# INSPIRING SCIENCE EDUCATION CONFERENCE 2016

APRIL 22-24, PALLINI, GREECE

**PROCEEDINGS**

ELLINOGERMANIKI AGOGI

Published by **Ellinogermaniki Agogi**

**Editors:**
Dr. Angelos Lazoudis, Dr. Stephanos Cherouvis

**Artwork:**
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This project has received funding from the European Union's ICT Policy Support Programme as part of the Competitiveness and Innovation Framework Programme (Grant Agreement no. 325123). This publication reflects only the editor's and contributors' views and the European Union is not liable for any use that might be made of information contained therein.



Printed by **EPINOIA S.A.**

**ISBN** 978-960-473-775-8

# Contents

# Enquiring and learning about particles, x-rays and exoplanets

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## Abstract

*Within the International Year of Light - IYL2015, the Italian National Institute for Astrophysics research – INAF - has launched the a "Projects of National Interest" (Progetti di Didattica di Interesse Nazionale PDIN), supported by the Italian Ministry of Education, Universities and Research, 'From Astronomical Light to Public Enlightenment' during which an open week with tens of laboratories about light was organised for schools. Some of these laboratories are traditional and some are EBL (Enquiry Based Learning) based. Here we discuss three of them, the first two already performed while the third one still in the planning phase.*

## Keywords

Astronomy, astrophysics, education, Enquiry Based Learning, elementary particles, exoplanets, x-rays, hands-on, black holes.

## 1. Introduction

As a public scientific research institute, we wondered what role we should have in the 'transfer knowledge' process from who has the most accurate content (researchers) to whom has to transmit it to students (teachers).

This is one of the reasons INAF, the Italian National Institute for Astrophysics [1] has an expert in outreach and education for the public and schools in each of its facilities. These experts network with each other and collaborate with teachers to plan and realise educational activities.

Given the huge number of Open Educational Resources (OERs) collected during the 15 past years, INAF also became a partner of astroEDU, the IAU platform for educators to discover, review, distribute, improve, and remix educational astronomy activities.

In 2015, an editorial board, made of INAF education experts and teachers, was constituted, with the task of producing the Italian astroEDU [2]. Moreover, with the IYL2015, INAF has launched a Projects of National Interest' (PDIN), supported by the Italian Ministry of Education, Universities and Research, 'From Astronomical Light to Public Enlightenment' during which an open week with tens of laboratories about light was organised for schools. Many of these laboratories are EBL (Enquiry Based Learning) based, and here we discuss three of them, the first two already performed while the third one still in the planning phase.

The first is 'Let's Break the Particles', a hands-on activity to learn that energy can be transformed into various forms. This activity has been peer reviewed and is on astroEDU.

The second is 'Hunt for Black Holes', a workshop in which high school students act as researchers learning to work on preliminary results from an FP7 Research project EXTraS (Exploring the X-ray Transient and variable Sky).

The third is 'Starlight and Life' for primary school students involving the theme of life in exoplanets related to the latest results from the INAF research project WOW (A Way to Other Worlds).

## 2. Light in Astronomy

To celebrate the International Year of Light [3], proclaimed by UNESCO in 2015, INAF developed a pilot project within the framework of Projects of National Interest' (PDIN), supported by the Italian Ministry of Education, Universities and Research, 'From Astronomical Light to Public Enlightenment'[4]. The educational pilot project, called "Light in Astronomy", has been proposed as a new event for the first year that will be implemented as part of the D&D projects for the following years.

In particular, the basic aim of the activities proposed for the quoted open week and, then, in the following years (as the whole apparatus will be kept and maintained) is to explain and clarify fundamental items like e.g.: Light is not only what we see; Light carries energy (heat) through space; Light brings us the footprints of the matter emitting it (in astronomy... but not only); Different species of light are differently absorbed by matter; Light hits our eyes but the radiation of the whole electromagnetic spectrum interacts with our whole body; Light opens our minds to the universe (in astronomy, but also, and maybe even more, in any interdisciplinary field like e.g. technology, philosophy, literature, religion, music, arts etc.).

As already noted above, the project will be carried out taking into account three specific constraints:

a) different levels for different age/quality target-groups;

b) different adopted locations (school, other public sites, professional structures) depending on the specific experiment/event;

c) wide coverage over the whole of Italy, taking advantage of the distribution of the italian astronomical structures (Observatories, Universities, etc.).

***Figure 1.*** *The project has a web site http://iyl2015.inaf.it which will contain a description of each single lab-experiment and each event, including target age-group, scientific and educational rationale and aim, needed/available instrumental material and procedures, space and cost requirements, availability to be actuated elsewhere, etc., so that schools and the more general public can follow their preferred event and/or make specific requests (for schools in particular).*

We also promote the collaboration with schools, cultural institutions, foundations and associations, and public and private administrations, which will support our programs, in the common aim of using a professional contribution to their didactic and/or outreach activity. The list of the activities and people involved in the pilot project Light in Astronomy is long and growing, and we are planning to transfer it to a more stable configuration, beyond 2015, so that the information will remain and a new program can be offered in the second year of this proposal and for the following years.

## 3. Activities' description

Here we'll describe three examples, the first is a hands-on activity about energy, it has been peer reviewed and is on astroEDU. The second is a workshop about X-ray astronomical objects in which high school students act as researchers learning to work as astronomers do.

The third is a laboratory about the search of habitable planets in the Galaxy which has to be implemented in the next months.

As already said these three educational activities are proposed according to different level of the Enquiry-Based Learning (EBL) method. EBL is a powerful means for students to learn both scientific content and scientific reasoning together. Different educators and researchers have described enquiry-based learning activities in different ways (e.g., Banchi & Bell 2008, Chinn & Malhotra 2002, Hunter et al. 2010, National Research Council 2000, Ontario Ministry of Education 2013), but most agree that the essence of enquiry is learning science in ways that mirror authentic scientific research practices, or "learning science as science is done" (Hunter et al. 2010). Scientific practices (sometimes called core skills, or reasoning skills, or critical thinking) are ways of thinking about and doing science [5].

### 3.1. Let's break the particles

The activity is set to learn that gravity produce kinetic energy [6]. Moreover, this kinetic energy can be used (if greater than the relative binding energy) to break atoms, particles and molecules to see "inside" and to study their constituents.

It has been planned for students from 8 to 14, and it is proposed in different ways according to the different levels of knowledge.

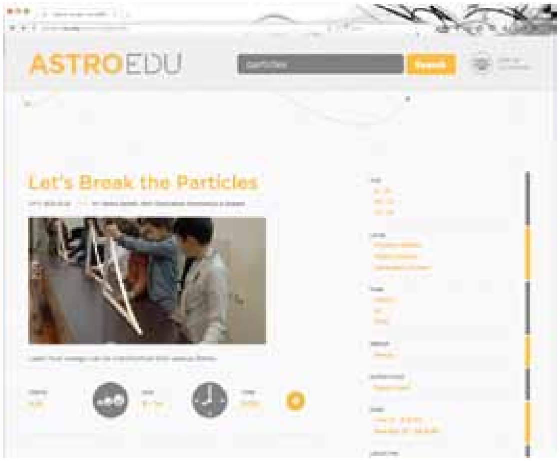


***Figure 2.*** *The activity in astroEDU web portal*

Students will use steel and glass marble on a slider to experiment and gather data to analyse.

This activity is done in three steps.

First, students release steel marbles at different heights of the slide. They will note that higher is the starting point, more distant will arrive the marbles. This will indicate that gravity produce kinetic energy.

Second, they will take the glass marbles (usually three), bound by the Adhesive Putty. This system represents a molecule or an atomic nucleus. Starting from the bottom of the slide they will reach the minimum height, for which the three marbles are separated.

Third, magnets will help to drive the trajectory of the steel marble in the case the system will be too large (as in the case of particle accelerator) [7][8].

At the end of the activity students should reach a number of conclusions:

1) a marble put at different heights of a slider reach different velocities and therefore energy is transforming, starting from the gravitational energy;

2) there is threshold energy to break a bound

system (like a molecule or an atomic nucleus) called “Binding Energy”;

3) studying the distance reached by the marble as a function of the starting height, the concept of friction is introduced.

Scientists use this effect to study the matter.

The material necessary for this activity are very cheap and easy to find, at the end of the one hour and half students should be able to discuss and give a brief explanation to the following questions:

- Why do different heights give different effects?
- What happens if we use different glues to bind the glass marbles?
- Do we need a longer slide if the glue is super resistant?
- What happens if the collision is not head-on but off-centre?

In essence, with a simple device (“the accelerator”), the student studies the effect of collisions between marbles at various heights. This allows to introduce the important theme of various forms of energy, such as potential, kinetic and binding energy and the possibility of transformation from one form of energy to another.

### 3.2 Hunt for Black Holes

EXTraS (Exploring the X-ray Transient and variable Sky) [9] is an European Union’s Seventh Framework Programme for research, technological development and demonstration going to harvest the hitherto unexplored temporal domain information buried in the serendipitous data collected by the European Photon Imaging Camera (**EPIC**) instrument on board the European Space Agency – ESA - satellite XMM-Newton[10], in 13 years of observations.

***Figure 3.*** *Students at work for EXTraS project. An experimental didactic program to be implemented in selected high schools of the participating institutions’ countries, aimed at involving students in research activities of the project.*

Hunt for Black Holes is a Workshop where high school students play as researchers. They will be able to work on preliminary results from EXTraS and will be introduced to the scientific research and industry in the field of Space Technology and applications.

The Workshop as a whole is a live role playing-like activity with a strong hands-on strategy and some more formal education. The participating students, divided into co-operating groups, will attend laboratories and lessons given by scientific researchers and aerospace industry representatives. The groups gather information about high-energy astrophysics, related space technologies and data mining and analysis. As in any other live role-playing activity, their ability to interact with experts will be fundamental to reach their goals. The formal goal of the students is to discover as many black hole candidates as possible, by exploring data extracted from the EPIC database and pre-selected by researchers. Whenever they think they discovered a black hole candidate, they are asked to submit it to their scientific tutor.

The Workshop lasts about 5-7 working days (40-50 hours), according to the specific situations and the students’ curricula. This educational strategy allows the attending students to use real scientific data and:

- to see real life applications for their studies in the field of research;

- to see real life applications for their studies in the field of space industries;
- to acquire a deeper knowledge of the Universe and the space technologies ;
- to focus on the main aspects of a complex problem;
- to develop skills in interaction, knowledge-sharing and team-building, discussion and problem solving.

We plan to run the workshop across a number of schools whereby the students that attend don't know each other. This way they also get the opportunity to work with other students of the same age but possibly from different social and cultural backgrounds.

We plan also to run a further 3 day session (20 hours) after the main Workshop, in which the students can use their data analysis experience to make a virtual proposal for a simulated high energy space telescope to increase the probability to find black holes. They will be asked to take into account the scientific rationale, the industrial technologies and a virtual assigned budget. The proposals will be discussed with a scientific high-level committee, who will choose the mission which "will fly". This activity goal allows the students to discover more on the interaction between science and technology and to understand the constraints due to a limited budget.

In order to prepare the Workshops, in every participating country we will collaborate with science teachers and communicators to develop hands-on modules both for teachers and students.

Namely, we will draft common Hands-on modules for students and Teacher training modules. The modules will have a common set of topics, but they will be tailored to the specific school curricula in the different countries. Every educational material (modules, lessons, videos) will be shared through a dedicated open access web site, so that the whole experience could be transferable to other schools.

We wish to underline that the "Black Hole hunt" will be the goal of a more general task of identifying the nature of sources discovered and/or characterized by EXTraS using automated algorithms developed by researchers. This will allow us to compare the results provided by the students to those provided by the WP7 of this project, devoted to "classification" of the sources. From this point of view, our educational activity will turn also into an experiment of citizen science, allowing us to assess the viability of involving non-expert (but trained) people in a complex classification task.

This activity is developed taking into account the Recommendation 2006/962/EC of the European Parliament and of the Council of 18 December 2006 on key competences for lifelong learning of European citizens.

### 3.3 Starlight and Life

Starting from the question whether life is unique in our planet or whether there are inhabited worlds in the universe, many astronomy research groups are involved in this interdisciplinary field (astrophysics, biology, geology, chemistry). The discovery of potential habitable planets orbiting around other stars, the possibility of niches favourable to life in satellites of the Jovian and Saturn systems and the capacity of life to adapt to extreme conditions, are offering new challenges. Among the key questions of the ESA 2015-2025 cosmic vision program there is: What are the conditions for planet formation and the emergence of life?

Within the IYL2015 and the national INAF program "A Way to Other Worlds" – WOW - we proposed to primary and middle school students a laboratory about the different kind of stars and the resulting difference in planets' habitat.

This first version of the laboratory, already proposed within in 2015, started from analysing the light of our star, the Sun, with the technique of spectroscopy and included the description of different spectra of stars using different lamps (with different chemical elements) and special diffraction glasses. From these concepts we described also possible different planets' habitat.

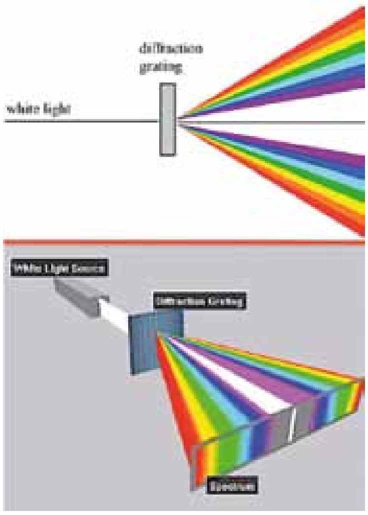


***Figure 4.*** *Diffraction glasses. Diffraction is defined as the process by which a beam of light waves is spread out as a result of passing through a narrow aperture or across an edge or "grating". As the light passes through this grating, each beam of light is split into its individual spectrum of colours turning white light into a full rainbow spectrum. This is the main principle behind what gives diffraction glasses their awesome visual sensation. White light will show the widest array of colours, whereas looking at a blue light for example will show its component colours [11].*

Now, starting from the same scientific content, we are planning a different and a new approach: we want the students face directly with four different alien habitat and, with the Enquiry Based Learning method, from those habitat they have to build up a correct panorama of possible planetary systems and living beings.

We'll assemble an exhibit made up of a four little black rooms, in each room a different star light will be simulated with different lamps, and also there will be e a different diorama designed according to that type of star (for example: a star colder than Sun with a blue and cold light will have a diorama with different Flora and Fauna from Earth).

Inside each room only 3 or 4 children can stand up for a total of 10-12 students at time. They will stay inside this room for the time necessary to register in a block note all what they see and think. Once out of the rooms the 4 groups have to compare their experience with the other groups of classmates and they will have one hour and half to collect some scientific and consistent conclusion about the different environments they have seen.

***Figure 5.*** *Extremophiles living beings, possible alien scenario. © Pinterest*

In this way, according to the typical approach of EBL, students are involved in developing their own questions to investigate based on intriguing observed phenomena, working in groups to plan and carry out an investigation to answer their question, and communicating their results with classmates to give everyone a fuller understanding (e.g., Institute for Inquiry at the Exploratorium, 2014). These activities are learner-centred, focused on what the learners do rather than on what the teacher does, but they are also not a free-for-all; the teacher has specific learning goals for students and can nudge and guide students towards those as the activity progresses [12].

## 4. References and Notes

[1] Institutional INAF Web Site http://www.inaf.it/en

[2] astroEDU Web site http://astroedu.iau.org/ astroEDU is a project of the International Astronomical Union under the framework of the IAU Office of Astronomy for Development

[3] UNESCO International Year of Light 2015 www.light2015.org/

[4] INAF International Year of Light 2015

[5] The Enquiry Based Learning method astroedu.iau.org/ebl/

[6] The story of kinetic and potential energy www.youtube.com/watch?v=7K4V0NvUxRg

[7] How does an atom-smashing particle accelerator work?

www.youtube.com/watch?v=G6mmIzRz_f8

[8] A quick look around the LHC www.youtube.com/watch?v=BEnaEMMAO_s

[9] The Web site of Extras www.extras-fp7.eu/

[10] ESA's X-ray space observatory XMM-Newton is unique. It is the biggest scientific satellite ever built in Europe, its telescope mirrors are amongst the most powerful ever developed in the world, and with its sensitive cameras it can see much more than any previous X-ray satellite. sci.esa.int/xmm-newton/

[11] From glofx.com/what-are-diffraction-kaleidoscope-glasses/

[12] From astroEDU astroedu.iau.org/ebl/

# CERN, Remote Telescopes, IceCube: The three Major Virtual Visits

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## Abstract

*In recent years a new prospective in education rises. Implementation of inquiry based learning methods; research philosophy and academic skills in education reveal the need of professionalism in every day school practice. Teachers and students often are asked to answer a scientific question, to perform an experiment, to collect data and process them. According to these statements, it's out of doubt that students must get familiar to the scientific procedure and research steps. Setting a scientific question in investigation teachers and students must know how to set initial questions and how to compose primitive theories to explain possible answers. Then teachers have to compose inspired question in order further to provoke students' curiosity and reveal theories' discrepancies. Teachers, students and parents all contribute into these changes materializing primitive envisions. Especially, a rural school can reform rapidly into a highly developing school. We can mention the High School of Pelopio, a rural school that achieved some of its pronounced educational goals. Teachers' and administration's vision for a new school began by encouraging teachers to participate into educational meetings, conferences and developing courses. Mainly, we noticed an interesting reformation in our classrooms. Apart from the growing interest we observed that students and parents regarded school via a new prospective and under different philosophy.*

## Keywords

CERN, IceCube, Remote Telescopes, Virtual Visits.

## 1. Introduction

How can we organize and reform a rural school? Designing a long period action plan can help a school? How can we implement theoretical predictions into real school environment and evaluate our findings? This is actually what we tried to do at General High School of Pelopio, a rural school. It is well known that teachers have to participate into educational conferences and courses (Baird and Fensham 1991). Meetings and courses are crucial for the overall progress and development of teachers (Shannon and Twale 1998). New trends in education had to be spread into a rapidly changing world (Tillema 1994). Modern educators and teachers are expressing a growing demand for lifelong learning programs (Hobson 2002). Additionally, all new trends must be implemented into classrooms and embodied in the traditional curriculum (Helsby 1995). In parallel students must accept and incubate modern pedagogical methods (Finn 1998). Working in groups, consisting working teams, preparing projects and presenting results are some of the new aspects of education (Cohen 1994). On the other hand, excellence groups (Howley 1989) and students' contests (Verhoeff 1997), seems to gain an important part of nowadays educational system. Furthermore, extroversion of knowledge gradually becomes a goal for many schools (Holland 1987). Astronomical and environmental events (generally science courses), cultural performances (theater) are of high educational content. But the question is how we can implement all these aspects into daily educational practice. We tried to apply some of these educational trends into a rural school (General High School of Pelopio) and we observe some remarkable results.

## 2. Teachers' constant learning

First of all, in order to face the problems we realized that teachers had to be educated and trained on new pedagogical and didactic trends (Day 1999). Teachers were encouraged to participate to several training and learning activities. During the first stages of our action plan teachers were educated mainly on new education trends, educational scenarios, ICT implementation in classrooms, modern pedagogical trends and new approaches in daily school life. It was clearly understood that traditional pedagogical methods were inefficient. On contrary whenever a new pedagogical method was applied a rising interest was observed. Teachers also appear more willing to test new approaches. As a result of all these activities we realized how important is for educators to attend training activities and programs. New prospective occurred and new methods applied in classrooms. This was the first step of a school that learns, evolves and develops. Secondly, teachers and students must organize and conduct a well-defined experiment to measure natural amounts related to the initially imposed scientific question. Students have to record the experimentally depicted data organize and evaluate them according to their importance. Following, the processing procedure is one of the most important steps in inquiry based learning procedure that thoroughly simulates the research procedure. Plotting graphs, calculating inclines, relating natural and scientific amounts are critical steps towards extracting scientific conclusions and results. Finally, students under teachers' supervision must compose and present an integrated research paper, with preliminary knowledge, assumptions, experimentation, data processing, results and conclusions based and supported on scientific references, rated and approved by international scientific community. According to these steps, we believe that it's very important to entangle the international research community into this scheme. Of course students but even more teachers in Greece are not familiar to all these statements. So, we strongly believe that we must embody activities, visits and lectures from university professors and researchers to our Secondary Education practice. The easiest way to achieve these goals is to just visit a research laboratory and meet the people working and performing research activities. Furthermore, invited lectures to students from academic professors are other important parameters of joining Secondary and Higher Education (that mainly supports research). Thirdly, developing some kind of collaboration between schools and universities or research institutes, we can entangle students into research activities. These kinds of collaborations are recently very popular. We can mention the project "Black Holes in Schools", where many students all over the world are participating into a research project trying to spot black holes from freely distributed night sky images taken by telescopes.

Of course, we can mention relative research programs related to pedagogical or didactics in Primary or Secondary Education, where new methods, techniques and ideas proposed and formed in Universities are applied in classrooms, but this is a backwards collaboration, while we are mainly interested in schools approaching research institutes. Since 2010, we developed several kinds of collaborations initially towards the direction of visiting research centres and inviting lectures from professors. Although, we recognized and recorded the impact of these activities, we realize that we really need to impose a research philosophy in Secondary Education and inspire students on inquiry based thinking in Junior and High Schools in Greece. So we planned extended research projects embodying virtual visit into a holistic approach of scientific questions.

## 3. Implementation

Secondly, teachers were encouraged to produce educational content. Educational scenarios were developed, learning materials ware produced and working groups organized. We introduced and encouraged a new innovative idea of organizing student groups with special skills and responsibilities (Johnson 1990). For example, the Event Organizing Group, the Promotion Group, the Media (e.g. video) Producing Group, the Drama and Astronomical Team were some of the most active groups. We uploaded most of the produced educational material and scenarios on electronic means (e.g. our website), while the working groups started producing projects and events. A group of teachers was responsible for each working group. They were setting final goals, organizing their working plan, scheduling meetings and evaluating their progress. This parameter was also an important aspect of a constant learning school (Schank 1994). We detected and evaluated all steps, extracting important conclusions of how a school can become a working community. Additionally, the educational material and scenarios seem to encourage students to further search for knowledge. As all this educational materials were available on the web, educators and teachers found additional teaching tools. At the beginning we organized a virtual visit to ATLAS, CERN. This activity was embodied into an extended educational program. Students participating in this program attended a sequence of lectures by their teacher about elementary particles, modern physics and cosmology. Then students called to present their own projects after working and collaborating in groups. The planned virtual visit was the top event related to this educational program. Before the virtual visit, students applied the software HYPATIA that simulates and resamples the real experiment at LHC CERN. Students tried to detect the Higgs Boson through virtual experiments conducted on their computers. Secondly, they attended lectures from experts, University professors and researchers about the experiments at CERN and the importance of studying elementary particles. After these introductory stages we connected via net with ATLAS CERN and we performed a virtual visit to ATLAS control room. Then students asked questions and discussed with researchers about the progress of experiments, difficulties, expectations and scientific matters. The positive impact of all these activities was that students really act as researchers operating software that simulates the real experiment. They tried out of thousands of recorded data to detect the desired particle, while they exchanged opinions with other researchers through virtual visit. Recording of data continued the following days by students. The question imposed to our students was to find and detect the Higgs Boson. We faced the challenge holistically while we introduced students to theory, they asked questions, then they presented their opinions and works, performed an experiment, recorded data, processed the data and presented evidence: the detection of Higgs Boson. Virtual visit was a necessary part of this sequence and not the only one activity.

## 4. Events

Developing our Astronomy project, we realized that we needed some hands on experience, observation knowledge and support by experts. These realizations were important on organizing the first Astronomical event in our school's region open to local community. The event was a result of an excellent collaboration between several working groups, teachers and authorities. The event-organizing group supported the whole action, the promotion group, the media group and astronomical team also took great responsibilities. Teachers from our school participated in several parts of the event, while we had the support of the Municipality of A. Olympia and the 7th Ephorate of Prehistoric and Classical Ancients (EPCA) of A. Olympia. We operated remote telescopes from distance, a professor from University of Patras gave Lecture about the Universe and finally we observed astronomical objects by telescopes. All these activities raised the interest of students and revealed a new orientation in learning procedure for our school. Local communities and authorities came closer to our school and we learned how to expand our audience (Hanifan 1916). We had now a strong team willing to work harder for our contest project.

From this point and on the final title of our project was clear. We decided to work on plants attitude and color on another planet. The contest's demand was a clearly defined scientific question, fully developed and answered through experimental and bibliographic justification. Although the difficulties, we managed to win the National part of the contest on March 2013 and the European part of the contest on April 2013. Of course this was the first step of a working methodology. Although it seems that our main goal was the win of the Contest this is not absolutely accurate. We initially tried to intrigue and provoke students to take part to all the related activities. It was the same with the participation of an environmental Contest and also with the drama performances of our school. Furthermore, we realized that extroversion events are extremely important for the educational practice (Elmore 2007). Secondly, and after the successful virtual visit to CERN we inspired the use of a remote telescope. Within the "Odysseus" contest, that mainly based on STEM philosophy we proposed a scientific question and we try through inquiry based investigation to find the answers to these questions. We then imposed the question "What would be the colour of the plants on another planet". In order to trigger and raise the interest of students we organized an astronomical event structured as follow: We encouraged students to present their own projects. Secondly we connected to a remote telescope and students detected and observed astronomical objects. We used the Ido Bareket telescope in Israel, which is a deep sky telescope so we observed galaxies, star clusters and even galaxy clusters. Thirdly, university professors introduced students and attenders into astronomical and cosmological subjects from the research viewpoint. Finally, students had the unique opportunity to observe the night sky by real telescopes that were positioned nearby. This activity really triggers the interest of students and the final profit for our school and students, was the first European position at the contest.

Apart from the contest procedure, we really introduced a new philosophy and innovative culture in our school. These activities really act as supplementary educational activities supporting the so-called Open School, as a school that promotes and diffuses knowledge from school to community. The ability and opportunity for students, parents and local community to view the night sky by deep sky telescopes is unique and for some of them a life time experience. According and following this activity we organized an environmental event that embodied lectures from university professors, volunteering activities from students, presentations from market representatives and finally chemical experiments presented by students, related to environment pollution and ecological scepticism. This event, really standardizes a new open education philosophy in our school and diffuses knowledge to local society, imposes and implements a new role to school.

The third major virtual visit integrates the scientific sequence of approaching the fundamental questions of our universe. First of all we approached the physics of elementary particles through a virtual visit to CERN. Secondly, we focused on Universe and observed deep sky astronomical objects, imposing the major question of how our world is been constructed and developed. Then in our third major virtual visit we connected to IceCube the neutrino observatory in South Pole. This observatory mainly detects neutrinos from deep sky stars trying to answer major questions about the development and evolution of our world. Within the framework of this virtual visit we prepared students during project and excellence cluster lessons. They prepared their own presentations about modern physics and elementary particles. Students recorded their questions about our cosmos and universe. Then, we connected via net to the IceCube observatory and students attended an introduction to hot science research projects. Then, the opportunity for questions was given to students and they asked really triggering questions to the scientists at South Pole. Finally, we integrated our virtual visit with lectures from experts and observations by telescopes in order to connect micro to macro.

## 5. Follow up

General High School of Pelopio continued its actions by supporting important events. Municipality of A. Olympia asked for supporting events related to Summer Olympic Games of London U.K., 2012 and Winter Olympic Games Sotsi Russia, 2014. Furthermore, students and teachers participated into several educational projects related to Science, History and culture. We can refer to the interdisciplinary project «Mythology of the Night Sky» where all the myths related to constellations were inquired. A visit to Athens Planetarium (Eugenides Foundation) in combination with a visit to Archeological museum of Acropolis contributed in the collection of evidence. According to this action we learned that an important part of education is the hands on activities (Hofstein & Lunetta 2004) and evidence collecting visits to science institutes, history and culture centers (Hooper-Greenhill 1999).

## 6. Conclusions

According to all these activities and statements we can conclude into some main findings. First of all it seems to be very important to support the extroversion of schools. The so-called open school is of great importance as far as concerns the diffusion of knowledge to society, families, parents, and locals, even to local labour. Secondly, developing a network of information and knowledge diffusion is critical for modern schools. New technology offers the appropriate tools in order to support these network primarily via Internet and secondly through collaboration, mobilities and exchange visits. Thirdly, the motivation for students is also significant, while their participation in organizing and supporting activities further develops their personality. Students are not just pathetic acceptors of knowledge, but they actively participate in all stages of learning activities. Furthermore, students are encouraged to form their own research, act as researchers and compose a research paper. This is another important parameter of our activities, while introduces a scientific philosophy in our schools. Bonding schools and research institutes or universities, and entangling students to a research and scientific learning sequence builds an inquiry learning behaviour, further cultivating critical thinking. Finally, as far as concerns the Greek Educational System, we can hardly embody such activities to every day teaching practice, so we have to try hard and insist. We owe these to our children.

According to our action plan we conclude that first of all it is of high importance schools to organize and plan their actions in long term (Sniehotta, Schwarzer, Scholz, & Schüz 2005). We realized that planning a three or four years plan will be absolutely beneficial for achieving goals and upgrading educational practices. This also reveals that an essential evaluation can only be performed after a long period (3-5 years) of actions and activities. Secondly we confirmed the importance of lifelong training for teachers and educators. Doubtless, participating in educational seminars, conferences and training meetings allow teachers to be always informed about new educational trends (Day 1999). Implementing all these compulsory methods in classrooms turns out to be extremely positive for students. Furthermore, organizing extroversion events by entrusting critical responsibilities to students was also one of our positive remarks (Elmore 2007). We observed that all these events joined teachers, students and local community together. Science and culture came closer to students and local society, while the interest of students rose remarkable. All these events include the element of collaboration and cooperation between several partners and promote our basic goal of knowledge diffusion. Additionally, participation in contests is another crucial parameter (Bishop 1991). Healthy competiveness between students and schools can only offer benefits to all participants. Winning a contest is not the key. We are mainly interested in the whole progress and steps of contest. We wish students to take part, work, search, compose papers and support publicly their projects. Of course a won contest satisfies students and encourage them for new tries. Another remarkable conclusion is the importance of educational scenarios, material and content (Jacobson 2006). All these produced objects are really useful for planning and orienting bigger action plans. Furthermore if all these educational objects are uploaded in websites, everyone can easily access and use them. Finally, we can claim that each step was an evaluated progress of a previous one, helping us to achieve goals and milestones. This is how a school learns by itself and by others.

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# Illustrating problem solving skills in ISE

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## Abstract

*Natural science problem based learning is one of the central teaching and learning methods and fixed in national science education standards of most countries. ISE as a project for implementing inquiry learning by using learning technologies on a large scale adapted research results and motivates teachers by giving them a hint about the effectiveness of their activities on student's problem learning skills. The teachers recognize the strengths and weaknesses of single inquiry activities, and they are motivated to organise inquiry based learning even in there other lessons. Therefore, this approach contributes to the sustainability of the project's idea.*

## Keywords

Problem solving competences, cognitive processes, inquiry based learning

## 1. Introduction

Nowadays, inquiry based learning is one of the most applied teaching techniques in science lessons. It is rooted in a long history of general educational sciences and follows the inherent structure of knowledge acquisition in natural sciences. Therefore, it is consequent by teachers to choose this sequence of wondering about an observed situation or problem, thinking about a strategy to get more knowledge, carry out the plan and finally draw conclusions. But there are a couple of factors influencing the efficiency of this approach in every day teaching. In order to acquire problem solving competence – one of the key skills science educators have identified to face the challenges of the future – by an inquiry based learning approach it is necessary for learners to follow the different steps and to exercise the different spatial abilities completely. Another important factor from a practical point of view is the necessary effort for planning such science lessons for actual topics and to carry them out during a conventional teaching day, between all the other commitments, duties and responsibilities of a teacher. These are two factors why indeed researchers often identify inquiry learning in classrooms, but these are mostly only single elements of this approach: it is hard to combine the complete problem solving approach with the teaching process without a deeper insight in science education research (which a lot of teachers do not have, based on their traditional education), and to intrinsically motivate the teacher when immediate results are not visible (as for a competence like problem solving a learning progression for this psychological construct could not be expected within a few teaching lessons).

For an audience of teachers, this paper describes the approaches used in ISE to overcome these two, exemplarily mentioned barriers of implementing inquiry based learning in every day science lessons. Aiming at sustainability it illustrates the application of research results on the premise that teachers accept this implementation approach, not of scientific completeness.

## 2. Problem solving competence

The ability to solve problems of the natural sciences is regarded as one of the key competences to succeed in future challenges. Consequently, science educators is Europe emphasize the features of problem solving processes as main characteristics for science courses: "What is needed are science courses that engage students in high-order thinking which includes constructing arguments, asking questions, making comparisons, establishing causal relationships, identifying hidden assumptions, evaluating and interpreting data, formulating hypotheses and identifying and controlling variables" [1]. Learning environments providing these elements allow students to built up a problem solving competence as described e.g. by the OECD as "(...) an individual's capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious. It includes the willingness to engage with such situations in order to achieve one's potential as a constructive and reflective citizen" [2]. For these learning environments it could also be distinguished between the nature of the problem situation, the underpinning cognitive processes of a problem solving process, and the context that framed the problem. The ISE project captures all these aspects. For acquiring problem solving competences, the cognitive processes are the most influencing factors. These are the steps to overcome from a given situation to a target goal (e.g. [4]). In [5] they are exemplarily described like:

• Exploring and understanding.

This task involves exploring the problem situation (observing it, interacting with it, searching for information and finding limitations or obstacles) as well as understanding the given information and the information discovered while interacting with the problem situation. However, the students should build mental representations of each of the pieces of information presented in the problem.

• Representing and formulating.

For building a coherent mental representation of the problem situation, the relevant information must be selected, mentally organized and integrated with relevant prior knowledge. This can be reached by representing the problem by constructing tabular, graphical, symbolic or verbal representations and shifting between representations or formulating hypotheses by identifying the relevant factors in the problem and their interrelationships.

• Planning and executing.

The planning process of this task describes that the students have to set themselves a goal. This includes clarifying the overall goal and setting sub-goals (where necessary) as well as devising a plan or strategy to reach the goal state. After that, in the executing phase, the plan will be carried out.

• Monitoring and reflecting.

The students should monitor the progress towards reaching the goal at each stage including checking intermediate and final results, detecting unexpected events and taking remedial action when required. Finally they also should reflect on solutions from different perspectives and critically evaluate assumptions and alternative solutions.

These are theoretical operators that describe accurately the aspects of the construct, but that are not necessarily useful to be applied by teachers. Therefore, some supporting phrases are developed for these steps. They are only examples to illustrate points to think about while designing these questions:

• Exploring and understanding
Questions
... dealing with the representation of the problem
... about relevant information to understand the problem
... dealing with different levels of understanding

• Representing and formulating
Questions
... concerning the exploration of correlations and dependencies
... concerning a precise description of the focused problem

• Planning and executing
Questions
... concerning the correct strategies of experimentation
... concerning strategies of variable control
... concerning strategies of data analysis

• Monitoring and reflecting
Questions:
... about application or transfer of the tasks
... about possible sources of experimental errors
... about enhancement of experimental settings

Additionally, different levels of proficiency are distinguished in fundamental science education research [6] and studies like PISA. In implementation projects like ISE the psychometrical scaling is difficult to apply, so for the acceptance of the approach by teachers the ISE Consortium decided to have two short items (questions) for each cognitive step of problem solving. Every step should have only a right answer on three levels: high proficiency, moderate proficiency and low proficiency. To give teachers support about the different levels of difficulty, each performance level is described by hints to the mental structure, the strategic problem solving behaviour, and the reference group assessed in PISA 2012 [7]:

• Students proficient at high level can
– develop complete, coherent mental models of different situations;
– find an answer through target exploration and a methodical execution of multi-step plans.

To estimate the difficulty of the tasks for this level, an average of about 10% of 15-year-old students should be able to answer on this level.

• Students proficient at moderate level can
– control moderately complex devices, but not always efficiently;
– handle multiple conditions or inter-related features by controlling the variables.

To estimate the difficulty of the tasks for this level, an average of about 45% of 15-year-old students should be able to answer on this level.

• Students proficient at low level can
– only answer if a single, specific constrain has to be taken into account;
– only partially describe the behaviour of a simple, everyday topic.

To estimate the difficulty of the tasks for this level, an average of about 45% of 15-year-old students should be able to answer on this level.

To make a short interim summary of the theoretical underpinning and the assumption made by the ISE project, the teacher (only he has the necessary language skills to design the questions for his students) has to create for each problem solving step two questions that fulfil the following requirement:
• multiple-choice (single-select), and
• with three possible answers all correct:
– one answer for a low performer on problem solving
– one answer for a moderate performer on problem solving
– one answer for a high performer on problem solving

## 3. Illustrating problem solving skills as assessed in ISE

One important educational scenario provided by the ISE project is dealing on renewable sources of energy. For this scenario, the authors have designed illustrative examples and published them in the "ISE Teacher Guide" [8]:

• Exploring and understanding

*Question one: Why do we need to think about renewable energies?*

high level: Because we are responsible for our future.

moderate level: Because as responsible citizens we have to be informed and able to discuss current issues.

low level: Because it's very present in media.

*Question two: $CO_2$ is a problem, because ...*

high level: $CO_2$ is accumulating in the atmosphere and reflecting thermal radiation from the earth so it can't leave the atmosphere. This contributes to the anthropogenic greenhouse effect.

moderate level: $CO_2$ is jointly responsible for human made climate change.

low level: $CO_2$ is harmful to the environment.

• Representing and formulating

*Question one: Which domains have to be taken into account for the change in energy supply to be successful?*

high level: Because of interdependencies social, economical and ecological aspects have to be considered.

moderate level: It's important that no jobs get lost or alternative jobs or retraining are offered to employees. Also investors have to be recruited.

low level: People have to be well prepared for the change in energy supply. So it's very important to promote the change and tell people why it is needed.

*Question two: What is the best way to start change in energy supply?*

high level: Change in energy supply would be easier and faster when less energy has to be produced.

moderate level: It's important to reduce energy consumption.

low level: It's important to reduce energy consumption.

• Planning and executing

*Question one: Which consequences can the increase of the price for electricity have?*

high level: Government has to think about how to disencumber citizens and companies which can't afford higher prices.

moderate level: Energy supply is an important economic factor. Companies may threaten with migration to a more cost-effective location.

low level: People become dissatisfied because they have to pay more money for electricity.

*Question two: What happens if a power plant is switched off without substitution?*

high level: Energy supply is an important economic factor. Lack of reliable energy supply can lead to degeneration of a highly developed country.

moderate level: Energy supply is not guaranteed.

low level: Cities getting dark.

• Monitoring and reflecting.

*Question one: What advantages has the use of a simulation against the look at a whole real world scenario?*

high level: Because of learning by trial and error I get a deeper understanding of the content.

moderate level: Because it's not possible to manipulate the real world conditions in the same way as in a simulation.
low level: Because it's funny to play with the simulation I'm more motivated to learn.

*Question two: The discussion about renewable energies and also the simulation mostly ignore important factors. An important but ignored factor is:*
high level: Use of fossil fuels for transportation and heat production
moderate level: Importance of cogeneration of heat and electricity
low level: Use of coal for barbeque

These questions don't fit statistical criteria nor are they suitable for scientific research on science education. But they indicate the weaknesses and strengths of the ISE learning scenarios by taking into account the main features of a problem solving construct used in PISA 2012. They enable teachers to monitor the progress of their classes if they follow an inquiry based learning approach.

## 4. Conclusions

One problem of bridging the gap between theory and praxis in educational systems is the transfer of empirical results and evidence based knowledge into the classrooms. Nowadays, teachers have a lot of commitments aside teaching, and a lot of roles to fulfil, beside being a "learning guide". One benefit of projects like ISE is that teachers can use a well-proven pedagogical framework and technology without investing too much time in constructing the lesson plans. ISE offers hundreds of possible learning situations for a wide variety of natural science subjects. The problem solving questions deal as "indicators" for teachers, motivating them to follow an inquiry approach and to build up technology enriched learning environments also after ISE.

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# Connecting Embodied Learning in educational practice to the realisation of science educational scenarios through performing arts

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## Abstract

*Embodied Learning constitutes a contemporary pedagogical theory of learning, which emphasizes the use of the body in the educational practice. Several researches related to various areas of expertise highlight the usefulness and the necessity of the body itself as a learning tool. Despite this, until recently the body was mostly used as a means to enable students' experiential participation and to attract their interest. Given the significance of Embodied Learning to new teaching methods and approaches, this paper presents results from a large scale implementation activity in Greece within the framework of the "Learning Science through Theatre", initiated by Science View during the school year 2014-2015. The Initiative is based on the pedagogical framework which was developed by the European project CREAT-IT and continues to be implemented in the framework of the European Project CREATIONS. This study aims at highlighting the fact that Embodied Learning is connected to the development of skills such as creativity and critical thinking, to the active engagement with scientific topics and phenomena and to the interdisciplinary connection of science with different forms of Art. The data were collected from thirteen (13) theatrical performances that were organized by secondary school students (500 subjects). In the Data analysis, meaning generation, communication and student motivation were analyzed in relation to isolated gestures, full body movements, students' emotional attachment, and facial expressions. As a consequence, it is suggested that Embodied Learning may lead to scientific learning outcomes of a higher quality while at the same time it may reinforce student communication and motivation in scientific topics.*

## Keywords

Embodied Learning, Dramatization, Theatre, Art, Creativity

## 1. Introduction

Embodied Learning constitutes a contemporary pedagogical theory of learning, which emphasizes the use of the body in the educational practice and the student-teacher interaction both inside and outside the classroom and in digital environments as well. Using the body is essential in concept representation and communication while this is also confirmed by the emphasis other fields and cognitive objects place on the body as a learning tool, such as dance theatre, kinesiology, athletics even Mathematics and Physics. All these cognitive objects have student collaboration, movement and the process of cognitive development as a common denominator.

Traditionally the body has not been used in education. Every involvement of the body had been consistently excluded from the educational practice, the process of learning and the interaction among students. The notion of Embodied Learning was not known and therefore not acceptable by the educational community such as the teachers and the students. Consequently it was difficult to understand that the body does not solely constitute a means of knowledge, or a mediator, but it also reflects the student's interaction with the environment.

Embodied Learning is closely related to constructivist models and to modern educational theories regarding the role of the teacher, of the student and of learning itself in the educational practice. Embodied Education has been defined as the basic concept which includes Embodied Teaching and Embodied Learning [7]. In fact, the terms Embodied Learning and Embodied Teaching are used alternately to refer to new scientific and educational practices [13].

In accordance with the constructivist principles, the body is used both inside and outside classroom for experiential learning and is not treated as a place of learning. The principles of Embodied Learning provide answers to questions related to the ways knowledge is constructed by students as they leave behind them the academic model of perceiving knowledge and treat each student as a whole, while they view everyone's body as a tool for knowledge construction and as a knowledge carrier [2], [6]. Language and full-body motion have been studied as an integral means through which students express thoughts and meanings when they interact with a set of collaborative digital games designed by the researchers [11] in creative and innovative teaching approaches [12]. This way, each student is placed in the center of the educational process, while disinterestedness is transformed into active participation and emotional neutrality into cooperation.

In Embodied Learning, new knowledge is affected by the conditions it is used and by the types of activities the student is expected to participate in. Consequently, the following parameters should be taken into consideration when designing an activity:

a) cognitive involvement to the topic, cognitive processes, representation of a scientific notion
b) body movements
c) expression of the student's feelings
d) clarity of instructions
e) holistic design of activities
f) student cooperation
g) ability of students to apply acquired knowledge to new environments

It becomes evident that Embodied Learning is in accordance with new educational practices, as it uses personality as a whole, and promotes the way students learn and not the content of learning in the learning process. However, only few studies have been conducted to link Embodied Learning to the dramatization of educational theatrical scenarios and to the representation of scientific concepts and knowledge, with the aim of developing student creativity and critical thinking, their active participation to the learning process, their deep understanding of scientific notions and phenomena and the interdisciplinary connection of Sciences to forms of Art.

## 2. Literature Review

### i. Defining Embodied Learning

The body can be defined based on two parameters. There is the embodied/biological/ sensual way of being, but at the same time there is also the sociocultural and relational/interactive way in which skills are developed. The notion of body in Embodied Learning, does not merely include that body itself but it also includes the senses, the mind, and the brain, that is the whole of the student's personality. The body functions as a natural source of meaning production, since it helps students to express themselves in a natural way. The body is defined as the human corporeal experience and the subsequent psychological consequences, while others state that the unconscious aspects of corporeal experience constitute the basis of cognitive activity and linguistic expression [9].

The primary characteristics of embodied learning are the following [5]:
a. sensorimotor activity
b. relevance of gestures [8] to the theme that is to be reproduced
c. emotional involvement

Both the sensorimotor system and body movements are involved in the process of Embodied Learning and the perceived stimuli can be transformed into a more stable memory and cognitive representations [1]. As it has been mentioned relevance of gestures refers to the analog or structural correlation of symbols and their meanings [10]. Given the aforementioned, it becomes obvious that embodied learning involves coordinated movements either of body parts or of the whole body in order for a learning goal to be achieved combined with the students' sensorimotor activity and their emotional involvement. The procedure that is followed during Embodied Learning is gradually escalating. During the first stage, the student may not proceed to a movement related to the representation of concepts. However, students understand that they are going to be exposed to scientific concepts and they are concerned about the way of representing them. During the second stage, movements are produced sometimes unconsciously or even as the result of imitation while during the third stage the students are asked to think of ways of representing the suggested content.

During the final stage which is also the most important one, students apply the newly acquired knowledge to new environments, through dramatization (image/interactive theatre) or role play, where they represent the scientific concept not only verbally or by using body movements, but also by participating both mentally and emotionally to the extent of embodying this new knowledge. It becomes evident that Embodied Learning is a procedure during which the student employs mental processes expressed through coordinated body movements which are linked to the represented content, through his/her emotional involvement and verbal communication skills.

It is worth stating that at each moment the student acts in a coordinated way and even though he/she is lead to random, unconscious movements, they are most of the times compatible with the content. This way the level of understanding and embodiment of new knowledge to the student's cognitive repertoire is verified. Everything that happens at each moment is of importance since the body is always active and becomes the sender and receiver of messages. The network of all momentary actions is thus gradually constructed which leads as a whole to Embodied Learning.

Furthermore, student-teacher cooperation either in a school or in a digital environment plays a pivotal role in Embodied Learning. This way, certain characteristics of a person or a group of people may affect the rest of the students. By visualizing this interaction in intersecting circles, students learn how their own experiences are met and complement those of others, even if they come from different socio-political and cultural backgrounds etc. Cooperation in school environment increases the students' learning outcomes, offers motivation and further enhances their social skills.

It is worth stating that student participation in the learning procedure with the help of Embodied Learning is not only limited to the student being physically present. Students' response depends on their personality, their physical presence, their mental development, their sensorimotor ability and their past experiences.

## 4. Research Design

**i. Organization and the "Learning Science though Theatre" action**

Taking into consideration the importance of Embodied Learning to new educational methods and approaches there has been an attempt to link this theory to the "Learning Science through Theatre" action 2014-2015 (LSTT- - http://lstt2.weebly.com/). This action is based on the pedagogical framework which has been developed by the European CREAT-IT project (http://creatit-project.eu/) [3], [4] and continues to be applied in the concept of the European CREATIONS project (http://creations-project.eu/). This initiative follows the principles of the Science Education Declaration, of creativity, of effective and efficient research and aims at enhancing creativity in classroom (http://www.opendiscoveryspace.eu/community/culture-creativity-curiosity-413201).

Given the fact that Embodied Learning is connected to the development of creative skills and of skills which enhance critical thinking, to the students' active participation in rendering and deeply understanding scientific concepts and phenomena and the scientific interconnection of sciences to arts, the present study aims at examining the contribution of Embodied Learning to:
a) the representation of scientific concepts (connecting movement to concept)
b) art (dance movements, humour in movements etc.) and
c) recording random/unconscious movements.

That is, there are 3 kinds of movements, those which are used in approaching/representing scientific content, those which are related to art and the unconscious/random movements.

**ii. Participants, Sampling**

Data was collected from 13 theatrical performances which were organized by secondary education students (500 subjects). High school students (Gymnasium and Lyceum) of Attica schools dramatized scientific concepts and knowledge related to their course syllabus, through a non-restrictive scenario entitled "Parallel Worlds" which related to the scientific fields of Biology, Astronomy, and Physics.

**iii. Methodology, Tools**

The methodological tool of content analysis was used to analyze the data collected from the observation of the dramatized scenarios and to connect them to the characteristics of Embodied Learning. Based on the theoretical framework presented earlier there has been developed a system of categorizing the ways which students through Embodied Learning: a) represent scientific content/generate meaning, b) communicate with one another, c) entertain the audience while they dramatize scientific scenarios which take into account both the teaching of sciences and theatre techniques.

## 5. Results

In order to attempt and combine Embodied Learning to theatrical performances of the schools which participated in the "Learning Science though Theatre" project, we watched and observed the performances (fig.1).

***Fig. 1*** *Awards to schools in the "Learning Science though Theatre" initiative*

As can be seen from the fig. 2 regarding to the category "Representation of scientific context/ meaning generation" Embodied Learning can contribute a lot both to the understanding and to the application of knowledge. As far as the understanding of knowledge is concerned, students seem to be able to understand the key features of each notion, using scientific terminology and simple vocabulary at the same time, to reliably describe notions and to use their past experience so as to describe scientific knowledge. For instance, in a theatrical scenario students sat next to each other and another student revolved around them in order to represent the movements of atoms, electrons, protons, neutrons, etc. Furthermore, one student who impersonated Aristarchus explained his theory showing the Sun and the Moon at the same time, or in another theatrical scenario another student impersonated a shooting star and used her whole body when other students pulled her from the scene so as to represent the fall of the star. Regarding the application of knowledge, students were several times able to link scientific notions to everyday life and to reach conclusions, such as a student who impersonated Fred Hoyle and popped a balloon with a needle to represent the Bing Bang.

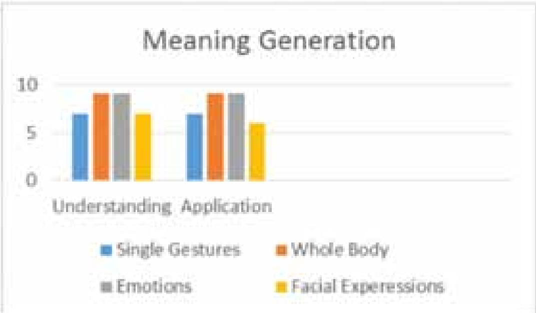


***Fig. 2** Embodied Learning and Meaning Generation*

It is really important to mention that whole body movements and emotional involvement reinforce the representation of scientific content/ meaning generation in relation to single gestures or facial expressions (fig. 2).

As far as "Communication" is concerned, Embodied Learning facilitated communication among students (fig. 3). For instance, regarding the successful rendering of meaning is concerned a scientist explains the rising temperature because of the Big Bang and his assistant shows the red table where the rise is described while at the same time she moves according to the music. Successful rendering of meaning is possible both through verbal and through non-verbal communication. For instance, a student explains that matter prevailed and utters the adverb "Finally!" while using his hand whereas another student-Physicist uses his facial expressions to show his irony towards all other sciences as he thinks that Physics is the only true science, expressing this way his irony in a non-verbal way. At the same time, students used appropriate material to help them render the scientific concepts. A student narrates the way the Universe began and the Big Bang theory and uses a red umbrella while another student who has the role for Fred Hoyle pops a balloon with a needle, an action that signifies the explosion. As far as student interaction and cooperation is concerned, all students worked together to accomplish a task. Actions such as body movements or scenes in the theatrical performances like the one where a student who pretends to be a particle runs around the stage and the scientist is anxiously trying to find her prove the interaction among students.

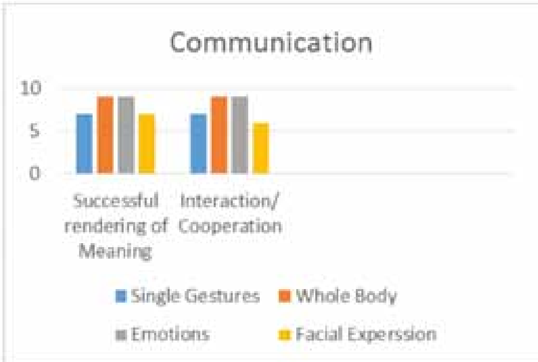


***Fig. 3** Embodied Learning and Communication*

The students managed to create a positive atmosphere both during the rehearsals and during the actual theatrical performance. Students' emotional and body involvement enhances student communication to a greater degree compared to facial expressions or simple gestures.

Since "Entertainment" is an important part of the theatrical performance, it is worth mentioning that students retained their interest throughout and enjoyed the whole procedure (fig. 4). Student creativity and imagination is evident in most theatrical performances. A student talks with Einstein and asks for his autograph while another student points to the Scorpius constellation while the planets dance hugging. In another performance, planet Pluto appears last on stage and being short of breath, which signifies that he is the last planet in our solar system, while another student-researcher is trying hard as we can infer from his facial expressions to discover the God particle, highlighting the importance of its existence. The students seemed to enjoy the whole process as humorous scenes in the performances verify. For instances, all students who participated in the performance where a party was held by the academic community to announce the discovery of the God particle, were laughing. All students have understood the clarity of roles; for instance, a student who pretends to be a particle runs around the stage representing particle movement while another student-scientist is trying to find her.

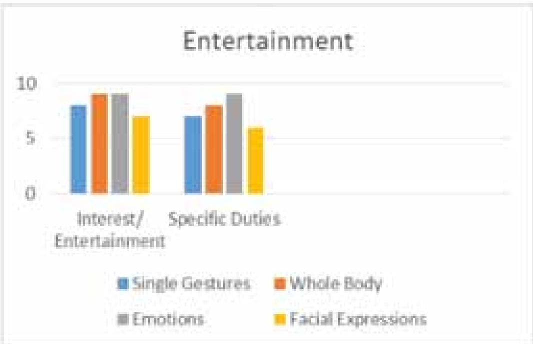


***Fig. 4*** *Embodied Learning and Entertainment*

The students have also included personal elements in their performances, which signifies a high degree of embodiment of the concepts. Students use their hands to emphasize specific parts, for instance the difference between astrology and science, while in some scenes students used their imagination; a student/journalist of a show, Ms. Poirot, appears holding a magnifying glass to solve the mysteries.

It becomes obvious that 2 out of 4 characteristics of Embodied Learning, those of whole body movements and of emotional involvement lead to a successful representation of scientific content, to student communication and enjoyment. Those characteristics appear with a very high frequency which underlines the relation of Embodied Learning to the aforementioned categories and subcategories. At the same time, there is a relation between the two subcategories within each category, which verifies the achievement of goals. On the other hand, it was observed that simple gestures and facial expressions play a significant yet not decisive role in using Embodied Learning in the educational practice, with a percentage of 68% and 62% accordingly.

Moreover, unconscious movements appear in a fewer percentage in whole body movements and in emotional involvement, which indicates that students in Embodied Learning act consciously, having fully understood the scientific scenario. On the contrary, they appear in a higher percentage in simple gestures and in facial expressions, which leads us to conclude that students may perform unconscious movements to express themselves in a more performative way.

## 6. Conclusion

This study aimed at connecting Embodied Learning in the educational practice to the dramatization of educational theatrical scenarios and the representation of scientific concepts and knowledge in the context of the "Learning Science through Theatre" project 2014-2015 The study examined the contribution of Embodied Learning to

a. the representation of scientific content (linking movement and concept)

b. Art (dance movements, humour in movements etc.) and
c. random/unconscious movements

The findings suggest that Embodied Learning leads students to the most successful representation of scientific concepts, enables the connection of student to modern forms of Art while even the unconscious movements performed by the students may be indicative of the degree of appropriation and embodiment of scientific concepts. Furthermore, collaborative learning is supported while student creativity is enhanced. Dramatization of theatrical plays could be included to the educational reality since it constitutes an exemplary educational practice. The learning environment of the "Learning Science though Theatre" project included authentic theatrical scenarios which were performed by the students and were in accordance with their interests and cognitive load. Finally, we examined the students' cognitive involvement, the representation of scientific content using their cognitive processes, their sensorimotor involvement using their bodies or gestures, their emotional involvement, social interaction and communication between the students, the use of past experiences and creation of new ones based on sociopolitical and historical framework and on beliefs and behaviors, their brain-body-emotion coordination, the holistic use of their personality and their motives.

## 7. Acknowledgment

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# Highlighting Good Practices in Teaching STEM via Webinars in the Framework of the European Project MARCH

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## Abstract

*Webinars in the framework of the European project MARCH aim to highlight good practices in teaching STEM as they have been recorded in the previous phases of the project. Five webinars were implemented in the framework of the project in Greece, and four more in Portugal, Germany, the UK and Bulgaria promoting the outcomes of the project to make Science real and attractive to young people. The webinars shaped an active Science community of teachers with positive attitude towards the next phase, this of the pilot implementation in schools. They served as virtual learning environments encouraging teachers to exchange and share knowledge, ideas and information, opening up to a global community and accessing the global open digital wealth of ideas and innovations.*

## Keywords

Engineering, Good practices, Mathematics, Science, Technology, STEM, Webinars

## 1. Introduction

The Webinars is an abbreviation of the term Web-based seminars, and consist lectures either presentations which are implemented on the Web (Webinars PE19-20, nd) simulating training seminars online. During Webinars, real time communication is achieved using audio, video and also data among two or more remote places (Suthers, 2001· Gibson & Cohen, 2003). One significant characteristic of the webinars is the capability of interaction at a distance between the speaker(s) and the participants in real time communication. Exchanging data as files, presentations, graphics (Brown, 2001), and also the potential of sharing common applications among remote users (Gürer et al, 1999), provide the added value of the webinars. They also provide the chance to speakers and the audience from remote areas to communicate in real time through the internet exchanging views and sharing data. The paper firstly records the pedagogical framework of the European project MARCH (MAke science Real in sCHools), its objectives and the phases of its implementation. The next units present the technological framework of organizing, implementing and also evaluating webinars by the participants. In particular five webinars as case studies are presented which put emphasis in experiential, active and inquiry based learning. The paper finally, discusses and outlines the role of the webinars in highlighting good practices and supporting in parallel the pilot implementation in schools of secondary education.

## 2. The MARCH project

MARCH is a network that aims to promote science as a force that can build up active citizens, help students to actively contribute to the learning process and also connect science to everyday life. The MARCH consortium consists of 9 partners from 7 European countries (the UK, Greece, Germany, Serbia, Lithuania, Bulgaria and Portugal) and it brings together key players in the field of science education, science communication and relevant policies.

The anticipated impact is an increased appreciation and application of the proposed methodologies amongst educators as well as an improved understanding of the career opportunities in science and research, leading to more young people choosing a career in science. The network's objectives will be achieved through an innovative methodology including local workshops bringing together scientists, educators, students, and other key players, as well as international 'Innovation Swap Workshops' (ISW) to focus on inquiry-based learning and interactive educational content that will make science teaching attractive to young people and present innovative international practices.

An initial scoping exercise took place in 2014, consisting of a collection of best practices through desk research and interviews in partner countries. Its objectives were to review the current state of Science Education and to map the state-of-the-art across Europe. The scoping analysis was based on both qualitative and quantitative research, including desk research on existing policies, practices and methodologies, in-depth interviews with relevant stakeholders, and online surveys among teachers and students. The results of the scoping analysis have been presented at the 1st International Conference that took place in Athens, in November 2014, and have been tested and enhanced in the following stage of the MARCH project, the workshops both local and ISW. Three ISWs and seven local workshops have taken place so far and the relevant reports are available on the MARCH website.

The next stage of the project involves the production of webinars, addressed to teachers, trainers and research staff from higher education from all over Europe and which will encourage participation from students too. School Pilots, organised around the key axes that emerged from the local and ISW, and are planned to take place in 2016. Via seven pilots, one in each of the participating countries, teachers and students will be able to test and enhance methodologies identified and presented in the previous stages of the project. The school pilots' period is the time for all interested teachers across Europe to try them in their own classes, incorporate them in their lessons and open up to new learning paths aiming to make science teaching more attractive and enjoyable for the students (MARCH toolkit, nd).

## 3. Organising the Webinars

Organizing webinars in the framework of the MARCH project aims to highlight and disseminate good practices in teaching STEM (Science, Technology, Engineering, Mathematics) as they have been identified during the previous phases of the project. Good practices are based on key findings of the scope analysis in 7 participating countries and also the expertise gained by both teachers and experts in national and innovation swap workshops and conferences which were held in 2014-15.

Five webinars took place in Greece within the framework of the European March Project and four more in Portugal, Germany, the UK and Bulgaria highlighting the outcomes of the project to make Science real and attractive to young people. Proposed good practices focus on the use of advanced technologies & simulations, new media to teach STEM topics, remote & virtual labs for inquiry based learning. Furthermore they approach experiential learning with outdoor activities, combining Art and STEM (STEAM), coding, and using robotics for special educational needs students.

All five webinars were organized by the Educational Radiotelevision and focused on making science more attractive to students of secondary education. The webinars involved at least two speakers and a moderator. In all five cases, at least one speaker was a teacher of STEM subjects who had implemented a good practice or/and an innovative methodology in teaching STEM. The second speaker was either a teacher of STEM or an expert (researcher or/and scientist) on STEM topics. At the beginning of the webinar session, there was a short introduction of the goals and phases of the MARCH project.

The series of webinars has a high impact not only during their real time presentation but viewing the recording afterwards on demand.

## 4. Technological approach

The platforms used to deliver the series of webinars were provided all by reliable entities. In particular, they were the Centra by the Hellenic Open University, the Big Blue Button by the Institute of Educational Policy and the Webex by European Schoolnet.

The first webinar was delivered in the framework of Creative Classroom Expert Talks introducing the MARCH project. It was co-organised by the Creative Classrooms of the etwinning network and used the Webex environment by the European Schoolnet.

The second, fourth and fifth webinar were co-organised with the ICT's Advisor of the Regional Directorate of Primary and Secondary Education in Western Greece and used the Centra v.8 (http://centra.eap.gr/) by the Hellenic Open University in the framework of "Webinars for ICT teachers". Virtual rooms were provided by the platform and the recordings are released on the relevant repository of webinars under the Creative Commons 3.0 license (Creative Commons, nd). The third one was co-organised with the Institute of Educational Policy and used the Big Blue Button platform.

## 5. Implementing the Webinars

Each webinar includes an introduction, some information for the project and lasts for about 60' – 90' according the following agenda:

- 5'-10' Introducing Speakers
- 5' - 10' Introducing the project
- 2X15' Lectures
- 20' - 25' Q&A session – Discussion
- 10' Outline

The following Table 1 shows the titles-topics for each one webinar and the relevant URL address for its recording.

| Title – Topic | Recording – URL |
|---|---|
| Making Science Real in Schools: Best practices for Creative STEM Classrooms | https://youtu.be/MzZHXumsluI |
| The art of coding | https://www.youtube.com/watch?v=pFPDiz28dCs |
| Developing a standard model of urban development of a city by students | https://www.youtube.com/watch?v=Tt0h2uFP8Ls |
| Approaching the education of students with special educational needs | https://www.youtube.com/watch?v=1mBPv5N_h20 |
| Methodologies and good practices in teaching STEM | https://www.youtube.com/watch?v=MqqNkssGKj0 |

***Table 1.*** *Topics and recordings of the Webinars*

In the introduction of all webinars there was a lecture regarding the outcomes and the good practices proposed within the previous phases of the project and also raised from the interactions and collaboration of teachers, students and experts. In particular, in Greece 110 good practices were submitted by teachers after a general call of the Ministry of Education to all secondary schools and they have been evaluated afterwards by the consortium. The evaluated and proposed good practices are aligned with the results of the International Office of Education of the Unesco' s research (Vosniadou, 2002) in regard with authentic learning environments connected with real life. They aim to cultivate skills and competences, which are necessary in 21st century (Punie & Carneiro, 2009) and shape the following axes, methodologies and pedagogical approaches (Papadimitriou, nd):

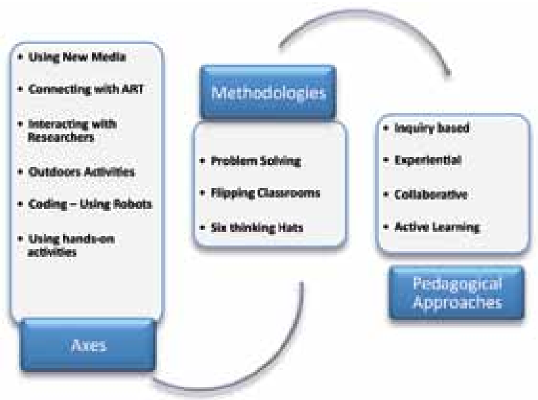
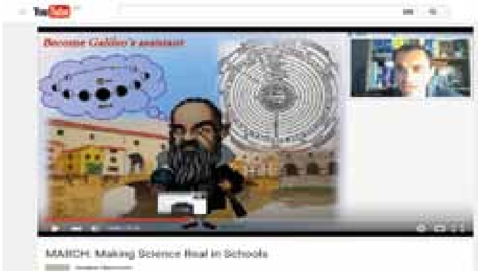



***Figure 1.*** *Axis, methodologies and pedagogical approaches in MARCH*

A key axis of the proposed good practices is the use and creation of new media in the STEM classroom. Within the umbrella concept of new media there are included social media, web2.0 tools, software and virtual laboratories. For example the good practice "Become Galileo's assistant" uses the virtual labs "Stellarium" and "SalsaJ". New media in youth communities, projects and schools are reshaping traditional education, opening up to more creative approaches and re-defining aspects of the educational procedure like assignments and evaluation (Buckingham et al, 2006).




***Picture 1.*** *1st Webinar: Become Galileo's Assistant*

Furthermore, the use of new media is crucial so as to flip classrooms (blended learning approach), gain time, interact with researchers, organise group working and experiential activities and implement outdoors activities for example projects and practices that take the student outside the classroom to the nature. Outdoor education is linked with many different educational approaches like experiential and exploratory learning and takes place mainly in the outdoors. It is based on interdisciplinary approach and uses relationships among people and natural resources (Priest, 2010).


***Picture 2.*** *1st Webinar: The life-cycle of invertebrates*

***Picture 3.*** *4th Webinar: Robots for special needs' students*

## 6. Evaluating the Webinars

During the 5 webinars an average of 55 teachers and 1 hub (a class where many participants joined) were connected as the following Figure 2 shows:

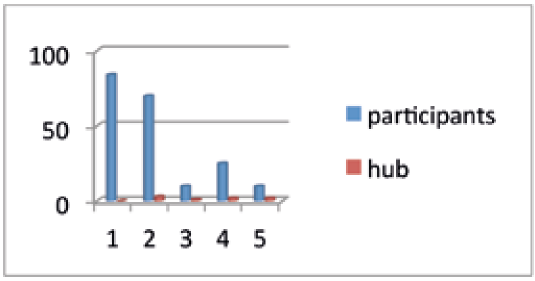



***Figure 2.*** *Participants and Hubs connected*

The previous knowledge of teachers for the MARCH project before the implementation of the webinar is recorded at the Figure 3:

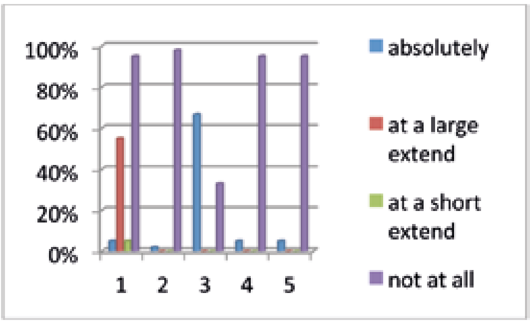



***Figure 3.*** *Previous knowledge for the MARCH project*

The previous experience of participating at the webinars is recorded at the Figure 4:

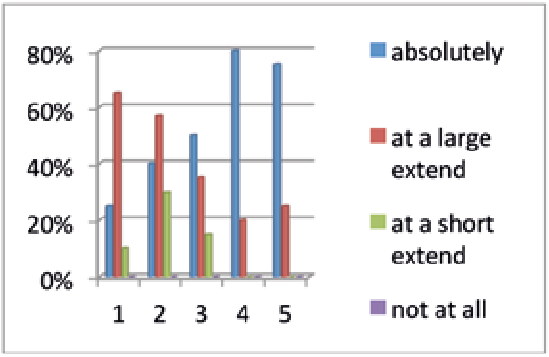



***Figure 4.*** *Previous experience of participating in webinars*

The overall assessment for each webinar is recorded at the Figure 5:

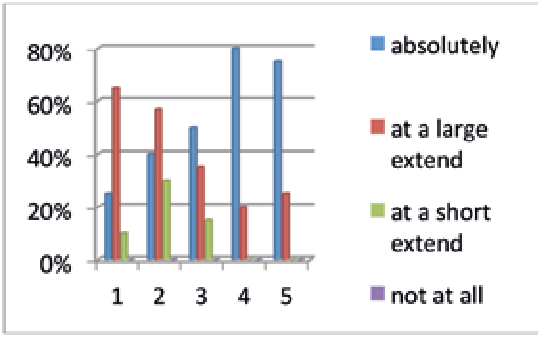



***Figure 5.*** *The overall assessment*

In regard with the ways that teachers have learnt about organizing this series of webinars, the majority of teachers says that they got informed by the social media of the Educational Radiotelevision and also the Regional Directorate of Primary and Secondary Education in Western Greece (blog, facebook). In addition they received an email for the second, fourth and fifth webinar. Teachers learnt for the first webinar by both social media and email of the active network of etwinning.

In qualitative responses, participants expressed their interest for participating in pilot implementation and record enthusiastic comments, as:

• Good Practices provide stimulus and inspiration to teachers.

• Communication and interactions within European teachers were achieved during the first webinar.

• A wealth of open resources and tools for the code week were presented at the second webinar.

• Interesting constructions by students and the relevant methods to construct them were presented during the third webinar.

• A variety of robotic constructions and robots aiming to engage special needs' students were presented during the fourth webinar.

• Exchanging of ideas and experiences, new approaches with concrete methods of development occurred during all webinars

• Teachers expressed their interest to participate in the pilots.

## 7. Discussion and Lessons Learned

### 7.1. Challenges encountered

An important challenge that has been occurred, is that the network of attendees doesn't exist previously and there was a need to built one that could reinforce participation. In the cases that there were preexisting networks, it is observed the number of attendees was much greater. To be more precise, the 1st webinar was co-organized by the Creative Classrooms and the etwinning network was exploited. The exploitation of a preexisting network and the use of the English Language had as a result for the webinar to be attended by teachers from 13 different countries, raising the total of participants to 84.

For the 2nd, 4th and 5th webinar, the network used was the one of the Regional Directorate of Primary and Secondary Education in Western Greece. This network follows a standard procedure including dissemination of the event, registration and evaluation. In particular, by using a mailing list, the network informs its members for the upcoming webinars. The members can choose the webinars they wish to attend by registering to the event. Then, they receive regular notification emails before the event and an email for evaluating the webinar after the webinar completion. The existence of this standard procedure, also contributes in the development of a network between the attendees who know one another, and this results in their active involvement during the discussion sessions. During the 5th webinar there were also two hubs (connection knots), from where people could attend the session. Concerning the 3rd webinar, there was an attempt to build a network from scratch. The webinar was made known to the audience by the exploitation of the social media of the Educational Radiotelevision (facebook and twitter account). The number of attendees was the lowest, reaching hardly 10 participants.

A second challenge was that the existence of multiple platforms (centra, hangout, bigbluebutton, webex etc.) created some technical problems. First of all, each platform has different special and technical characteristics, environment and registration procedure. Consequently, each person wishing to attend the webinar had to complete a registration, to follow a certain procedure, and in some cases (i.e Centra) concrete software was needed to be previously installed in the computer. The speakers, also, were expected to familiarize themselves with the way the platform works and the different tools it disposes.

### 7.2. Recommendations

Taking into account the aforementioned challenges, it could be recommended for a single platform to be adopted for all webinars, simplifying in this way the registration process and familiarization with the platform's functionalities for both audience and speakers. Another recommendation would be the development and strengthening a network so as to ensure more people attending the webinars. The March website and a variety of each partner's social media (ex. facebook groups, twitter hashtags, blog) could contribute towards this goal.

The webinars shaped an active Science community of teachers with positive attitude towards the next phase, this of the pilot implementation in schools. They served as virtual learning environments encouraging teachers to exchange and share knowledge, ideas and information, opening up to a global community and accessing to the global open digital wealth of ideas and innovations. Pilot results will also feed into the policy recommendation paper that will be put together towards the end of the project, based on all its outcomes and findings, and which we hope will lead to change, enhancement, improvement in the way Science is taught across Europe, by making it more attractive to students, highlighting its relevance for career purposes in an ever changing Europe, in an ever changing world.

## 8. Acknowledgements

We wish to acknowledge the contribution provided by all partners from the MARCH Consortium which are the following: British Council of Greece, Bulgaria, Portugal, Germany and Servia, CSAP, jungvornweg, Ciência Viva, EDC, British Science Association, Educational Radiotelevision - Ministry of Education, Research and RA of Greece, Science Communication (SciCo), Forum Democrit

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# The Impact of Scientific School Contests on Students' Attitude towards Science and in following scientific careers

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## Abstract

*This paper presents the impact of a European scientific school contest on students' behaviour towards science and towards considering following scientific careers. Based on the data and input received from participating students and coach teachers, the contest had a positive impact on students in terms of enjoying science as well as in developing basic skills and competences. After participating in the contest a considerable percentage of students mentioned that they now consider more seriously the option of following a scientific career. Finally such initiatives also seem to improve students' inquiry skills and their understanding of how science works.*

## Keywords.

Astronomy, contest, science, careers

## 1. Introduction

Over the past decade there is a falling interest of young people in science in general and in following scientific carriers. Although young children tend to have a natural curiosity about the world around them and about how things work, they seem to lose their interest as they make their way through school. Thus, it is important to focus on the way science is taught and ensure that students keep interested in learning and doing science. The "Science Education Now: A renewed Pedagogy for the Future of Europe" report [1] makes a presentation of the current state of science education and based on the validation of two major projects, namely Pollen and Sinus-Transfer, suggests a series of recommendations so as to improve the science teaching methodology by following and implementing the inquiry-based teaching model.

In this paper we examine the impact on raising students' interest in science and in following scientific careers through a European school science contest. The contest aimed to contribute in increasing young students' interest in science and in following scientific careers - specifically careers in space exploration - by adapting and promoting the inquiry based teaching approach. The focus of the contest was on space exploration and astronomy which is one of the most appealing subjects for students of both primary and secondary schools [2] and which seems to attract equally male and female students. Although astronomy and space exploration is not included in most countries' physics curricula it can be deployed in order to teach a great variety of subjects related to physics, chemistry and mathematics in a modern and appealing way. Through such contests, students experience a completely different aspect of science which is far from being boring and inexplicable as students commonly believe [3] and start perceiving it as an interesting and appealing subject. This behavioural change of students towards science is a key point in inspiring them to pursuit scientific careers in the future.

## 2. The aspects of the contest impact investigated and methodology followed.

Students between the ages of 14 and 18 from around Europe were invited to participate in the contest by forming a team from 2 to 5 members and develop a space related-project. Participating teams could choose to submit their project in one of three different categories; a) Solar system; b) Co-evolution of life; c) Spaceship-Global cooperation. For each category one team would be declared winner after a two-round evaluation process (one national round per country and one international round between national finalists). The team set specific and measurable objectives which reflect the impact of the contest on different levels. Some of the objectives set are the following:

- Students' inspiration in following a scientific career or a career in space

- Students' and teachers' reactions

- Students' and teachers' involvement

To measure the objectives stated and thus outline the impact achieved on all the strands mentioned above, the team deployed metrics of both quantitative and qualitative nature. More specifically, the team developed two different sets of questionnaires which included questions that aimed to provide both quantitative and qualitative data related to the objectives set above. The first set of questionnaires developed was handed to participants for answering upon registration. The first questionnaire (from now on called BSQ (Before the contest Student' Questionnaire) aimed to record students' behaviour towards science and space exploration prior to being involved in the contest and where answered by them upon registration. The second questionnaire (from now on called BTQ (Before the contest Teachers' Questionnaire) aimed to record teachers' profiles, their expectations of the contest and their view towards inquiry based teaching.

The second set of questionnaires was given to teams upon submitting their project. The questionnaire targeting coach teachers (from now on called ATQ (After the contest Teachers Questionnaire) aimed to record their view towards inquiry based teaching after the contest, their overall assessment of the contest and their point of view on their students' performance during the contest. The questionnaire targeting students (from now on called ASQ (After the contest Students Questionnaire) aimed at documenting their overall experience of the contest and their current view on space-related topics. These two sets of questionnaires targeted all contest participants and the questions included provided both quantitative and qualitative feedback.

## 3. Teachers' questionnaires

### 3.1 Teachers' profiles

Out of 121 teachers participating in the contest we obtained 80 BTQ questionnaires (66.1%) and 89 ATQ (73.5%). Although the majority of teachers were male teachers the difference was not that vast (60% males and 40% females). Most of the teachers were between the ages of 41 to 55 (51.25%) and another 28.75% belonged at the age group between 31 and 40. As indicated in the figure below, there is a big distribution in the years of experience as a teacher. The fact that the there is an analogy between the years of experience and the number of participants (the more years of experience the more participants) could indicate that as teachers gain on teaching experience the more confident they fill in participating in broader initiatives that go beyond the traditional ones taking place in their school.


***Figure 1.*** *The percentage of coach-teachers per years of experience.*

Another interesting feature of the teachers' profiles is that only 38.74% stated that they are physics teachers, a percentage that we had expected to be higher. Only 10.32% were mathematics teachers and another 12.26% stated that they teach chemistry. 15.48% of the teachers stated that they teach a non-science related subject. This distribution between the teaching subjects of coach teachers could be proof that astronomy is an appealing and interesting subject not just to physicists but to teachers from other fields even not science-related. Additionally, this fact could also play a role in terms of interdisciplinarity of the projects. Teams whose coach teachers are not physicists or teach other science topics as well as physics are more likely to produce projects that are more interdisciplinary.

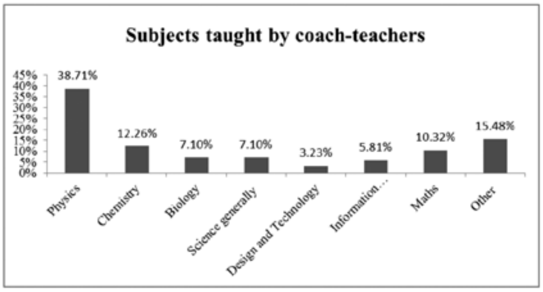


***Figure 2.*** *Subject taught by coach-teachers participating in the contest.*

**3.2 Teachers' expectations for their students**

Focusing on teachers expectations from the contest for their students, 90% stated that they are interested in making their students more enthusiastic about space exploration and 77.5% stated that they want to facilitate their students in improving their inquiry skills. Based on their answers in the ATQ these expectations were highly achieved as 83.54% stated that they believe that their students have become much more enthusiastic about science and only 13.92% believe that their students' enthusiasm has increased but only a little. Respectively 84.81% of teachers believe that their students have become more curious about space exploration and science in general. In addition 84.81% of teachers believe that their students have learnt a lot about space exploration focusing on the subject of their project.

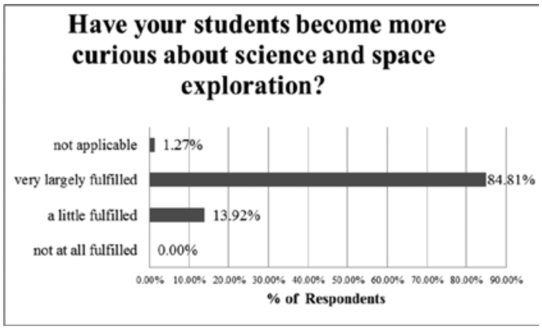


***Figure 3.*** *Answers by coach teachers on students' raising interest about science and space exploration.*

When commenting on students' behaviour during the implementation of their project 74.68% believe that their students have greatly improved in working in teams and the rest 25.32% believes that the have improved to a satisfactory degree. About 82.02% of the teachers stated that the choosing of the project's theme lied upon their students, thus indicating a high degree of initiative from their side on this matter. Only 17.98% of the teachers stated that the subject of the project was their own choice.

Based on their answers in the 'open-text' questions, teachers also seem to pay great attention on the emotional impact of the contest on their students. According to teachers' statement the emotional involvement of the students increased their sense of teamwork which was the key factor in continuing with their project in pressing times. Additionally, teachers believe that the emotional involvement of the students also resulted in them recalling what they have learnt more easily and overall become more enthusiastic about space exploration and science in general. Another interesting fact that stems out of teachers' comments is that the teams were eager to disseminate their work to their fellow students and local community. This fact could also be attributed to the students' emotional involvement, their excitement in their projects and taking pride in their work. The enthusiasm of students in promoting their own work has also acted as a trigger in inspiring their fellow students to engage in similar initiatives.

Focusing on the teachers' second most popular expectation – improving students inquiry skills – 64.56% of the teachers believe that their students have greatly improved in formulating questions and developing strategies to answer their questions and 34.18% believe they have gained some experience. With regards to improving students' skills in using ICT tools 53.16% of the teachers believe that their students have gained a lot of experience and 43.04% believe that their students have gained only some experience.

## 4. Students' questionnaires analysis

### 4.1 Students' profiles

Out of 438 students' participating in the contest we obtained 226 BSQ questionnaires (51.6%) and 143 ASQ (32.6%). Percentages regarding the gender of the students demonstrates an interesting fact; in the BSQ 67.70% were male students and 32.30% females while in the ASQ the percentage of female participants has increased (58.74% male students and 41.26% female students). These second set of percentages seem to be aligned with current studies which indicate that both female and male students are equally attracted to astronomy-related topics [4]. In addition, the increase of female students during the implementation of the contest could indicate that girls may at first be more reluctant to engage in astronomy related activities but once involved in the process their enjoyment seems to increase and they are more likely to complete the activity they started.

### 4.2 Students' interest in science and in following scientific careers

Upon rating their enjoyment of science on a scale from 1 to 10 (10 being the maximum) 82.3% rated their enjoyment between 8 and 10 while 17.26% were between 5 and 7. These numbers indicate that most students participating in the contest already had a high interest in science; however students with an average interest were also inspired in participating. The respective percentages of the ASQ indicate that overall participants have an increased interested in science after participating in the contest. Students now rating their enjoyment in science between 8 and 10, is 89.51% while students rating their enjoyment of science between 6 to 7 is 10.49%. Contrary to the BSQ there are no students rating below 6 (only 1.40% corresponds to rating "6") while the average has also increased a little (8.70 before the contest and 8.93 after the contest). This increase in their enjoyment of science is also in accordance with what teachers have stated on their students increasing interest in science.

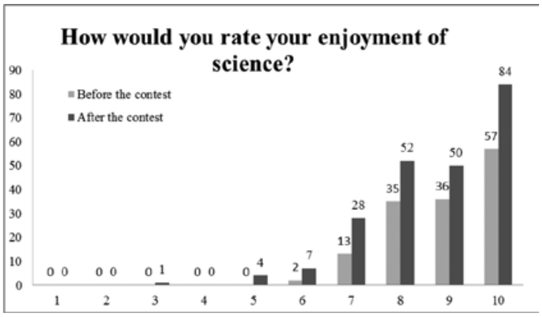


*Figure 4. Students' degree of enjoying learning science.*

In order to check whether this increase in students' enjoyment also stems from their participation in the contest, students were posed with a second question: "Do you enjoy science more now than before the competition?" Given the fact that upon registration 59.29% of the students rated their enjoyment in science between 9 and 10 (10 being the maximum) and 40.71% students rated their enjoyment in science between 5 and 8 it was expected that the amount of participants that could be more significantly affected by the contest were around 40% of the participants. The answers to the question above however, indicate that 47.93% enjoy science more than before the competition and 52.07% enjoy science as much as before the competition. This result indicates that the contest had a positive impact on students who enjoyed science at an average rate and in addition students who already took great enjoyment in science were also more inspired due to their participation to the contest.

When students were asked if they are considering a career in science upon registration 61.88% of the students said "Maybe", 31.68% said "Certainly" while a percentage of 6.44% declared they were absolutely not thinking of a scientific career. The students' answers on the same question after the contest have changed towards most positive responses. The students' percentage saying "No, absolutely not" has decreased to 4.13% and student who said "Maybe" has also dropped to 51.24%. On the contrary, students saying "Certainly" have increased by 13% reaching 44.63%. These results indicate that the contest has affected positively mostly students who were undecided about choosing a career in science or not. The change in numbers between "Maybe" and "Certainly" students before and after the contest is an indication that the contest may have contributed in making up their mind and inspiring them towards following a career in science. Although small, the drop in the percentage of students who had answered "No, absolutely not" before the contest also indicates that overall, the contest may have affected students overall behaviour towards science and in following scientific careers.

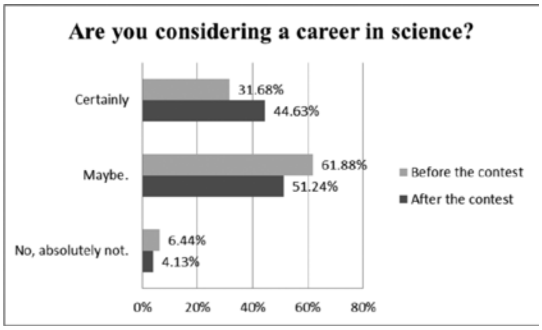


***Figure 5.*** *Students' visions on following a scientific careers.*

With regards to the students overall idea about the contest, the vast majority (90.08%) stated that they have enjoyed a lot their participation in the contest and only 9.92% said that they have enjoyed their participation only a little.

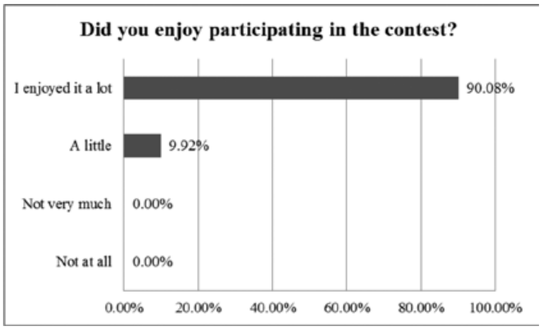


***Figure 6.*** *Students degree of enjoyment of the contest.*

This positive reaction to the contest is also enhanced by the fact that 80.99% of the students indicated that they want to learn a lot more about science and space. These two results of the questionnaires strongly indicate the high positive impact of the contest on students in term of being more positive towards learning about science and space exploration and it can be an inspiration in engaging in more similar activities in the future. Additionally students were asked to comment on the competition itself and point out its most positive and most negative things. On the positive side students' answers mostly focused the knowledge they have gained on the subject at hand and in how to make a project (38% of the comments), their enjoyment in working with teammates (14.5% of the comments), the inspiration they got in learning about space (15% of the comments) and their enjoyment in participating in an initiative that gave them the opportunity to demonstrate their work and learn about the work of others. Other comments were about their opportunity to work on their time management and inquiry skills, their chance to do something creative and the fun they got in participating. The fact that the most common comments among participants were about the knowledge they have gained strengthens the indication that the contest had an impact on participants' cognitive skills.

On the negative side about 29% of the students comments focus on the fact that they wished to have more time to work on their project, while 18% said they didn't find anything negative about the contest. The percentage of students stating they didn't have enough time to work on their project, in combination with the fact that the average time spend on projects by teams is around one week could be an indication, that students got started with their project later than what it would have been ideal for them or that they didn't have as much time as they would want due to school obligations. However, this could mean that overall students' time management skills could be improved. Perhaps this could be a reference point for future contests where special attention should be made in guiding the contestants to make an affective time schedule for their project. Some students also had comments about needing more guidance and instructions or having some minor problems with their submissions.

On commenting about whether the contest had a cognitive impact on the participants, we have taken into consideration three different sources of data. Firstly, as mentioned above, about 84.81% of teachers believed that their students have learnt a lot about space exploration focusing on the subject of their project. The second source of feedback is the answers to the respective question asked to students where 64.46% of them have stated that they have learnt a lot about science and space due to the contest and 34.71% stated that they have learned about science and space to a smaller degree. Lastly, the quantitative data received from the open-text questions indicate that according to students one of the most important benefits from the contest was the knowledge they have acquired in space exploration and science. Overall, all the feedback derived on the cognitive impact of the contest to the students indicate that all participants have benefited from the contest on this matter. However, besides the fact that the students have indeed gained knowledge, another interesting point to look at, is the process through which this knowledge was gained. According to students' comments, teams appear to have enjoyed themselves during the making of their project. Overall, students seemed to have enjoyed working in teams and they enjoyed the challenge of making a project. Many participants also stated that the learnt about how to make a project and how to make an inquiry, which indicates that, the contest has also influenced to a degree the participants' metacognitive skills. Additionally, on the matter of understanding how science works, 64.22% of the students stated that they know more about how scientists and researchers work in comparison to what they knew before the contest and 27.52% stated that they have learnt a lot more on the matter. In the process of understanding how science works another indication is that 41.32% of the participants, stated that they came in contact with scientists. In most cases the scientists contacted were from local universities and science centres.

## 5. Conclusions

According to our findings, it can be assumed that the contest had a positive impact on students' attitude towards science. The increase of students who consider following a scientific career is among the achievements of the contest. The fact that to their vast majority students have stated they enjoyed the contest is also an important aspect as it can contribute in changing students' notion of learning science and make them fill more inspired in engaging in science.

Focusing in the quantitative data received, our analysis has shown that students have enjoyed the fact that they were given the opportunity to choose freely the subject and the manner they want to work on. Their experience in the contest has taught them how important it is to be able to manage the available time and to be able to coordinate teamwork. Students seem to appreciate the fact that such initiatives help them improve their inquiry skills and learn about science in their own fashion. They seem to be particularly pleased with the fact that they have been given the opportunity to act based on their will and on subjects that interest them the most. Having taken enjoyment in their work is not only reflected on the answers given by the students; it is also reflected on their work. The projects submitted in the project are not simplistic; they are to their majority attempts to propose new ideas on space exploration based on scientific facts. The quality of the projects and the overall performance of the teams indicate that students had the will to invest in the contest and put effort in producing a quality entry.

Many teachers stated that they have witnessed a behaviour change in their students with regards to their performance in school and their collaboration with fellow-students.

Overall, it is safe to say that based on the impact of the contests, such initiatives are like to increase students interest in learning science and consider following science and space related careers, as they are initiatives which encourage hands-on creative activities and allow students to take initiative, use their imagination and inquiry skills and engage in activities that allow them to truly enjoy the learning process. The engagement in one such initiative could act as a trigger to revive a student's lost interest in space exploration or to inspire a student who has not had contact with this subject before. Additionally, the constant involvement of students in such initiatives could act in an aggregative manner and help students maintain a high interest in learning science through their inspire them in following a relative career in the future.

## 8. Acknowledgements

The data were derived by the Odysseus contest which was co-funded by the European Commission under the 7th Framework Programme.

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# Inspiring Teachers for Inspired Children

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## Abstract

In this paper we present the efforts to build a strong and very active community of educators in Portugal. The main aim is to present the strategy adopted by our institution in Portugal to help teachers motivate their students towards science literacy. We will present our vision and how we are building the necessary road to achieve this goal. How to effectively train and inspire teachers, how to provide continuous support, how to sparkle students interest for science, how to innovate in classroom and how to create inclusive environments.

## Keywords

Community building, teacher training

## 1. Introduction

NUCLIO is a non profit association devoted to public outreach and education in the field of science, in particular astronomy. Since 2004 NUCLIO started training teachers on the use of real research in classroom providing support to the use of cutting edge tools and resources in schools. In 2012 our association started a new stage by becoming an official training centre for teachers in Portugal. In the framework of our offer to teachers not only we share the thematic of astronomy as a hook of inspiration to students but we also provide training on the necessary methodology to reproduce the scientific method in classroom.

Astronomy is not a subject area per se in schools in Portugal but, as it happens in the majority of the countries, different topics appear in several different subjects. Astronomy is a powerful and inspirational thematic to inspire students for science, in fact, the International Astronomical Union in its strategic plan published in 2010 [1], makes a very good case for Astronomy as a driver for the development of nations. The document presents also a very well consolidated vision that astronomy can be a driver to cross disciplinary experiences and set the perfect stage to prepare students to the world of work.

The strategy adopted is to provide support to all teachers participating in our challenges, trainings and events but also to try and engage the whole schools and local community. This strategy is what we describe briefly in this paper.

## 2. The Method

The problem of decreasing interest for science is a known issue and has been debated in several important documents as for instance the Rose Project [2], the Rocard Report [3] and a Critical Reflection on Science Education in Europe [4] . A common suggestion from these and other important studies is the adoption of a student centred methodology and the preparation of teachers to uptake the role of tutors, to step down the central stage and give the floor to students. This requires a whole transformation in schools starting from the setup of rooms to the setup of minds.

A powerful driver of this desired innovation is the use of ICT as an accessory tool for the amplification of student's horizons. In Portugal schools are fairly well equipped in terms of ICT. This is a result of the technological plan approved in 2007. Most schools have at least one computer per classroom, data projector and very often a smart board. However, due to the recent financial crises severe cuts were necessary and it obliged the government to put their plan on hold. The missing component, to the full implementation of the plan, was the stage of training teachers.

The use of ICT in general is very poor and innovative practices are driven by champion teachers, those that are willing to go one step beyond in the benefit of their students. School's strategies are, in general, very exam oriented and

have to handle lots of bureaucratic work. These ingredients together represented a pit stop in the construction of innovative learning spaces. In order to support educators to face these strong constrains we had to develop a strategy to support our partners in this education journey, a strategy that would not collide with existing policy and expectations.

The developed method had several stages, carefully planed and implemented:

### 2.1. Training Teachers

Training teachers is the first step of a joint journey. Unlike many other training events NUCLIO believes that teachers need to find in trainers a partner that will provide continuous support. As a training centre, certified by the Ministry of Education, NUCLIO promotes accredited courses where educators are introduced to innovative tools, resources and student centred methodologies. In the framework of Inspiring Science Education (ISE), in particular, we walk along the creation of inquiry based scenarios following the big ideas of science (fig 1).

***Figure 1.*** *ISE teacher training session*

The specific course has a total of 30 hours where we use astronomy as a main hub for science ideas. A selection of astronomy tools and resources are presented and teachers invited to create their own inquiry scenarios using the shared material as a reference. The next step is to apply the prepared material with students and collect the result.

### 2.2 Inspiring Students

This is a crucial step for the design of our strategy. In fact, students are the reason we promote such variety of projects. We believe that by empowering teachers we are opening new opportunities to students and better preparing them to take the lead in the future of our existence in this planet. When we ask teachers to adopt the proposed tools, methodology, etc., we are asking them to step way beyond their comfort zone. But this is not only the case of the vast majority of teachers, it is also the case of students, who are very accustomed to mechanized exercises where the answers are always in the last part of the book.

But this is not the only challenge faced by the teacher. In most societies students are required to perform well in national exams, their academic future depends on it. So any diversion from the traditional path of exam preparation might not be well embraced by them. On top of that, one of the most common complaint is related to dense curricula and lack of freedom to design it according to the specific needs and specificities of each group of students.

Actually these ingredients are the perfect mix to drive students away from their natural curiosity and creativity and drive teachers to mechanized structuring of their lessons. In his TED, "Do Schools Kill Creativity", Sir Ken Robinson gives us the perfect recipe to drive students away from a fruitful construction of the science literacy, in a nutshell, he describes most of the education systems in the world [7].

In order to help teachers overcome some of these barriers we promote demo activities in schools where we try to engage students in the use of some of the innovative tools we trained their teachers to use (fig. 2).

***Figure 2.*** *ISE demo activity with students*

These demo sessions, with the catchy name of "NUCLIO on the road", are in the format of a master class where we present a science topic trending at the specific moment of the visit, like for instance gravitational waves nowadays, we then invite them to participate in a research exercise where we introduce them to an ISE scenario. Usually the result is very encouraging and acts like an ice breaking and an invitation for the students to explore more.

**2.3 Engaging the Schools Community**

The obstacles are not ending here, in many occasions colleagues in the same school are not supportive or open to the new developments. Often they can even be an impediment for the implementation of the project in the school. In many occasions a simple activity where our team share the vision of the project, its benefits and expected outcomes with the rest of the team solves many issues and provides new opportunities for further engagement of members of the same community. In order to achieve this goal, the whole school community is invited to these demo activities and special workshops for teachers are promoted. The idea is to engage other teachers from the same or different subject area around the same experience. It is a gentle push towards interdisciplinary collaboration and a silent recognition for the teachers that invited us to the school and helped organize the event. Very often these visits set the stage for further training, this time involving more members of the community involved in the activity.

**2.4 Engaging the Local Community**

The support of the local community is also a key aspect for the success of the implementation of the new vision brought by the inspiring teacher, the teacher that is our partner in the training course or other similar activity. Awareness actions are necessary. In order to present the renovation strategy, that NUCLIO is usually inviting teachers to adopt, a science café is organized by the end of the day of activity. This can take diverse format according to the expected audience. The most used model is to promote a small talk about a topic of interest and in between the question and answer sessions inform the families of the students, the rest of the school community and in many cases the education authorities, about the innovative strategies we are inviting the school to adopt. In some cases, after working with the students for a few hours, they uptake the role of scientist and present the lesson learned to their parents. Either model presents a nice framework to engage the overall community.

## 3. Cascading and empowering

Training teacher is a lifelong mission and there are not enough hands to productively ensure the reach of innovation to many at the same time. Dissemination and outreach actions will certainly be enough when aimed at the 10% already converted teachers and communities. The problem at hand is how to reach the remaining 90%, unaware of our existence and in many cases not interested in stepping out of their comfort zone. The above listed initiatives are one way to reach out, but another also equally effective trigger is the word of mouth and the collected evidence of the impact of the different projects in the student's development as an overall.

We trust the professionalism of the teachers we train and hope that they will be agents of change in their circle of influence. If every teacher is capable of successfully share his or her experience with other colleagues, then the cascade effect will ensure the continuation of the process. This format of empowering teachers is working for over 20 years in the framework of the Global Hands-on Universe [8], initially created at the University of California at Berkeley and later adopted by the Galileo Teacher Training Program [9], one of the largest astronomy education efforts in the world endorsed by the International Astronomical Union and UNESCO as a legacy of the International Year of Astronomy, counting nowadays with over 30 000 teachers trained in nearly 100 countries.

This model is very sustainable as it is not dependent in any particular funding model. It is based on volunteer effort and the secret of its success is the movement created around its vision and the many visionaries around the world ensuring its continuation.

## 4. Community Building: Online presence and special gathering days

In recent years the support to teachers gained another dimension with the flexibility introduced by the use of online solutions. NUCLIO started recently to promote online training sessions along with support sessions on demand. Teachers participating in our training events have now the possibility to request online support for the preparation of their scenarios, for the implementation phase or at any other moment where support is necessary.

In parallel with this initiative a series of webinars on specific astronomy topics are being prepared connected to the different existing demonstrators (ISE scenarios prepared by the project team members) and preferably connected to the school curricula.

Another important community building event, launched in this school year, was a series of sessions conducted in several parts of the country, the "Pilot Days". Days specifically targeting pilot teachers of Inspiring Science Education where participants were involved in fruitful discussions related to the implementation of this model of activities in schools. Participants had the opportunity to discuss specific topics about the project proposed methodology, new scenarios were presented and teachers were invited to explore new features in the platform and/or new existing material. NUCLIO believes that it is crucial to provide to our partners, schools in Portugal and abroad, as many opportunities as possible to share their experiences, provide useful input and to gather the necessary face-to-face support.

## 5. Certification and recognition and internationalization

Besides the certification of attendance and completion of the accredited training courses NUCLIO also provides certificates to schools, teachers and students that somehow were involved in the project. Every year, in the framework of Inspiring Science Education and other projects, NUCLIO gathers teachers in a national event where certificates are distributed and teachers have the opportunity to share their experiences with other colleagues and the public in general.

NUCLIO believes that best practices should be shared and equal opportunities provided to teachers and students all over the world. With this vision in mind our institution shares with partners from all over the world all possibilities to further enhance their knowledge and skills. We believe that the collaboration between teachers from different parts of the world is highly beneficial for the constructions of a world without borders. We share funding opportunities, we promote contests in the framework of our projects and other friend's projects. We help schools in the process of presenting their own proposals to funding opportunities such as, for instance, Erasmus + mobility actions etc. The materialization of this vision can be seen in the multiple international training gatherings that we have been promoting over the last years (fig 3).

***Figure 3.*** *International training session in La Palma*

## 6. Conclusions

The construction of the future of mankind starts at home, while we are nurturing our children and offering them all the possibilities to build their own vision of our condition as human beings in this beautiful planet. Schools are the next pillar in the construction of our literacy, science in particular. They are the continuation of our homes and the places where we prepare the next generation of leaders and decision makers. What is the value associated to a literate person? What is the price we are willing to pay to ensure that the new generations have a strong global citizenship awareness accompanied with the necessary knowledge and skills to take wise decisions? How far are we willing to go to ensure that every child gets the best possible opportunities? Maybe only a few will read this article, if you do and you are willing to make a change and to make a difference, join our efforts.

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# Linking Spatial Thinking and Problem-Solving Skills of Young Children

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## Abstract

*Recent studies stress the rewarding effects of spatial thinking on students' attainment in STEM disciplines or pursuit of a STEM career. However, there is no rigorous research of the way spatial thinking influences other skills (e.g. problem-solving). Problem-solving skills assist humans in prioritizing their problems and in finding solutions using mental/cognitive processes. A question worth pursuing is whether (and how) spatial thinking is connected to problem-solving skills. Hence, the paper's objective is to give evidence of that link and to provide the grounding for enhancing spatial thinking in formal learning settings with the aim of educating the future skilled students.*

## Keywords

Problem-solving, questionnaires, spatial thinking, video games.

## 1. Introduction

During the past decades, many scientists have expressed an increasing interest in spatial thinking. According to Sinton spatial thinking is "*the ability to visualize and interpret location, distance, direction, relationships, movement and change in space*" (p. 733) [37]. Spatial thinking is arguably as an important form of thinking as others (e.g. verbal, logical, hypothetical, mathematical) because the ability to think spatially is of high importance for both workplace and different scientific domains, but it is also crucial for everyday life [29].

The significance of spatial thinking has also been demonstrated in the report entitled "Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum" by the U.S. National Research Council, which underlined that "*without explicit attention to [spatial literacy], we cannot meet our responsibility for equipping the next generation of students for life and work in the 21st century*" (p. 10) [ibid.].

Spatial thinking is considered as a significant ability for STEM disciplines (Science, Technology, Engineering and Mathematics). More specifically, the development of geospatial skills is associated with the increase of participation in STEM fields. The lack of spatial thinking acts as a barrier for students leading them to dropout [38]. Furthermore, spatial thinking can predict one's success in STEM fields and constitutes an essential element for achieving innovation, however due to being neglected by educational systems it has been missed [30]. Except from STEM fields, spatial thinking is also associated with social sciences, humanities [13], and education [1], demonstrating in that way its interdisciplinary character.

Spatial thinking has three major building blocks [29]: (a) concepts of space, (b) tools of representation, and (c) processes of reasoning. All these elements may be implemented in everyday activities such as locating one's home, giving and following directions or navigating in known and unknown spaces. For example, in order to find suitable areas for constructing a winery based on various criteria (altitude, distance from towns, rivers and protected areas) someone should grasp spatial concepts such as location, distance/proximity, zone of influence and elevation, use representation tools such as maps and terrain modelling, and be able to perform reasoning processes, such as combining maps and evaluating multiple criteria to make inferences about the potential areas.

Spatial thinking utilizes the properties of space in order to successfully solve problems and give answers in various issues [ibid.]. In other words, space plays a critical role, because spatial thinking uses it for constructing the model of the problem, exploring its nature and formulating possible solutions related with space. It also provides the necessary means for analyzing space, which makes it a valuable tool for decision-making. Hence, it is an ability that may enable problem-solving, whether regarding everyday activities such as parking or more advanced activities such as reading an X-ray.

Based on Duncker [8], "*a problem arises when a living creature has a goal but does not know how this goal is to be reached*". Actually, a problem is an amalgam of three elements: (a) a given state, which describes the current situation, (b) a goal state, which describes the desired situation and (c) a set of operators, the means to achieve the transition from one state to the other [25]. In that context, problem-solving skills are essential because they assist humans in prioritizing their problems. Furthermore, they enable them to find suitable and unique solutions to these problems, using various mental and cognitive processes by following a logical succession of steps. Just as spatial thinking is considered as a high-level cognitive process so is problem-solving, because it takes place in the problem solver's cognitive system and manipulates cognitive representations.

There are many kinds of problems that humans encounter in their everyday life, but those which have a STEM context are unique and complex. Johnson-Laird [20] argues that the three types of reasoning (deduction, induction, and abduction) are essential for the solution of a problem, but also other forms of thinking may contribute to the solution as well. A question worth pursuing is whether spatial thinking or spatial literacy can promote problem-solving in information, verbal, mathematical, etc. problems.

The present paper reviews state-of-the-art literature on research relevant to problem-solving and spatial thinking abilities. Hence, the main objective is to examine on a theoretical basis, whether spatial thinking and problem-solving skills are linked to each other using problem-solving questionnaires and video games. The establishment of such a link provides the grounding for enhancing both skills, spatial thinking and problem-solving in formal learning settings with the aim of educating the future skilled students.

## 2. Related research

The relation between problem-solving and various other cognitive and thinking skills has been the subject of numerous studies in the past. For example, problem-solving skills have been associated with critical thinking skills [21], coping skills/psychological adjustment[1]

*1 Coping is the effort to solve personal and interpersonal problems and to seek ways to master, minimize and tolerate stress or conflict.*

[5], reflective thinking skills [6], motivation and innovation skills [24], and metacognition skills [2]. The findings from these research studies suggest that there is a positive relation between problem-solving skills and those skills; the increase of the former leads to the improvement of the latter or vice versa.

During the last few years, the relation between spatial thinking and problem-solving skills has also been studied. However, these studies associate one element of spatial thinking (e.g. the type of visual representation[2]) with a specific type of problem-solving (e.g. mathematic or word problems). Boonen et al. [3] explored how the type of visual representation and reading comprehension is connected with verbal problem-solving. The results indicated that reading comprehension and spatial ability is associated in a greater extent to a successful solution of a verbal problem than the choice of type of visual representation. Mohring et al. [27], investigated the ability of pre-schoolers to locate targets and to reason about proportions. Reasoning can be considered as a special type of problem-solving. The results revealed that proportional reasoning and spatial thinking are highly correlated abilities.

Therefore, the above-mentioned research studies have highlighted the probable link between spatial thinking and problem-solving skills. Thus, further and more systematic research is worth pursuing for connecting these two.

## 3. Problem-solving and spatial thinking

Problem-solving is classified based on various features, such as the amount of the information, the clarity of the statements, or the possible answers. Fischer et al. [10] stated that problems can be either analytic or interactive; analytic problems provide all the nessecary information to the solver and usually have one single choice while interactive problems engage the solver to uncover some of the information needed and multiplie choices are available. On the other hand, Mayer distinguishes: (a) well defined problems where the given state, the goal state, and the set of operators are well defined and (b) ill-defined problems where the goal state and the operators are not clearly specified [25]. If the problem has one single correct answer then it is characterized as convergent, otherwise if it has more than one correct answer it is classified as divergent. Fig. 1 shows an example of an analytic, well-defined, divergent problem.

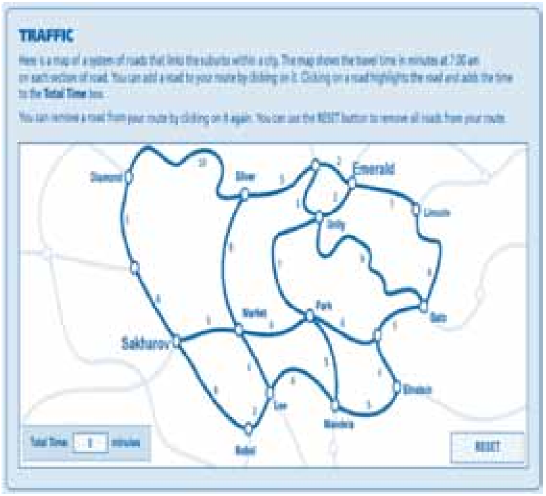


***Figure 1.*** *"Traffic" item from PISA's 2012 questionnaire [34]*

Problem-solving is accomplished in two phases: (a) problem representation and (b) problem solution. At the representation phase, the solver identifies the issue to be resolved and creates a representation of it (including all the available information about the problem, knowledge about the possible set of operators that will be used, and existing knowledge if the solver has faced similar situations). At the solution phase, the solver designs a possible solution and executes it. Most of the times, building an appropriate representation

*2 According to Hegarty et al. "Visual imagery refers to a representation of the visual appearance of an object, such as its shape, color, or brightness, while spatial imagery refers to a representation of the spatial relationships between parts of an object and the location of objects in space or their movement" (p. 685). There are two types of visual representations: pictorial which is associated with visual imagery and visual-schematic which is associated with spatial imagery. [18]*

of the problem (including internal and external forms of representation) is vital for successfully solving everyday problems [35]. However, the creation of an adequate visual representation of the problem is not an easy process. For example, children find it difficult to mentally represent a word problem [39].

The contribution of spatial thinking at both phases may be very valuable. At the representation phase, the solver should generate and manipulate mental representations of the problem in order to thoroughly study and understand it. At the solution phase, the solver could spatially represent the solution of the problem using graphs for example [26].

### 3.1. Discipline-based problem-solving and spatial thinking

Spatial thinking and more specific visual-spatial abilities play a crucial role in many disciplines (physics, chemistry, biology, engineering and geoscienses). For example, the discovery of the double helical structure of the DNA molecular by Watson and Crick or the general and special theories of relativity by Einstein constituted scientific advances that rely on the ability to visualize scientific phenomena and manipulate these abstract images.

According to a report of U.S. National Research Council regarding Discipline-Based Education Research, visual representations and spatial thinking can promote conceptual knowledge and have a great influence in the development of high order problem-solving skills in various disciplines [28].

In particular, Johnson [19] argued that the ability to mentally rotate various objects is highly related with solving mathematical problems (geometry and complex mathematical word problems). Spatial thinking is also highly related to mechanics or kinematic problems (problems that examine the motion of objects in space over time) and in a lesser extent to problems from the subfield of electricity or magnetism [40]. Chemists rely on spatial thinking to visualize 3D structures based on 2D representations, mentally rotate and reflect molecules and identify and characterize stereo centers [17].

### 3.2. Spatial dimension of PISA's problem-solving questionnaire

The relation between spatial thinking and the ability to solve problems in various scientific fields was well studied and analyzed by researchers. A question worth pursuing is whether spatial thinking finds its way into problem-solving tasks. For this purpose, questionnaires developed by the Programme for International Student Assessment (PISA), addressing 15 years old students, were analyzed.

PISA 2012 focuses on literacy in mathematics, while PISA 2015 focuses on literacy in sciences and for first time introduced Collaborative Problem-Solving (CPS). According to PISA's draft framework CPS is defined as "*the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and efforts to reach that solution*" (p. 49) [32].

PISA's 2012 problem-solving questionnaire consists of 4 core units with 16 measurable students' actions (items) in total and each core unit lasts for 20 minutes [34]. On the other hand, PISA's 2015 questionnaire [33], contains 35 items of problem-solving and 44 of CPS. The majority of the items engage students in explaining various graphs, analyzing data from tables, and making inferences about the phenomena that they study.

The questionnaires were analysed based on the geospatial task ontology, which was developed by Golledge et al. [11, 12]. In their effort to match geospatial concepts with geographic educational needs, they created an ontology which consists of 45 geospatial concepts organized in five categories, from basic concepts called primitives to complex ones, which are

4th order derivatives. Later, Grossner [16] added several other concepts (from the field of geography and geology) to the initial list reaching a total number of 98. However, he did not include some of the concepts from Golledge's initial list. Charcharos [4] based on the list of Golledge and Grossner created an enriched list with 131 concepts while keeping the original categorization, to accommodate the complexity and diversity of the geospatial domain. These concepts came from Geography Information Science and Technology Body of Knowledge (GIS&T BoK), Teachspatial, Schools Online Thesaurus (ScOT) kai ITS Education.

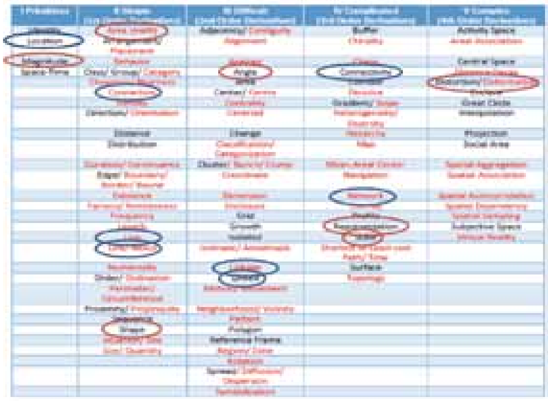

***Figure 2.*** *Golledge's initial and enriched list of geospatial concepts [4]*

Fig. 2 displays the initial list of Golledge's geospatial concepts (words in black) and the enriched list (words in red). As it can be seen from Fig. 2 the 4th order derivative "distortion" has as prerequisites the primitive "magnitude", the 1st order derivatives "shape" and "area" (with the mathematical meaning of the term), the 2nd order derivatives "angle", and the 3rd order derivatives "representation" and "map" (all these concepts are marked with a red circle in Fig. 2 while with blue circle are marked the prerequisites concepts for "network").

Golledge tested his geospatial task ontology and the results (Fig. 3) showed that at the age of 10 children can understand 2nd order derivatives ("pattern", "coordinates", "reference frame", "distribution" etc.) while at the age of 15 can fully comprehend 3rd order derivatives ("map", "scale", "overlay") and partially comprehend 4th order derivatives ("projection", "interpolation"). Children of this age face difficulties to conquer other concepts of this complexity level such as "spatial association" [12].

| Tier | Geospatial concept | Grade | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | K | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Primitive | Spatial Primitives | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Simple | Relative Distance/Direction | X | X | X | X | X | X | X | X | X | X | X | X | X |
| | Shape | | X | X | X | X | X | X | X | X | X | X | X | X |
| | Place-based Symbol | | X | X | X | X | X | X | X | X | X | X | X | X |
| Difficult | Boundary | | | X | X | X | X | X | X | X | X | X | X | X |
| | Connection | | | X | X | X | X | X | X | X | X | X | X | X |
| | Distribution | | | | X | X | X | X | X | X | X | X | X | X |
| | Pattern | | | | X | X | X | X | X | X | X | X | X | X |
| | Reference Frame | | | | X | X | X | X | X | X | X | X | X | X |
| | Coordinate/Grid | | | | X | X | X | X | X | X | X | X | X | X |
| | Zone | | | | | X | X | X | X | X | X | X | X | X |
| Complicated | Map | | | | | | X | X | X | X | X | X | X | X |
| | Legend | | | | | | X | X | X | X | X | X | X | X |
| | Map Projection | | | | | | X | X | X | X | X | X | X | X |
| | Slope/Gradient | | | | | | | X | X | X | X | X | X | X |
| | Scale | | | | | | | X | X | X | X | X | X | X |
| | Surface | | | | | | | | X | X | X | X | X | X |
| | Hierarchy | | | | | | | | | | X | X | X | X |
| | Overlay | | | | | | | | | | X | X | X | X |
| Complex | Interpolation | | | | | | | | | | | X | X | X |
| | Global Warming | | | | | | | | | | | | X | X |
| | Spatial Association | | | | | | | | | | | | X | X |

***Figure 3.*** *Age range of various geospatial concepts [12]*

### 3.2.1 PISA's 2012 questionnaire

Fig. 1 shows a sample item from PISA's 2012 questionnaire. Clearly, this question has a spatial dimension because the solver needs to evaluate different possibilities using a network diagram in order to find a meeting point that satisfies a condition on travel times for all three participants in a meeting. This item includes various geospatial concepts such as, location, connection, link, linked, connectivity and network.

Two other sample items from the same questionnaire are Question 2 and Question 6. In Question 2, the solver needs to find the shortest path in terms of time between two distant locations on a map using again a network diagram. This item includes the previously mentioned concepts from the sample item of Fig. 1 and also introduces the concept of shortest time or its spatial equivalent shortest path.

In Question 6, the solver needs to create a coherent mental representation of the problem, to imagine the behavior of the robot, to identify the relevant factors in the problem and their interrelationships and then to conclude that the robot will push the yellow block until it meets a wall or a red block and that it turns 180 degrees.

### 3.2.1 PISA's 2012 questionnaire

Regarding problem-solving, in the item "Bee Colony Collapse Disorder", students are asked to explain why the disappearance of bees might result in a decline in bird population. In the item "Fossil Fuels" students explore the relationship between burning of fossil fuels and $CO_2$ levels in the atmosphere. Through these items, students understand the concept of spatial association.

The spatial dimension is also evident in the item entitled "Volcanic Eruptions" (Fig. 4). This item focuses on the distribution pattern of volcanoes and the impact of volcanic eruptions on climate and the atmosphere. Students are asked to choose which location is least likely to experience seismic or volcanic activity based on the maps on the right side of Fig. 4. This item includes the primitive location and various derivatives such as distribution, pattern, map, area, representation, and spatial association.

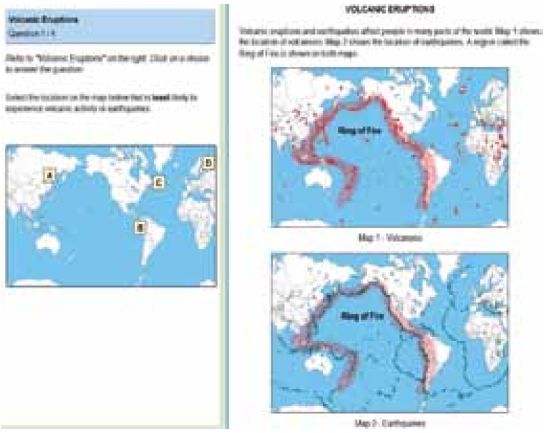


*Figure 4. "Volcanic Eruptions" item [33]*

The item "Groundwater Extraction and Earthquakes" is more advanced than the previous ones, because excepts from maps and their related concepts it also introduces the concepts of legend, symbolization and isolines (Fig. 5). In order to fully understand how tectonic plates create rifts and earthquakes, students should also use higher cognitive abilities such as spatial visualization, because they should create a mental representation of tectonic plates and then imagine how they move and how such movements relate to earthquake activity.

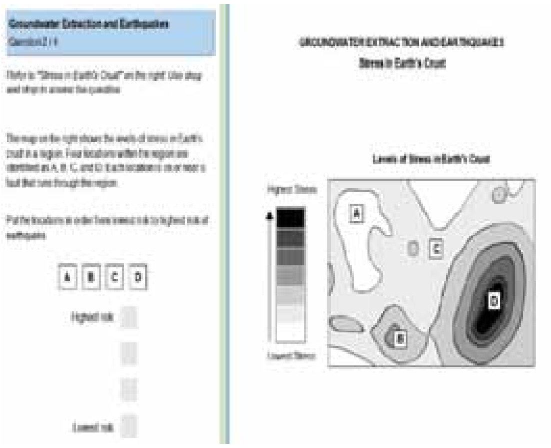


*Figure 5. "Groundwater extraction and earthquakes" item [33]*

The item "Blue Power Plant" focuses on a power plant that uses the differences in the salt concentration between salt water and fresh water to generate electricity and introduces the "spatial" concepts of connectivity and network.

On the other hand, CPS includes chat-based tasks where students interact with one or more agents, or simulated team members, to solve a problem promoting collaborating and organizing skills. In the "Visit" item, a group of international students is coming to visit the students' school, so they are asked to accomplish three tasks: (a) plan the visit, (b) assign visitors to guides and (c) respond to an unexpected problem that will arise.

At the first phase of this item, students should decide which location among three choices is the best for showing to the foreign students. This phase has partly a spatial dimension: at some point, students conclude that one of the three choices is far away from their school and they will not meet the time criteria imposed to them. This implies the concept of zone of influence (buffer) because students should create a “2-hours’ time zone” around the school and examine which of the three available locations intersects with it.

**3.3. Spatial and problem-solving aspects of video games**

During the last few decades, due to technological development, there is a transition from board games to video games. There are plenty of genres such as puzzle, strategic, action or massively multiplayer online role-playing games (MMORPGs), etc. All these genres have been associated namely with entertainment, but have also various others benefits, such as the enhancement of perceptual and cognitive abilities [22], the development of spatial reasoning and mental rotation skills [9].

Action video games and MMORPGs are distinguished from other genres because they emphasize at physical challenges, including hand-eye coordination and reaction time. In other words, players should manipulate several items (except from their avatar[3]) that enter or exit their visual fields and react quickly in order to interact with these items [15].

Experienced game players, especially those who often play action video games, have better performance (in terms of accuracy and speed) in numerous cognitive and visual-perceptual tasks [23]. In addition, experienced players tend to track more objects at once, filter out irrelevant visual information and predict with higher accuracy how 3-dimensional objects would appear when rotated.

Oei et al. [31] investigated whether action and non-action video games enhance executive function[4]. Their results indicated a link between action video games and enhanced attention and visual-perceptual skills of players who engaged with the game “Cut the Rope”[5] (Fig. 6). In particular, this game improved executive brain functions, which include memory, decision-making, planning, and problem-solving.

Furthermore, similar puzzle games to “Cut the Rope” such as “Where’s my water” or “Pudding Monsters” rely on spatial visualization and especially on mental animation for solving problems [36]. For example, in Fig. 6 the player should mentally visualize the motion and movement of the candy in order to collect all three stars and feed the little green monster.


***Figure 6.*** *“Cut the Rope” snapshot*

The interactive, decision-affecting environment of action video games and MMORPGs constitute an excellent tool for improving spatial reasoning and navigation (Fig. 7), developing problem-solving and quick-thinking skills, enhancing perception, improving decision-making [14]. For example, strategic video games such as “Command & Conquer: Red Alert” or “Civilization” help children to improve their problem-solving skills with consequent increase of their school grades [ibid].

*3 In action video games and MMORPGs the player controls the avatar of a character. The avatar navigates through various levels, collects objects, avoids obstacles and battles enemies.*

*4 Executive functions are cognitive skills, that are used to organize thoughts and information and to act to novel situations. They are crucial for high order planning, reasoning and problem-solving [7]. In terms of a video game, they include task switching and stimulus-response interference.*

*5 “Cut the Rope” is a physics-based puzzle video game, the objective of which is to feed candy to a little green creature while collecting stars.*


***Figure 7.*** *3D spatial navigation in "Space Engineers" game*

MMORPGs are more complex than the previous ones because they represent a massive virtual world, in which the player interacts with other friendly players and collaborate with them in order to accomplish various individually or collaborative missions with different complexity levels (here the concepts of problem solving and CPS are implied).

For example, as depicted in Fig. 8, the player uses two different maps at scale (see the bottom right corner of Fig. 8) to navigate in the area or between different realms. In addition, the player should calculate approximately the distance between the others players in order to execute various spells and hits. This genre has clearly a spatial aspect because it engages the player to subconsciously deal with the concepts of location, space-time, direction, orientation, distance, proximity, area, rotation, map, navigation, representation, scale and virtual reality.

***Figure 8.*** *"Aion" gameplay snapshot*

## 4. Conclusion

Problem-solving is a crucial skill that helps individuals dealing with various problems in their everyday life. The paper examined the relation between spatial thinking and problem solving skills based on PISA's 2012 and 2015 problem-solving questionnaires and video games.

More particular, in PISA's 2015 questionnaire 5 out of 8 core items have a spatial dimension and 3 out of 5 are purely spatial. In the core items, various spatial concepts were included from primitives (location) to $4^{th}$ order derivatives or complex concepts (spatial association). However, according to Golledge et al. [12] it is uncertain whether students may fully grasp the concept of spatial association which implied at "Bee Colony Collapse Disorder" and "Fossil Fuels" items because this concept addresses to older children.

Regarding the spatial and problem-solving aspects of video games, there are clues that such a relation exists and video games can contribute to enhancing these skills. That link provides the grounding for enhancing spatial thinking in formal learning settings, through gamification, with the aim of educating the future skilled students.

Although spatial thinking and problem-solving seem to be closely related, further evidence is needed to verify that relation. Future research includes the design and implementation of an experiment for testing spatial skills in correlation to problem-solving skills and examining the relative contribution of spatial thinking to problem-solving.

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# Exploring Science via Studying Building and Sharing Models

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## Abstract

*Inspiring Science Education (ISE) learning scenario incorporates an inquiry model supporting learners' creation and discussion of their ideas. Randomness and object motion are important science concepts, albeit difficult to learn. Computational representations enable us to introduce discrete and qualitative forms of modelling, which can support teaching and learning of complex subject. Two previously developed activities on randomness and falling objects have been adapted to ISE authoring tool. The adaptation has the aim of making available research results while ensuring autonomous use by the teacher. We are currently testing demonstrators in Italian schools to gather evidence on their use in classrooms.*

## Keywords

Computational model, ISE learning scenario, inquiry scaffolding.

## 1. Introduction

### 1.1 ISE inquiry model

Linn, Davis & Bell [1] define inquiry as "the intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments. In science inquiry projects, students communicate about scientific topics, evaluate scientific texts, conduct investigations, ask questions about science or technology policies, create designs, and critique arguments, often using technology resources". The Inspiring Science Education approach to inquiry adds a model to structure the scenario and lesson plans of the teachers based on five learning activities (Fig. 1). "ISE does not perceive learning by inquiry as following specific step-by-step instructions in a linear sequence of activities, but rather as experiencing activities that blend and merge together. ... highly structured and more open-ended inquiries both have their place in science classrooms". [2]


***Figure 1:*** *ISE Inquiry model.*

An inquiry model template might scaffold the teaching/learning process of science if it becomes the map of classroom activities, encompassing collaborative discourse and argumentation of the investigation at hand, shared by teacher and learners. During their activities, students should keep track of: questions or purposes of the investigation; predictions; data collected, analysis of the data, emerging ideas and reflections. Class discussions might be organized to compare and discuss the records of predictions, hypotheses, data and interpretations. Opportunities for students to engage in collaborative discourse and argumentation offer a means of enhancing students' conceptual understanding and their skills and capabilities in scientific reasoning [3].

**1.2. Learning Scenarios**

In the following, we present two learning scenarios based on ISE inquiry model (Fig. 1).

In our view, an important aspect is how teacher use the ISE inquiry model to foster and support discussion and reflection in class. Thus, we allocate tasks to individual, small group or class for each learning activity and provide details on how they should be done in order to create the conditions for fruitful discussion. For instance, tasks there are likely to produce more than one answer should be favored for discussion. To this end we ask students to record the output of each task in reports that form the basis for discussion. We advise the teacher to conduct classroom discussion at end of the "Hypothesis Generation & Design" and "Analysis & Interpretation". Classroom discussions are important to agree on how to conduct the inquiry and to assess if there is a need to repeat the investigation phase. Examples of tasks for individual, small group, classroom as well as teacher role in the context of learning scenario are provided in section 3.1.

"Guess my Garden" and "Falling objects" are two scenarios promoting learners' creation, revision and discussion of their models about, respectively, random phenomena and free fall motion. Random phenomena and object's motion near the earth are two subjects present in the curricula of primary and secondary education, encompassing key concepts in science. These concepts are known to be difficult to approach for both teacher and students. Interactive dynamic simulation can help making the abstract concrete and support student construction of models [4]. "Guess my Garden" and "Falling objects" derive from previous research projects; "Guess my garden" was developed within the WebLabs EU Project [5]Cyprus","page":"712-721","source":"HAL Archives Ouvertes","event":"Fifth Congress of the European Society for Research in Mathematics Education (CERME 5, "Falling Body" is inspired by research done by the Boxer group directed by Andrea di Sessa at Berkeley [6]. Both activities were developed on the basis of an innovative approach: in "Falling body" students use computational environment to build models of free fall motion. In "guess my Garden", pupils share models to develop random phenomena concepts.

*Falling Object:* Developing models of phenomena by students learning science is advocated, but difficult to pursue due to the complexity of dealing with the required math (i.e. algebra and calculus). "Programming-based representations might be easier for students to understand than equation-based representations" [7] for the purposes of physics instruction, algebraic notation with a programming language. Whatis novel is that, more than previous work, I take seriously the possibility that a programming language can function as the principle representational system for physics instruction. This means treating programming as potentially having a similar status and performing a similar function to algebraic notation in physics learning. In order to address the implications of replacing the usual notational system with programming, I begin with two informal conjectures: (1 "... laws of nature expressed as simple programs can be run, and students can see the effects of the laws, for example in actual motion of objects. In developing their own versions of laws, students can see, consider, and react to their symbolic hypotheses" [6]. Based on the ideas outlined above Andrea di Sessa developed an activity on falling body where students reconstructed Galileo's law by writing programs. Students are asked to write a program simulating the motion of a ball dropped from someone's hand. The simulation is constructed (Fig. 2) using a tick model, i.e. at each tick of the clock we calculate the new velocity and positon of the ball. Since the tick of our clock is the basic unit of time we multiply by 1, so we can leave out the time interval from our calculations. For constant velocity we just add the velocity to the position; for constant acceleration we update the velocity adding the acceleration. Combining the two instructions we get a model of free fall.

Fig. 2 shows Scratch implementation of the tick model. By repeating the instructions, the ball is animated while the "dot" command leaves a mark at its current location. Students construct their model interacting with the output of their developing definition.

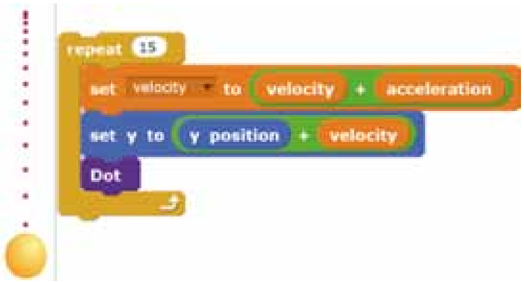


***Figure 2:** Tick model of free fall*

Depending on the age and time available, the activity includes developing simulation of: dropping a ball, tossing a ball, and dropping a ball with non-negligible air resistance.

This activity has been replicated by Di Sessa group in many classrooms, from late elementary school through high school. Furthermore, Di Sessa "Falling Object" has inspired a similar activity developed by Alan Kay [8].

Guess my Garden: Guess my Garden has the objective to cross the difficulties of pupils to understand probability by standard approaches [9;10]. The activity was based on a microworld, the Random Garden, for representing random generators manipulating their sample space (i.e. the list of all possible outcomes of the generator); thus a dice is modelled by inserting the number 1 to 6, un unfair dice will have some numbers replicated, etc.

A random generator (Fig. 3) is an artefact that extracts at random one of the item it contains. The item extracted is automatically reinserted after the extraction.

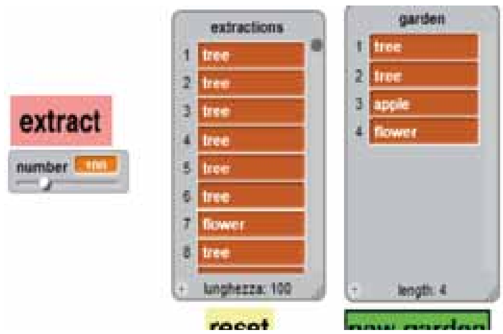


***Figure 3:** A random number generator*

The activities do not guarantee that the meanings constructed by the pupils are coherent with mathematics or with the teacher's educational goals. Such coherence should be achieved by means of mathematical class discussions orchestrated by the teacher [11].

This lesson plan was executed in different middle Italian school by a teacher with the assistance of researchers [12].

## 2. Classroom testing

A new version of the two learning scenarios "Guess my Garden" and "Falling object" has been developed for ISE authoring tools, aiming at making the activities independent of the presence of researchers. To this end the two activities were restructured following the approach described above. Furthermore, the modelling aspect of the activities have been re-implemented since they are based on programming environments no longer available (ToonTalk [13] for Guess my Garden and Boxer [14] for Falling Body). In the new version we use Scratch [15] a cloud based programming environment that runs on a browser.

Both scenarios are based on the results of previous projects. A common characteristic of activity developed within research project is involvement of researchers in classroom testing. The research phase aims to overcome major learner difficulties within a subject domain through innovative approach. Part of the innovation implies a different role for the teacher in the classroom i.e. from instructors to guide of the students' inquiry activity. This point is crucial for the success of the same activity when scaled up to actual classroom situation.

By analysing classroom testing done in the research phase of the two proposed activities we have identified some critical aspect of educational scenarios:

Students should be allowed take different approaches and make errors. Both are important elements of a learning process and key elements of a fruitful discussion. The teacher role is more of a guide than that of an instructor.

On-line activities and use of computers tools should be complemented by reflections on their results by production of written reports.

The two lesson plans assume the use of tools like modelling and simulations. Familiarity with the tool is a key to the learning process. I.e. time should be allocated for non-casual encounter with the tool.

The transposition of the original research activities into the ISE learning scenarios attempts to scaffold the learners via a strong structuring of the activities with emphasis on group discussion and reflection.

The ISE authoring tool allows us to incorporate problem solving questions within the learning scenario. The delivery and analysis of the test is automatized allowing the teacher to monitor their class average performance and compare it to current PISA results on problem solving. Here is an example of problem solving question of "Guess my Garden":

"The random garden configuration that is equivalent to a game of two dices has:

36 items in total. Throwing two dice we can get a total of 36 different combinations since each die has 6 possible outcomes.

One instance of 2 and one of 12, since there is only one possibility to get them: (1,1) and (6,6).

7 as the most repeated item. Because this the item with the largest number of possible combination: (1,6), (6,1), (2,5), (5,2), (3,4), (4,3)."

Note that all answers are correct, while answer a) corresponds to high performance; b) to low; c) to moderate.

This built in feature of the ISE environment will help us assess the scalability of our approach. In addition, we will use the Nature of Science [16] pre/post test to assess students change of perception on the experimental science practices. We will collect students written reports to monitor the actual unfolding of the inquiry processes Finally we will gather information on the teacher role in delivering the scenario with the classroom to assess the teacher dependent part of the approach.

If all conditions describe above will be fulfilled, we expect to record a significant difference in student's response between pre and post test on nature of science. Moreover, average of answer to problem solving question shall be similar or above to European mean value based on PISA 2012 Framework. Other useful information will be obtained by analysing student's reports to observe the evolution of ideas, language, and science concepts.

To test our hypothesises we sent a call to school aimed at recruiting between 5 and 10 Italian middle school teachers located in Genoa. We are currently testing the activities with 8 local teachers. Only one out of eight expressed an interest in testing "Falling Object", this is likely due to the stress of the Italian curriculum on probability while the physics and math of motion at the lower secondary level is considered optional for in depth treatment. As a consequence, we will only focus on data coming from the "Guess my Garden" trial to assess our hypothesis.

The remaining of the paper discusses the adaptation of the original activities to the ISE context.

## 3. Guess my Garden

In this section a brief description of the educational scenario's learning activities is provided.

*SMALL TALK (Orienting & Asking Question):* The first two phases of experiment involve reflective and practical activities aiming at exploration and consolidation of some key issues related to randomness (e.g. unpredictability, fairness, indeterminism, random walks, etc.). In the first phase pupils collect, propose, and analyse sentences, talks, and episodes related to randomness. Pupils write individual reports and discuss some of the emerging items with the rest of the class. Each considered item is discussed in terms of key questions such as "is it random or not?", or "is it predictable or not". The results of the discussions are reported in a shared class document.

*RANDOM WALK (Hypothesis Generation & design):* The second phase is based on the simulation of a random walk (fig. 3). In the original "Guess my Garden", the random walk was done with LEGO robots: students built the robot and play with it [17]. The robotic parts of the original activity have been removed to facilitate the adoption of the activity reducing the required lab resources and time. In the simulation, each step of the car is controlled by the toss of a coin: if head move forward, else move back (Fig. 4). Before play with the car, students predict if the car might fall off the table. The fall of the car is a counter-intuitive hypothesis not supported by everyday experience. After experimenting with the simulation, either individually or in small group, the students write a report of their experiments. The reports are used by the teacher to promote a classroom discussion.

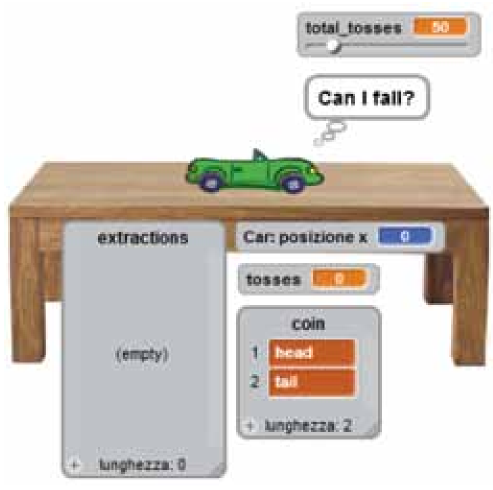


***Figure 4:*** *The random walk simulation*

*RANDOM GARDEN (Planning & Investigation):* The Random Garden is a microworld, for representing random extraction processes. By modifying the list of items in the "random garden" the students manipulate the sample space of their random generator (Fig. 3). In this activity students work in small groups. One group design a random generator while another attempts to predict its content by analysing the extractions. Students alternatively play the role of garden's builder and garden guesser. To analyse the extractions students copy the list of extractions in a spreadsheet to count and plot the number of individual occurrences of the extractions. The original ToonTalk implementation used specific capabilities of this programming environment to implement both the random generator and analysis tool in the same environment. In ISE we choose to simplify the programming side moving the analysis into a tool more familiar and transparent to teachers. Again, the students build a report on what characteristics make a garden easy or difficult to guess and the strategy used for guessing it.

*GUESS MY GARDEN (Analysis & Interpretation): T*he "Guess my Garden" game. can be organized as a contest within a class, several classes or schools. The rules of the game set a limit to the number of item in the garden (e.g. 12) and the time for guessing. The team that discover the content of the opponent with the least number of extractions or less time wins. After the game the teacher design a test based on the random generator proposed for the game to foster a discussion leading to a definition of probability associated with the content of a sample space. The game is an important part of the educational scenario engaging students in motivating activities that allow for an extensive exposure and investigation of the tool. The rigid set of rule provide scaffolding for guiding the exploration of the activity. A familiarity with the affordances of the random garden is a prerequisite for successful inquiry.

*RANDOMPEDIA (Conclusion & Evaluation)*: The inquiry on randomness is concluded by combining the previous reports in a final document written following an encyclopaedic entry stile (for example those in Wikipedia, as suggested by the name chosen for this activity). If possible, the document should be written for an audience and include references to textbook descriptions of the subject at hand. In this phase the traditional instructor role of the teacher is prominent.

### 3.1. Inquiry in Guess my garden

The "Guess my Garden" learning scenario in ISE includes a detailed guide on how to structure the activities, the tasks for the various actors involved, and reminder for the preferred teacher role in a given task. Table 1 summarizes the content of the teacher guidance in the scenario.

The table schematically reports a brief description of the actors' tasks for each learning activity of the ISE inquiry model.

***Table 1:*** *Guess my garden lesson plan.*

| **Small talk** (1 hours) | |
|---|---|
| **Actors** | **Task** |
| Individual | Describe everyday situations involving randomness in a report |
| Whole class | Small talk about random, main results of discussions are reported in a shared class document. |
| Teacher | Introducing random/non-random and predictable/non-predictable classification and motivating students. |
| **Random walk** (2 hours) | |
| **Actors** | **Task** |
| Individual/ Small group | Students experiment with the random walk simulation; collect data of actual coin's tosses; and write a report. |
| Whole class | Classroom discussion and report on both results of random walk and coin's tosses. |
| Teacher | Assistant and guide classroom discussion |
| **Random Garden** (2hours) | |
| **Actors** | **Task** |
| Small group | Pupils become friendly with random garden and plan the group strategy for the next game. All information must be write on a report |
| Teacher | Assistant |
| **Guess my garden** (2 hours) | |
| **Actors** | **Task** |

| | |
|---|---|
| Small group | Analyse the extractions and guess the garden. Formulate of a strategy for the next game. |
| Whole class | Classroom discussion about garden, components of garden to be hard to solve, the concepts used for guess, how many extractions are necessary. |
| Teacher | Judge of the game. Provides students with examples of gardens to solve. Assistant during discussion. |
| **Randompedia** (1hour) | |
| **Actors** | **Task** |
| Whole class | Randompedia report |
| Teacher | Ensure correctness of content including proper reference to text book |

## 4. Conclusion

A new version of the two learning scenario "Guess my Garden" and "Falling object" has been developed for ISE authoring tools.

The adaptation has the aim of making available innovative approaches from previous research while ensuring autonomous use by the teacher in standard classroom settings.

The inquiry model incorporated in ISE the authoring and delivery tool provides a template for guiding the activity. Guidelines for the teacher have been developed and incorporated in the educational scenario. We assume that this transposition may foster they independent use by teacher. In parallel, we have developed a number of assessment measures to validate our hypothesis. These measures include the problem solving question building to the ISE delivery tool, the Nature of Science pre/post test, analysis of students written reports, interviews with the teacher to elicit their actual role played in the phases of the learning scenario.

We are currently testing our approach with Italian middle school teachers; the classroom trial is in progress.

## 5. Acknowledgements

We would like to thank Andrea di Sessa for the "Falling Body" activity and numerous past discussions with one of the author on the Boxer approach to physics learning. The "Falling Object" adaptation to ISE of is our own independent work. Michele Cerulli was a key member of the ITD team developing "Guess my Garden", Yishay Mor from the Weblabs project contributed to its design and development.

The ISE project has received funding from the European Union's ICT Policy Support Programme as part of the Competitiveness and Innovation Framework Programme. This paper reflects only the author's views and the European Union is not liable for any use that might be made of information contained therein.

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# Following Curiosity on Mars

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## Abstract

*Students will follow the rover Curiosity on its way to the red planet Mars by using the World Wide Telescope.*

*The didactical approach is based on scientific inquiry in order to give students the enjoyment of finding out for themselves and initiates appreciation of the nature of scientific activity, of the power and the limitations of science.*

*The main question will be: Where is Curiosity now? The educational activity will benefit of e-learning tools like World Wide Telescope-WWT and some web resources.*

*Because students will have to solve a real problem of the humankind - finding a new house for humans, they will have to accompany the rover Curiosity on Mars. The final product of the teams of students will be the presentation of the journey slide show and of Mars bussines card.*

## Keywords

Inquiry-based learning, ISE portal, World-Wide Telescope, Research on Mars' surface, Curiosity rover.

## 1. Introduction – goal and aims of the lesson

In this case students will have to follow the rover Curiosity on its way to the red planet Mars by using the World Wide Telescope.

This lesson is in connection with the following Big Ideas of Science Education [1]:

6. The solar system is a very small part of one of millions of galaxies in the Universe.

10. The diversity of organisms, living and extinct, is the result of evolution.

And it is also connected with:

11. Scientific explanations, theories and models are those that best fit the facts known at a particular time.

12. The knowledge produced by science is used in some technologies to create products to serve human ends [1].

The main goal of this learning activity is that students will gain experience in the use of maps, measurements and observations to determine location of objects. The aims are:

– Identifying questions that can be answered

through scientific investigations.
- Documenting and exploring the Mars surface by using the World Wide Telescope.
- Developing descriptions, explanations, predictions, and models using evidence.
- Thinking critically and logically to make the relationships between evidence and explanations.
- Communicating scientific procedures and explanations.
- Presenting the main ideas of every team's project.

## 2. Description of the activities

The lesson is based on scientific inquiry in order to give students the enjoyment of finding out for themselves and initiates appreciation of the nature of scientific activity, of the power and the limitations of science [2].

The main question will be: Where is Curiosity now?

Hypothesis: Is Mars planet appropriate for sustaining life as we know?

The educational activity will benefit of e-learning tools like WWT, and some web resources. Because the students will have to solve a real problem of the humankind they will have to accompany the rover Curiosity on Mars.

The final product of the teams of students will be the presentation of the slide show.

*1st learning activity*: Making Mars business card

**Task**: Search on: http://space-facts.com/mars/

and also use World Wide Telescope in order to complete Planet Mars business card!

Mars is the fourth planet from the Sun. Named after the Roman god of war and often described as the "Red Planet" due to its reddish appearance, Mars is a terrestrial planet with a thin atmosphere composed primarily of carbon dioxide. Mars and Earth have approximately the same landmass. Even though Mars has only has 15% of the Earth's volume and just over 10% of the Earth's, around two thirds of the Earths surface is covered in water. Martian surface gravity is only 37% of Earth's (meaning you could leap nearly three times higher on Mars).

Mars is home to the tallest mountain in the solar system, Olympus Mons, a shield volcano, is 21km high and 600km in diameter. Despite having formed over billions of years, evidence from volcanic lava flows is so recent many scientists believe it could still be active.

*2nd learning activity*: Mars Odyssey or trying to conquer this planet

**Task:** Create a timeline of all the Martian missions.

Search on: http://mars.jpl.nasa.gov/programmissions/missions/log/

Search also on: http://mars.jpl.nasa.gov/odyssey/

*3rd learning activity*: The rover Curiosity on Mars

The Mars Science Laboratory will begin surface operations soon after landing in August 2012 and continue for at least one Mars year (approximately two Earth years). The overall scientific goal of the mission is to explore and quantitatively assess a local region on Mars' surface as a potential habitat for life, past or present. The MSL rover is designed to carry ten scientific instruments and a sample acquisition, processing, and distribution system. The various payload elements will work together to detect and study potential sampling targets with remote and in situ measurements; to acquire samples of rock, soil, and atmosphere and analyze them in on board analytical instruments; and to observe the environment around the rover.

The MSL mission has four primary science objectives to meet the overall habitability assessment goal:

The first task is to assess the biological potential of at least one target environment by determining the nature and inventory of organic carbon compounds, searching for the chemical building blocks of life, and identifying features that may record the actions of biologically relevant processes.

The second task is to characterize the geology of the landing region at all appropriate spatial scales by investigating the chemical, isotopic, and mineralogical composition of surface and near-surface materials, and interpreting the processes that have formed rocks and soils.

The third task is to investigate planetary processes of relevance to past habitability (including the role of water) by assessing the long timescale atmospheric evolution and determining the present state, distribution, and cycling of water and carbon dioxide.

The fourth task is to characterize the broad spectrum of surface radiation, including galactic cosmic radiation, solar proton events, and secondary neutrons. (http://msl-scicorner.jpl.nasa.gov/ScienceGoals/)

*4th learning activity*: Present your ideas regarding the way to gain a new house for humans!

Students are ready to build a slide show by using a new tour in WWT, than to present their ideas in front of the others.

Finally they will present the results of their self-assessment.

Teaching according to the inquiry-based approach can stimulate students' learning gains and their interest in science. On the other side, digital, interactive tools can be effectively used to achieve these aims. [3].

Learning science by inquiry involves the learner in raising research questions, generating a hypothesis, designing experiments to verify them, constructing and analyzing evidence-based arguments, recognizing alternative explanations, and communicating scientific arguments [4].

## 3. Inquiry-Based Science approach of the lesson

This lesson is following the instructional model of IBSE which consists of five learning activities: *Orienting & Asking Questions*; *Hypothesis Generation & Design*; *Planning & Investigation*; *Analysis & Interpretation*; and *Conclusion & Evaluation* [2].

The first inquiry based approach consists of wondering how to follow the rover Curiosity on Mars surface? (Fig.1)

How to create Planet Mars Business Card?

How to create a timeline of all the Martian missions?

What do we intend to find on Mars?

***Figure 1.*** *Orienting: Provide contact with the content and/or provoke curiosity*

Then: Can, or could, Mars support life?

How is the environment of Mars?

Use World Wide Telescope in order to search on Mars surface!

***Figure 2.*** *Generation of Hypotheses or preliminary explanations*

For finding data about Mars you can search on http://space-facts.com/mars/ and

http://www.windows2universe.org/mars/mars.html

***Figure 3.*** *Planning and investigation*

For Analysis and Interpretation: the challenge is: *Search Mars surface and try to find if us, humans, will be able to place a human settlement on Mars?*

***Figure 4.*** *Analysis and Interpretation: Gather result from data*

Finally students will present their ideas regarding the way to gain a new house for humans on Mars, after searching its surface by using World Wide Telescope. Just run your slide show and explain what you have discovered on Mars by using WorldWide Telescope for accompanying Curiosity.

It seems that one day Mars could be the second house for humans.

***Figure 5.*** *Conclude and communicate result/explanation*

3. Testing: Following Curiosity on Mars Demonstrator with students

Following Curiosity on Mars was designed for 3 class hours, in high school, 17-18 years old students.


***Figure 6.*** *Students from "'Grigore Moisil" National College testing rovers*

It was tested with students from "Grigore Moisil" National College – Bucharest, Romania. The registered videos during testing it can be watched here:

https://www.youtube.com/watch?v=klZeaDuXSnc

https://www.youtube.com/watch?v=xXsL6k0HdCk

https://www.youtube.com/watch?v=4UOsNx01WwU

https://www.youtube.com/watch?v=dWoaGkt22wo

https://www.youtube.com/watch?v=FgOi5oa7rLQ

## 4. Running Following Curiosity on Mars

This demonstrator was presented in the two series of training and demo workshops, one named "Inspiring Science Lessons - Big Ideas of Science in interdisciplinary approaches" and the other one "Inspiring Science Experimental Approaches".

The Training and demonstration workshops "Inspiring Science Lessons - Big Ideas of Science in interdisciplinary approaches" in the Inspiring Science Education Project were organized at: The Teachers House Valcea on 13th of February 2016, The Prahova School Inspectorate and The Teachers House Prahova, on 20th of February 2016, "Sfanta Varvara" Secondary School from Aninoasa, Hunedoara on 27th of February 2016, "Gheorghe Magheru" Secondary School from Caracal, Olt County on 12th of March 2016, "Grigore Moisil" National College from Bucharest, Romania, on 5th of March 2016 and 14th of March 2016, "Horia Hulubei" High School, Magurele, Ilfov county on 17th on March 2016 and Natanael High School from Suceava, on 19th of March 2016.

Almost 400 teachers of Science participated in the workshops.

***Figure 7.*** *Running Following Curiosity on Mars*

## 5. Conclusions

The ISE Demonstrator Following Curiosity on Mars was very appreciated in Romania, where the transdisciplinary approaches are recognized for increasing students motivation for learning.

The applied questionnaires at the end of the conducted workshops revealed that the ISE Demonstrator Following Curiosity on Mars has an approach of teaching and learning science which has to be continued in Romania, where we need more lessons scenarios and more Problem Solving Questions.

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# An environmental approach on the importance of Light

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## Abstract

*Light can come from the sun, a flame or a light bulb. It has many different meanings and could mean many different things in different situations. As light is necessary to the existence of life itself, mankind has made several attempts to understand its nature and characteristics, as well as to learn and control it.*

*We design and implement innovative educational activities relating light with common weather phenomena such the rainbow. We also suggest activities about the need for sunscreen use and the important health concerns on sun exposure.*

*The goals are to spark students' interest about light by addressing topics which are frequently seen in the wake of a rainstorm on one hand, and of personal health significance on the other. This paper presents the educational activities that have designed and being implemented for students from both primary and secondary education. The educational scenarios are available on Inspiring Science Education (ISE) Repositories.*

## Keywords

Environmental science, Light, Meteorological phenomena, Solar radiation, Sun Protection.

## 1. Introduction

STEM is everywhere; it shapes our everyday experiences. Moreover, high quality STEM experiences develop critical thinking skills, increase science literacy, and enable the next generation of innovators.

Thus, according to European Schoolnet (2), in order to keep Europe growing, we will need one million additional researchers by 2020. The same time the US Bureau of Labor Statistics (1) estimates that STEM professions will expand 1.7 times faster than non-STEM occupations between 2010 and 2020.

Following the above needs the European Union supports and implements a variety of important projects in STEM education – such as ISE, Go-Lab, Scientix, etc.

In the above context, the International Year of Light and Light-Based Technologies (IYL 2015) which was a global initiative adopted by the United Nations (A/RES/68/221) and has offered several opportunities during 2015. It aimed to raise awareness of how optical technologies promote sustainable development and provide solutions to worldwide challenges in energy, education, agriculture, communications and health.

Science education helps learners understanding aspects of the world around them, both the natural environment and that created through application of science, serves not only to satisfy – and at the same time to stimulate – curiosity but helps individuals in their personal choices affecting their health and enjoyment of the environment as well as for their choice of career (3).

The educational activities presented, target students from primary and secondary education. To plan these didactical proposals we have taken into account the national educational curriculum (7) and the Principles and Big ideas of Science education (3) and Inquiry Based Science Education (4).

The motivation was to help students watch, understand, enjoy and marvel at the natural world. Our educational objectives are from the Bloom's revised taxonomy (5). In order to achieve our educational objectives, we integrate Information and Communication Technology, online simulations and other resources found in Inspiring Science Education (ISE) repositories and other online educational resources.

In this context we present two educational scenarios from the field of science education - environmental science awareness - that aspire to awaken students' curiosity to nature observation and science activities, enable them to enjoy and understand science. Moreover it is desirable to prepare reasoning skills and attitudes to the future citizens of our world.

## 2. Rainbow formation as a physics teaching proposal at elementary schools

A Rainbow is a beautiful natural phenomenon which continues to impress people all over the world. It is caused by the interaction of sunlight with small water drops in the atmosphere, and it appears in the form of multicolored arcs.

Due to the curriculum, students in the 5th and 6th grades of elementary school become familiar with reflection and refraction of light (7). Following the different phases of the inquiry learning scenario that is presented, they recall what they have learned, face a common natural phenomenon, construct knowledge and develop links between their science activities and the world around them (13).

### 2.1 Phase I - Orienting & Asking questions

Using a video and some photos we try to stimulate student's curiosity about the problem we face. The learning topics are recognized and the main variables are identified. (Fig.1)

***Figure 1.*** *Using video and photos in the Orienting & Asking questions phase*

### 2.2 Phase II - Hypothesis Generation and Design

Students answer small questions, which guide them to identify all the concepts which are related to the problem. They discuss about their findings, and finally formulate their own research question on the subject, and make specific hypothesis. (Fig.2)

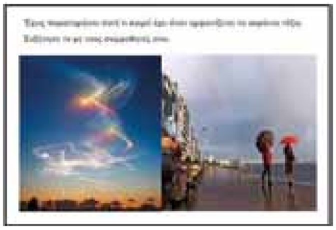

***Figure 2.*** *Hypothesis Generation and Design*

### 2.3 Phase III - Planning & Investigation

In this phase students are following a set of steps, each one corresponding to a question. At first students carry out a small experiment (6), in order to discover both the law of reflection and refraction. They next investigate and understand the mechanism of the rainbow formation by light dispersion through a prism. Afterwards they investigate in which position we can observe a rainbow. (Fig.3 a, b, c).

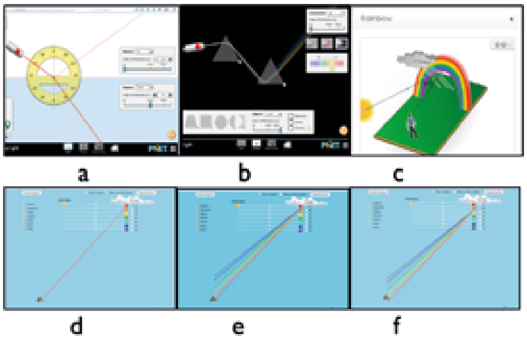


***Figure 3.*** *Planning & Investigation*

Finally they investigate the color of the beam that reaches the observer's eye from every single water drop using a simulation about rainbow formation (9) (Fig.3 d, e, f)

### 2.4 Phase V - Analysis & Interpretation

A "hands on" activity takes place. Students are asked to draw the light path when it meets travelling a surface of a new medium. This procedure is needed to make meaning out of the collected data and synthesizing new knowledge.

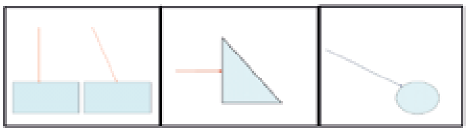

***Figure 4.*** *Analysis & Interpretation*

### 2.5 Phase VI- Conclusion & Evaluation

Each team makes their own conclusions by answering a set of questions which guide them to picture out the outcomes of their research. They discuss and finally present their work in a collage or an electronic presentation.

## 3. Sun protection education as an introduction to many different curriculum areas.

Overexposure to ultraviolet (UV) radiation from the sun and artificial sources is of considerable public health concern. Children are particularly at risk as sun exposure during childhood and adolescence appears to set the stage for the development of both melanoma and non-melanoma skin cancers in later life and other health effects.

Schools are an excellent place to teach healthy behaviors such as preventing overexposure to UV radiation. More specifically children are more acceptable to adapt new skills and behaviors – sun safe behaviors – in the school environment (11).

In the following didactical proposal we hope to arouse students' curiosity about the consequences' of sun exposure, prove the necessity of sun protection and built attitudes and habits not only for the school time but for their future life (14).

### 3.1 Phase I - Orienting & Asking questions

In this phase students are able to recognize the learning topics. We trigger student's curiosity using videos relative to the subject. (Fig.5)

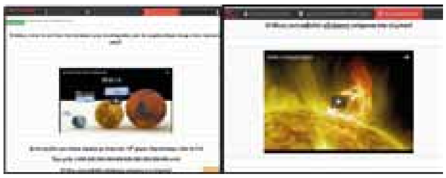

***Figure 5.*** *Using video in the Orienting & Asking questions phase*

### 3.2 Phase II - Hypothesis Generation and Design

Students formulate their own research question on the subject by answering guided questions, and discussing about their findings. (Fig.6)

***Figure 6.*** *Hypothesis Generation and Design*

### 3.3 Phase III - Planning & Investigation

During this phase students are following a set of steps, each one corresponding to a question. By watching videos, they learn fundamental notions about sun, solar radiation and sun protection. Students discover the importance of sun protection by watching a simulation about solar rays reaching the earth during a year and an experiment about ultraviolet radiation detection.

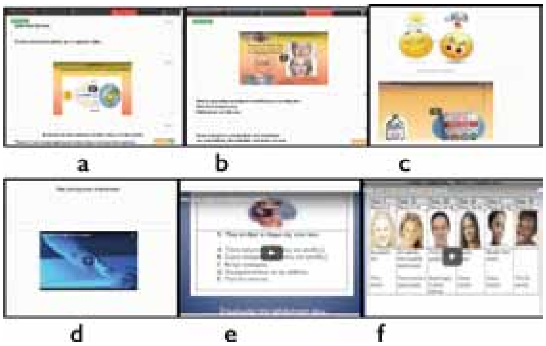


***Figure 7.*** *Planning & Investigation*

Finally they take a quiz in order to discover their skin type, according to the Fitzpatrick Skin Type scale (12). (Fig. 3 a, b, c, d, e, f).

### 3.4 Phase V - Analysis & Interpretation

Students conduct a small statistical analysis by counting the number of students of each Fitzpatrick Skin Type. They discuss the sunscreen use (12).

### 3.5 Phase VI- Conclusion & Evaluation

At the classroom we present our conclusions to each other and we discussed about the final results of our project. The extension of our knowledge is accomplished by presenting an everyday agricultural activity. (Fig. 8)

***Figure 8.*** *Discussion*

## 3. Conclusion

From the didactic point of view, both the topics of the rainbow formation and the sun protection involve scientific inquiry (search, describe, explain, predict a natural phenomenon), scientific literacy (speaking, listening, interpreting, reading and writing about science) and scientific numeracy (maths provide tools for description, analysis and presentation (8). They can become a rise for awesome activities including science and art.

In summary, we state that the above educational scenarios lead students working in teams as researchers, questioning and exploring a certain subject, and result their own conclusions.

It will possible be a valuable teaching aid for teachers who believe in the role of science in daily life. Particularly to ones who support that early science education should enable every individual to become an informed citizen who can take decisions and appropriate actions that affect positive their own lives, the society and the natural environment.

Additionally, it may lead more students to choose studying science and take up occupations requiring scientific knowledge.

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# The steps for elaboration of the “Rosetta stone” demonstrator

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## Abstract

*The Rosetta Stone is a granodiorite stele, found in a small village in the Delta called Rosetta, with writing on it in two languages (Egyptian and Greek), using three scripts (hieroglyphic, demotic and Greek) with a decree issued at Memphis, Egypt, in 196 BC on behalf of King Ptolemy V. Because it presents essentially the same text in all three scripts (with some minor differences among them), the stone provided the key to the modern understanding of Egyptian hieroglyphs. The demonstrator implies the idea to learn a language, through immersion, as a direct result of being a part of the culture and the world of the country of the respective language, instead of sitting in a classroom. To use computer technology to simulate the way that people learn their native language—with pictures and sounds in context, and with no translation. As a result, we use the idea of the Rosetta stone phenomena to elaborate interactive technology-based learning solutions that are dedicated to changing people’s lives through the power of language and literacy education.*

## Keywords

Demonstrator, Rosetta Stone assessment, problem solving skills, technology-based learning, Egyptian script

## 1. Introduction

The ISE project funded by the EU aims to develop key competencies. Each competency should be seen as a combination of three elements (knowledge, skills and attitudes) knowledge of which varies depending on the context requires.

ISE Demonstrators are part of service-oriented architecture where learning experiences are dynamically constructed taking into account user profiles and pedagogical templates based on inquiry based science methods.

## 2. Learning objects

Current developments in eLearning have promoted the concept of reusable learning objects. Traditionally, learning was organized in lessons and courses covering predefined objectives. In eLearning environments the material is broken into smaller independent pieces named learning objects that can be used as they are or in combination with other material to form higher level objects covering the learning needs of the users on demand and at the right time. In this context, the fundamental idea behind learning objects is that instructional designers can build small instructional components that can be reused a number of times in different learning contexts [Wiley, 2002]. Learning objects are stand-alone pieces of information that are reusable in multiple contexts, depending on the needs of the individual user. The important question should be the granularity of such an object, topic of many discussions. Different content models addressing granularity of learning objects are resulting in different implementations (reviewed by Verbert and Duval, 2004, 2008; Balatsoukas, Moris, and O'Brien, 2008). Also different pedagogical approaches may be used, requiring different implementations of learning objects. Many times the pedagogical approach is strictly bound with the learning object, reducing the possibilities for reusing this object in different contexts.

The proposed definition to be used for learning object is a collection of digital materials — pictures, documents, simulations — coupled with a clear and measurable learning objective.

The proposed definition to be used for learning scenario is a priori description of a learning situation, independently of the underlying pedagogical approach. It describes its organization with the goal of ensuring the appropriation of a precise set of knowledge, competences or skills. It may specify roles, activities and required resources, tools and services.

The proposed definition to be used for lesson plan is instructor's road map of what students need to learn and how it will be done effectively during the class time.

Based on these three definitions the authors bring out the following definition for **ISE demonstrator**: *Realized learning scenario, based on appropriate lesson plan(s), consisting of learning objects, elaborated using inquiry based science methods.*

## 3. What are the steps to elaborate a new ISE Demonstrator?

A scientific demonstration is a scientific experiment carried out for the purposes of demonstrating scientific principles. In science classrooms as well as in many other fields and locations, models are used either as visual aids or to demonstrate a principle or process. For the realization of an ISE Demonstrator, we adhere to the scenario template and step-by-step guidance for planning the lesson.

The authors used the five step scenario template for the ISE Demonstrators:

Identifying the target audience and analyze their needs was the first step for elaborating the demonstrator. The important part was to define the competence level of the targeted auditory for the subject of the ISE Demonstrator and their expectations on the outcomes. In the second step was important to identify the learning needs of the target group and the expected outcomes of the ISE Demonstrator. (When the target audience is well known, one can determine their wants accurately and formulate the ISE Demonstrator outcomes accordingly). The learning outcomes shaped the goals of the ISE Demonstrator. They were to be achieved by means of objectives, formed like tasks implemented in the ISE Demonstrator accordingly. To pick the most relevant ones determining the learning outcomes a DIF (using **D**ifficult, **I**mportant, **F**requent parameters) analysis was done. The third step included choosing the situation for the ISE demonstrator forming the appropriate level of interaction. Choosing the appropriate type of ISE Demonstrator (Skill-Based, Problem-Based, Issue-Based, Speculative, or Gaming) formed the forth step. The fifth step included the design of the ISE Demonstrator from Identification of a realistic trigger event, through creating a believable and relatable protagonist toward turning feedback into effective instructional tools. As shown on

Fig. 1, specifying concrete objectives for student learning helped to determine the kinds of teaching and learning activities to be used in class, while those activities defined how to check whether the learning objectives have been accomplished.


***Fig. 1***

In addition to keep ISE Demonstrator Quality standards on every step we had to take into account the following criteria. The elaborated ISE Demonstrators should be well-defined, inquiry based, working (with all links and material available), simple to use, adopt and change. They should be relevant, inspiring and motivating to learners and teachers, connected with real world problems and to a Big Idea of Science. The last, but very important step was the evaluation process of the ISE Demonstrator.

## 4. How did we apply these steps on the "Rosetta Stone" ISE Demonstrator?

At some point during the fourth century, all knowledge of ancient Egyptian scripts was lost, leaving no method available to decipher the language of hieroglyphics which had been richly preserved on ancient Egyptian monuments, stone tablets, and sheets of papyrus. Fortunately, while on an expedition to Egypt in 1799, Napoleon's army discovered an artefact which has become known as the Rosetta Stone. This stone contained the inscription of a decree issued in 196 BC by Ptolemy V Epiphanes. The decree was repeated three times in two languages, Greek and Egyptian, with the Egyptian version appearing twice, once in hieroglyphics and once in demotic, a cursive form of the hieroglyphic script. Fortunately, there is an abundance of information on ancient Greek dialects and therefore, the stone's Greek version of the decree contained the key to decipher the meaning of the ancient Egyptian texts. Today, because of the Rosetta Stone, we can interpret many ancient texts and inscriptions of Egyptian hieroglyphic and demotic scripts found on sheets of papyrus and monuments throughout Egypt.

One of the big challenge in crafting a learning experience is figuring out how to engage the learners. All groups of learners are different from one another – they all learn in a different way – they have different styles of learning. There are many ways to create engaging and interactive learning. The key is to engage the learner and create an experience that is memorable and enjoyable as well as educational. Moreover, taking into account the previous knowledge (background) of Learners can significantly reduce learning time, since learning activities that are intended to fulfill learning goals that have been already fulfilled at a satisfactory (for the Learner) level in the past could be excluded from the learning experience. All these factors have to be decided by the teacher himself. Keeping in mind the objective and subjective factors, the teacher can change the lesson in depending education level.

**The first step before** we start the implementation of the scenario was to determine the age category to which is directed the educational material.

Ancient Egypt is of interest to small and large pupils, since today is difficult to explain how the Egyptians have reached such heights of development of society, culture, art and construction, more than 3500 years BC. Restricting the age category helps in determining the depth of facts interpretation. Determinant of putting age limits are the national requirements for the education program in “history and civilization” of the Bulgarian school, where the 7-th class is determined.

Since the material is not completely historical, as it relates to language learning and linguistics and art and methods such as induction, analogy etc, it can be used in optional courses and compulsory classes.

For the realization of the demonstrator, we adhere to the scenario template and step-by-step guidance for planning the lesson taking into account the requirements of the education program in “history and civilization” of the Bulgarian school for the 7-th class.

Formulated were some questions to verify the general level of knowledge of the material related to the history of Egypt. Before answering questions students were asked to track video to recap the most important elements related to the power of Egypt and the building of the pyramids.

The teacher was facilitated to draw the attention of students to the main purpose of the lesson - Egyptian script and its main characteristics and elements of the shaped letter - pictograms and ideograms

Proposed were several tasks illustrating these concepts. The main objective of these tasks was to connect shaped letter use in everyday life e.g. signs, road signs and emoticons. In the proposed and elaborated tests was provided a field where students could record their answers. It was elaborated with the Google form tool, which allows the teacher to collect and analyze the submitted responses. These tests were designed to test the observation abilities of students in reading unfamiliar circuits or signs, which was an important prerequisite for orientation in real life.

In the next step of the scenario, the teacher gave factual opening and attempts to read the Rosetta Stone. He directed students to the main findings, which had made Champollion in his discovery. A hypothesis was raised what could be done to match hieroglyphic writing to the Latin alphabet and thus planning the investigation how students could express their thoughts by the means of Egyptian hieroglyphs. While resolving the proposed tasks students themselves had to make the correlation between the Latin alphabet and hieroglyphic writing.

Important part of the demonstrator was oriented toward analysis and Interpretation. In this phase of the lesson students were given the opportunity to decipher and code texts. To achieve this ability it was necessary to translate the texts written in hieroglyphic letter in English and then in Bulgaria and vice versa. This exercise was very similar to the deciphering of the Rosetta Stone, as Champollion did, based on his knowledge of Greek and Coptic languages and alphabets (the languages in which the Egyptian inscription was done).

With the help of questions the teacher facilitated reaching the conclusions that on this principle of change of the letters with hieroglyphs or with other characters was based the encryption of texts and as application the digital codes of computer code tables and characters.

Taking into account the level of competence of the students the teacher could show the table with the character set in the computer. He could create an example, using the Code function in Excel, which displays the codes of the characters.

## 5. Evaluation and assessment of the “Rosetta stone” Demonstrator

The Rosetta Stone Demonstrator enables teachers to use in their lessons factual material that is related to Egyptian culture. The purpose of this demonstrator is students to become aware of the interactions between different languages and their structure. To boost their motivation for learning new languages by revealing the unity in diversity, and the common features of various cultural and linguistic forms.

In the demonstrator, the comparative method by which the Rosetta Stone has been translated was used. This is the basic method for solving linguistic tasks as they are presented to students. Linguistic tasks are essentially logical tasks. They help us to look more closely at the symbols displayed, and search for matches, for explanations of what we see, to connect it with our previous knowledge, and develop our observation skills. As a "added effect" we expand our knowledge and the relationship between the various disciplines taught in school. Many current teachers have limited experience with DEMONSTRATORS software from the learners' perspective and may be novices as well using this technology for teaching. Unlike textbooks, software structure of Demonstrator is often not transparent and can be difficult to "skim" for both content and program operation. Additionally, it could be difficult to get a fully operational version for evaluation.

So evaluation of the Demonstrator referred to the process of investigating it to judge its appropriateness for a given subject learning setting, identifying ways it may be effectively implemented in that setting, and assessing its degree of success and determining whether to continue use or to make adjustments in implementation for future use. We could think of these three stages respectively as selection, implementation, and assessment. Considerations of implementation could and arguably should be an integral part of the selection process. Assessment was carried out by the target group for which the Demonstrator was elaborated. It was invincibly made by teachers/tutors - professionals who should use it in the educational process and by learners - direct users of this content. The evaluation was done as traditional assessment using conventional methods (driven by checklists or forms, guided by appropriate methodological frameworks or linked to theory and research-based criteria) and as performance based assessment, measuring student's creativity and the level of application of the obtained knowledge in real-life contexts. The key in evaluation was to determine whether the teaching presence in the Demonstrator (that either do not involve tutorial software or represent blends of tutorial and tool-oriented applications) in combination with the content was effective for the given objective.

The authors used the modified Jamieson, Chapelle, and Preiss (2004) criteria which was operationalized for a judgmental analysis of the Demonstrator. The following parameters were accounted:
*learning potential of the Demonstrator:* The degree of opportunity present for beneficial focus on form;
*Learner fit of the Demonstrator:* The amount of opportunity for engagement with the Demonstrator under appropriate conditions given learner characteristics;
*Meaning focus:* The extent to which learners' attention was directed toward the meaning of the Demonstrator;
*Authenticity of the Demonstrator:* The degree of correspondence between the learning activity and target activities of interest to learners out of the classroom;
*Positive Impact:* The positive effects of the Demonstrator activities on those who participated in it;
*Practicality:* The adequacy of resources, supporting and being used in the Demonstrator.
The following scheme (Fig. 2.) for evaluation was used:

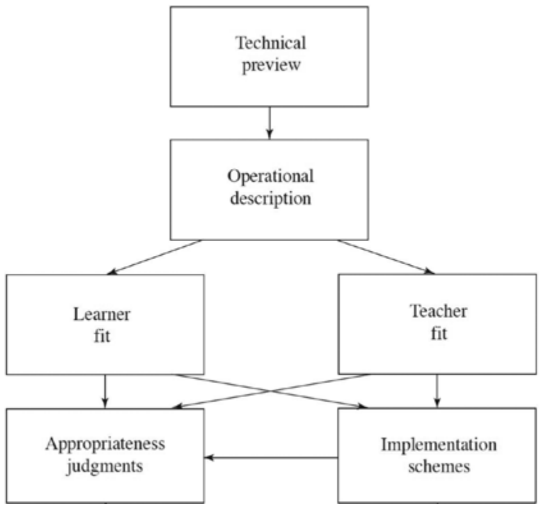


***Fig. 2***

## 5. Conclusions

The "Rosetta stone" demonstrator is working issue-based demonstrator. It is well-defined, inquiry based, simple to use, adopt and change. It is relevant, inspiring and motivating to learners and teachers of the 7-th class of the Bulgarian school (students of age 13~15), but is appropriate also for the secondary schools of the country.

The "Rosetta stone" demonstrator is connected with real world problem. It exploits a Big Idea of Science.

It contains big learning potential, showing the root of coding and of linguistic semantics.

It gives great opportunity to learners for engagement and attraction of their attention.

It drives attention to everyday activities of the target audience explaining semiotic meanings.

It uses adequate resources in support, thus having high practicality.

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# Fostering connections among Improvisational Art and Science Education. The implementation of "Meaning Generating Trajectory"

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## Abstract

*This presentation describes work-in-progress and initial activities of the implementation of improvisation and creativity in Science Education. The main objective of this presentation is the description of a learning theory which argues that the art of improvisation, although derived from the experiences of improvisation in theatre, can be customized in STEM courses. Through a special constructed 'meaning generating trajectory', improvisation theory, creativity and inquiry-based learning (IBSE) alternate components of art of 'improv' (spontaneity, engagement, social and interactive skills, investigation, creativity, reflection) and science learning theories (experience of every-day life, collaboration, digital artefact, scientific method, gamification, evaluation). Finally, a brief qualitative analysis of science theatre activities -which took place in Greece-based on the 'meaning generation trajectory consist the initial meaningful and inspiring activities of this research..*

## Keywords

Improvisation, Creativity, Science Theatre, Scientific Method.

## 1. Introduction

Since the beginning of the 21st century, the theory and research associate creativity with cognitive, psychometric and humanitarian aspects, emphasizing different disciplines [1]. Thus, more and more researchers recognize that creativity is a social phenomenon with main elements the motivation, the interaction and the disposal [2], [3], [4]. Regarding the interconnection of creative dimension to education, modern research and practice show that students tend to have the ability to be creative in terms of everyday life [5], [6]. Meanwhile, Eisner [7] developed the strong opinion that students are creative meaning-makers, mainly through the arts. At this point it appears the role of improvisation. The concept of 'improv' is identified in the fields of arts [8] and in Managerial or Organizational Improvisation [9]. However, there are few studies stressed on improvisation performance during the teaching practice [10].

## 2. Literature Review

In modern literature and practice out various approaches to creativity in education describingit as a "democratic" approach. Banaji [11] analyzed in Democratic Politics Creativity, Unique Creativity, Creativity for Social Interest, Economic Creativity, play and Creativity, Creativity and Knowledge, Creativity in Technology and Creativity in the Classroom. About creativity in the teaching of natural sciences the following modern definition prevails:

"Deliberate and imaginative activity that produces original and unique results with respect to the student. This occurs through the creation of individual or social ideas and strategies, which are justified critically and generate consistent with the available evidence, explanations and strategies" [12].

Berk & Trieber [13] argue that the art of improvisation, although derived from the experiences of improvisation in theater, can be customized in the classroom if exploit the features of the new generation (Net Generation), multiple intelligence and learning styles, as well as, diversity of cooperative learning activities that already take place in a student-centric environment. Thereby, improvisation organized in cooperative learning activities, can be a powerful tool for deep learning.

There are four basic didactic reasons the use of improvisation: a) is in line with the characteristics of the current generation of students, known as the Internet Generation [14], b) touches multiple intelligence and the emotional intelligence (EQ), c) enhances collaborative learning and d) promotes deep learning through active participation of new ideas, concepts, or problems connecting activities with previous knowledge, adapting the content to real-life matters and evaluating the results presented within by reflection [15], [16].

## 3. Meaning Generation Trajectory

Based on the theories developed above, we tried to create a conceptual trajectory that illustrates scientific meaning generation through improvisation and creativity.


***Figure 1:*** *Meaning Generation Trajectory*

Initially, the role of 'spontaneity' in educational science was mentioned by Vygotsky [17] who characterized the superior knowledge, as the argument emerges from everyday spontaneous common sense activities. Similarly, according to Cua et al. [18] formal education requires spontaneous learning from everyday life experiences.

The second track refers to the role of active involvement (engagement) during the learning process. In this field, we have to stress the role of improvisation in the social and interactive skills of the students. According to Merrell & Gimpel [19], social and interactive skills are not easy to define, because of the variety of definitions under the light of different disciplines. For this reason, there are 7 elements to identify social skills, which: a) is prime search during learning, b) contain specific and distinct verbal and nonverbal behaviours, c) involving effective and appropriate imports (initiations) and responses, d) optimize social assistance, e) is inherently interactive f) social performance is affected by the behaviour of the participants and the environments within which they occur, g) deficits and excesses in social performance can be traced to interference.

Inquiry Based Learning (IBSE) is the way that scientists work and activities through which students learn both the scientific concepts and scientific processes [20]. The final component of this trajectory is the 'Reflection' on the results that are presented and evaluated by both the students and teachers. Specifically, as indicated by Tavares et al. [21] through the use of specific research protocols for the evaluation and reflection of the Science study through exploratory methodology (IBSE) gives several benefits, such as active and enhanced by numerous sources create meanings for natural phenomena.

Consequently the sequence of a meaning generation trajectory in terms of improvisation and creativity in teaching STEM courses is a chain that expands the levels of research and understanding. Within this context, we attempt to stress below a brief qualitative analysis of science theatre activities, based on Improvisation, Creativity and Inquiry Based Learning.

## 4. Qualitative analysis of science theatre activities

In order to practically support this theoretical attempt, we will analyze part of the action 'Learning Science trough Theatre', a Greek project that is based on the pedagogical framework developed by CREAT-IT [22].

| **Pedagogical practices (educational and cultural characteristics)** | | |
|---|---|---|
| **Counseling** | Experience | ICT |
| **Edutainment** | Entertainment | Gamification |
| **Investigation** | Engagement | Collaborative learning |
| **Inquiry** | Scientific Method | Constructionism |
| **Creativity** | Interdisciplinary | Inclusion |
| **Reflection** | Experience evaluation | New Proposals |

***Table 1:*** *Analysis categories and axes*

Table 1 shows the analysis axes of these performances, which are part of the broader category of "Educational Practices", with educational and cultural features.

Initially the axis of 'Counselling' aimed at the experience and to use ICT for the development of social -behaviour skills and cognitive skills. In the second axis we find the term Edutainment where any entertainment content designed to educate and entertain. Our third pillar of analysis observes social and interactive skills developed by students through active engagement, and collaborative learning.

Subsequently, Inquiry-Based Learning is based on searches, queries and questions of students rather than the presentation of the curriculum by the teacher. The 5th axis involves creativity which incorporates interdisciplinary and inclusive education.

Finally, the axis of reflection for the teaching process is a complex and multi-layered process involving all existing concepts for learning and the subjective experiences of each trainee.

### 4.1. Performances Video analysis

More specifically, we will attempt to develop the approach of 'Meaning Generation Trajectory' in the analysis of chosen activities through the broader category Pedagogical practices with educational and cultural features.

Video Resolution 1:

At the beginning of the first video the show presented some actors are seeking how light created emphasizing the phrase "in the beginning was the light." At this point, students use their experience (notes for the course trying to co-build understanding) of the natural phenomenon, through interactive interactions inspired by their everyday life [23]. Learning opportunities that make sense for students in interactive interaction taking place in this part of the show [24].

The following slideshow video enhances the parallel mediation of artefacts through using new technologies [25]. In other words, students implicated various sources and activities that are either incorporated in the main stage, or operated as a reference framework to support meaningful learning experiences for the students themselves (orchestration).

After viewing the presentation, followed by the main part of the show consists of humorous show, "Talking to the stars", where the main guest is the sun. At this point, we see that concepts are the negotiating point between the emission guests. Through their humorous dialogues, they integrate scientists who studied the phenomenon as: Aristarchus, Ptolemy, Newton, and Galileo. This interaction strengthens the idea of communicative approach [26] and achieves its implementation through collaborative meaning generating.

At this point, we have to admit that the idea of a theatrical performance on the science could be useful at the level of daily teaching practice. Alexander [27] argues that the properties of expansion and accumulation can transform the classroom discussion of the familiar routine pattern: closed question / answer / feedback in a productive dialogue with meaning, where questions, answers and comments are built gradually through coherent and expansive research and understanding chains. Consequently, we could consider that the creation of the theatrical performance can be based on creating meanings orbit involving improvisation in teaching of the scientific meaning generation.

Spontaneity on the creation of theatrical performance could be the beginning of engagement of all pupils according to the interest of each field (journalists, scientists, dancers and others), which incorporates the social and interactive skills of the students who will need to work together to build the structure this play. The connection between Creativity and Inquiry is very important to this analysis. Some examples may shed light to this dimension:

*Creativity Examples:*

Linguistic expressions: Sun: "Let me and my sunbeams illuminate not only your body but also your soul."

Dance: Ballet for sunbeams

Poetry: the shooting star ... intervenes and removes the sunbeams reciting poem.

Daily practice: Correlation of stars with astrology.

Video / ICT: Presentation with information about planets.

Finally, reflection could take place both during the creation of the theatrical performance, and after the end of the show, taking into account the relevant feedback from the public [28].

Video Resolution 2:

In the second video [29] presented theatrical performance based on the Big Bang. The high school students have initially incorporate new technologies through video presentations projection for the birth of the world. Then, they stress humorous dialogues among scientists. The interaction of scientists through experimenting and humorous quotes, give the feeling of Edutainment (humour and fun). These dialogues are based on numerous controversies of science. Finally, students use music and dance to reflect big bang theory.

Video Resolution 3:

In the 3rd show [30] protagonists choose to be the elements of the solar system. In this video, we easily see use of ICT, active involvement of all students in various ways and dance integrating music and for better representation of phenomena, by relating them with their everyday experience (rock music). Another important aspect is the effort to interconnection and interdependence of science that through controversies demonstrate the necessity and their correlation. Finally, as far as the evaluation and feedback is concerned, they presented a video of the experience of students in the creation of the theatrical performance, demonstrating active involvement and fun all in the course of preparation.

## 5. Conclusions

Through this brief presentation we attempted to integrate improvisational, creativity and scientific elements in creating a meaning generation trajectory which may open a new 'window' in science didactics while it opens the horizon of creative investigating both teachers and students. Constant moving through the orbit of the trajectory may begin with spontaneity and end ends to evaluation process, but it includes new proposals that trigger the start of a new track of meaning generation. However, this field of research demands further theoretical and practical investigation, in order to be supported and strongly documented.

## 6. Acknowledges

We gratefully acknowledge the support of Science View and the Faculty of Philosophy, Pedagogy and Psychology of National Kapodistrian University of Athens without which the present study could not have been completed.

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# Informal astronomy and space education in the consructivist environment

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## Abstract

The description of the work I have presented as my experience in the organization of extra-curricular activities with students in astronomy and space, the forms and methods, results and some good practices in teaching astronomy in the constructivist environment. Participation in joint projects with research organizations, use of online labs and remote ones, work of students with CCD camera.

## Keywords

Constructivist environment, astronomy education, space, informal education

## 1. Introduction

One of the major educational problems at present is the alienation from the school and the lack of willingness to study, especially in the field of science subjects, The motivation of the students for education and attracting their interest towards science could be successfully accomplished in constructivist environment by means of the relatively new approach (method) in education the method of research or study/ Inquiry Based Learning/ applied to the learning of science - Inquiry Based Science Learning.

According to that approach the learning is based on " studying, research" of issue or phenomenon with the participation of all students in a class in all stages/phases of the lesson – in the discussion in the beginning of the lesson, setting of the major scientific issue and the formulation of a hypothesis, performing of experiments and their analysis, discussion. Thus, the students come to the facts by themselves and give their suggestion concerning the relationships among them. They take the role of young scientists/ researchers.

Linn, Davis and Bell [1] give the following definition: "The research work could be defined as a conscious process for problem diagnosing, doing experiments and defining of alternatives, planning of research work, giving scientific research suggestions, looking for information, designing of models, discussing with classmates, forming of clear argumentation" The research approach in science and in particular in Physics and Astronomy enables the development of skills and opinions which will be useful lifelong for the young people. According to Gaydarova et al. [2] these skills are undoubtedly called key competences because they lie in the basis of a successful professional integration.

One of the ignored or misunderstood aspect of the extracurricular activity is its role in the development and maintenance of the cognitive interest towards science in particular Physics and Astronomy.

The participation of students in various organizational forms of extracurricular activities as clubs and schools, festivals and events special camps in Science during the holidays related to Physics and Astronomy could give the essential identification and development of the cognitive interest challenged by curiosity and inquisitiveness by integration of specific educational matter, methods and means in entertainment and interesting activities.

## 2. The significance of the topic

is defined by the fact that a major part of the after educational organisations (PEO) with the exception of the National Astronomical Observatory (NAO) and the National Astronomical Observatories with a Planetarium (NAOP) do not organize and hold activities including students, related to science in particular Physics and Astronomy. No research work is being performed for identification and studying of the cognitive interest resulting after the activities and their eventual influence on the choice of a future career, related to science and personal development of the students and the young people.

## 3. Effects of the extracurricular and after school activities

Based on my observations during summer camps and green schools and conversations and interviews with their leaders it was found , that the main impressions ( which are the most long lasting) are the positive emotions they have experienced during the event or the activity, the interesting and entertaining educational activities and games related to science and mostly to Physics and Astronomy.

According to Masoni [3] "The positive effects which the extracurricular activities have on students are mainly influencing the behavior, better grades at school, completing school and becoming successful adults in a social aspect"

In their research Hall and all 2003 [4] make the summary "More and more clues show that participation in extracurricular activities (OST – out – of – school- time) positively support the development of young people as a whole".

Other research authors Langdon, D., McKittrick, G., Beede, D., Khan, B., & Doms, M. 2011 [5] show that the early development of interests and competences in the field of science as well as showing of professional models to copy and the authentic experiences could be important prerogatives, which lead the participants to take part in the school courses in Science and Math" and "aim degrees and work positions in the field of Science and Technique"

## 4. Activities for promoting of the learning interest

In the Municipality center as forms of extracurricular activities in relation to Physics and Astronomy are offered the following : Astroparty" , A Classroom under the stars ".Aiming development of the cognitive interest are the modules:

Science – educational activities including the sets NTSE Nano-Tech Science Education in the project with the same name of the EU[1]"Photonics Explorer"[2], "Explore the colours" a portable laboratory for water research of Water Monitoring Challenge[3], education project of the platform SCIENTIX[4], related to virtual and remote laboratories in Physics and Astronomy, , " A Universe in a box" of the project UNAWE[5], which is especially developed for under school age and primary school students;

"Astronomy and space in my school" – activities of the project SPACE AWARENESS[6], Earth Cam – taking pictures of the Earth's surface from Space from the onboard camera of the International Space Station Lunar Mission One[8] – Send Your Footprints to the Moon", " The World Week of Space[9], "International night for Moon Observation (InOMN) and sending of a radio image of all the participants worldwide.

The activities are organized and held in a daily and most often in a three day camps and/or "green schools" according to a program specified in advancement in a constructivist environment using the methods "Learning by making", ' Learning by Empathy", learning based on games, research based education, project based education. The forms of work with students are Group work, Teamwork as for some of the tasks the students work individually. \ most of the activities are held outdoors in Nature (a landing for observation of meteors, the bank of the Danube river).

## 5. Moon Bounce Project

Drawings of students of the Astro-club at the Centre and the Maths High School "Geo Milev" Pleven were sent by a radio telescope to the Moon and then again returned to the Earth.

The project is named Moon Bounce and was accomplished by the radio astronomer Daniela de Paolis and a team of radio amateurs by the radio telescope Dwingeloo in Holland. They have created a way to send images to the Moon and back and the project included schools worldwide. The campaign started in April as up to April 15 , the drawings had to be sent to the site of the co-organisers Galileo Teacher Training Program (GTTP)[10].

Up to April 25, there was a stage of online voting for selection of the drawings to be sent to the Moon.

The topic of the project was related to the golden plates launched by the space crafts Voyager 1 and 2 in 1977.

The preliminary preparation included activities in the Art workshop and the students put in pictures the main accents of the records in the plates – flora and fauna of the Earth, View of the Earth from Space, visible constellations and of course the Cosmic Rhodopa Mountain – The observatory on Mount Rozhen and the folk singer Valya Balkanska whose voice in the Rhodopa folk song " Izlel e Delju Haidutin" is flying in Space on the board of Voyager.

This additionally promotes the interest and has a positive effect on the motivation in Science studies.

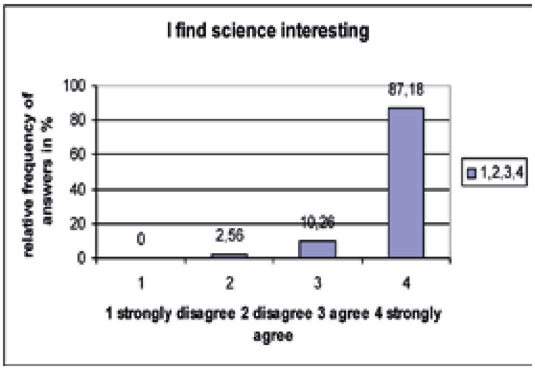
## 6. Survey Organisation

During school year 2013/2014 were organized and held several "green schools" with students of the Pleven region and 8 summer camps with students of 2 regional primary schools. In the module "Natural science" and "Astronomy were tested several resources of the project Go-Lab[10.] The applied form was work in groups of 3 or 4 students observing the sequence of the research approach organization. The practical activities included elaborating of simple devices in Astronomy using available materials- i.e. a square, a sun clock, a spectroscope "Pizza box" and an evening " Astro party" with astronomical observations of visible planets and constellations, a laser Astro show.

Aiming analysis of the impact of the activities held on the students as well as their attitude towards science there were used the scientific approaches of observation and a survey – forced ordinal scale of Linkert with 9 questions and 4 possible opinions: strongly agree, don't agree, agree and strongly disagree, The total number of students participating was 39. The method we used was described in "Monitoring and Evaluation Framework for the International Astronomical Union's Office of Astronomy for Development" (IAU 2014) with respect to an approved project of . OAD, Task Force 2: Astronomy for Children and Schools, Project TF2A-2014 Astro party.

## 7. Data analysis

Based on the obtained empirical data it was concluded that the students are extremely motivated for learning activities in the cases when knowledge is presents in an untraditional way in a specific extracurricular environment which the base of the Municipal center provides. The results are shown in percentages. For example 87.18% of the students answered by "Strongly agree" that they find science as interesting and just 2,56% expressed disagreement. A relatively high percentage 79.49% answered "Strongly agree" that learning Science would help them find a good job. A more profound analysis of the data obtained comes ahead.




As a long term leader of the School in Art I try to integrate the activities of several of the projects in Physics and Astronomy with Fine Art. In many cases the children work in the art shop after having practical activities in the "Science" hall.

## 8. Conclusion

The research approach in learning guarantees that the acquired knowledge, skills and competence would be more permanent and more functional and could be used for solving of other learning problems. In this approach / method of learning are easily formed all key competences which are defined by the EU – basic competences in the field of Science and Technologies, digital competence, skills for individual learning, communication in foreign languages. The exchange of good practices and ideas, educational materials and technologies enable the introduction and using at school of more effective methods and forms of work either in the classroom or as extracurricular work.

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# From the Earth, to the neighbourhood of stars

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## Abstract

*The object of this study was to investigate the effects of the use of digital tools in the educational practice of science and specifically of our solar system study in kindergarten. The research work, deals with our solar system and how children of preschool age may understand concepts around this by using digital tools.*

*The choice of this issue (an approach and effort understanding our solar system from preschool children), was based on the difficulties faced by pupils of early childhood on basic concepts of astronomy and for the excitement they present to observation, study and discovery of our solar system.*

## Keywords

Collaboration, meaning generation, preschool education, solar system

## 1. Introduction

In this research, the case study observation is used, carried out by the researcher as "non- participatory observer", to acquire data concerning the individual conduct of sample members and their interactions as a group of users in the use of educational software and the meaning generation in the subject of astronomy, in connection with the use of technology.

## 2. Theoretical frame

The study of astronomy from preschoolers encourage young students to work as scientists, as "young" astronomer and follow scientific measures, such as observation, creating assumptions and forecasts, experimentation, presentation of findings and results, verification or breaking down initial cases and to learn, to supplement or amend their previous knowledge [1] (Ampartzaki & Kalogiannakis, 2015).

Infants have an innate curiosity, which is important for the teaching of Science [2] (Kalogiannakis, 2009), and it should not be ignored, but to create the conditions for greater study. The main difficulties are, for the study of science in kindergarten, derived primarily from the experiences that make up the young students from the social and natural environment [3] (Tzimogiannis, 2012).

Such therefore must be the activities implemented in kindergarten. According to Kamii and De Vries, in the literature, there are two similar types of activities, the "physical knowledge activities" and "activities knowledge of science" (learning of science). In the first case, knowledge arises through the activities of students. In the second case, the teaching more focused on the object itself, in terminology and in the research process. In kindergarten mainly indicated the second way [4] (Ravanis & Bagakis, 1998).

Specifically, anything related to astronomy, stimulates the imagination and interest of young children, however students of early childhood education, who are in the early even stages of their development, have not yet conquered the stage of abstract thinking and find it difficult to comprehend some notions of space [5] (Panayiotou & Ramandani, 2012).

The understanding of the universe is a challenge to human thought. In the field of education, the study of celestial bodies has yet been introduced at low levels. This is possible to do with the appropriate teaching methodology in order to overcome the difficulties of thinking of young students and enable them to provide appropriate mental schemata, which keep up with scientific models (or that we recognize as school knowledge). At one level should the students to understand the Earth's sphericity. At a second level, to comprehend that the Earth is a celestial body that is part of a solar system. Finally, to be able to realize that the Earth rotates around its axis and around the sun, understanding that will help them understand the alternation of day and night [6] (Ravanis, 2009).

The meaning generation, according to the construction theory of Papert [construnctionism] is a key element of learning and not ready understanding and abstract concepts and information. With the use of ICT, students have the ability and opportunity to produce meaning generation [7] (Kynigos, 2006). It is important for students (regardless of age group) to build [construct], explore, create and manipulate structures and utilize a variety of media and sources of knowledge in order to reach the production of meaning. So we are interested to exploit the educational process technology tools based on logic and the concept of "white-box" [8] (Kynigos, 2004). The term constractionism (or construction constructivism), comes from the word construct and founded by S. Papert, «father» of the logo. The whole approach has a dual form. On the one hand, based on constructivism, where learning is building cognitive structures and the student takes the role of "master" constructing objects, knowingly and then understood. On the other hand, students are actively involved in the process of construction thinking by sharing their ideas [9] (Glezou & Grigoriadou, 2009).

In contemporary school, a key point is to promote collaborative learning. Cooperation in school is a key and essential part of the conquest of learning, as well as through social interactions has been an increase of students' performance. Collective activities keep awake the students' interest and motivation to engage in the cognitive object at a high level [10] (Vosniadou, 2006). In collaborative learning teamwork and collaboration runs throughout the learning process. The basis of the collaborative learning is constructivism. New knowledge is constructed and transformed from children. Learning is regarded as the process that the student makes the activation of acquired cognitive structures or constructing new cognitive structures. Students are no longer passive recipients of new knowledge [11] (Dooly, 2008). Social interaction and collaboration yield results in cognitive development and according to Jones & Mercer (1993) [12] the development of the individual (biological and psychological) is not realized in isolation. According to Vygotsky, children develop cognitively as solving a problem through cooperation while taking advantage of someone else's experience [13] (Wood & Wood, 1996).

The ICT and digital tools contribute to the development and education of students, such as the development of cooperation and social interaction between the team members and the cognitive development of students [14] (Zaranis & Economides, 2009; [15] Kaklamanis, 2005). The utilization of technology support collaborative learning , while providing fertile ground for the development of various skills such as communication, problem solving, critical thinking , etc. [16] (Kyridis, Drosos & Dinas, 2003 ).

## 3. The research

The research process followed by the researcher, based on qualitative research approach, according to which the investigation is based on the assumption that individuals construct social reality with the interpretation which they give in the evolution of situations.

This study investigated:

1. How do preschool children perceive and understand basic characteristics of our solar system?

2. How does the use of technology can support and promote learning and understanding on astronomy at preschool age?

3. Is the technology able to support and promote the skills of communication and cooperation among toddlers?

Time (duration) assigned to conduct the investigation calculated to 21 hours. Data collection took place at the end of the school year 2014-2015 (May-June 2015). The survey was conducted in school kindergarten room in Athens.

For the collection of survey data were used: observation by completing an observation sheet and the resulting composite - products produced by the interaction of the infant with the digital tool. For the implementation of the research utilized the personal portable computer researcher, who had installed a very specific digital construct.

When indirect observation, studied both individual, and collective behavior during the occupation of the sample members with the microworld. The microcosm is a digital environment whose components are tools, open for exploration and change, thus offering scope for learning through discovery, investigation and problem solving [17] (Kafai & Resnick, 1996).

## 4. The sample

The sample is small and consists of twenty (21) preschool children of both age groups (4-6 years), who were enrolled in public kindergarten Prefecture of Athens. More specifically, first they were 19 infants and 2 second age infants (preschoolers). In the sample there were also 9 boys (infants) and 12 girls (including 10 toddlers and preschoolers 2). Finally, the 21 children sampled, 19 whose mother tongue is Greek and two of them have a different mother tongue, but knew the Greek language in a high level.

The sample of children had knowledge of the solar system, had not yet become systematic and organized teaching for the course with the use of new technologies, but had done in conventional ways (reading fairy tales, construction, etc.). Teaching conventionally had occurred four months prior to the survey.

The students had previous experience of using the computer, but no prior knowledge of the Scratch programming environment.

## 5. The intervention

The intervention followed the teaching methodology applied in kindergarten, but also special teaching methodology applied for teaching science (eg the individual activities attended simulations, was experiential representation-presentation by a group in the other groups).

Initially there was a discussion with the children about the solar system in plenary order and recorded the first researcher knowledge. The discussion expanded with questions, thoughts and ideas of children around our solar system and what they would like to learn additional about it.

Their first knowledge and ideas not only stayed in recording notes from the teacher - researcher, but as an additional element were the sketches of children that have been generated through their teamwork and made in short stories.

Then followed a ten-minute video with information about the solar system. Information concerning our planets, their place in our system, their composition, their naming. Apart from the planets, the video refers to both the sun, central celestial body in our planetary system while referring to the satellites of the planets in meteorites and constellations, and the first mission from Earth to the moon. Finally, a review of the Greek mythology and correlation with our planetary system. The members of the sample recorded their knowledge in sketches.

In the next step, the students in small groups (2-3 pupils) worked together to solve the puzzles of the microworld. The researcher at this stage watched the cooperation of groups, without interfering in their work and noted on the relevant form any comments.

By the end of the game, through the interactive process, the sample subjects began exploratory procedures. Each team looked to find additional information (depending on the concerns of group members), investigated (other groups utilizing conventional through-illustrated books on the subject, other groups utilizing ICT) and finally he made a short story related to that topic. For recording and creating, initially, the young students have used conventional means and then their story made it more "interactive" through the Scratch. After all groups have completed this process, there was a presentation of all digital stories, was a discussion about the difficulties, experiences and impressions of the teams and was the necessary feedback and suggestions of ideas to make the appropriate changes and modifications, both stories made by the children and the original microworld. The role of the researcher, not changed either at this stage. The kindergarten teacher-researcher role was supportive and non-participative in the investigation process had only offered help when it was deemed appropriate to give adequate encouragement to infants at the points prevented from the procedure.

## 6. Results

The data gathered from the qualitative analysis of the observation of the sample members (Protocol Monitoring and Observation Recording Sheet), in carrying out the investigation, and the recording of the views of the subjects through discussion, and from the resulting products produced by the interaction of the infant with the digital tool, and their investigation and how react to each other, in order to reach a conclusion.

By collecting and analyzing data, this research about meaning generation, shows that preschool children are able to perceive details and information on the subject (position and motion of the planets, the moon as a satellite of the earth, morphology of the planets, connect with the Greek mythology). More specifically, they are able to understand the form of the heliocentric solar system and did not think it as a geocentric system, they comprehend the movement and behavior of the planets (which is related to the changing seasons and the alternating day and night). Extensive study in depth the specific endpoint in this study was not made, but reference was made relative to the beginning of the research process, which showed that the sample subjects were aware of the process. At the same time, they comprehend the position and shape of the planets in the system, a receipt with the appropriate arguments on the part of the sample subjects. They are also able to comprehend the basic morphology and characteristics of the planets are our planetary system. Finally, positive effect on the production of meaning seemed to have parallelism and correlation made by Greek mythology.

Furthermore, according to the research, the collaboration between team members becomes easier and more meaningful. The cooperative action of the subjects of the sample had progressive evolution and observed that it was a positive contribution of technology in the process towards cooperation by using conventional means. The members worked more interactive, prompting subjects other when necessary. The technology has proven to be an appropriate means to support and develop research, discussion and achieve the ultimate goal. Regarding collaborative action, sharing leadership roles and mutual engagement, in 50 % there was excellent cooperation, where group members equally handle the microworld, responded after the discussing, develops knowledge through dialogue. In the remaining 33.33 %, there was no debate and no cooperation in the academic and technological part, answered only one or two children from each group primarily and there was no cooperation between themselves and the handling of the computer was a child only.

Finally, the use of technology, results in learning and the meaning generation were in more depth, as students engage in more activities and they also had more fun, but also they communicated more with each other.

In this study, it was revealed that through the use of ICT and experimenting, children had the opportunity to link prior knowledge with the new / different perspective of knowledge (possibly did not realize until now) thus lead to the meaning generation. In addition, through a common goal and the immediacy of the result of their actions (through the investigation on the Internet, but also engage in the microworld and in two stages), infants showed great enthusiasm and mobilized interest to a greater extent than conventional means. Even if there was a hesitation and anxiety (due to meager previous experience on the digital games) in some of the subjects of the sample, but quickly surpassed. In fact contributed to this good cooperation and communication developed between groups.

## 7. Conclusions

The results of this research show that preschool children are able to perceive details and information on the subject (position and motion of the planets, the moon as a satellite of the earth, the morphology of the planets, connected with the Greek mythology), to make correlations and generate ideas and concerns to be investigated. Noteworthy is the positive effect it seemed to have the meanings production, parallelism and correlation made by Greek mythology.

The results of this research show that the interaction of the sample subjects to digital technologies (exploration, dealing with the microworld, dealing with the scratch to create stories, video monitoring) contributed towards our goals with respect to the teaching subject of astronomy (study of the solar system) in kindergarten, such as to “ interpret “ elements of the world through observation, description and symbolic representation.

At the same time, they seize the computer in such a way as to serve in their work (discovery and verification information). Regarding our findings in relation to the characteristics of the microworld, they observed that the sample subjects in absolute percentage showed great interest and fun levels and high motivation to engage in the microworld, but also to explore for further information on the internet. About the content of the game, the observation of the behavior and the engagement of infants and microworld showed that children developed or singled out knowledge and notions of astronomy.

Particularly important was the research results regarding the collaborative activity of the sample subjects when dealing with technology. As was expected the selection or production of a suitable support material for resolving questions and concerns, through teamwork and shared discovery.

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# Inspiring Science Education in Romania

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## Abstract

*The main ISE project's goal in Romania is to motivate and to inspire the Science learning and that is why Inquiry-based learning (IBL) is promoted to embrace curiosity, fundamental human trait, as a natural impulse to learn and think.*

*Based on some of the Big Ideas of and about Science and using the WorldWide Telescope, the Romanian team developed 4 demonstrators for Astronomy, Science and Physics lessons: Following Curiosity on Mars, The Blue Planet, Is sky the limit? - A journey between stars and Finding a new house for humans in the outer space.*

*In Romania the ISE project was promoted to over 6,000 teachers and enrolled over 400 schools. We promote all the events from the project via e-mail, press release, on the website community and on Facebook, where we created the "Inspiring Science Education Romania" page. We also created the Romanian Science Teachers Community on the ISE portal.*

*The project results were presented in the ISI proceedings of The International Conference on Virtual Learning – ICVL 2015.*

## Keywords.

Inquiry-based learning, inspirational digital resources for Science teaching, scientific research activities for students.

## 1. Introduction

Understanding science is essential in today's society when there is major threat to the future of Europe: science education is far from attracting crowds and in many countries the trend is worsening.[1].

A central idea in the project is that teaching according to the inquiry-based approach can stimulate students' learning gains and their interest in science. Another premise is that digital, interactive tools can be effectively used to achieve these purposes. ISE set out to design, plan and implement large-scale pilots to stimulate and evaluate innovative use of existing eLearning tools and resources (e.g. interactive simulations, educational games, VR and AR applications, modelling and data analysis tools, eScience applications, as well as, digital resources from research centres, science centres and museums) for scientific disciplines and technology, enhancing science learning in 5,000 primary and secondary schools in 15 European Countries [4].

## 2. Inquiry-Based Science Education

The Inquiry-based learning is often described as a cycle or a spiral, which implies formulation of a question, investigation, creation of a solution or an appropriate response, discussion and reflexion in connexion with results [3].

Learning science by inquiry, on the other hand, involves the learner in raising research questions, generating a hypothesis, designing experiments to verify them, constructing and analyzing evidence-based arguments, recognizing alternative explanations, and communicating scientific arguments [5].

The ISE Project does not perceive learning by inquiry as following specific step-by-step instructions in a linear sequence of activities, but rather as experiencing activities that blend and merge together. So that it's instructional model of IBSE consists of five learning activities: *Orienting & Asking Questions*; *Hypothesis Generation & Design*; *Planning & Investigation*; *Analysis & Interpretation*; and *Conclusion & Evaluation* [4].

Ten Big Ideas of and about Science are the heart of the Inspiring Science Education's repository of eLearning tools and resources. These 'Big Ideas' represent overarching principles in the science curriculum and can also be looked at as 'umbrellas' where the content material from various science subjects can be brought under the same 'umbrella' in order to develop a common theme running through the science curricula over time. According to Harlen's report (2010) the goals of science education should not be conceived "in terms of the knowledge of a body of facts and theories but a progression towards key ideas which together enable understanding of events and phenomena of relevance to students' lives during and beyond their school years."[2]. In this report 14 such ideas are identified and include ideas of science and ideas about science and its role in society.

Big ideas of science:

1. All material in the Universe is made of very small particles. Light in all different wavelengths permeates the Universe. (This idea is slightly changed from Harlen's original)
2. Objects can affect other objects at a distance.
3. Changing the movement of an object requires a net force to be acting on it.
4. The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.
5. The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate.
6. The solar system is a very small part of one of millions of galaxies in the Universe.
7. Organisms are organised on a cellular basis.
8. Organisms require a supply of energy and materials for which they are often dependent on or in competition with other organisms.
9. Genetic information is passed down from one generation of organisms to another.
10. The diversity of organisms, living and extinct, is the result of evolution.

Ideas about Science:

11. Science assumes that for every effect there is one or more causes.
12. Scientific explanations, theories and models are those that best fit the facts known at a particular time.
13. The knowledge produced by science is used in some technologies to create products to serve human ends.
14. Applications of science often have ethical, social, economic and political implications [2].

## 3. About the ISE Demonstrators

All the lessons and education scenarios and plans available in the Inspiring Science Portal have been created and validated by European science teachers active in teaching STEM (Science, Technology, Engineering and Mathematics) and are suitable for different levels and curriculum settings. Teachers have the option to use and adapt these lessons or educational scenarios or create their own.

The ISE teachers used the ISE Authoring Tool to design their lessons and educational scenarios following the inquiry based learning approach (IBL). They are able to develop and include assessment tasks for students' problem solving competencies based on the PISA 2012 problem solving framework. The ISE Delivery Tool enables the delivery of lessons and educational scenarios to teachers and students. This delivery tool has been developed to take into account the demands of different devices such as desktops and tablets as well as the usage of assistive tools to support students with disabilities [6].

The project's use of eLearning tools and resources is coupled with an evaluation framework, evaluating progress on learning achievements, based on the PISA 2012 framework for the assessment of students' problem solving competence of students. This approach offers the basis for validation of the introduction of technology-supported educational innovation in European schools, thus ensuring real impact and widespread uptake [4].

Lessons and educational scenarios are designed, in the different phases of IBL, to include tasks to assess students' problem solving competencies.

Based on some of the Big Ideas of and about Science and using the WorldWide Telescope (http://www.worldwidetelescope.org/), the Romanian team developed 4 demonstrators for Astronomy, Science and Physics lessons. Their names are:
- Following Curiosity on Mars (http://tools.inspiringscience.eu/delivery/view/index.html?id=d93824f5b89746c9bea155ba4b6fbd25&t=p)
- The Blue Planet (http://tools.inspiringscience.eu/delivery/view/index.html?id=4ca6689c694143f6af473a71356c2abf&t=p)
- Is sky the limit? - A journey between stars (http://tools.inspiringscience.eu/delivery/view/index.html?id=26cf0bfacc0647bfad1ffcecca235a6a&t=p)
- Finding a new house for humans in the outer space (http://tools.inspiringscience.eu/delivery/view/index.html?id=b547e01954c4438a84f5026fe36803cd&t=p)

For example, Following Curiosity on Mars, is a scenario developed by the ISE Romania team, starting from the Big Idea 6. The solar system is a very small part of one of millions of galaxies in the Universe and 13. The knowledge produced by science is used in some technologies to create products to serve human ends. In this case students will follow the rover Curiosity on its way to the red planet Mars by using the World Wide Telescope (Fig.1).

The didactical approach is based on scientific inquiry in order to give students the enjoyment of finding out for themselves and initiates appreciation of the nature of scientific activity, of the power and the limitations of science. They will have to search if Mars *can or could support life. And how is the environment of Mars?* The main question will be: Where is Curiosity now? Because students will have to solve a real problem of the humankind they will have to accompany the rover Curiosity on Mars. The final products of the teams of students will be the slide-show with Mars surface details and also the bussines card of the planet.

***Figure 1.*** *Following Curiosity on Mars - demonstrator*

The ISE Authoring Tool offers teachers two additional features which they may use to enrich and support the delivery and assessment of a science lesson. These are: the option of adding multiple-choice formative assessment questions at any point during an Educational Scenario and the option of adding problem solving questions at the end of four of the inquiry phases. For both of these options teachers are also presented with a graphic analysis report of the results of this assessment for their students.

Following Curiosity on Mars was presented in the training and demo workshops "Inspiring Science Lessons - Big Ideas of Science in interdisciplinary approaches" held in: Ramnicu-Valcea, Ploiesti, Aninoasa, Caracal, Suceava, Magurele and Bucharest.

## 4.The Romanian Communities on ISE portal

The portal is hosting many communities of the science teachers. We created some communities like The Romanian Science Teachers Community: http://portal.opendiscoveryspace.eu/community/comunitatea-profesorilor-de-stiinte-723629

***Figure 2.*** *The Romanian Science Teachers Community*

The newest community is dedicated to the Inspiring Science Festival which will be held between 2nd of April to the end of May in all The Romanians Regions (http://portal.opendiscoveryspace.eu/community/inspiring-science-festival-ro-840774)

***Figure 3.*** *The Inspiring Science Festival-RO Community*

## 5. ISE Workshops and festivals in Romania

In Romania the ISE project was promoted to over 6,000 teachers and enrolled over 400 schools until March 2016. We promoted all the events from the project via e-mail, press release, on the website community and on Facebook, where we created the "Inspiring Science Education Romania" page (https://www.facebook.com/pages/Inspiring-Science-Education-Romania/393269194159210)

***Figure 4.*** *Inspiring Science Education Romania FB page*

In 2014-2015 we organized: two visionary workshops for teachers, one student's workshop and two practice reflection workshops. In the same time we created a National Contest of Inspired Science Lessons for teachers in partnership with INTEL (http://portal.opendiscoveryspace.eu/activities/723629).

***Figure 5.*** *Practice and reflection workshop, "Traveling in the Universe" Sinaia, September 2014*

***Figure 6.*** *Big Ideas of Science for Inspiring Science Education, October 2015 - "Grigore Moisil" National College, Bucharest*


***Figure 7.*** *ISE Project presented at International Conference on Virtual Learning, Timisoara, October 2016*

In 2015-2016 we organized two series of training and demo workshops, one named "Inspiring Science Lessons - Big Ideas of Science in interdisciplinary approaches" and the other one "Inspiring Science Experimental Approaches" and a series of Inspiring Science Festival in the development regions of Romania.

***Figure 8.*** *ISE team from Ilfov at Moisil College, Workshop Inspiring Science Lessons - Big Ideas of Science in interdisciplinary approaches, March 2016*

The Training and demonstration workshops "Inspiring Science Lessons - Big Ideas of Science in interdisciplinary approaches" in the Inspiring Science Education Project were organized at: The Teachers House Valcea on $13^{th}$ of February 2016, The Prahova School Inspectorate and The Teachers House Prahova, on $20^{th}$ of February 2016, "Sfanta Varvara" Secondary School from Aninoasa, Hunedoara on $27^{th}$ of February 2016, "Gheorghe Magheru" Secondary School from Caracal, Olt County on $12^{th}$ of March 2016, "Grigore Moisil" National College from Bucharest, Romania, on $5^{th}$ of March 2016 and $14^{th}$ of March 2016, "Horia Hulubei" High School, Magurele, Ilfov county on $17^{th}$ on March 2016 and Natanael High School from Suceava, on $19^{th}$ of March 2016.

Almost 400 teachers of Science participated in the workshops.

***Figure 9.*** *Big Ideas of Science in interdisciplinary approaches at Suceava, March 2016*

They discovered what is new on the ISE portal, they talked about the Big Ideas of and about Science, they ran the ISE demonstrators and lessons. Mihaela Garabet presented the Eratosthenes experiment which took part on $21^{th}$ of March 2016 and the demonstrators Eratosthenes Experiment and Following Curiosity on Mars.

The first Inspiring Science Festival was held at Lugoj, in Timis county and it was very appreciated, especially by the students. Just two words are enough to describe it: excitement and joy of knowledge. Some of the experimental activities can be seen on: http://portal.opendiscoveryspace.eu/activities/840774.

*Figure 10. Inspiring Science Festival at "Anisoara Odeanu School" - Lugoj*

## 6. Eratosthenes Experiment

Eratosthenes experiment is already famous in Romania. In March 2016, 267 Romanian schools from the worldwide 1142participated in Eratosthenes experiment remake.

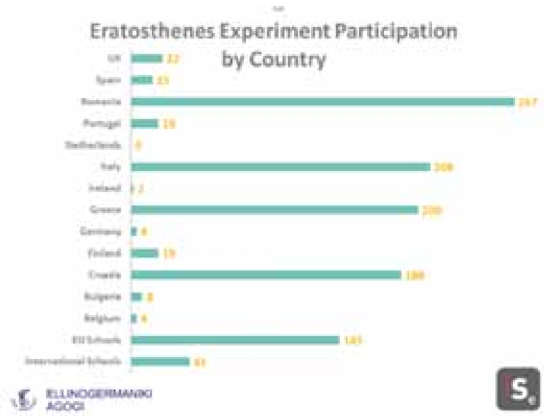


*Figure 11. Eratosthenes Experiment schools participation in March 2016*

*Figure 12. Eratosthenes team from "Grigore Moisil" National College, Bucharest, Romania, March 2016*

## 7. Romanian finalist in the ISE Learning Scenarios Competition 2016

The Inspiring Science Education Competition has the aim to highlight excellence in the creation of learning scenarios or lessons based on the tools, resources and materials available in the Inspiring Science Education Portal.

The lesson *Equilibrium and balance,* made by Cristina Nicolaita, from "Gheorghe Magheru" School, Caracal, Romania was mentioned s one of the 7 finalists of this competition.

*Figure 13. Equilibrium and balance, made by Cristina Nicolaita, from "Gheorghe Magheru" School, Caracal, Romania*

*Figure 14. Cristina Nicolaita, from "Gheorghe Magheru" School, Caracal, Romania, showing her lesson in the „Big Ideas of Science in interdisciplinary approaches" Workshop at Caracal*

## 8. Conclusions

The ISE Project is very apreciated in Romania, where the Science teachers are very openminded and they knew that much effort is neccesary for increasing students motivation for learning.

The teachers are trying to do their best with students which enjoy to use blended learning instead of the traditional teaching and learning methods. Everybody enjoy the e-tools repository where there are a lot of resources. The ISE Demonstrators are also very appreciated.

The applied questionnaires at the end of the conducted workshops revealed that the teachers need more training on how to develop IBSE lessons and how to design the Problem Solving Questions for assessing student's skills.

The ISE approach of teaching and learning science has to be continued in Romania, where we need more lessons scenarios and Problem Solving Questions.

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# Reflection of ISE idea for linking school education and scientific research in the National Strategy for effective implementation of ICT in education and science in the Republic of Bulgaria

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## Abstract

*We live in dynamic environment that sets everyday challenges to society and citizens. In order to respond to this dynamics and develop adequate behavior and necessary social, technological, professional and personal skills we need a radically different approach to education. Our children need to be prepared for living in a digital society and be part of the so called knowledge economy. In order to develop innovative products with added value fitted to the information society, students must develop research skills, critical thinking and scientific consciousness from their very early age and developing working synergies between classroom and research centers is a must in the 21st century.*

*The importance of these processes has been considered quite seriously by the European Union and the European Commission has supported a series of innovative projects such as Open Discovery Space and Inspiring Science Education that were expected to make the change in the paradigm of the traditional education. The article describes in detail the response of one member state government to the European initiatives and the reflection of the idea for linking school education and scientific research in the National Strategy for effective implementation of ICT in education and science in the Republic of Bulgaria for the period 2014-2020 [1].*

*The strategy sets its priorities in several directions, including but not limited to:*

*- Development of unitary modern ICT environment for education, science and innovations;*

*- Implementation of integrated digital management in all spheres of education and science and automation of the administrative work of*

*university and school teachers and scientists;*

*- Priority development of generally accessible, universal and compatible (standardized) digital content (including access through mobile devices) as well as significant reduction of paper workflow in education and science;*


## Keywords

Universal access, technological synergy, fibre backbone, cloud technologies, inspiring science education, ICT strategy, digital society, knowledge economy


## 1. Introduction

The Strategy for Efficient Implementation of ICT in Education and Science (2014-2020) sets the basic goals, tasks, directions in the informatization of the education and science system in the Republic of Bulgaria up to the year 2020, as well as defines the basic principles, approaches and terms for successful realization of the informatization process. It was adopted in early July 2014 by the Bulgarian Council of Ministers and was widely accepted by the Bulgarian society. One of the reasons for its universal impact not only over academic circles but also over much larger groups of organizations and business companies is its integrated nature combining in unique way the interests of educational and research community as well as that of public institutions. The development of the Strategy was inspired and supported by few major Pan European projects such as Open Discovery Space (ODS) and especially Inspiring Science Education (ISE). These initiatives clearly showed the major trends in developing modern education and science through creating synergy and utilization of common resources such as cloud infrastructure, broadband communications and education platform, concentration of digital resources and successful teaching pedagogical practices.

The Strategy generalizes the expert vision of ICT implementation in Bulgarian education and specifically:

- Development of unitary modern ICT environment for education, science and innovations;

- Implementation of integrated digital management in all spheres of education and science and automation of the administrative work of university and school teachers and scientists;

- Priority development of generally accessible, universal and compatible (standardized) digital content (including access through mobile devices) as well as significant reduction of paper workflow in education and science;

- Development and adoption of recognized standards and metrics for ICT competency including ICT skills as a component in the career development in education and science;

- Implementation of national external assessment of digital competencies of primary students on graduation and certifying IT skills of students of specialized study course (profiled) and vocational schools;

- Achievement of coordinated planning and realization of ICT projects of the educational and scientific institutions at European, national and regional level – from separate initiatives to realizing long-term and prioritized goals involving maximum stakeholders and achieving economy of scale;

The Strategy outlines how the concentration of resources such as digital fiber backbone and educational and science cloud ICT infrastructure could facilitate the synergy between education and science and also help the automation of the administrative duties of educational practitioners giving them more free time for creative and innovation activities.

## 2. Implementation activities

Bulgarian educational community embraces the idea for implementing ICT innovation in everyday work. Throughout the period 2014-2016 more than half of the Bulgarian schools took part in different activities related to implementation implementing ICT innovations in education thus supporting the implementation of ISE project. Some figures that could describe the situation:

From the existing 2556 Bulgarian schools (2015 est.) 1 327 filled e-maturity questionnaire (average score 74/100) and 1 246 prepared an ICT action plan (1 169 did both). Since international cooperation and exchange of good practices is among the primary ISE targets it is useful to mention also that 927 schools translated their plans in English or other EU language, thus showing their interest to collaborate. 871 of these schools chose curriculum areas of interest relevant to science when they filled their action plans thus showing the huge potential for linking educational with science activities nationwide. In these potential BG ISE schools, there are almost 15 000 classes, 19 000 teachers and over 320 000 students.

The ICT Implementation Strategy was written from well-known figures in the Bulgarian education and Science - mainly working in ICT departments of major universities and scientific institutions. Among them there are also people that participate in ISE being part of the local partner institution. This synergy of interest helped the team to promote within the strategy some of the most important aspects of ISE such as cloud technologies based education and science development environment, unified information environment and modernization of education and science infrastructure, development/implementation of digital publically accessible and universal education resources, broadening up digital distance education forms, production and use of information and knowledge etc. The Strategy has three main stages and most of the activities described there fully correlate with ISE development and penetration concept, thus giving ground to the reasonable assumption that experts just decided to implement what proved to be successful throughout ODS and ISE implementation.

## 3. ICT in school program

The national program „Information and communication technologies in school“ (ICT in school) of the Ministry of Education and Science donated more than 6 Mln Euros in 2014 and 2015 to approximately 1000 innovative schools based on their ICT preparedness. The experts from the Ministry used e-maturity questionnaires and school ICT action plans developed through ODS and ISE projects in order to rank the schools and give them subsidies for high-speed internet, Wi-Fi access and innovative hardware (more than 20,000 computer terminals, laptops, tablets and other devices were installed in schools in that period).


***Fig. 1*** *Cover page of ICT in school program of Ministry of Education and Science – Republic of Bulgaria (http://internet.mon.bg/ikt)*

Other important component of the national program ICT in schools was the upgrade of the national educational cloud infrastructure and setting the major fiber lines connecting the 28 regional educational inspectorates which are situated in the regional cities all across the country. A special initiative was started for concentrating all digital school resources countrywide to the educational cloud, as well as starting some strategic talks with major ICT vendors such as Microsoft and Google to facilitate the distance learning activities with their software platforms. The Ministry of Education supported also through one of its establishments the purchase of Adobe Connect platform software which enables few hundred teachers simultaneously to communicate through

5 different virtual rooms thus facilitating international collaboration and massive participation in projects like ISE.

## 4. Correlation between national innovation initiatives and ISE concept

As we could see, the major Strategy initiatives are quite in line with the overall development of the abovementioned large scale European projects. Some elements of the three stages of the Strategy, that could be considered relevant to ISE concept for example, are as follows:

*I stage. Key investments – short-term (2014-15)*

- unified backbone network, connecting regional educational inspectorates, universities and science centers;

- national ICT cloud infrastructure for the needs of education and science;

- a backup center for storage, data processing and provision of services;

- national digital education and study content management platform;

- education portal and digital handbooks for all sciences and mathematics subjects.

II stage. Mobility and security – middle-term (2016-17)

- permanent optical or high-speed connection with educational institutions;

- digital platform for video-training, teleconferences and R&D;

- regional resource centers for data and content;

*III stage. Universality and sustainability – long-term (2018-20)*

- unified education environment for ubiquitous learning (u-learning);

- transition to digital textbooks for all subjects;

- virtual classrooms and laboratories;

- open and universal access to education and science resources.

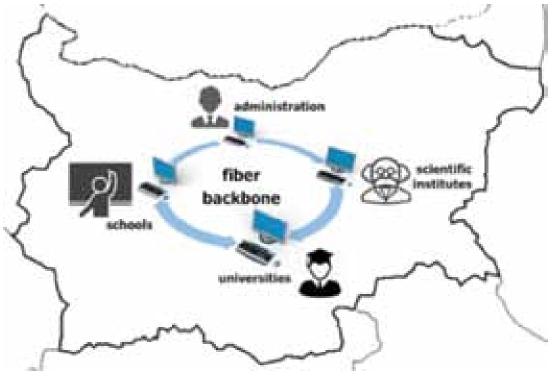


***Fig 2.*** *Implementing the idea for universal backbone and ICT cloud infrastructure [2]*

## 5. Conclusions

As stated by Osborn and Hennessy „While there are changes in the views of the nature of science and the role of science education, the increasing prevalence of Information and Communication Technologies (ICT) also offers a challenge to the teaching and learning of science, and to the models of scientific practice teachers and learners might encounter...“ [3]. In this aspect we must confess that modern education sets serious requirements to not only way of teaching and learning but also to the basic understanding of innovation and preparing kids for future life challenges. Projects like Inspiring Science Education are perfect manifestation of that concept and Bulgarian Strategy for effective implementation of ICT in Education and Science and its realization are valid proof that the EU message was heard and well accepted by Member States, encouraging innovation both at national and international levels.

Our expert analysis that was made inside the

Strategy shows potential benefit from its implementation in several directions, related to ISE, such as:

• Sustainable and beneficial environment for provision of quality education and science;

• Strengthening teamwork and international cooperation;

• More prepared school and university students in view of life realities;

• Raise of school and university teachers' and scientists' prestige;

• Free exchange of quality education and science content;

• Strengthening the role of stakeholders in the Pan European education and science space;

• More spare time and personal privacy for teachers and scientists.

Inspiring Science Education project proved to be successful not only through its implementation activities but also with its overall influence on national and international legislation and strategic documents all across Europe and Bulgaria is a perfect success story in that aspect.

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# Using Astronomical Research in School Education

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## Abstract

*We present a number of resources designed to support teachers when teaching astronomy, and to add a context to wider topics. The resources use current research, and are all freely available on the web. While they are largely targetted at the UK curriculum there are clear applications internationally. The resources are integrated into best-practice demonstrators as part of Inspiring Science Education (ISE).*

## Keywords

Astronomy, education, inquiry-based, research-led

## 1. Introduction

The UK government has specified that science and engineering are important for the global economy [1]. Physics as a subject is seen as *the* essential step for training in most science and engineering disciplines and is therefore in demand as a need for social and economic growth [2][3]. As a mark of its importance, in 2014, the UK government pledged support for £67 million in new programmes to train specialist maths and physics teachers. However, the number of students taking A Level physics is declining [4][5]. Furthermore, in the 2012 PISA survey, the UK ranked 21st in Science out of 65 countries [6] with no improvement seen since the previous 2006 survey. An important regime is thought to be the transition period defined as ages 11-14 where students appear to lose their interest in physics, or motivation for studying further. We also see a sharp decrease in the number of female students who wish to study physics at a more advanced level, with only one in five Physics A Level students being female, and one in five schools sending no female students on to do physics at age 16-18 [7]. Improving the student learning experience and increasing student preparation for physics in later school years could potentially improve physics take up (or at least improve the learning and teaching experience). In particular, there are many recommendations for an emphasis on using science enquiry in the classroom [8]. This can be enabled by integrating current research into the classroom, and providing opportunities for school children and teachers to take part in the scientific process.

Using real research tools and real scientific data can promote scientific understanding as well as provide practise of the scientific process [9]. Here we outline a number of resources we have created or upgraded in order to provide examples of current, exciting research activities and bring research to the classroom. Each resource is stand alone, freely available to all and is accessible online, built to capitalise on the increasing use of internet and web-based in the classroom [10][11] [12]. In tandem, each resource has an example (best-case) demonstrator for teachers to clone and use as a template, before they adapt or edit as appropriate for their own classroom requests. These resources are provided with links to curricula for the UK where appropriate, with a specific aim to improve usage by teachers in a country that is focused on a strict curriculum-defined education [13]. Although, our resources are focused and designed around astronomical concepts and research, we are, in fact, using astronomy as a tool, or hook [14][15], to improve teaching of fundamental concepts in physics and science. Indeed, the Institute of Physics surveyed physics undergraduates at eight Russell Group universities and found that for 53% of first year students, astrophysics was of significant interest in attracting them to their physics programme [16]. Furthermore, the intake of male and female students to GSCE Astronomy in the UK is 60:40 compared to the much larger gender bias of ~80:20 seen in physics (e.g. [14]).

Here we present some of the astronomy resources included as part of the Inspiring Science Education (ISE) project [17], and designed to teach concepts such as the lifecycle of stars (Section 2), the electromagnetic spectrum (Section 3), rocket science and optics (Section 4). (For other astronomy-based resources see the review in [14].) In what follows, we introduce each resource under their generic science focus, link to the research carried out in that area, and discuss the resources we have created for engaging students and teachers in meaningful scientific experiences.

## 2. Lifecycle of stars

This topic consistently features in high-school curricula (e.g. [18][19]) but anecdotal evidence has suggested that it is a topic which teachers feel uncomfortable teaching. In the UK the number of physics classes taught by teachers without a relevant higher education qualification in physics increased from 21% to 28% between 2010 and 2014 [20]. Even teachers with a background in physics are often unfamiliar with the astrophysical concepts in this topic.

Furthermore, it is a big challenge to clearly present the different stages in the life of stars in a way that is both visually appealing and scientifically rigorous. We found there were very few time-lines for the evolution of stars that did not contain a very high level of detail or did not simply present vague snapshots of the life cycle of stars. This led to the creation of Star in a Box.

### 2.1 Star in a Box

Star in a Box (SiaB) [21][22] is an interactive Hertzsprung-Russell diagram, which compares the brightness of stars against their temperature to show the different types of stars and their lifecycles, from formation to death. The underlying science is based on the published theoretical isochrone models of [23]. It allows the user to interact with the resource by comparing different information and reading values of stellar mass, temperature, age etc., as well as fundamentally seeing that the properties of their "model" star change as it ages.

Students can interact with the graph and learn names of the stages of stars e.g. main sequence, red giant etc., as shown in Figure 1. Some of the features include: (i) exploring the lifecycle of stars with different masses; (ii) learning the names of the different stages; (iii) plotting and clicking on a graph to see where different stars sit in terms of their brightness and temperature; and (iv) the ability to download data and create their own plots in Excel or other software.

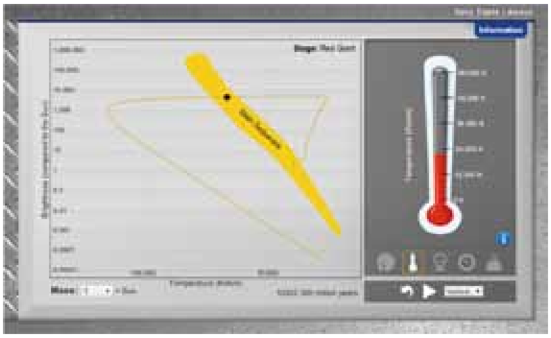

*Figure 1. Screenshot of the Star in a Box web tool.*

Exploring SiaB raises questions about why stars have different stages as they age and why stars have different properties. Students can use their knowledge of the lifecycle of stars to plot their own versions of the HR diagram and explore what this graph means. After using this resource, students can: (i) describe the relationship between a star's mass and its life span (ii) state that stars above a certain mass end their lives in a supernova (iii) name the stages of a star's life cycle for different masses of star (iv) describe the relationship between a star's mass, age and its position on the Hertzsprung-Russell diagram.

To help familiarise students with the HR diagram, they are provided with data on nearby stars in order to allow them to plot their own HR diagram using cut-out circles (e.g. Figure 2). This activity allows students to gain experience with (i) logarithimic axes (ii) the vocabulary of luminosity/brightness and temperature (iii) the link between colour and temperature and (iv) understand that stars have different sizes (e.g. giants/supergiants/dwarfs). It also provides a kinesthetic element to this activity and is therefore a powerful way to get students involved with creating their own plot, discussing what they can see (the Main Sequence etc.) before they move onto further study with the interactive online SiaB.

The basic tool is for all ages, but supplementary activities and questions as included in the ISE demonstrators are provided for students at different levels. The questions for 14-16 are aligned with the content of the UK secondary curriculum, combining learning the subject knowledge with using numeracy skills to plot and interpret the HR diagram. Using the data exported from SiaB, advanced students can also plot the parameters on view as a function of time, and compare different stars with each other in a more numerical way, and explore the Stefan-Boltzmann Law.

*Figure 2. A example of «paper based» SiaB in the classroom - a HR diagram made bu students using paper. After this activity, they move on to the online SiaB resource.*

Although SiaB is an online, interactive tool all of the software is available publicly. To make SiaB able to be used in a wide variety of scenarios, the web technology used to create this online tool has virtually no dependencies, being built on HTML, CSS, and JavaScript. SiaB can be downloaded and run locally without any specialist tools, other than a web browser. To further widen the use of SiaB we have made it available in multiple languages, thanks to translations by volunteers.

## 3. The Electromagnetic Spectrum

A huge range of astronomical objects and phenomena can be seen at different wavelengths, from the afterglow of the Big Bang at microwave wavelengths, to the most extreme objects in the Universe in gamma rays. Although knowledge the full range of phenomena is not generally expected of students, exploring the Universe across a range of wavelengths can give a useful insight into the EM spectrum. Much of the difficulty in making the observations is that large regions of this spectrum (other than visible light and parts of the radio spectrum) are heavily scattered or absorbed by the Earth's atmosphere [24] and so require experiments on sub-orbital rockets, balloons or satellites. The need for space telescopes, is a subject that can inspire and engage students, and links to many other parts of the curriculum.

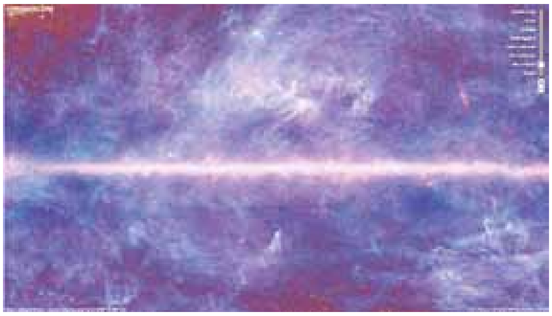

***Figure 3.*** *Chromoscope [24], showing the sky as seen by Planck [32].*

### 3.1 Chromoscope

A fun resource to allow students to deepen their understanding of the EM spectrum is Chromoscope [25]. This resource lets you explore our Galaxy (the Milky Way) and the distant Universe in a range of wavelengths from gamma-rays to the longest radio waves (covering the full EM spectrum). Using a simple interface, one can change the wavelength, explore the sky, and zoom in on regions using only your mouse or touchscreen interface. Chromoscope provides an exciting and engaging way to explore the electromagnetic spectrum through the Universe.

Features include: (i) exploring the sky; (ii) zooming on a region; (iii) fading between wavelengths; (iv) searching for specific objects; (v) switching between 16 different language translations provided by translators in the community; (vi) embedding within other websites and/or installing locally on a standalone machine; (vii) displaying tags in KML file (c.f. Google Earth); (viii) displaying constellation outlines; and (ix) sharing the link to the current view with others.

The multiwavelength data displayed in Chromoscope (see Figure 3) is real data from astronomical observatories and telescopes. This includes: gamma rays (Fermi [26]), x-rays (ROSAT [27]), visible light ([28][29]), Hydrogen alpha [30], near-infrared (WISE [31]), far-infrared (IRAS [32]), microwave (the Planck Satellite [33]) and radio waves [34].

Each tile-set used for Chromoscope contains over 5000 images, covering a range of zoom levels. While compressed archives are not too large (typically 10-50 MB per wavelength), the uncompressed files take up a large amount of space and bandwidth. The latest version is available on Github [35] and the data files can be downloaded individually if required [36]. Every zoom level quadruples the number of images required, and so for higher zoom levels users are able to link to higher resolution alternatives, such as World Wide Telescope [37]. Although the source files for the live version are stored on scalable infrastructure, users requiring faster access can store them locally.

***Figure 4.*** *Multiwavelength Universe [36].*

### 3.2 Multiwavelength Universe

The Multiwavelength Universe tool [38] tests students' knowledge of the EM spectrum in the context of astronomy, and asks them to research further. The interface allows users to match up the images of objects seen as different wavelengths (see Figure 4). Responses are scored and a final result given. Exploring the Universe in this way should raise questions about why regions of the sky, and specific objects, change their appearance with the wavelength of observation. Students can then use their knowledge of the EM spectrum to explain and make sense of the differences and similarities between wavelengths. To aid students with further work, information about every object is provided, along with web links for further information, to allow students to research a chosen object and conduct further investigation.

## 4. Satellites and space observatories

With the ever-increasing impact of satellites and other space-based technology on our lives, the nature and applications of satellite technology are becoming more prevalent in the school curriculum at all ages [39][40]. The uses of satellites include communications satellites, Earth-observation, space-based astronomical observatories, and human spaceflight.

At primary and lower-secondary phases, the topic is often used as a context for teaching about the scale of the Universe, life in space and the uses of satellites, as well as teaching a range of other topics such as forces and motion. At secondary school, students are expected to have an appreciation for the physical principles of reaching space, though the detail to which this is required depends on the age. The educational applications range from an understanding of the uses of multi-stage rockets, to calculations of the orbital speeds required. In the context of space observatories, there are many other curriculum links, from the electromagnetic spectrum (see Section 3) to the optical resolution of telescopes.

***Figure 5.*** *Design a Space Telescope [39].*

### 4.1 Design a Space Telescope

The Design A Space Telescope tool [41] allows students to use their knowledge of a range of topics to design a space telescope to meet a set of mission requirements. It is aimed at secondary school students aged 14-18. Students must specify: (i) the mirror size; (ii) the scientific instruments used to make observations, specifically the wavelengths (from sub-millimetre to ultraviolet); (iii) any cooling required for those instruments; (iv) the orbit to be used; (v) the launch vehicle; and (vi) the launch site (see Figure 5). An "advanced" mode adds in spectrometers as an instrument option, more realistic consideration of the cooling technologies, and a wider range of rockets and launch sites. A drop-down menu displays the masses, costs and sizes in order to help students keep within budgetary and practical constraints.

Masses, costs and mission scenarios are semi-realistic, based on past, current and future astronomical instruments and space observatories. Supporting material is provided via an online guide, so teachers do not need to be familiar with all the details. The web tool works in all modern browsers, and does not require any additional software or plugins. There is a lot of text, particularly in the guide, but it is hoped that in the future it will be possible to provide a version that is translatable.

***Figure 6.*** *Screenshot of a student using Star in a Box on a tablet.*

An offline, downloadable version of the tool [42] performs the same calculations using a Microsoft Excel spreadsheet, accompanied by a downloadable student guide. This also includes example questions that link to a range of areas of the school curriculum.

The motivation for this activity stemmed from a similar process that takes place at the European Space Astronomy Centre (ESAC) when designing future missions, which also uses calculations in an Excel spreadsheet - though in that case the calculations are of course more detailed.

## 5. Examples of use

The resources detailed above have been integrated in the best-practice demonstrators for the ISE project, with the learning scenarios available through the ISE UK community [43]. Photos of their use are shown in Figures 6 and 7.

To date, the ISE resources portal have had over 18,000 unique visitors and over 5700 European teachers registered to use the resources during 2015. In total over 1500 learning scenarios were created by teachers across Europe in 2015. In the UK, 999 delivery sessions of ISE learning scenarios took place. Three of our resources have been selected as one of 34 Inspiring Science Education "Showcases" [44] making them very prominent amongst almost 100 demonstrators currently available as part of ISE.

## 6. Conclusions

We have developed a number of online, interactive resources to help bring astronomy research into the classroom. For the UK, we have added curriculum links where appropriate and show that these resources encompass fundamental physics concepts, as well as promote deep learning in STEM subjects in general. All of these resources are open access, both in terms of the underlying software and their access for students and teachers globally.

***Figure 7.*** *Photo of students using the Multiwavelength Universe tool.*

## 7. Acknowledgements

We acknowledge funding from the European Union as part of Inspiring Science Education (grant agreement no. 325123). We acknowledge support the Science and Technology Facilities Council public engagement schemes (ST/J000248/1 and ST/H000453/1). We acknowledge Rob Simpson for his creation of Chromoscope. We thank Sarah Roberts, Abi Ashton and Franziska Batten for comments on the use of the resources.

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## Abstract.

*Anatolia College is a non profit educational institution in Greece. Cultivating Environmental Awareness has always been a priority in Anatolia College and both the Elementary and Secondary school have an Ecology and a Green Club. To provide a systematic introduction in the basics of the Green Initiative & an integral approach to the Green Field, Anatolia College established a Center for Green Education, the first of its kind organized worldwide by a High School.*

*The Center will soon start its operation, aiming at making students familiar with Green Chemistry's principles and able to comprehend certain environmental issues and what sustainability is.*

## Keywords.

Green Education, Green Initiative.

## 1. Introduction

By educating future citizens on environmental issues, starting from early education stages, any community can have a wide-ranging and long-lasting, positive environmental impact on the world. Younger students can be molded into environmentally concerned adults, helping to bring the harvest by planting the seeds. Introducing simple and every day examples provides students with the appropriate stimulus in order to cultivate an environmentally friendly way of thinking and acting [6].

The "Green Program" can contribute to raise environmental awareness and can thus have an impact on consumer behaviour and everyday lifestyle of students [3].

*What is Green Chemistry?*

Green Chemistry is the Chemistry that produces non toxic products, through procedures that do not destroy the Environment and do not harm human health. Moreover, Green Chemistry is the "Chemistry of Reduction": Waste, Danger, Cost, Materials, Energy, Non Renewable sources [1, 2].

*Why Green Chemistry for Students?*

Green Chemistry is a way of thinking as well as acting. Green perception deals with all the environmental problems by taking into account the protection of the Environment [4].

Every citizen should become familiar with the meaning of Sustainability, as well as with the 12 Principles of Green Chemistry.

## 2. Aims of the program

Students should get familiar with Green Chemistry's principles and comprehend certain environmental issues and what sustainability is. Students should learn how to design, organize and implement certain environmental activities working in groups, starting from their schools and expanding to other schools, cultural associations, provinces, etc.

Students should develop special communicative and social skills that will allow them to contribute in improving the quality of life and building a society with more sustainable consciousness.

## 3. Description of the Program

The establishment of the Anatolia College Center for Green Education is an educational breakthrough, as there has never been a Green Education Center organized by a high school (the environmental education of students worldwide, is offered by higher education Institutions). The Green program will be available for Elementary and Secondary school students. This innovative program is the first of its kind and aims at introducing younger students to sustainable development, protection of the environment and preservation of resources, through application of Green Chemistry principles.

### 3.1. Content of the Program

The educational activities selected and organized were divided in four theme units, the same for both Primary and Secondary Education, and will be presented at a different level of difficulty, depending on the age and the theoretical background of the audience. The theme units are: Energy, Water, Soil and Food Chemistry. In every unit a certain pattern is followed: concerns on the issue are provided, a sample of education activities is given and the experiments to be performed in the lab are fully described.

#### 3.1.1. Theme unit: Energy

*Concerns:*

Coal and lignite, soil and natural gas are used to produce almost 90% of the energy worldwide and their use is not going to be reduced in the future due to increasing demand; although production and consumption of non-renewable energy sources contribute to climate change and despite the fact that renewable energy sources' use is increased (figure 1).

***Figure 1:*** *Renewable Energy Resources*

*European Commission:*

Energy Strategy for Europe και U.S. Energy Information Administration [3].

*A sample of educational activities:*

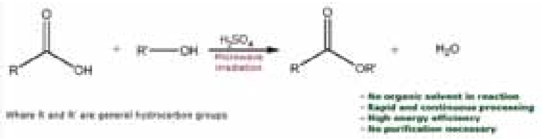
Microwave assisted esterification for production of fruit and flower perfumes

#### 3.1.2. Theme unit: Energy

Microwave assisted synthesis of esters with floral and fruity scent:

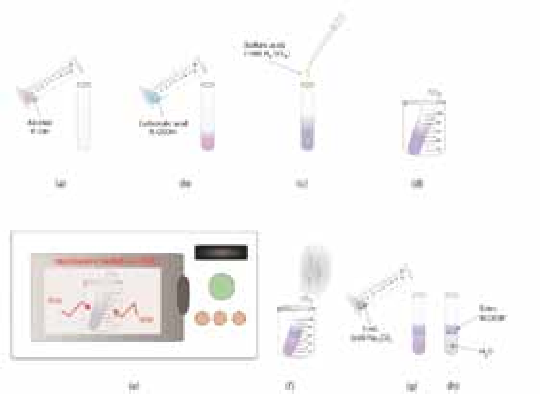
An educational organic chemistry laboratory experiment has been developed, that features a discovery based microscale Fischer esterification utilizing a microwave reactor.

Fischer esterification requires the boiling of a mixture of acid and alcohol with $H_2SO_4$ as a catalyst, and after equilibrium is obtained, the ester is separated and cleaned up with time and energy consuming procedures.



***Scheme 1:*** *Advantages of microwave assisted esterification*

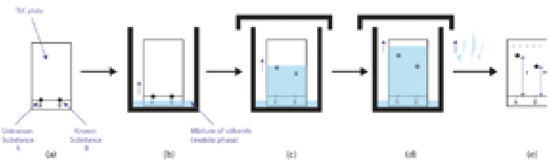
Microwave assisted reaction is performed in a short duration of time, 1 minute compared to 2 hours, while energy consumption, reaction yield, cleanliness of the product and absence of solvent, make the reaction greener (Scheme 1).



***Scheme 2:*** *Microwave assisted esterification*

Groups of students synthesize a unique ester from known sets of alcohols and carboxylic acids (Scheme 2).

Each group identifies quantitatively the produced ester by matching their scent to that of known synthetic commercial products and by using Thin Layer Chromatography (TLC) method (Scheme 3).



***Scheme 3:*** *TLC Methodology for Ester Qualitative Identification*

## 4. Educational approach

The program is based upon lab activities, interdisciplinary and project based learning. Particularly, during the program the complex and confusing science topics can be comprehensively presented through direct connection to everyday life. Hands-on activities, as well as interactive lesson plans (interdisciplinary approach), are the basic components of this project-based approach.

## 5. Anticipated results

Upon completing the Green Education Program students should be able to:

Understand complex and difficult terms that are presented through their applications in everyday life

Comprehend terms as: Sustainable Development, Life Quality, Environmental issues and dangers

Validate Green Chemistry and its ability to innovate and provide solutions to problems

Participate in group activities and actions that contribute to the upgrade of everyday life quality.

## 6. Conclusions

The Center for Green Education at Anatolia College is a "Green" initiative that aims to provide students with the essential information and knowledge to raise their environmental awareness so that as citizens of the future, they'll move the world towards a more sustainable direction

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# Babies and the Moon

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## Abstract

*In this paper we will present a scenario that is being used to support teachers being trained on the use of the Inspiring Science Education (ISE) authoring tool. In the framework of this project NUCLIO is promoting a national series of events where demo activities are promoted in schools from several different regions in Portugal. The main aim is to provide a concrete example on how to build a successful lesson using the inquiry methodology while targeting content of the curriculum. The main target age is students from grades 7th to 9th. This activity is supporting the vision that by using the proposed methodology we are enhancing the problem solving skills of the students while addressing topics of the national curricula.*

## Keywords

Astronomy, inquiry, planetarium software

## 1. Introduction

Inspiring students for science subjects is a challenge being faced all over the world. In particular, when they reach the 7th grade, other interests are beginning to take the lead in their minds and very often we find a steep decline in their interest for science.

In this workshop we present a very successful experience in Portugal where we are inviting teachers and students to embark in a fun and very educative session. Several innovative components are presented in the implementation of the Babies and Moon scenario (fig. 1), built using the Inspiring Science Education platform. A brief description of the whole experiment is presented here.

***Figure 1.*** *Planetarium Software Stellarium*

## 2. The method

The exercise follows the inquiry based learning methodology and tries to use a cross disciplinary approach targeting topics from different subject domains. In Portugal students from the 7th grade have to revisit the phases of the Moon and the Earth-Sun-Moon system as a whole. In this exercise we try to target misconceptions related to the Moon while inviting students to make their own research. The topic to be discussed is the influence of the Moon in us, in particular on the birth of babies. Students are invited to make their own hypothesis and propose their own experiment in order to prove their hypothesis. In this workshop we are presenting a structured inquiry, as we drive the students, after letting them explore the multiple possibilities using a planetarium software, namely Stellarium.

Students start by checking the phase of the Moon on the day they were born and produce a whole classroom dashboard with the collected data. After all information is retrieved they analyse the distribution and start drawing their own conclusions. A classroom discussion follows. A general discussion about the validity of the data and glimpses of statistics and error is also introduced. In the next stage they are invited to discover if the phases of the Moon are the same, on the same day, in the different hemispheres. Using the same software, they are invited to virtually visit different parts of the planet and explore the differences of the Moon as seen from different angles. The next challenge is to discover if Earth as seen from Moon (fig. 2) exhibits phases and to understand the duration of the phases and its correlation with the Moon phases.


***Figure 2.*** *The Earth seen from the Moon using the software Stellarium*

After they complete their research they are invited to discuss their conclusions with their colleagues. Finally, a whole classroom discussion is set and students are invited to discuss the results of their experience.

The teacher acts as a tutor in the whole process gently driving the students along the whole process.

## 3. The tools – Building Scenarios with Inspiring Science Education authoring tool.

The whole scenario was built using the Inspiring Science Education authoring tool. The tool allows the construction of the different steps with very useful tips on how to present the material and which problem solving components to explore in each phase. The proposed software to explore and retrieve the necessary data is Stellarium, Stellarium and Celestia are both exceptional tools for teaching astronomy and can be used in the classroom to demonstrate various astronomical concepts.

Stellarium shows a realistic sky in 3D and can be used to demonstrate, for example; the movement of the planets and stars, the constellations, the brightness of various objects and what objects can be seen from different geographical places at different times of the year. It can also be used to explore the sky on specific dates in the past and in the future ranging from year -99.999 to + 99.999. The tool is very precise and scientifically correct. It presents a modern design and is visually very appealing.

## 4. The experience

Students find it very interesting to be able to explore the sky on the date they were born. In particular students that have not used the tool before tend to get lost with the numerous possibilities for exploration.

The Moon exploration using this tool allows students to explore in depth the different phases.

In many of the cases where we did the experiment for the first time students felt a bit uncomfortable with the proposed methodology but with the continuation they began to be more interactive and participative.

We had two different groups of teachers participating / proposing this activity. Many of them have participated in professional development activities where they learned how to use the different tools. But one of the purposes of these demo activities in school was to attract the attention of new teachers, many not experienced in student centred practices at all. For the experienced teachers this was a good opportunity to put in practice their learning during the training events. For the newcomers, in general, it was a pleasant surprise.

## 5. Conclusions

In the particular case of Portugal this part of the curriculum is appreciated, in general, by students. Several different activities, using inquiry, can be used in alternative. But the use of ISE platform and Stellarium as an additional element to the activity provoked a very good reaction from the part of the students. Further studies are now necessary in order to identify how well students retained the delivered content.

# Gaining Media Literacy by Utilizing Web 2.0 Tools in Primary School IT Education

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## Abstract

*We live in a digital era. Students today are the digital natives that use digital media very often and with ease. However, when working with students one notices that they are, in fact, computer and media illiterate.*

*The main goal of today's IT science classes is not only to teach students basic computer skills but to also provide them with appropriate and more in depth media and computer literacy.*

*This paper presents the results of an experiment conducted with primary school students (age 14). Upon mastering the Office 365 platform, children were given assignments to research topics in groups. Themes were selected and distributed with the specific goal to stimulate research options for learning media.*

## Keywords

Digital media, media literacy, Office 365 portal, project based learning, web 2.0 tools

## 1. Introduction

The future is now [1]. Although we think that kids nowadays are competent with new technologies that are growing at an alarming rate every day - we couldn't be more wrong. The kids today and the kids that were born in our time, are in fact the same. They are just kids. They are born with the same feelings, abilities to develop skills and curiosity to discover the world. However, the circumstances of growing up in modern civilizations have changed and that is understandable. The underlying problem is that adults are not changing adequately enough to keep up with the changes in order to be competent parents and teachers. Thus, we provide children with all of these technologies but we ourselves are uncertain of what to do with it, since we are unable to show them how to properly use new technologies.

Thus, we provide them with new hi tech things and expect them to learn how to use them by themselves and to not get into any danger. Moreover, we hope that they will use it for smart things, such as learning, exploring or any other positive aspects. Our expectations are unrealistic.

We don't give two-year-old children knives and expect them to know how to slice bread and to naturally, not injure themselves, after only a few hours. Today's children are no different. They also need guidance, maybe now more than ever before.

Students today are the digital natives that use digital media very often and with ease. This possibility gives them the impression of having a vast and solid knowledge in digital media. However, when working with students, one notices that they are, in fact, computer and media illiterate.

According to Wikipedia, Media literacy education provides tools to help people critically analyze messages, offers opportunities for learners to broaden their experience of media, and helps them develop creative skills in making their own media messages [2]. This is one of the underlying reasons for this paper, which actually presents a report of the project that the author conducted with their students. It is perfectly clear that even if Croatian students are acquiring adequate IT education, regulated by curriculum and despite the bad equipment, it is insufficient in terms of the upbringing of new generations. Even the authors Pfaff-Rüdiger, Riesmeyer and Kümpel, in their research conducted in Germany, came to the conclusion that the role of the school in mediating media literacy is marginal – generally speaking, the curriculum only includes technical skills like typewriting and handling of Microsoft Word [3]. It is important to emphasize that the role of the IT teacher is not only to educate students on how to gain skills in handling software and hardware, but it is also to provide them with proper media literacy. As author Frau-Meigs states: "By building knowledge and competencies in using media and technology, media literacy education may provide a type of protection to children and young people by helping them make good choices in their media consumption habits, and patterns of usage." [4]

There is still no consensus on how to prepare today's children for the new world. Prensky suggests Plan B as he concluded that students today need an education that moves past the academic model of "learn now so you can accomplish later" to a new model of "accomplish now, and learn as you do." [5]

This paper presents an IT class conducted in a different manner to what was initially set out in the curriculum. The point of this experiment was to briefly introduce students to new tools (based on the Office 365 platform) and to then hand over the teaching baton to them. A teacher is a kind of mentor, a coordinator for group work and a traffic officer who guides in the right direction. In this type of project, students are greatly responsible in the self-learning process with higher intrinsic motivation. The expected results of this type of project are longer-lasting knowledge with students experiencing a higher sense of self-confidence upon project completion.

Moreover, learning in an online environment does not seem boring due to the projecting environment that is closer to today's generation. A significant portion of their lives is taken over by social networks. It important to teach today's students on the hazards of social networks, but to also give them the opportunity to get acquainted with the educational purpose in such an environment.

## 2. Choosing the right LMS tool

During my work as a teacher, I held g various discussions with my students regarding the internet and internet services. From grades 5-8, they learnt what the internet is, how it functions in theoretical terms, what are its main services and purposes, by means of a vertical type of curriculum. Throughout this period, we talked about the internet from a critical point of view. I came to the conclusion that the 8$^{th}$ grade students' awareness s regarding the accuracy of information in the internet world was very high. They had developed a way of thinking in terms of what is and what isn't useful on the internet and the skills needed for retrieving the right and accurate information on the internet. After years of experimenting and learning in different applications, students developed skills and autonomy to learn by themselves and to “manage” new applications without fear of doing something wrong.

Thus I came to the conclusion that it was time for a higher level of their learning and information processing.

The important question was to find the right tool which would support my idea of creating the project. The tool had to have good features for team work - easy sharing and collaborative options for working on documents (as well as on presentations), the possibility of easy communication among students in groups and with the teacher, and some additional tools for polls and announcements. And, of course, another important requirement is that the platform provides a safe environment for working within closed groups.

Throughout the past years, I have introduced various tools (Edmodo, Google Drive, Moodle platform) into my classes, but after a thorough analysis of the Office 365 portal, I decided to go with it.

An additional argument for utilizing this type of online learning was to bring learning closer to my students by using tools that they use in their everyday life – social networks, instant online communication and simply working on computers at their own pace. As Office 365 offers Yammer, a social network with features similar to Facebook, I decided that it was the best choice. Based on students’ feedback, I was right. An important feature of Yammer and the other Office 365 applications is that they have the option of using smartphones to connect and collaborate. I cannot get used to the fact that when I walk through my school’s hallways I see my students with their heads deep in their smartphones. So, I decided to use that as an advantage for motivating my students to work on their school projects.

## 3. Plan and Implementation of project – Exploring Web 2.0 option for education using the Office 365 Portal

The project that was conducted with students was written in **ISE Scenario** using ISE Portal. All of the phases will be explained in detail in this paper.

### 3.1 Orienting & Asking questions – Get familiar with the Office 365 Portal

**In this phase** we started concretely working on our project. First I introduced my students to the portal. I showed them how to login (using Carnet identity service) on the website https://office365.skole.hr/ and then I showed them what the portal offers. The initial introduction of the Office365 portal was conducted in a real classroom through frontal learning.

All students and teachers (Croatian academic community) have access to the Office 365 portal by using the Carnet identity service (e.g. mirena.maljkovic@skole.hr). Through this portal, students can **download** up to five **Microsoft Office** licenses (Figure 1).


*Figure 1*

The portal also provides online services as shown on Figure 2, such as **Yammer** (Social Network), **One Drive** (Cloud storage),

**Delve** (Collaborative work), **Video** (Upload and exploring Video and video channels), **Word Online**, **Excel Online**, **Power Point Online**, **OneNote Online** (notebook online) and **Sway** (interactive presentations and papers).


*Figure 2*

After students logged into the portal and explored the environment, I emphasized the specific tools that I expected to be used during their project.

First I showed them **One Drive – cloud storage service** with 1 TB capacity.

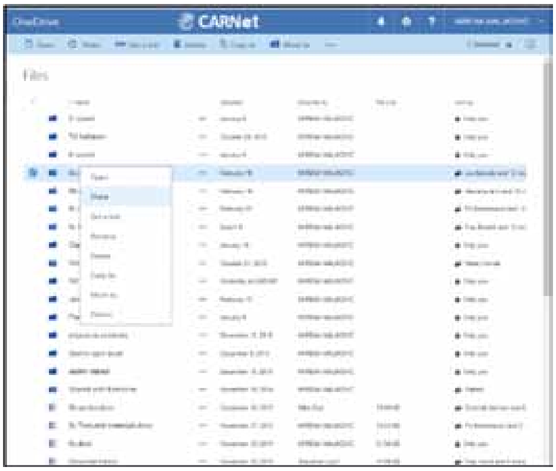


*Figure 3*

The advantage of this is that the folder can be shared with others, which we use during our project (Figure 3). We did an exercise to try to upload files, make folders and most importantly, share folders and files with teacher and colleagues.

After the exercise in One Drive tool, we got familiar with **Word Online**. This tool has all the important features like the classic Word application, but an advantage is that a document, once opened, is automatically saved on One Drive Folder and, of course, shared with other persons (Figure 4). Changes performed to the document are immediately evident to all persons allowed to access it. And for each person accessing the document you can see what is being edited. That feature is very practical for this type of collaborative learning.

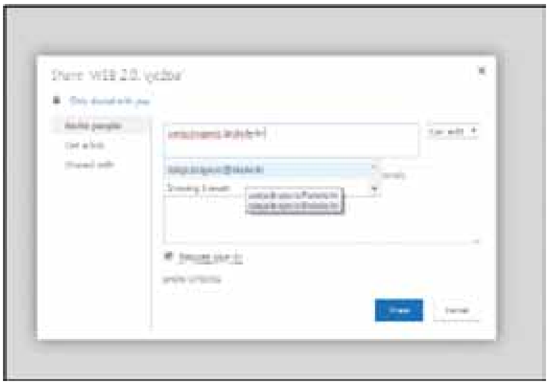

*Figure 4*

Students managed the One Drive and Word Online easily because they were familiar with the tool so they just upgraded their knowledge with the document sharing feature.

On the other hand, **Sway** was more challenging. It is a tool for making presentations, but these presentations are not so similar to Power Point. Since I wanted my students to be more independent, I asked them to learn how to make a Sway presentation on their own. I directed them on how to search and watch online tutorials. However, sharing the presentation was our mutual effort (Figure 5).

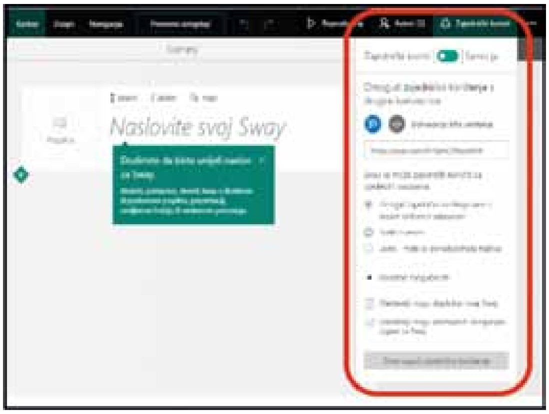


*Figure 5*

And finally, the most important channel for student - student and teacher - student communication is **Yammer**. In Yammer I created closed groups with the colleagues. (Figure 6).

While working in Yammer, students can communicate through chat, but the tool also provides other means of communication, such as Posts, Announcements, and Polls.

As expected, students accepted Yammer and managed it with ease.

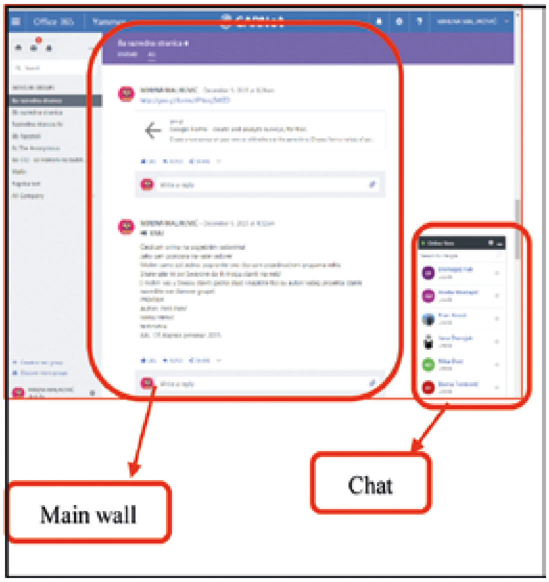


*Figure 6*

## 3.2 Hypothesis Generation and Design - Division of tasks

After students became familiarized with the Office 365 tools and options, they were divided into two groups within the class. The group division was conducted by random selection.

The students were divided in two groups, each containing 5-7 students. They were orally presented with the subject and were given short instructions for approaching and processing the subject.

**The first exercise is to have** a "live" discussion and to delegate a group leader, leader›s deputy and work assignments. Then, the group name needs to be defined. Yammer›s survey can be used for that purpose (Figure 7). After groups have been established, the teacher creates Yammer groups and includes group members.
Each group gets its subject:
Web 2.0 tools
Communication tools on Internet
Educational tools
Safety on Internet
On-line shopping
Office 365
Google Drive

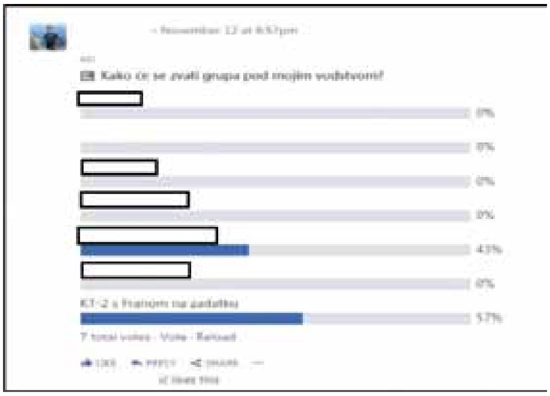

*Figure 7*

**The second Exercise:** Students explore the subject in general. After they are acquainted with the subject, they engage in a more detailed task assignment after which they explore and acquire the data. The acquired data is being shared via One Drive or written in the Word online shared document (Figure 8).


*Figure 8*

### 3.3 Planning and Investigation

After students have studied their subjects, they are assigned tasks.

The leader has to communicate the task assignments on Yammer. Also, the leader needs to be available to the group in case their help is required.

**Students are divided based on the following tasks:**
• Acquiring and selecting important data – texts and pictures (no copy-pasting of large amount of data because it requires extra effort for e.g. person who creates a movie)
• Creating a Sway presentation (two students)
• Creating a promotional movie of the subject or video tutorial of the tool (two students)
• Creating a Kahoot quiz which follows content presented in Sway project and movie
• Each task is mostly assigned to two students, one of which is leading the presentation.

The teacher helps in case of a problem. Usually, the first question is where to start from. The teacher can point to the Yammer wall or chat. For example, with "Educational tool" subject pupils have been directed to Carnet's e-Laboratory.

Students who are creating Sway presentations are obliged to share their work with the teacher, so that teacher is informed about the content and able to correct it, if necessary. Students do everything by themselves, acquiring the data, getting acquainted with the tools for project and sharing.

### 3.4 Analysis / Interpretation

After the data has been collected, it has to be processed for reading the information out of it. Depending on the gathered data or information, this step can be very complex. Therefore, the teacher and/or an **analysis-tool** can help.

Teachers can support the students› process of **data investigation** by organizing collected data and interpreting them by identifying key issues.

When solving problems, solutions found by experts can also be examined, and compared with the students› own solutions for the same problem.

The opinions or results of experts can be found by students via online or offline inquiry provided by the teacher via links/documents/other materials.

When projects are done, students present their projects in front of another group. First, they present their Sway presentation, and then the movie (which can be integrated within the Sway presentation). Upon completion, the listening group takes the Kahoot quiz, which verifies their gained knowledge.

### 3.5 Conclusion & Evaluation

After each group has presented their project and verified the gained knowledge of the listening group via Kahoot quiz, pupils engage in an argumentative discussion of each other's project's success. After each other's evaluation, they are asked to take a Google forms survey with questions regarding the success of other group's project and project based learning. Figure 9 show the results of the Google Form survey.

**These are links to some final Sway presentations**:
E learning tools:
https://sway.com/qvLqerJrG6db1KWH
Office 365:
https://sway.com/ZLwbedFDc037VmMt
Internet safety:
https://sway.com/jaLfdAbHf8IFlTvK
Web 2.0 tools:
https://sway.com/MTDfJBe2qFODq78G
Communication tools:
https://sway.com/6CFpkZxMk9XH6NDR
On line shopping:
https://sway.com/r0w1YuczV34TaSQx

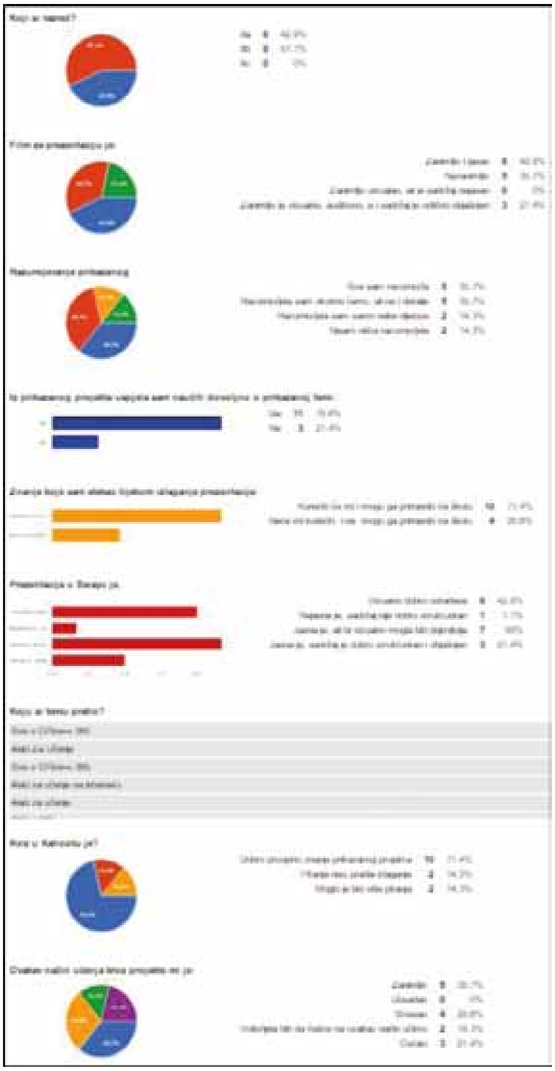

*Figure 9*

## 4. Conclusion

Working as an IT teacher, I feel it is my responsibility to educate my students to become people and citizens with outstanding media literacy. Of course, the Curriculum highlights concrete knowledge gained by working in the default prescribed software and along with certain degree of knowledge in hardware and processes in IT world. However, our obligation as teachers is not only to provide children with factual knowledge but to research and to try to improve their classes, respecting new achievements in Media Literacy. Authors Pfaff-Rüdiger, Riesmeyer and Kümpel suggested a skill based model of media literacy with three dimensions (Figure 10) [3].

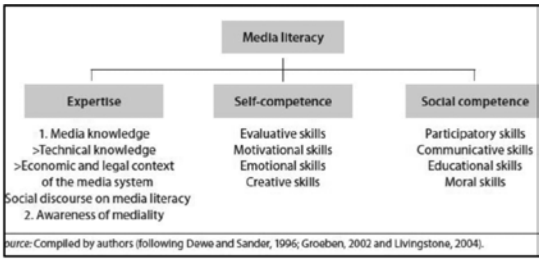


*Figure 10*

During my experiment with students, I concluded that all dimensions were respected. The main goal wasn't to conduct only one project teaching class a year with only one group of students, but to involve this type of learning in everyday teaching, both with younger and older groups of students.

As can be seen from the results of the Google survey and in the conversation with my students, it can be concluded that students like this type of learning. Since the project was conducted in a group, students were forced to work with each other, which led to developing additional skills, such as patience and greater responsibility, since they were forced to also depend on others. Additionally, they were given great responsibility and freedom to conclude and evaluate their own results, which resulted in a greater sense of achievement. Students had to separate good and important information in the big ocean of the internet and the skills that they developed during this process are very important and will be helpful for their further education and active life as a responsible citizen. However, the most important conclusion of this project is that students have realized that tools they normally use in everyday life, such as social networks, can also be used for their own education, which made this education process much more fun and therefore, more effective.

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http://marcprensky.com/wp-content/uploads/2015/12/+Prensky-PlanB.pdf [visited 12-Mar-2016]

# Integrating Innovative Practices in Secondary Special Education in Greece

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*"The wandering star within the play-of-time space has become exactly what it is: a planet. Cannot humans, too, fist inhabit what their place is—within the play of-time space? With nostalgia and the yearning for faraway places? Provided that adventure and the return home can still be distinguished from one another."*
*Kostas Axelos*

## Abstract

*The current financial crisis has brought significant changes in the global and the European economic environment. The causes and the effects of the crisis demanded serious and effective decisions to be taken, affecting many areas of European citizens' lives. Education is no excluded undergoing, in first, clearly negative measures (cuts in government spending on education, teachers' salaries reductions, etc.) but, in a second though, giving possibly the necessary motive to a courageous and scientific opening to the "play of the world" - according to K. Axelos "the world deploys itself as a game". The 'best' answer to the crisis is education itself. Three initiatives (from UNESCO, OECD and the European Commission) since the end of the 20th century, 'opened' the debate on important changes to education in developed countries, revealing the imminent need for significant changes to take place in education. Moreover, in 2008 three technology companies (Cisco, Intel and Microsoft) expressed concerns that graduates of schools and universities entering the workforce do not really have the skills necessary for the new digital era and they also identified the need to focus on the, so called, 21st century skills (ATC21S™). STEM skills are increasingly recognized as a major component of the basic education in today's economic environment. In this context, the European Union supports and implements a variety of important programs in STEM education – such as iSe, GoLab, UDLnet, Scientix etc. According to the European Schoolnet, keeping the European economy into growth, 1,000,000 additional STEM researchers will be required, by the year 2020. Education ought to prepare our students to cope with the changes, providing them critical and creative thinking. Thus, (a) taking the torch from our last school years' activities and (b) taking into account all the above into amount, we designed and implement(-ing) a numerous of innovative educational activities. The educational activities presented, target typical development students from mainstream education and students with special educational needs and/or disabilities. The students are seen as unique individuals and our educational objectives are an effort for an inclusive education and one school for all. We try to open and connect our school with the outside world using open access scholarships and open educational resources.*

## Keywords

Inclusive education, innovative science teaching

# 1. Introduction

## 1.1 The social context

Article 24 of the UN Convention on the Rights of Persons with Disabilities states that we have to ensure persons' with disabilities right for an inclusive education and lifelong learning directed also to the development – to their fullest potential – of their personalities, talents, creativity, mental and physical abilities (Article 24 §1 (b)). We should also facilitate the learning of sign language and the promotion of the linguistic identity of the deaf community (Article 24 §2 (b)) providing "reasonable accommodation" – means necessary and appropriate modification and adjustments not imposing a disproportionate or undue burden (Article 2). This goal, in the present global and European economic environment [12, 13, 15] is a very demanding task since «*Educational institutions will have to do more with less in the coming years*» [29] requiring a well-planned and coordinated action.

Moreover, according to the European Schoolnet [14], to keep the European economy into growth, one million *additional* researchers will be required by the year 2020 in STEM (Science, Technology, Engineering, Mathematics) science fields. Recognizing that STEM skills are an increasingly important component of today's basic education and the 'shifting' from an industrial-based to information-based economy, European Union supports and implements a variety of important programs in STEM education – e.g. Scientix (www.scientix.eu), iSe (www.inspiring-science-education.net), GoLab (www.golabz.eu) etc. The imminent need for significant changes to take place in education was pointed out since the end of the 20th century. Three initiatives, from UNESCO [10], OECD, [1, 30] and European Commission [17], opened the debate on important changes to education in developed countries.

In 2008, three major technology companies – Cisco, Intel and Microsoft – identified the need to focus on so-called 21st century skills [18] they initiate Assessment and Teaching of 21st Century Skills (ATC21S™) project. It is worth noting that the concern of ATC21S™ was not only to define the 21st century skills (see Figure 1) but also to demonstrate the methods appropriate for assessment, the types of technologies needed, the teaching approaches that these changes will trigger [6]. It is worth mentioning that apart from large multi/trans-national companies, similar practices have been adopted from the, so-called, *liberated companies*, where there is no hierarchy system present and employees are required to work, make decisions and take responsibility in groups [7, 34, 39, 41]. In such companies, also, the employment of the workforce requires, increasingly, critical thinking skills, complex forms of communication and information management skills. Thus, our students should, on the one hand, be prepared for the new forms of work and jobs that have not yet been created and, on the other, to be familiar with new tools and new technologies [19]. Education therefore requested to prepare our students to cope with the rapid social changes, providing them with new ways of thinking associated with creativity, critical analysis, problem solving, decision making, etc.[19].

## 1.2 Teaching in Special Education

Teaching in Special Education is a very challenging task. We must take into account *each* student's special education need. Major difficulties can be raised since a) our students can't easily connect core scientific ideas with mathematical formulation or use the knowledge gained in a different context [31], b) their representations are universal and not easily modifiable [11, 21] and c) the significant difficulties regarding (short term, working, long term) memory function [32]. For example, students with autism spectrum disorders (ASD) are strong visual learners, so they may struggle to process information in a 'clear' verbal format [16].

| | |
|---|---|
| *Ways of Thinking*<br>• Creativity and innovation<br>• Critical thinking, problem solving, decision making<br>• Learning to learn, Metacognition | *Ways of Working*<br>• Communication<br>• Collaboration (teamwork) |
| *Tools for Working*<br>• Information literacy<br>• ICT literacy | *Living in the World*<br>• Citizenship – local and global<br>• Life and career<br>• Personal and social responsibility – including cultural awareness and competence |

***Figure 1.*** *The 21st century skills [4]*

To teach science effectively, we integrate educational practices such as: 7E open Inquiry Based Science Education (IBSE) [23], Big Ideas of Science (GoLab, 2015), 'adding' the *Art* component to STEM – becoming STEAM, metamemory strategies [24, 33], analogies [2], Information and Communication Technology (ICT), online repositories (i.e. Inspiring Science Education (iSe), UDLnet and GoLab), and international practices [37]. We want to emphasize that the educational activities presented target typical students as well students with special educational needs and/or disabilities. The educational activities, presented in short in the next sections, can be found on the blog of the author, https://4myfiles.wordpress.com, and on the corresponding repositories.

## 2. Innovative Science practices

Taking the torch from our previous activities [25] and taking into account all the above into account, we designed and implement(-ing) a numerous of innovative educational activities in Public Special Junior High School of Thessaloniki (Central Makedonia, Greece – https://eidgymthess.wordpress.com/). The students are seen as unique individuals and we try trying to maximise the educational outcomes and to open and connect our school with the 'outside' world by, i.e., presenting our didactic proposals participating in conferences and open educational resources [25]. We have to pointed out that for all this didactic proposals we try to get involved as many teachers as possible – and of course as many students as possible.

### 2.1.1 How light ...Jumps.

This activity is part from "Lasers & Bubbles"– a top-5 on 2015 ISE Contest "Learning with light" – didactic proposal (see here http://wp.me/p3oRiZ-h9 and http://wp.me/p6Hte2-14) [27]. Students as photons, had to make decision on the materials separating line about where to turn: left or right and so they undergo the changes in their (light) path via two different materials. The analogy demonstrates light's capability to ...jump on atoms – in order to pass through a crystal material – just like we jump on rocks to pass across a river. The analogy also demonstrates how a non-crystal material traps light – just like we will fell into the river's rock end – see http://wp.me/p3oRiZ-hu. This dramatization it turned to be a very joyful activity and it was presented with a poster at CREAT-IT 2015 "Inquiry Based Learning and Creativity In Science Education" (http://www.scientix.ea.gr/) [25].

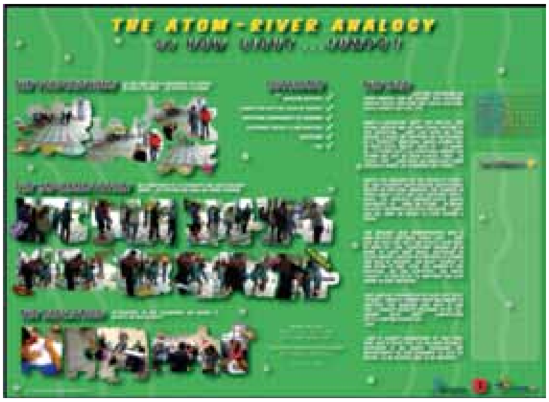


***Figure 2.*** *"How light ...Jumps!" poster.*

### 2.1.2 Interdisciplinary Astronomy Activities

On November 9th, 2015, three didactical hours were dedicated to Interdisciplinary Astronomy Activities (IAA) – see http://wp.me/p6Hte2-1I [26]. Five (5) teachers joined their "forces" and our students in three groups and in rotation, were engaged a) in a unique images presentation of the Cosmos in the mobile planetarium STARLAB (http://www.planitario.gr/tholos-starlab-classic-standard.html), b) in a video session on solar system, space missions and Universe, in our school's library and c) in tactile activities such as Meet our home and Meet our neighbors (http://nuclio.org/astroneighbours/resources) and the creation of planets' 3D models.

***Figure 3.*** *Photos from IAA (see http://wp.me/p6Hte2-1I)*

With the above hands-on activities we had the pleasure to join the Cosmic Light Edu Kit / International Year of Light 2015 program. After the activities, we did a "small" research: our students had to fill an evaluation form on IAA (Figure 4).

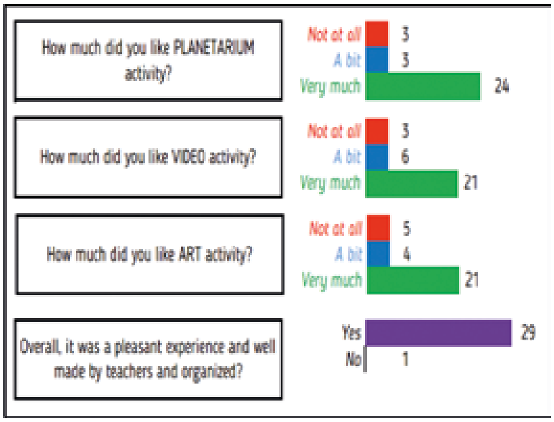


***Figure 4.*** *Here you can see four (4) Q & A after IAA (see http://wp.me/p6Hte2-2q)*

We received 30 answers, of half of our school students, and in Figure 4 you can see a "small" but significant result of IAA's impact. The activities were presented with a poster at EGU General Assembly; 2016 [26]. We want to highlight that hands-on activities for students are hands-off activities for teachers and cultivates metacognition [24].

### 2.1.3 Volcano Eruption & Big Ideas

Here you can see an activity for Geology Class, using poster as educational material [28] in order to connect a 'real life' phenomenon (volcanic eruptions) with the Big Ideas ("a set of cross-cutting scientific concepts describing the world around us" - www.golabz.eu/big-ideas). The poster was created for the Scientix's competition "Media in STEM Award" and it was the winning entry for the graphic category (see here http://goo.gl/kIcmmm and this facebook post https://goo.gl/2bQ7qs).


***Figure 5.*** *"A Volcanic Eruption and the Big Ideas" project (see http://wp.me/p3oRiZ-mv)*

Our students had to inquiry about volcanoes (via internet & using the IWB) and to match A, B, C, D volcano phases (on the left) with as many as possible, Big Ideas (on the right). Through this multisensory approach we want to underline the unity of the science aiming on the memory and the "perceptual fluency" of our students [33]. The winning entry was also presented at the pre-conference workshop "*Innovating Science & Maths teaching with media-based tools and approach-*

*es*" of The Media & Learning Conf., (see http://goo.gl/nQYKa7). Posters are a "drawn to the eye" visual tool that can be part of many lesson plans and activities (e.g. as an advance organizer, as a common reference content, a resumption material, a cross thematic material, etc.), fitting our students' educational needs, maximising the success of the educational objectives. Posters are suitable to teach core scientific ideas and a great tool for deep scientific understanding integrating cross thematic objectives. Moreover though posters we can activate our students to plan, to implement and evaluate a lesson [28].

#### 2.1.4 Science Theatre

This school year, under the School Activities Programme "School Garden - Recycling / Environment and STEM education," and with the help of Dr. Eleftheria Mpaka (Teacher of Drama & Author), we implement a theatrical performance based on Yio Somei's book "Jake in the Sea" [36]. Through this science theater we highlighted the values of biodiversity and the environment. The theater was presented throughout the school with great success and we also participate in "Learning science through theater" (see here: http://lstt2.weebly.com) – which is based on the pedagogical framework of the European project CREAT-IT (http://www.creatit-project.eu/), the guidelines for creativity in science education (http://goo.gl/afHTE5) and the support of the European project CREATIONS (http://cordis.europa.eu/project/rcn/198210_en.html).

***Figure 6.*** *From our theatrical performance based on Yio Somei's book "Jake in the Sea" (see http://wp.me/p3oRiZ-n9)*

We succeed to integrate the emotion component in learning [22] in a multimodal learning environment [40]. Teaching theatre is a way of enhancing self-image and self-esteem of students. Using theatrical techniques as educational tools and help the learning process in a school with students of special educational needs and/or disabilities.

## 3. On-going and Future work: steps ...beyond

Aiming the modernization and consolidating innovation practices in growth of our school unit, at least in a medium-term plan, we will present the following activities that are not going to be completed during the current school year, but they are going – in long-term – to add educational value, involving students & their parents/guardians and teachers. These activities give us the opportunity to take Curricula a step beyond and manifestation of a solid education proposal for interdisciplinary activities on 'hot' scientific topics – that our students are not going to get involved in their schools years.

Under the School Activities Programmes we are implementing an environmental and project focused on media careers: a) the "School Garden - Recycling / Environment and STEM education" project and b) the "School Radio" project. Our school radio will be an activity to be continued for several years – joining the European School Radio (http://european-schoolradio.eu/) – help understanding media technologies and promoting media careers. In the environmental project we have organized to plan fruitful trees at our school garden and to make an inquiry on environmental parameters (soil, sand, gravel and water, acids bases salts etc.) on pulses (beans, lentils, chickpeas, fava & broad beans), since 2016 is the International Year of Pulses, according UN (http://www.un.org/en/sections/observances/international-years/).

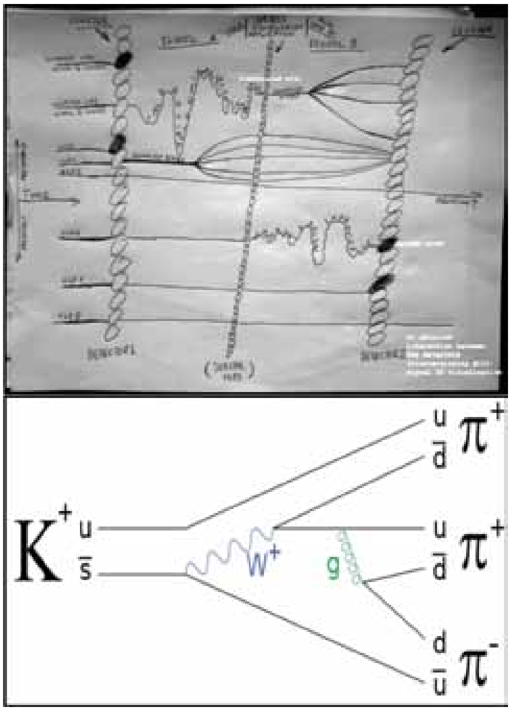


***Figure 7.*** *Graphical music scenario (top) [38] and Kaon-Decay's Feynman diagrams (bottom – from https://en.wikipedia.org)*

Introducing teachers & students to the basic aspects of black holes, BHIMS (Black Holes In My School) project gives the opportunity to engage in to classroom with new tools and resources and experiment the use of a student centered model (see http://goo.gl/UoDXOx & http://goo.gl/fm14oW). From our point of view, we enrolled the on-line lesson and we try to see how our students evaluate the impact of the use of such methodology implementing the scientific method. To this end we implement an ILS (Inquiry Learning Space) and we want to thank Rosa Doran (http://nuclio.org/) for her invitation to this project. Our students would never ever dream to research on the variation of a double star, investigation if there is a black hole!

Going forward, we are also participating in the CREATIONS project. The CREATIONS project aims to demonstrate innovative approaches and in Scientific Research through creative ways that are based on Art and focus on the development of effective links and synergies between schools and research infrastructures [8]. In this context we engage our students in a welcome video to the "Longyearbyen Skole", developing a frame for the next Global Science Opera in Real Time (http://goo.gl/jJo6v0) and we are raise the debate ov how we can use music to teach, introductory, string theory [5, 20] and Feynman diagrams [42]. In Figure 7, you can see the analogy between the graphical music scenario (top) [38] and to Feynman diagrams (bottom). Moreover, string theory – in very simple words – tells us to 'see' elementary (subatomic) particles as different energy vibrations of a very very small string.

## 4. Discussion

The first pillar is to offer students educational activities in order to facilitate their learning and to provide them the necessary experiences for life. The educational activities presented involve students working in teams inquiring and exploring different aspects of a task. The educational outcomes are, among others, knowledge gaining on the core scientific ideas, better relationships between teachers, students & parents/guardians, and boost of students' self-esteem [25, 35]. The emotion component has been integrated in learning [22].

The second pillar has been the design of medium-term & long-term innovative educational activities All the above are objectives to an effort for an inclusive education and they were developed with use of open access scholarships and open educational resources [43] in the framework of European Projects like iSe, GoLab, UDLnet.

There is also a third pillar: to engage as many teachers as possible and to support them in innovative science teaching, by all means. In the near future we are planning to developed or/and support teaching practices on coding & robotics (see Figure), space, movies, special education and sign language.

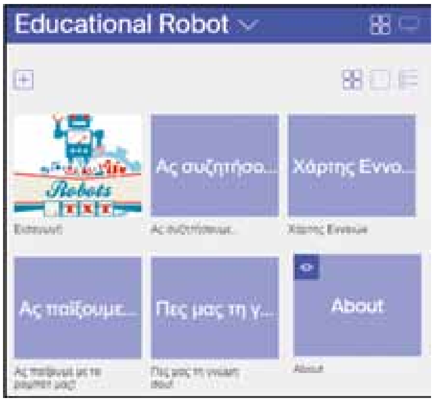


***Figure 8.*** *A innovative ILS on educational Robotics (in Greek) from Eleni Psara (http://goo.gl/pl8boj)*

Science education, on our point of view also, establishes a wider framework of individual completion through the development of critical thinking and the urge to act, locally & globally, aiming to raise the awareness on human rights, world peace and safeguard human dignity building, ultimately, a culture of peace [9].

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# Enhancing Reading Comprehension of Students with Reading Difficulties or Dyslexia in the 3rd Year of Primary School, by Implementing Inquiry Based Science Education with Digital Technologies

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## Abstract

*According to reading comprehension research, successful reading comprehension is based on successful reading process. However, in recent years, there has been an increasing diagnosis of elementary school students with learning difficulties and particularly with reading difficulties or dyslexia. Furthermore, the wide variety of ways in which these students are categorized does not provide a substantial assistance to them. In educational settings, they are characterized as students with reading difficulties, and in clinical settings are characterized as students with dyslexia.*

*Therefore, it is important to change the perspective of reading difficulties or dyslexia from "disabilities" or "deficits" to a more positive perspective. This means overcoming some "barriers" on their reading process and exploiting their strengths, one of which is their creativity, should be one of the priorities of teachers. Digital technologies help such students to overcome the barriers they encounter and promote their creativity. Moreover, Inquiry Based Science Education, as a student centered approach, makes science education more attractive to them.*

This case study bridges the gap between Inquiry Based Science Education enhanced by digital technologies, creativity and inclusion of students with reading difficulties or dyslexia, by exploiting the multiple representations provided by interactive texts and the creativity of these students. As a result, not only meaning generation regarding concepts of our planetary system is achieved, but students are also motivated to communicate their findings in creative ways.

## Keywords

Creativity, Digital Technologies, Inquiry Based Science Education, Reading Difficulties.

## 1. Introduction

Successful reading comprehension of a text is based on successful reading process, in which the written symbols of the text are decoded and converted into a phonological code. However, the failure of some students to decode words, is responsible for a major part of the difficulties they encounter in order to comprehend a text [1].

During the past few years, an increasing diagnosis of primary school students with reading difficulties or dyslexia is noted. There have been several attempts to categorize these students, who are classified into many groups and subgroups [2]. However, these efforts are seen by many scientists as false and meaningless [3]. As Pierson notes [4], a typical example is the fact that these students, in educational contexts, are characterized as students with reading difficulties and in clinical settings are characterized as students with dyslexia. In order to help these students, it is vital to change our perception about of dyslexia from "disability" or "deficit" into a more positive and active perception [5], [6]. Helping such students overcome some "barriers" they encounter, such as the decoding of words of a text, which results to reading comprehension [5] and exploit some of their strengths, one of which is their creativity [7], could contribute to their inclusion in the learning environment.

However, in educational context, the reading skills dominance, as a basic procedure with which knowledge is acquired, brings about huge problems concerning the education of children with reading difficulties or dyslexia. Regarding science education in elementary school, students approach scientific knowledge and basic scientific concepts by reading texts from textbooks. Additionally, students' experiences from the world around them, lead them to deep-rooted misconceptions [8]. Some misconceptions are associated with the characteristics of our solar system's planets, such as their size, their position in the solar system and the possibility of human survival on other planets, besides Earth.

Inquiry Based Science Education (IBSE) enhances students' interest in science and has been proved to be an appropriate teaching method for all students, from the most "weak" to the most "capable" [9], as it enhances students' reading comprehension [10]. Additionally, multiple representations of scientific concepts determine and influence meaning generation by students with reading difficulties or dyslexia. Thus, the utilization of texts that incorporate more than one semiotic systems, such as written and spoken text, images and motion, and which are commonly accessible with digital technologies, can provide assistance to students with reading difficulties or dyslexia, because these texts address almost all of their senses and ensure their understanding of scientific concepts [11]. It seems that IBSE, enhanced by digital technologies, has the potential to help students with reading difficulties or dyslexia overcome the obstacles they encounter, strengthening their reading skills and interest in science and to help them generate scientific meanings.

According to Pedaste et al. [12], the major phases of IBSE are five: orientation, conceptualization, investigation, conclusion and discussion. However, considering that creativity theories underline interactive and dialogical approaches to learning [13], in this research study the discussion phase has been replaced by the creativity phase, where one student with reading difficulties or dyslexia and one student without such difficulties, work together to communicate their investigation findings in a creative way, using digital tools.

At this point, it is important to underline that simple access to inquiry based learning software is not enough for scientific meaning generation. Students' learning environment should incorporate scaffolding elements, so that students can successfully interact with this environment, thrive in it and learn through it [14].

In this case study, the integration of new technologies in science teaching with IBSE is attempted, in order for students with reading difficulties or dyslexia and students without such difficulties to generate meanings regarding the planets of our solar system. Furthermore, we examined the role of scaffolding elements of the learning environment of these students and the role of creativity to their empowerment, by providing them creative opportunities with digital tools.

## 2. Methodology

In this case study, a qualitative research approach has been applied. The tools that have been used to conduct the research are: a) the educational software "Shall we go to another planet?" with which students investigated the basic characteristics of the planets of our solar system, b) the "Little Bird Tales" software with which students communicated with a creative way their investigation results c) eleven worksheets, ten of which were used by the students to record the main characteristics of the planets and the sun. The eleventh worksheet was used as a scaffolding element in order to guide them, regarding the creation of a digital story in the educational software "Little Bird Tales", d) a questionnaire, as a tool for evaluation from the students of the software "Shall we go to another planet?", e) a computer, as a recording medium of students' dialogues and f) the diary of incidents of participant observation.

The most appropriate data collection method for this case study was the participant observation, where the researcher-observer is involved in the activities, attempting to observe them. The research takes place in a classroom of a school of foreign languages. The sample consists of a team of two students, one of which displays reading difficulties, according to the teacher (Student 2, or S2). The other student does not display such difficulties (Student 1, or S1). S2 is 8 years old and S1 is 7.5 years old. Both of them attend the third grade of primary school.

Considering the general purpose, the aims and the theoretical background of this case study, a system of data categorization has been developed, in order for the research aspects to be elaborated in depth. As a result, research data have been classified into five broad categories of analysis: 1. Evaluation of subject matter, 2. Meaning generation, 3. Scaffolding, 4. The educational software "Shall we go to another planet?" and 5. Creativity.

This study is divided into two phases. During the first phase, students investigate whether humans can survive on other planets, besides Earth, exploiting the information provided by the software "Shall we go to another planet?". At this phase, the categories of analysis that are formed are the following: 1. Evaluation of subject matter, 2. Meaning generation, 3. Scaffolding and 4. The educational software "Shall we go to another planet?"

Having obtained answers to the above questions for each planet separately, the second phase of the research follows, where students, with the assistance of a worksheet, communicate their findings, by exploiting the digital storytelling tool "Little Bird Tales". They cooperate in order to create a digital story about an imaginary journey to one of the planets of our solar system. At this phase, the categories of analysis that are formed are the following: 1. Scaffolding and 2. Creativity.

## 3. The educational software "Shall we go to another planet?"

The software "Shall we go to another planet?"

is a microworld, developed in the E-Slate platform, which is a microworld development system. The E-Slate platform is a computational environment that incorporates a more coherent set of scientific concepts and relationships [15]. The most important structural element of this microworld is its "browser" which changes content according to the handling of the microworld button "Go to another planet". This "browser" contains information about the sun and the nine planets of our solar system in the form of text, which can be projected in multiple representations (multimodal text), for example, static images, moving images and spoken text. In this way, students are capable of hearing the text displayed in the "browser", using the built-in text to speech software. Thus, the students, through their navigation in the microworld, investigate and collect information in a scaffolded way, on whether humans can survive on another planet, besides earth. Figure 1 displays a screenshot of the microworld user interface, where the basic structural elements of the microworld are distinguished.

***Figure 1.*** *The microworld "Shall we go to another planet?"*

## 4. The educational software "Little Bird Tales"

During the second phase of the research, students communicate their findings about the planets and the conditions on them, creating their own digital story in the «Little Bird Tales» tool. This online digital tool, gives students the opportunity to create their own talking book, where they draw the images of the book, they type the text and finally they record their voices. In this way, students have the control and full responsibility for the creative process and their final product. However, in this case study, students are guided in crucial points by a worksheet with questions, regarding the plot of the story and the characteristics of the planets. As a result, they think and discuss in order to create the plot and finally the digital talking book. Figure 2 displays a screenshot of the product (talking book) of the creative process of the students.


***Figure 2.*** *Talking book created with the digital tool "Little Bird Tales"*

## 5. Results

As we can see in Figure 3, regarding students' participation rates in each category of analysis in the first phase of the research, S1 (which is the student without reading difficulties or dyslexia), notes higher rate (57%) in the category of Evaluation of subject matter (55.2%) and the category of Meaning generation. Instead, S2 (the student with reading difficulties or dyslexia) notes higher participation rate in the category of Educational software "Shall we go to another planet?" (54.8%) and in the category of Scaffolding (53.8%).

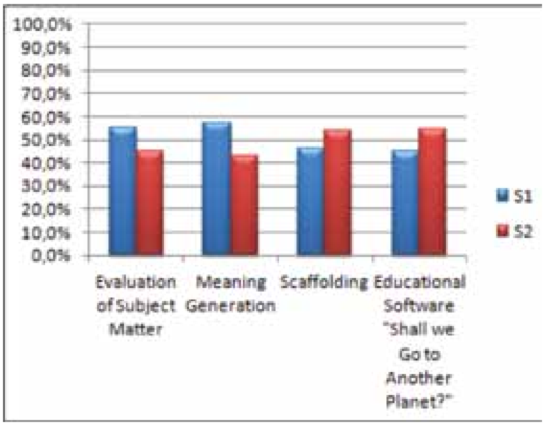


*Figure 3. Students' participation rates in the categories of analysis of the first phase*

As we can see in Figure 4, regarding students' participation rates in each category of analysis in the second phase of the research, S2 (the student with reading difficulties or dyslexia) notes higher rate in the category of Scaffolding (54.3%) and the category of Creativity (52.4%). This means that S2 notes higher rates of participation in both categories of analysis of the second phase of the research. Instead, S1 (the student without reading difficulties or dyslexia) notes lower participation rates in both categories of Scaffolding (45.7%) and Creativity (47.6%).

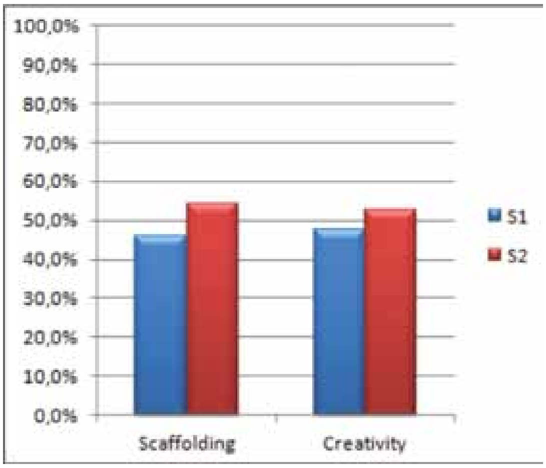


*Figure 4. Students' participation rates in the categories of analysis of the second phase*

## 6. Conclusion

Comparing the above participation rates of both students in all categories of analysis of this research, we can draw a general conclusion. Thus, the student with reading difficulties or dyslexia seems that has been benefited more by the scaffolding elements of the learning environment than the student without such difficulties, while he had been more creative by exploiting the digital storytelling tool, in relation to the student without reading difficulties. Moreover, it appears that the software "Shall we go to another planet?" noted a greater influence on him, than the student without reading difficulties. Instead, the student without reading difficulties seems that has noted in a slightly greater extent meaning generation of science concepts, while he noted a slightly increased success in the category of the Evaluation of subject matter, compared to student with reading difficulties or dyslexia.

As a result, it seems that Inquiry Based Science Education (IBSE), enhanced by the appropriate digital technology tools, along with the appropriate scaffolding elements of the learning environment, help students with reading difficulties or dyslexia overcome the barriers they encounter when reading and comprehending a scientific text and enhance the meaning generation process regarding concepts related to the planets of our solar system. Furthermore, the exploitation of creative activities using new technologies, highlights the talents of students with reading difficulties or dyslexia, resulting in a more effective communication of the students' investigation findings.

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# The Effect of Vertical Jump Exercise Program in School Setting: A Pilot Study

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## Abstract

*The vertical jump is of decisive importance for the performance in sport and school settings. The aim of this scenario is for the students to become acquainted with the different kinds of jumps and to obtain relative experience. Furthermore the students will focus on using the correct vertical jump technique and training in order to improve their performance. The students, aged 11-12 years old, were grouped into three teams (A=plyometric training, B=jumping ability training, C=control group) for a trimester. First they were taught in the correct vertical jump technique, then they analyzed and applied what they had been taught, and finally they were measured in two types of vertical jumps (CMJ, SJ). For the statistical analysis 2-way ANOVA with repeated measures was used with the help of SPSS 19.0. The results indicated that both the A and B teams improved their performance in both types of jump, with the team following the plyometric training having the greatest improvement.*

## Keywords

Countermovement Jump, Squat Jump, Testing, Volleyball, Plyometric Training.

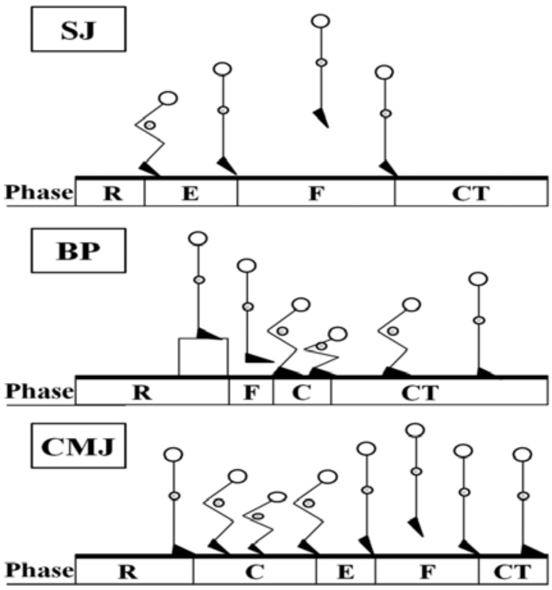
## 1. Introduction

Sports performance in athletics is a combination of many factors such as anthropometric characteristics of male and female athletes, their physical abilities, the correct execution of the techniques of movement etc. Physical abilities are defined as the abilities of the human being which contribute to the execution of various physical activities. One of these is the vertical jump. The vertical jump is of decisive importance for sports performance because the optimum performance in this assists the athletes in a combination of many sports movements. It is also one of the most basic indicators of the level, quality and training condition of the athletes [4].

The objective of this scenario is for the students to become acquainted with the types of jumps and adopt the relevant knowledge; to focus on the correct execution of their technique; to utilize their knowledge by through building on new knowledge, to use digital tools, to explore cooperatively the basic mechanisms that affect the types of jumps (Countermovement Jump, Squat Jump, Drop Jump) and, finally, to study the role and the type of training appropriate for their improvement. Finally, to learn how to evaluate and be evaluated.

The involved scientific areas are Physical Education, Physics and Information Technology (IT).

### 1.2 Review of bibliography




Muscular power is a determinant factor in the improvement of record-performance in sports such as volleyball [3]. Muscular Power (P) is defined as the ability to produce work (W) in the unit of time and the formula applied is P=W/t. [12]. In a simplistic way we could say that power expresses how strong and quick an athlete is.

Muscular power is directly related to the improvement of the vertical jumping ability [7] [19]. The vertical jump determines the level of performance in many sports [20], and ~~it~~ constitutes a control testing with which muscular power of the lower limbs is evaluated [1] [21].

Vertical jumping ability is a complex polyarticular ability, is influenced by age and sex [9], neuro-muscular coordination, volatility, the type of muscular fibre and the hardness of the tendon [6], training [1], and especially the ability to transfer energy from the joint of the pelvis to the calves of the leg through the diarticular extended muscles of the knees [18] [6]. Children apply the same model of time sequence between the phases of a jump as adults [15].

Vertical jumps differ depending on their starting position and are categorized as:
a) Squat jumps, which do not use stretching beforehand, and the angle of the knee in the starting position is $90^{o}$,
b) Drop jumps from a plinth whose height varies and is followed by a vertical jump,
c) Countermovement jumps where stretching is used before the propelling movement upwards.

Bobbett et al., [5] mention that during the execution of a maximum vertical jump, most athletes use counter movement which leads to a coordinated bending of the hips, the knees and the ankles as well as a fast sequence of joints before ascent. That allows them to obtain higher articular momentum at the beginning of the boost thus allowing the opportunity of increased production of work in respect of (SJ). Various researchers have shown that counter movement jump increases the height of a vertical jump [13], provided that it increases the proactivation of the muscles of the lower limbs [2] and allows the use of the dynamics of the Stretching Shortening Cycle (SSC) [11] [13]. In the Stretching Shortening Cycle (SSC) during the eccentric phase, the muscle expands and stores flexible energy; this is followed straight away by a concentric phase where an energy transfer takes place. This combination forms the natural the functioning of the muscles [16].

The contribution of energy of the knee joints and pelvis is greater compared to the one of the joint of the calves of the legs [14]. The data showed that the speed of taking off in the vertical jump was instigated by different parts of the body described as follows: 56% by the expansion of the calf, 22% by the bending of the sole, 10% by the expansion of the body, 10% by the participation /use of the hands and a small percentage, about 2%, by the movement of the head.

### 2. Procedure – Planning

The time required for the scenario was a trimester during which the students were supposed to research, understand, analyze and apply the techniques of the vertical jumps

(Countermovement Jump, Squat Jump, Drop Jump), to develop their creativity and to cultivate cooperative skills.

Initially, they received and processed the necessary information about the jumps, their function mechanism and the way of executing them; then the relative worksheets were filled in. They were taught to execute them correctly and finally they practiced themselves in order to learn ways of improving themselves through experience. At the end of the trimester the final assessment was made not only by the professor of physical training but also by the students themselves. The scenario adopts the holistic approach to knowledge and is also based on explorative, discovering and active learning.

The students of the school, aging from 11 to 12 years old, were split into three smaller groups. The criterion used in order to split the children into teams was the level of their systematic involvement in a particular sport, volleyball, which was taught during this specific trimester. Hereupon, each group followed a specific training course, to improve jumps throughout the whole trimester.

The first group (A, N=11) carried out a plyometric training course with jumping exercises, the second one (B, N=11) followed a training course in order to improve jumping ability with speed, whereas the third team, named the control group (C, N=11), followed only the normal school program of Physical Training, that included teaching the technical skills of Volleyball (passing, forearm pass, spike). Students were trained and given precise instructions on how the procedures were going to be carried out, the objectives of the scenario and the course to be followed.

### 2.1 Planning

In the beginning all students were measured in respect of height, weight, and their performance in the two vertical jumps (CMJ, SJ). The weekly course included two didactic units, each about 45 minutes long. In each didactic unit there was practice in speed, jumping ability, as well as the technical skills of volleyball (passing, forearm pass, spike). Random and fluctuating practice was applied for the learning of the technical skills.

- Before the beginning of each didactic unit, students were given information, explanations and clarifications regarding its content for 5 minutes.
- The didactic unit was formed as follows:

a) General warm up (3 minutes running, 10 minutes stretching)

b) Main part

- Execution of jumping and technical skills program for group A
- Execution of running and technical skills program for group B
- Training of technical skills (passing, forearm pass, spike) for group C
- The duration of the main part was approximately 30 minutes.

c) Recovery (relaxed running and stretching 5 minutes)

- During the main part, the level of difficulty in the exercises[2] was gradually increased.
- The exercises progressed from simple to more complex.
- The exercises were continuously conducted with movement which involved either motion or intervening exercises.
- Between the exercises and until instructions for the following exercises were given, there was complete rehabilitation.
- Jumping exercises were conducted at the beginning of the intervention with increasing intensity and quantity.
- Speed exercises were conducted at the beginning of the intervention with increasing quantity.

The regulation of the quantity and intensity of the strain of the whole program was based on alterations of the proposed programs [8] [10] [17].

### 2.3 Experimental procedures - Protocol of measurements

All the trials were valid and reliable and appropriate for the age group of the children participating in the research. The measures were conducted at the beginning and end of the trimester in the schoolyard where the lesson of physical education was taking place. All the students who participated in the intervention were measured but only the female students who were not in adolescence were evaluated and especially in respect of:

- ➢ Body height:
  Each student was put in a height meter (220 Seca type, Germany) with no shoes and with stretched knees. Each was standing up in an attention position, looking in front and taking a deep breath. At the moment of exhalation the vertical point of the height meter dropped and gently touched the top of the cranium dome. The accuracy of the height measuring was 1/10$^{th}$ of a centimeter and was written down immediately to the relative protocol of the assessed.
- ➢ Body weight:
  Each student stepped on a scale for humans with accuracy of 0.100 kg (Tanita TBF-300GS, Japan) without wearing shoes and wearing a light sport uniform. Its weight was recorded with an accuracy of 0.100 kg.
- ➢ The height of the jumps, for all types of jumps, was measured in centimeters (cm) by using Ergojump System Bosco (MuscleLab 4010/4020e Ergotest Technology as). All the jumps that were measured were jumps where the students did not use their hands, which they placed on the hips.

1) Squat jump 90$^o$
   The student began with his legs bent at a 90$^o$ angle and his hands placed on the hips. He performed a vertical jump as high as he could. He made two attempts and the best was recorded.
2) Countermovement Jump
   The student began from a standing position with his hands placed on the hips. With the command “let' s go” he bent the knees with a counter movement downwards and by getting the appropriate impulse, he performed the vertical jump. During the bending of the knees, the body was kept in a straight upright position. He made two attempts and the best was recorded.

## 3. Results

Statistically significant differences were observed between the groups in jumping [F(2, 10)=5.87, p=.004] that is, the effect of training methods was different concerning the development of jumping ability in total measurements.

The interaction between the two factors (group and training methods) in relation to time was not found to be statistically significant [F(2,10)=.138, p=871]. Application of Scheffe post hoc test showed the following statistically significant differences: a) between the first and second measurement (Scheffe value = 2.20 (p<.001) of group A (plyometric training) and group C (control group program), b) between the group B and control group program (Scheffe value = 1.80 (p<.05). No statistically significant differences were noticed between group A and group B in jumping performance, with a Scheffe value on the second measurement equal to.60 (p>.05).

## 4. Discussion

Both training methods (A=plyometric training, B=jumping ability training) seemed to produce positive results related to an improved performance in jumping ability up to a point where no differences were located. As a result, comparison between training method A and training method B revealed no statistically significant differences in the second measurement, although a superiority tendency of training method A compared to training method B was also noticed.

Future research should focus on the effect of gender in the improvement of the vertical jump and the influence of biological maturity to this end.

## 5. Acknowledgments

For the formulation of this didactic scenario, we would like to thank firstly our students for the effort they made, their patience, persistence and disposition to try to enrich their knowledge. Without them nothing could have taken place. We would also like to thank Mrs Maria Maridaki, deputy professor in TEEFA in Athens, for the overall aid she offered in the realization of this intervention.

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# The Effect of an Educational Scenario on Throwing Skills Development, Understanding of Physics Concepts and Initiation into Olympism Values in First School Age

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## Abstract

*Basic manipulative skills development consists one of the primary physical education goals today. Acquisition of these skills strengthens the individual to effectively participate in sport, gaining positive experience in friendly relation to fair play and lifelong exercise (Gallahue, 1996; Graham, 2008; Logsdon et al., 1994). An educational scenario using The Information and Communication Technology (ICT) aims at fostering of throwing skill incorporating concepts of physics and values of the Olympic Idea (Kioumourtzoglou, 2001). The purpose of this research was to investigate the effect of an educational scenario using ICT on throwing skill development in first grade children. It was investigated whether children can learn to perform the basic skill of throwing when their teaching is supported by a developmental physical education program and by the using of both academic concepts and ICT. Method. A total of 52 primary school children (28 boys and 24 girls) aged 5,43 ± 0,63 years participated in an educational scenario and a developmentally appropriate learning program on throwing, lasting for two weeks. Before and after the implementation of the program, the children were assessed on the fundamental skill of throwing by the second edition of Test of Gross Motor Development (TGMD, Ulrich, 2000). Results. The implementation of the educational scenario and developmentally appropriate learning program on throwing resulted in a significantly improved (p: 0,000) throwing (from 1,97 ± 0,13 to 1,97 ± 0,13). Conclusions. It seems that basic manipulative skills are being effectively taught by the use of both Educational Scenario and Developmentally Appropriate Physical Education Programs.*

## Keywords

*Motor skills*, basic manipulative skills, Object control *skills*, TGMD-2, motor development, developmentally appropriate physical education program, social skills, Olympic values, first school age.

## 1. Introduction

Basic kinetic skills represent a fundamental group of skills for a developing person as they constitute a basis where all further personality development will rely upon. Basic kinetic skills of handling objects constitute an important part of the basic kinetic skills as they form the kinetic baseline for participation and success in any kind of physical activity and athletic skill during adolescence and adult life. In the present study we will focus on the development of the basic kinetic skill of handling objects "throw. The aim of our scenario was to help little students in the development of throw skill and simultaneously to teach them important issues on the history of the Olympic Games, as throw was part of pentathlon in ancient Greece.

**1.1. The concept of basic motor skills**

As mentioned above, basic motor skills constitute the first stage of motor skills. Their definition consists of the functional skills that contribute in everyday action and motility of the individual, as well as in the improvement of living status and the desire for lifelong physical exercise. More precisely, they are an "organized row" of basic movements, which include combination of "kinetic models"[1] of two or more parts of the body (Gallahue, 2002:30). Basic motor skills are very important for the developing individual as: (a) they constitute the basis, by means of kinesis, for further development of more complex skills, (b) Children tend to enjoy practicing them, especially when they are incorporated in an attractively designed, appropriate physical exercise program, (c) Once children acquire these skills, they retain them forever, (d) They contribute to the mental, psychological, emotional and social development of the child.

**1.2. Groups of basic motor skills**

Relevant Greek and international literature classifies basic motor skills in three groups (Δέρρη, 2007; Graham et al., 1998): (a) Stabilization skills or static skills: This group includes skills which constitute the basis for all the other skills (like handling and moving), as all movements require a stabilization element (Gallahue, 2002:32). (b) Moving: This group includes all skills that require body movement from one point to another to different directions (horizontal, vertical, diagonal, forward, backwards or sideways). Movements like jump, hopping, side steps, continuous jumps and skiping belong to this group. (Gallahue, 2002).

(c) Handling skills: This is a big group of skills, including movements with which people handle objects. They are divided to "rough" handling skills and "subtle" handling skills. The first subgroup consists of movements that require exercising force to or from an object, like throwing, receiving, kicking or stopping a ball. In the second subgroup there is emphasis on kinetic coordination, control and movement quality, reflecting to movement correctness and accuracy.

## 2. Methodology

The objective of this research is the investigation of the effect of an educational scenario on throwing skill development and initiation of students in the Olympic values. To achieve this goal, we designed an experimental study aimed at verifying the results gained by the application of the educational scenario. Our sample consisted of two "physically equivalent" groups (Vamvoukas, 2000: 362) in terms of both the number and characteristics of their members and made up the total survey sample belonging to the first grade population.

Thus, the final sample consisted of 52 students of primary school age (28 boys and 24 girls) who, at the first performance criterion, had a mean age of 5,9 ± 0,63 years, a mean weight of 24,30 ± 4,71 and a mean height of 123,68 ± 5,48 and who were enrolled in the school year 2014-2015. All children participated regularly throughout the experimental procedure without any case of subject exemption.

*1 The term "kinetic model" refers to the performance of a single movement that is not considered a basic motor skill.*

### 2.1. Tool selection

In this research TGMD-2 was selected because is the newest version of the test and used to collect survey data and control differences between the experimental group and the control group. It was implemented at the beginning and end of the intervention program in order to carry out the research observations on data collection.

### 2.2. The intervention program

For the development of the fundamental skill of throwing in students of primary school age, we designed and implemented an experimental program including six interventions. Initially, one intervention concerned aformisi, three the skill of throwing and two the initial and final measurement respectively lasting 45 minutes each and designed to be implemented on both the experimental and control group twice a week for the first grade.

The basic structure of each lesson was tripartite. In the lesson plans there were images depicting the schematic arrangement of students in the general lesson area, which we created using the specific program of Easy Sports-Graphics BALLSPORTS 1.0 (Schreiner, Becker-Richter, Schreiner, & Becker, 2010). In lessons concerning throwing, there were activities focused initially on throwing for distance and finally on throwing accuracy. The exercises included in these activities were of different levels and requirements; for instance throwing from different distances. The emphasis was on distance, speed and accuracy. Throughout the whole lesson information about the Olympic Games and some elements of physics concepts were given where possible. Evaluation and self-evaluation leaflets concerning throwing and Olympic Games were given to the participants. Thus, specific hardware, including a computer, an interactive whiteboard, a projector, a scanner, a printer and speakers and specific software, such as search engines, video, and a Word program were used.

The cause for the beginning of the educational intervention was the Ancient Olympic Games event. A short movie was disturbed. To be more specific children watched a short animated film (7:42 min) on an Ancient Olympic Event based on the tale *Despina and the Dove* (Τριβιζάς, 2001). In this way, they gain useful information concerning the Games of that ancient era (i.e. stadium, naked athletes, sports, judges, prize values, ideals etc

After a brief discussion, what followed was an experiential approach to running and throwing skills in the schoolyard and the crowning of winning students with Olive Wreaths.

Throwing skill development was achieved through implementation of three intervention programs, lasting 45 minutes each having also devoted a two hour-instruction on the specific skill assessment as initial and final measurement respectively, using TGMD-2 test and the observation method in order to get measurable results. During the measurement process, throwing skill included some behavioral data which both were presented as performance criteria and defined behaviors that represent a mature skill pattern and were separately assessed. So, throwing assessment was made by means of four criteria.

## 3. Statistical analysis

All statistical analysis was performed using (SPSS). The significance level in all statistical analyzes was set at 5% ($p < 0{,}005$). Data were expressed as means ± standard deviation (SD).

## 4. Results

It seems that implementation of the Educational Scenario on Throwing Skills Development caused a significant improvement (p: 0,000) in the performance of throwing. Its teaching caused a statistically significant improvement ($p < 0{,}005$).

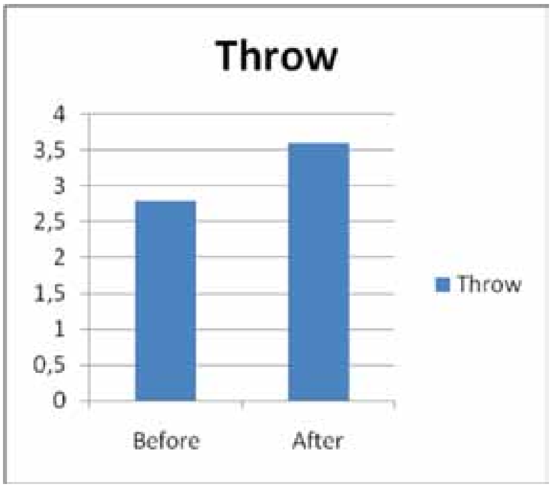


***Figure 1.*** *The fundamental skill of throwing before and after*

## 5. Findings

It seems that children were assisted to better learn and perform throwing motor skill. This research finding is, in our opinion, particularly important for effective physical education teaching.

## 6. Conclusions

Physical Education Instructional Scenarios seem (a) to have assisted children of primary school age to develop their throwing ability, and (b) to have allowed teaching of other cognitive or academic subjects too –in this work was the Olympic Values and Ideals. So, it seems that basic manipulative skills are being effectively taught by the use of both Educational Scenario and Developmentally Appropriate Physical Education Programs.

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# Different Approach for Assessment of Student's Problem Solving Skills

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## Abstract

*The article describes the known approaches for assessment of student's problem solving skills. We make a comparative analysis of different methodologies used for assessment of student's problem solving skills. A different approach for assessment of student's problem solving skills and its methodology is suggested. The results of practical usage are presented and the relevant conclusions are made.*

## Keywords

Education, assessment, problem solving skills

## 1. Introduction

In the 21st century individuals should have ability to solve different kind of problems in a fast-changing borderless world.

The curricula at school focus more on content rather than skills. i.e. the attention is paid on content instead of the outcomes after graduation. It is important to develop in classes the ability to solve real world problems and students to be properly assessed during the training at school. It is not easy, because problem solving is a complex skill which requires additional abilities such as critical and creative thinking; self-directed learning, team working, communication etc. Fact that students are good in the school subjects does not mean that they have skills in problem solving.

The results from the PISA 2012 assessment of problem solving, which was conducted on computer and involved about 85 000 students in 44 countries and economies [1] show that students in Singapore and Korea, followed by students in Japan, score higher in problem solving. Bulgaria is on the bottom of the chart.

Educational systems in the countries are deferring in their structure, educational goals, curriculum content, pedagogical practices, applied approaches, assessment methods are different, too. Students who perform significantly better in problem solving than students in the rest countries show similar performance in mathematics, reading and science. This survey shows that educational systems in the countries on the top of the chart give their students opportunities that prepare them better for handling real-life problems in contexts that they do not usually encounter at school.

## 2. Problem solving assessment methodologies

### 2.1. Traditional assessments

Traditional assessment (TA) are the conventional methods that are taken with paper and pencil (true/false, matching or multiple choice tests, quiz, essay, exam).

*Advantages of Traditional/Standardized Assessment*
1 Well-designed tests and quizzes can effectively determine whether or not students have acquired previously learned information.
2. Possibility to make direct comparison of scores across large groups of students.
3. Traditional assessment score is reliable, i.e. the test score do not depend on the estimator.
4. Educators teach students how to manage tests, including strategies for selecting correct answers from a listed group.
4. TA requires much less time and less cost to prepare examine papers/tests.

*Disadvantages of Traditional Assessment*
1. Testing materials are often isolated from real life.
2. TA does not show the thought process which led students to arrive at the answer they selected.
2. Students answer questions without the need to apply long-term critical reasoning skills.
3. Not all students learn the same way and that is why they can't demonstrate their knowledge in the same way.
4. Tests are much less revealing about what we really know and can do.
5. A student's attention is focused on and limited to what is on the test.

### 2.2. Authentic assessment

The alternative names of authentic assessment (AA) are alternative assessment, performance based assessment and direct assessment. This assessment method measures how well students can apply or use obtained knowledge in "real-world" contexts and also students creativity; ability to work in collaboration with other individual, written and oral expression skills. This kind of assessment encourages students to think, more than just memorize and is integration of teaching, learning and assessing. AA includes a task for students to perform and a rubric by which their performance on the task will be evaluated.

There are five major types of performance samples [2]:
1. *Performance Assessment* - requires collaborative students work and encourage them to apply skills and concepts to solve a complex problem.
The task may be to write, revise, and present a scientific report to the class; conduct a short time science experiment and analyze obtained results, prepare a position in a classroom debate etc.
2. *Short Investigations* – students are asked to interpret, describe, calculate, explain or predict and to understand relationships among concepts.
3. *Open-Response Questions* – assessment task include a brief written or oral presentation; a mathematical solution; a drawing, a diagram, chart, or graph.
4. *Portfolios* – include journal entries and reflective writing; peer reviews; student notes and outlines; rough drafts and polished writing
5. *Self-Assessment* - requires students to evaluate their own participation, process, and products. The basic tools of self-assessment are evaluative questions.

*Advantages of Authentic Assessment*
1. This method allows assessment of complex learning outcomes.
2. Opportunity to assess the process as well as the product.
3. Instructional goals are related to real world context.
4. Assessment of the progress as well as the performance.

5. Students are able to participate in the process of assessment and also to assess their own knowledge.
6. It evaluates the "whole student"

*Disadvantages of Authentic assessment*
1. Constructing performance assessment is time consuming.
2. Scoring is often questionable because if the scoring guide is not properly prepared.
3. It may be an added cost to the schools.
4. Difficult to compare results across the students.

## 3. Comparative analysis of problem solving assessment

### 3.1. Comparison of problem solving assessment

The following criteria should have in mind when assess problem solving ability of the students [3]:

- Information and Discovery – to understand the goal; to determine which information will be most effective and to uncover some information exploring the problem; how many steps are required for solving of this problem, evaluate and select credible sources, determine constraints, define criterion for judging final product.

- Analysis and interpretation – the student classifies and compares information using appropriate criteria, determines what type of information will be most effective; identifies strengths and weaknesses of information,

- Plan and apply a strategy - student selects to try one or more strategies, that he is familiar with; select appropriate theory, principles, approach; considers working backwards; gathered useful tools or methods; map out subproblems

- Solve the problem - student is able to draw a graphic/table/diagram/etc., to explains the potential effectiveness of a proposed solution or approach, to illustrate the strategy; he is able to formulate a final answer; all elements of the solution are legible and organized)

- Evaluate Outcomes – student reviews problems that are relative to the results, gives specific considerations of need for further work.

### 3.2. Analysis of problem solving assessment

Assessment is a complex process and it must be fair, consistent, valid and reliable for all individuals. Traditional methods of assessment of students (e.g., examination; tests, oral presentation) are necessary to be supplemented with other methods that can evaluate non only learned material but also ability to solve real life problems.

Nightingale [4] suggested some suitable methods for assessment of critical thinking and problem solving skills, such as:
• do science experiments
• conduct research
• write reports
• read and interpret literature
• solve problem that have real-world applications
• develop a problem scenario
• Analyse a case
• Draft a research bid to a realistic brief

## 4. Different approach for assessment of student's problem solving skills

In Bulgaria assessment in the secondary education is used traditional assessment methods – short exam in the beginning of the classes and test or essay during the term. Some school's teachers try to stimulate students to work in short team and to collaborate in order to prepare presentation on given task (scientific experiment, short-time research, literature review, etc.).

In the classes at Vocational Secondary School

| | | | | | |
|---|---|---|---|---|---|
| Name of student ____________________ | | | | | ____ Date |
| Criteria | | | | | Points |
| Points | 4 | 3 | 2 | 1 | |
| Science concept | Student demonstrates a full understanding of the topic | Student demonstrates a good understanding of the topic | Student demonstrates a good understanding of part of the topic | Does not understand the topic very well | |
| Research | The presentation includes four or more soulrcues and shows thorough research | The presentation includes three sources and shows efforts in research | The presentation includes two sources and shows some research | The presentation includes one or no sources and shows no efforts in research | |
| Vocabulary | The student uses all proper terminology in presentation | The student uses mostly proper terminology in presentation | The student makes some mistakes in terminology during the presentation | The student makes many mistakes in terminology during the presentation | |
| Graphics and tables | Graphics and tables explain and reinforce presentation topic | Graphics and tables are relevant to presentation topic | Graphics and tables rarely support the presentation topic | Presentation does not include graphics or they are unrelated | |
| Order | Logical sequence, good overview | Logical order of presentation | Some order of ideas but jumps around | Ideas are not ordered | |
| Conclusions | Conclusions are reasonable and based on the presented data | Conclusions are partially supported by the evidence | The conclusions are mostly inconsistent | Conclusions are not presented | |
| Eye contact | Holds attention of audience with the use of direct eye contact | Student use direct eye contact but frequently returns to notes | Student uses eye contact occasionally and reads most of the slides | No eye contact with audience. Student reads all report | |
| | | | | Total | |

***Table 1.*** *Presentation rubrics, developed for Vocational Secondary School of Computer Technologies and Systems – Pravets*

of Computer Technologies and Systems – Pravets we combine individual problem solving processes with communication processes which encourage students for collaboration. The assessment is focused not only on individual cognitive skills but also on the social skills related to establishment and maintenance shared understanding, group organization, etc.

The tasks, given the students in class are project and presentations of short-time scientific research. The rubrics for assessment of student's projects and oral presentation are developed and students can participate in assessment process.

The rubrics for assess individuals that develop scientific problem presentation are given in Table 1.

Practice in the school is presentations to be done by small group of students (two, three of four people). It is important to assess participation of each individual in the process and interaction with others students. The students can receive two more poise from the team workmates. The maximal score become 30 points.

## 5. Conclusions

Teachers do not have to choose between authentic assessment and traditional assessment. Often, teachers use a mix of traditional and authentic assessments to serve different purposes. When the rubrics are used to assess problem solving skills they must be designed to function across all disciplines in order to determine how well students can apply learned skills to solve practical problems.

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