to arouse students' interest in the subject of the class and to find out the students' earlier knowledge about the issue;
2. Explore - students in groups make analyses, research, they make hypotheses and look for answers to their questions;
3. Explain - the teacher asks students to share the results of their work, he or she helps them explain the information they acquire, formulates conclusions, interpretations of experiment results;
4. Extend or Elaborate - the teacher helps to make a given idea more general by extending it and providing new context; the students try to apply and save the knowledge they have gained;
5. Evaluate - students analyze and evaluate the effects of their work by answering the teacher's questions, by solving a task or a quiz. On the other hand the teacher may evaluate the degree of understanding the analyzed question by the students and their skills. It may be carried out in the form of a self-evaluation or the students evaluation among themselves, as well as a formal evaluation by the teacher.

The IBSE method may also be applied during certain classes.

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6 http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf [dostęp: 19.11.2020]

7 https://lesley.edu/article/empowering-students-the-5e-model-explained

8 Iwona Maciejowska, Teaching science and nature by scientific inquiry and investigation and a cooperation with industry - as the basis of the ESTABLISH project 35 (3/2010), Toruń 2010

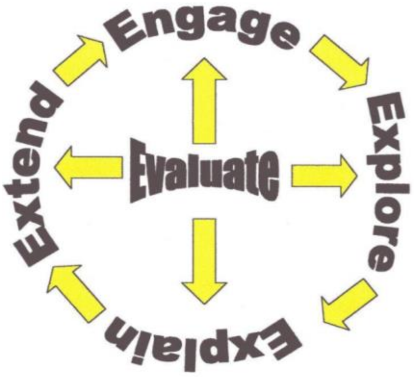

Figure 3. 5E Model

Other teaching methods activating the students may also be enumerated. Many of them are supported by educational applications, which make the classes more attractive during day studies in the classroom, as well as in online teaching. They are, among others:

- Brainstorming
- Problem analysis, for example with the use of mind maps
- Experience, environmental observations
- Astronomical observations
- Laboratory work
- Field work
- Data analysis
- Gamification, namely learning based on games
- Phenomena simulations
- Questionnaires, quizzes
- Various kinds of discussions

Let us see that the teaching and learning methods intermingle, they connect and interrelate. For example the questionnaires, quizzes, educational games or simulations may be applied during flipped learning. Science experiments, carried out in a laboratory (stationary or virtual) usually correlated with data analysis, team work or the IBSE method. Environmental observations are often carried out during field work, in particular astronomical, experiments and measurements are made, educational games are applied with the use of various applications on mobile devices.

It is worth mentioning that activating methods play an important role during **remote teaching**, when it is necessary to support students while they work from home. The asynchronous platforms (such as Moodle, Microsoft Office 365, Google Workspace) allow to provide educational materials in various forms, putting them in order, access in any place and time. It is possible to share information during discussions at forums, providing responses when students solve their tests, do their tasks, but such actions are not carried out in real time. Synchronous meeting serve this, as they are realized with popular communication tools, such as: ZOOM, Teams, Cisco Webex, Google Meet, Skype. Their functionalities allow to plan and run meetings with students in involving forms.

The synchronous contact tools have functions, which provide the possibility to arrange groups and to control them to a certain extent. During remote classes the students play roles, communicate with images, texts, chats. It is necessary to involve students, since a presentation in a form of an on-line lecture may be not enough. It is worth to provide the content in a situational context, form of a quiz, game - generally such forms, which let the students take a certain risk, which may be a positive or negative motivator. Positive aspects of solutions connected with taking risks are that the student will be encouraged with adding energy, developing self-esteem, avoiding boredom, paying attention to puzzling phenomena. On the other hand negative emotions, such as fear, anxiety, speed, may impede learning, not giving enough time to acquire the content, destroy self-esteem. The possibility to use hints while doing the exercises, option to correct an answer, appreciation, may prevent possible negative feelings.

The lesson scenarios, prepared in the Future Space project, contain many exercises, which may be done by students during remote classes with the use of technology and communication tools supporting the Programme (described in the previous chapter). It is possible to apply flipped learning and assign the real time meeting for a discussion with students, their presentations, posters, results of observations, experiences or simulations. It is helpful in deepening the obtained knowledge and it also develops the communication skills and presentation skills.

The teacher's role, who decides about the method of running the class and the applied teaching methods, is such a way of conducting a class, which activates students, arouses their interests and helps them develop their main skills.

7. BEST PRACTICES IN TEACHING NATURAL SCIENCE (STEM)

The idea of subject teaching in schools originated in the 18th century. On the Polish land the subject teaching appeared along with a deep transformation of education introduced by the National Education Commission in 1773. Learning became available for all social layers for the first time, girls were allowed to learn on equal rights with boys and young people started to learn Polish language, history, mathematics and natural sciences. In the western Europe subject teaching appeared broadly in the beginning of the 19th century. For example in the Victorian era, the English schools taught reading, writing and counting, but also geography, history and singing.

During over 200 years of its existence, subject teaching was adjusted to changing social needs, but only in the last decades the disciplines actually began to intermingle. The interdisciplinary idea appeared in curriculum and in the western education systems certain fields of knowledge started to interrelate in the framework of one school subject. An example may be teaching physics and chemistry in certain French -lower secondary schools.

INTERDISCIPLINARITY

The purpose to introduce interdisciplinarity to schools is the indication that both the description, as well as understanding the processes of the surrounding world often goes beyond one field of knowledge and sometimes it is possible only in the meeting point of many fields of science.

The Space Schools Programme also offers to teachers the examples of interesting interdisciplinary classes scenarios. They are connected with a widely understood space research and they combine such fields as: physics, astronomy, mathematics, geography, biology and the basics of entrepreneurship. The scenarios were prepared in such a way so that on the one hand they should meet the assumptions of the current curriculum (2021-2022) in the above mentioned subjects and on the other hand - to help the teacher prepare interesting classes with modern and unexpected applications of school knowledge.

SOFT SKILLS

The changing social needs caused paying attention to the development of soft skills in the education process. In Poland the skills for many years were (and still are) developed mainly on the level of primary school, in the western countries, the soft skills are developed until the university level. As far as the education systems in Europe are very different, almost all of them try to keep balance between developing the basic competencies and soft skills. In the societies these days the skill of critical thinking, cooperation in a group, building relations, creativity and communication skills are as important as knowledge and the skill of using it. Soft skills are particularly important for the managerial staff and on levels connected with working with people will be valuable for every person in daily life. Today they are often called the skills of the 21st century.

TECHNOLOGY, COMMUNICATION AND OTHER ACTIVATING METHODS

The developed scenarios of classes refer mainly to the content of teaching. In many cases the subject itself - irrespective how new and unexplored for students - does not necessarily have to be interesting for them. The way of sharing knowledge and running the class plays an important role here. A properly prepared lesson may also serve the development of soft skills.

Below we present a set of good practices in teaching exact and natural sciences.

Class Subject

Students' interest in the problem discussed during the classes and focusing their attention is a key element of an effective sharing of knowledge and shaping skills. The subject of the lesson should correspond to the problems of daily life and the teacher must be able to indicate the applications of shared knowledge. It is the only way to prove to students that physics or any other science describes the processes around us, it is necessary in our daily life and develops their future. It is a good idea to refer to space research and astronomy discoveries.

Project your own lesson

Defining how the class will develop is the most important step of projecting them. We suggest to reach as often as possible for a form basing on a (simplified) process of running scientific research or engineering design. It will let young people discover on their own and examine the interdependencies in the real world, it will certainly arouse interest in the discussed subject and it will partially also help the teacher present the methods and research tools we use to obtain an objective description of the surrounding world.

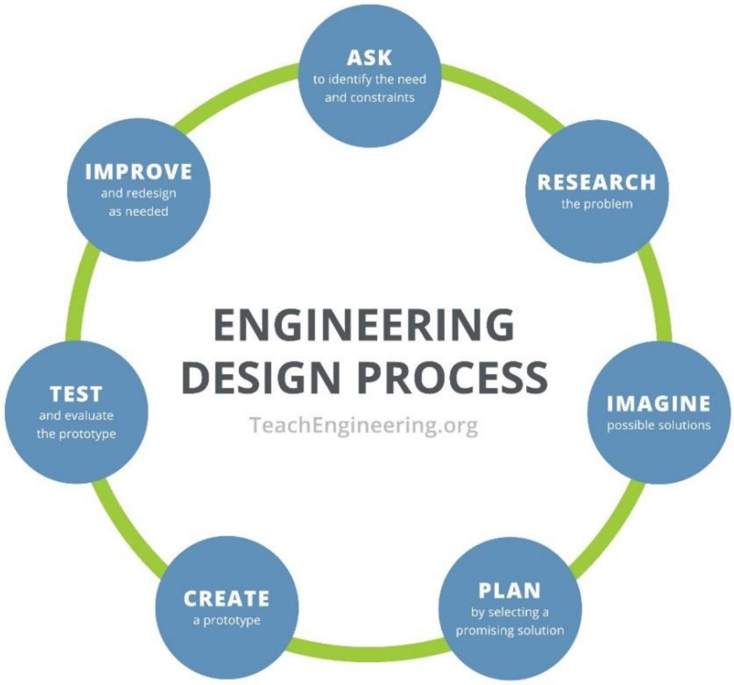

Figure 4. https://www.teachengineering.org/design/designprocess

Example lesson scheme may look as follows (Figure 4.):

1. define the problem,
2. do the basic research (find out what the problem is about) and define the requirements for the investigated solution,
3. point to potential solutions during a brainstorm,
4. choose the best one,
5. make a prototype (in case of a technical solution) or prepare conditions to test the selected solution,
6. test and introduce adjustments... repeat as long as you obtain a solution, which fulfills the assumed requirements,
7. present the solution.

Teacher's role

Most of the above presented steps not only can, but actually should be performed independently by students. The teacher should be only an initiator and a moderator of discussions between particular groups of students. Thanks to this, students can practice critical thinking, they learn to falsify erroneous theories and such discussions develop their self-esteem.

Do not neglect the last point of the scheme. Presenting the solution in the classroom should be made by one of the students and it should contain:

- short summary,
- indicating the assumed solution (understanding), which led to the required solution of the problem,

- conclusions from bad solutions (the ones, which did not lead to the required solution), the teacher's support may be necessary here.

Such a summary is an important element, which will let the students practice the self-presentation and work on the proper choice of content.

The above scheme also shows to the students a simple method - the first approach - with which it is possible to look for solutions of most problems.

Working with students

Irrespective of the method of working with students, divide them into small teams of 2-3 persons. Team work teaches young people to cooperate, it lets them share knowledge quickly and develop skills inside the group. An often used method of division consists in grouping students in respect of their skills - in case of groups of 3 persons, every one of them may have students with better and poorer skills. Prepare conditions for teamwork. Change the setting of benches in the classroom, the students in the groups should be facing each other (keeping the social distance, if necessary), to be able to share their ideas and opinions.

Using the ICT

Teaching is effective if a student focuses his or her attention on the discussed problem during the whole lesson. Preparing the activities, which will be able to ensure this, definitely is the most difficult part of the preparations. Theoretically it is easy to involve students when they do their research work, but lots of schools are rarely equipped with enough complete sets to carry out experiments in every group of students. Information and communication technologies are helpful here, computer workshops and smartphones, which almost all student have in their pockets.

One of the solutions are e-experiments. Under the European projects one of the Polish university developed complete sets of experiments in physics , which are visualized on the computer screen (http://e-doswiadczenia.mif.pg.gda.pl/glowna-en). E-experiments may be carried out in a school computer classroom, where students have to be split into small, 2-persons teams so that every group has access to a computer and is able to get involved in the tasks.

It is a good idea to use physical phenomena simulators, but also other natural sciences and exact sciences. One of the best known equipment is PHET developed at the Colorado University in the USA. The PHET simulator enables the teacher to image phenomena, but the students also can experiment in a computer classroom - they can do virtual physical experiments with the use of the software.

The computer classroom is occupied permanently, or its caretaker is not very helpful? Today almost every student has a smartphone in his or her pocket. It is a very powerful tool, which, thanks to applications, may be easily turned into a measurement device to use at physics and other exact sciences. It is an easy way to involve all students in the classroom and make them feel as great inventors. The Google Play and App Store have rich libraries of free educational applications enabling for example the examination of the Doppler effect, changes of the light intensity in the distance function. .

We encourage to use computer based technologies in the classroom as often as possible:

- with the use of a short movie's fragment available at such platforms as Vimeo, Kizoa or YouTube, for example by defining the problem at the beginning of a class,
- by combining the English language classes with physics/chemistry/biology and using the real data from space missions in the classroom, available in the websites of science centres,
- by evaluating the students' progress with the use of free applications, such as Plickers, Socrative or Kahoot.
- by gathering in one place and by sharing the Internet resources with the students by the Padlet platform.

Preparing classes based on the proposed scheme with the use of the ICT tools will certainly take more time than preparing traditional classes. However, increasing the students involvement and a longer focus on the problem will result in better grades. Our project partners report that the average increase of school rates was as much as 20% (one grade higher) in comparison to classes, when traditional methods were used.

Example of a class - dependence between the light intensity and the distance

The class may start with a presentation of photos or films showing satellites cruising around the Earth and the space probes examining Jupiter or objects located further in the Solar System. Students - on their own or with the teacher's support - should note the easily visible difference of the size of solar panels: the probes directed in distant areas have much bigger panels than the satellites around the Earth. Some of the students should notice that it may mean that there is a relation between the distance from the Sun and the size of the sound panels size, so there is a physical relationship between the radiation intensity and the distance. This conclusion should be assumed as a working hypothesis to be examined by students during the class.

In the beginning of classes the teacher divides students into 2-persons teams, in which every person will do the following experiment. It is enough to have a smartphone or even an older mobile phone, which has a diode, which lightens the photos. A smartphone should have the **ŚWIATŁOMIERZ** (light meter) application (there are many free applications of this kind available at Google Play, a light meter is also available at Phyphox and Physics Toolbox Sensor Suite, see the software index), the second will issue light from the diode lightening the photos. Students should measure the light intensity in 3 - 4 fixed distances between the telephones and the measured value of brightness and the distance between the telephones and record it in a table on a piece of paper. In this way they can discover a law in physics on their own. The measurements may be done 2 - 3 times for the same distances, which allows to refer easily to the problem of measurement uncertainties.

Example of a class topic - Examining the thermo-insulation properties of building materials based on renewable raw materials.

The scenario was developed in the framework of the European BLOOM Project (*Boosting European Citizens' Knowledge and Awareness of Bio-Economy Research and Innovation)* and was tested in the classroom with students. The lesson had an experimental nature and was a part of a cycle of classes connected with bio-economics.

Students were split into groups. Every group had a measurement kit with temperature sensors and a software for data collection and analysis of measurement results. After a short introduction to the measurement technology supported by computers, students worked in groups. They tested hot water cooling in vessels wrapped in various insulation materials, such as: mineral wool, moss, wood chips. Every group used different insulation material, water beakers and a bigger vessel. Before the experiment the students made a research hypothesis and later they measured temperature changes during hot water cooling in two vessels: one was wrapped with an insulation material, and the other was not. The temperature changes registered by a computer (example results at Figure 5) were presented by all group representatives, which enabled the results comparison and a discussion at the class forum.

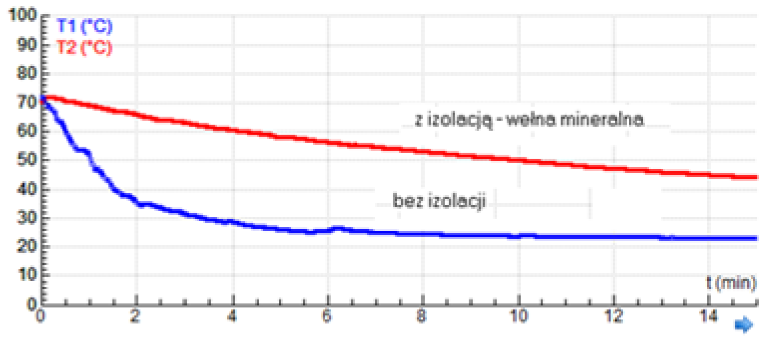

Figure 5. The registered graphs of water temperature changes while cooling in the beaker wrapped with mineral wool and without the use of an insulation material.

The measurement result analysis was quite difficult due to various initial temperatures. It was an opportunity to have a discussion how to modify the experiment to make the results as reliable as possible. In effect the temperature differences were compared while the cooling water temperature dropped in the vessel without the cover and with a thermal insulation cover (Figure 6). The students also proposed to repeat the measurements and to examine other materials.

	Type of insulation material	Water temperature decrease [°C]	Water temperature decrease [°C] - no cover	Temperature difference [°C]

gr. 1	mineral wool	26.2	48.7	22.5
gr. 2	wood chips	21	41	20
gr. 3	polystyrene	22.9	52	29.1
gr. 4	moss	20	45	25

Figure 6. Comparison of results of measurements made by students. Measurement time 15 minutes

Polystyrene appeared to be the best thermal insulation material, but the experiment result was not the most important purpose of the class. Students developed various skills: doing research work, measurement data analysis, cooperation in a group, communication, negotiations, presentation of their work results.

In classes with an extended curriculum in physics it is possible to extend the scope of research - carry out the analysis of the cooling curve, build a mathematical model based on the Newton law and compare the modeling results with experimental data.

8. GENDER EQUALITY IN THE EDUCATIONAL CONTEXT

Education is a catalyst for social change and reflects how human rights are realized in practise. It creates opportunity for both, men and women, to increase their skills and to provide them with ability for further development of their knowledge throughout their lives. Education gives tools to handle with difficult situations, find better paid jobs and combat the risks of social exclusion. Due to that entire societies benefits from educated citizens.

In all research on social inclusion, employment rates and job quality indicators, women are more endangered than men of social exclusion, unemployment and low-quality jobs. Those statistics stays in contrast to overall higher success rates of girls and women in the EU in terms of completing school, education, accessing higher education or participating in lifelong learning.[9]

[9] "Gender in education and training", European Institute for Gender Equality, 2016, p.4-10

To reduce this imbalance, gender stereotypes has to be deconstructed. First step to achieve it is to define the factors that implies gender in-equality. Among main factors are:

- Gender-based different choices across study fields;
- The feminisation of the teaching profession versus the masculination of teaching tertiary education;
- Gender stereotypes in education;
- Gender-based violence at school.

Gender-based different choices across study fields

Norm internalisation is a process which happen on individual level, boy and girls starting activities related with science education has already well-established gender identities[10]. Statistics shows that women are underrepresented in some study fields so-called STEM: science, technology, engineering and mathematics, while they are over represented in other, like humanities and social sciences. They study subjects that lead to lower pay and lower status job, despite the fact that they achieve better grades and outnumbered boys among new university graduates. Moreover, studies shows that parents expect their sons, rather than their daughters, to work in STEM field, even if they perform in those subjects at the same level. For higher gender equality in education participation of girls in STEM study has to be increased.

Feminisation of teaching in primary and secondary schools

In most EU countries women constitute majority of teachers at the level of primary and secondary education, while tertiary education teacher positions are mostly embedded by men. The trends of choices across study fields are also reflected among tertiary teachers were most women dominate in medicine and health sciences while men in natural sciences and technology. Nonetheless, there is overall overrepresentation of men in senior academic positions in most EU Member States, which are better paid, with higher-status position and hold influence on policy and decision-making.

Gender stereotypes in education

When it is expected that a person should act in defined way based on his or her sex it is called gender stereotyping. In education gender stereotyping is reinforced mostly by teachers and materials that are used by students. It is also deeply entrenched in the history of each discipline were among inventors and achievers in science and technology, women were under-represented. It strengthened stereotypical gender patterns and is transferred into the behaviour and choices of individuals.[11]

Social norms of the society, students and teachers live in, influence learning environment. In this context gender stereotyping can impact on the preferences for disciplines, expressed by boys and girls. This issue is also raised in the report “Criteria for gender inclusion” prepared in frames of Hypatia project realised under Horizon 2020 programme. In the document, authors used

[10] Criteria for gender inclusion, Hypatia Theoretical Framework, European Union’s Horizon 2020 Framework Programme for Research and Innovation (H2020-GERI-2014-1) under the grant agreement No. 665566, p.17

[11] “Gender in education and training”, European Institute for Gender Equality, 2016, p.4-10

implied science learner concept. In this concept the structure of STEM study courses is a derivative of explicit or implicit assumptions about what constitute science learner, so-called implied student. In most cases those assumptions refers to male learner what in consequence can lead to exclusion of girls from study programme[12].

Gender-based violence at school

In research the correlation between violence and early school leaving wasn't examined, however literature suggests it.[13] Violence at school takes form of bullying by peers. It can have form of physical, verbal abuse or intent to cause psychological harm through humiliation or exclusion. Frequently bulling is gendered and reflect unequal power relations. Students may be bullied because of non-confirmative attuite which stays in contradiction to expected gender norms.

Implementation framework

The important role in gender inclusion plays understanding of constrains and conditions that influences implementation of science education. Some of them may be explicit but others are implicit. Nonetheless the educator should be aware of them and try to counteract. Those conditions and constrains can be related with factors described in previous chapter. But there is set of them which were not captured so far.

In the frames of the Hypatia project, realised under Horizon 2020 programme, theoretical framework had been developed. It described four levels in which gender inclusion should be considered and implemented. Those levels are:

- Societal/Cultural (conditions coming from society)
- Institutional (institution itself and its chosen pedagogy)
- Interactional (where activities are being realised)
- Individual (related with learner's knowledge)

It is important to mention that first two levels are beyond educator control, but being aware of them may help to find a remedy their effects.

The Individual Level

On the individual level the educator should avoid phrases which can build presumptions into the activity and give impression that those activities are for certain kinds of learners. [14] It is also important to ensure that the activity correspond to different ways that learners being interested

[12] Criteria for gender inclusion, Hypatia Theoretical Framework, European Union's Horizon 2020 Framework Programme for Research and Innovation (H2020-GERI-2014-1) under the grant agreement No. 665566

[13] Nesse Network of Experts, Gender and education (and employment): gendered imperatives and their implications for women and men: lessons from research for policy-makers, European Commission, 2009, Brussels, p.45

[14] Criteria for gender inclusion, Hypatia Theoretical Framework, European Union's Horizon 2020 Framework Programme for Research and Innovation (H2020-GERI-2014-1) under the grant agreement No. 665566, p.15-17

in the subject. It should be avoided to present to learners activities that are strongly gendered and may lead to the following internalisation of "female" or "male" learner. Activities should encompass a variety of different ways of engaging.

Educator should:

1. "Ensure that the activity takes a point of departure in what learners already know about the scientific subject matter, acknowledging that different learners have different kinds of prior knowledge that may be relevant in different ways.
2. Ensure that the activity gives equal consideration to specific details of the activity and the bigger picture.
3. Ensure that the diversity of science is represented to the largest extent possible in the activity.
4. Acknowledge that individual learners may have experienced gender exclusion in some types of institutions.
5. Encourage all learners to participate to an equal extent, and set high expectations for all learners." [15].

The Interactional level

The interactional level is defined by multiple situations in daily life which influences young learners and their education choices. Interactions between participants of activities may reproduce and/or strengthen inequality.

In this context educator should:

1. "Ensure that the activity has a balanced approach to participants' learning preferences, i.e. includes thinking tasks, motor skill tasks, and value-related tasks
2. Ensure a suitable variation of different interaction forms.
3. Ensure that the different roles required by the activity have equal status, or that the roles rotate between participants.
4. Ensure that the involved science educators and scientists reflect a variety of personalities. Girls and boys are most inspired by role models they feel psychologically similar to. Otherwise, the standards set by the other person become a contrast that girls and boys may react against." [16].

The Institutional level

Institutions organize work in a way which reflects adopted ideologies. For the educator it is to recognize it and be aware in which spheres it can influence gender exclusion in order to better counteract.

Educator should:

[15] Criteria for gender inclusion, Hypatia Theoretical Framework, European Union's Horizon 2020 Framework Programme for Research and Innovation (H2020-GERI-2014-1) under the grant agreement No. 665566, p.17-18

[16] Criteria for gender inclusion, Hypatia Theoretical Framework, European Union's Horizon 2020 Framework Programme for Research and Innovation (H2020-GERI-2014-1) under the grant agreement No. 665566, p.19

1. “Be explicit about the socio-scientific role of the institution (research, industry, education) when addressing learners, and about how this shapes the science education activities in question.
2. Ensure the best possible alignment between the institution’s stated aim and the activity’s opportunities for gender inclusion.
3. Acknowledge that different pedagogical approaches appeal to learners in different ways.
4. Ensure that a balanced approach to the discipline is taken.
5. Ensure that the variety of ways of conducting research within the scientific discipline are represented in the activity.
6. Ensure that the physical learning environment support the planned activities.” [17].

The societal/ Cultural level

Gender identity is shaped by society and culture (it can differ between nationalities and societal groups). In this context the educator role is to recognize and remedy its impact on individuals.

Educator should:

1. “Acknowledge that science may be represented in certain gendered ways in the public sphere. If taking a point of departure in these public representations (to spark interest in activity), consider how to support multiple ways of participating in the activity, beyond those publicly recognized.
2. Consider the way gender is implicitly or explicitly conceptualised by stakeholders (ministries, politicians, funding organisations, interest groups etc.) and the potential effects of this conceptualisation on the activity.
3. Consider what is included in the definition of ‘science’ in national cultural context, and what is excluded. Assess whether employing a broader conception of ‘science’ in the activity could support the inclusion of a broader range of learners.”.[18]

SUMMARY

Science education is strongly influenced by gender aspects. Research shows that there is strong imbalance between boys and girls in choosing STEM activities. In order to make STEM more inclusive there is need to recognise all conditions and constrains that constitute this situation. Educators plays important role in implementation of science education, therefore they should be aware of those constrains and counteract them.

[17] Criteria for gender inclusion, Hypatia Theoretical Framework, European Union’s Horizon 2020 Framework Programme for Research and Innovation (H2020-GERI-2014-1) under the grant agreement No. 665566, p.21

[18] Criteria for gender inclusion, Hypatia Theoretical Framework, European Union’s Horizon 2020 Framework Programme for Research and Innovation (H2020-GERI-2014-1) under the grant agreement No. 665566, p.22

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11. Council of Europe, „Study on "Combating gender stereotypes in Education", M. Bohan, 2011, CDEG (2011) 16, page 3

9. Glossary

Soft skills – skills, which may not be measured, such as: creativity, ability of communication, critical thinking, cooperation in a team, relation building.

Flipped learning - also referred to as advanced learning - teaching method, which consists in a change of a lesson concept: students prepare a new subject at home - they acquire new content and during school classes they use and perpetuate their knowledge.

Role models – patterns to follow, in the Future Space project these are recorded interviews with persons, who were successful in various professions connected with space subject.

STEM – abbreviation of *Science, Technology, Engineering, Mathematics* - exact and natural sciences.

[19] https://rm.coe.int/cm-rec-2019-1-on-preventing-and-combating-sexism/168094d894
[20] https://search.coe.int/cm/Pages/result_details.aspx?ObjectID=09000016805d5287
[21] https://rm.coe.int/1680590fe5

SAMR Model – model of integration of technology in education developed by PhD Ruben Puentedura. The name SAMR comes from the first letters of names of particular levels: Substitution, Augmentation, Modification, Redefinition.

IBSE (Inquire Based Science Education), teaching based on discovering, scientific investigation - method of teaching, method of learning natural sciences. Contrary to the providing way of sharing scientific knowledge, facts, definitions and issues, IBSE is based on developing attitudes and research competencies and on supporting the students' independence.

Gamification – teaching method, learning based on games.

Gender - this term was introduced by psychologists to differentiate between the biological and social gender. This phrase refers to the relation, between a man and woman, developed socially. The relations are determined by social roles and decisions of daily life realized by particular persons (for example: the clothes they wear, the work they do, the knowledge they can gain). While the biological gender is unchangeable, the social gender may be defined depending on circumstances. Relations between genders differ depending on culture, race, religion or social class. In certain enterprises there is a relationship between gender and the occupied position. It is common among students to choose a specialization socially considered as appropriate for their gender[22].

Equality - the concept of equality assumes, that a person, a thing or circumstances have the same quality at least in one aspect. For example: if two persons have the same status in at least one normative aspect, they should be treated equally because of that aspect. Another issue is which aspects are normatively appropriate and which are not.

Equality was often associated with morality and justice. For many years the emancipating movements used the notion of justice to emphasize inequality[23].

Gender equality - the notion of gender equality assumes that men and women have the same social status (as human beings). Therefore they should have equal chances to be able to realize their potential both in the scope of gaining knowledge as well as by involvement in political, economic and cultural areas. "The same value is assigned by the society both in the scope of similarities, as well as differences between men and women and the roles they take."

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[22] A Guide for Gender Equality in Teacher Education Policy and Practices, ISBN 978-92-3-100069-0, UNESCO 2015

[23] Equality definition, Stanford Encyclopedia of Philosophy, *First published Tue Mar 27, 2001; substantive revision Wed Jun 27, 2007*