CREATIONS: Developing an Engaging Science Classroom

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Abstract
Taking into account the strongly decreased interest of young people in science and mathematics, this study aims to propose a new creative pedagogic approach in order for this tendency to be reversed, developed in the framework of EU project CREATIONS. The first implementation activities of this approach, addressing both students and teachers, have been already taken place and the initial results of the implementation leads to quite positive conclusions, concerning the motivation and interest in learning science.

Keywords: Creativity, Inquiry Based Science Education, Art, Large Research Infrastructure

1. Introduction
The publication of the "Science Education Now: A renewed Pedagogy for the Future of Europe" report (1) brought science and mathematics education to the top of educational goals of the member states. The authors argue that school science teaching needs to become more engaging, based on inquiry based and problem solving methods and designed to meet the interests of young people. According to the report, the origins of the alarming decline in young people’s interest for key science studies and mathematics can be found, among other causes, in the old fashioned way science is taught at schools. The crucial role that positive contacts with science at a younger age have in the subsequent formation of attitudes toward science has been emphasized in many studies (2). However, traditional formal science education too often fails to foster these, affecting thus negatively the development of adolescents’ attitudes towards learning science. Also, as Kinchin has pointed out (3), the tension created between objectivism (the objective teacher-centered pedagogy) and constructivism (the constructive and student-centered pedagogy) represents a crucial classroom issue influencing teaching and learning. The TIMSS (Third International Mathematics and Science Study) 2003 International Science Report (4) specifically documented that the three activities accounting for 57 percent of class time were: teacher lecture (24%), teacher-guided student practice (19%), and students working on problems on their own (14%) in science classes in the European countries participating in the study. Furthermore the recent TALIS (Teaching and Learning International Study) results (5) demonstrate that the current science classroom learning environment is dominated by traditional pedagogies that are not able to support the introduction of the scientific methodology. The fact is that there is a major mismatch between opportunity and action in most education systems today. This revolves around the meaning of "science education," a term that is often misappropriated in the current school practice, where rather than learning how to think scientifically, students are generally being told about science and asked to remember facts (6).
This disturbing situation must be corrected if science education is to have any hope of taking its proper place as an essential part of the education of students everywhere. However, school practices have not changed in ways that reflect this progress. Moreover, modern technologies (e.g., use of social networking tools, remote and virtual labs, advanced visualizations, simulations, virtual worlds and shared collaborative environments), which go beyond the use of simple applications and the internet have not been fully integrated/incorporated in the current science learning environment. According to the recent work performed in the framework of the large scale initiative PATHWAY (7) the deeper problem in science education is one of fundamental purpose. Schools, the authors argue, have never provided a satisfactory education in sciences for the majority. Now the evidence is that it is failing even in its original purpose, to provide a route into science for future scientists. The challenge therefore, is to re-imagine science education: to consider how it can be made fit for the modern world and how it can meet the needs of all students; those who will go on to work in scientific and technical subjects, and those who will not.

In this framework, CREATIONS (http://creations-project.eu/) as a multinational EU project is aiming to demonstrate innovative approaches that involve teachers and students in Scientific Research through creative ways (from STEM to STEAM). By basing on Arts and focusing on effective links and synergies between schools and research infrastructures, young people’s interest in science and in following scientific careers is expected to be affected. The project is addressing the potential impacts of international research facilities on advancing science education, in using case studies from one of the largest research infrastructures of the world: the European Organization for Nuclear Research (CERN).

1.1 Concept and approach

In our study a creative approach in science education is presented, in order to generate alternative ideas and strategies within scientific enquiry as an individual or community. Figure 1 offers an overview on this pedagogic approach. At the core of the proposed approach are the creative scenarios and school-based activities and the accompanying pedagogic principles. Creative science education is the main context within which the project is developed. At the bottom of the graph arts education philosophy and methods is positioned as a ‘holder’ within which creative science education is being nurtured, grown or ‘encultured’ via arts practice. As we move in towards the center of the graph, we can see that one of the main drivers for CREATIONS creativity is possibility thinking for all involved. This means being able to ask ‘what if’ and ‘as if’ questions such as:

- What if I/we choose to explore this scientific question rather than that one?
- What if I/we use this arts approach to help me explore my question?

As we move in another layer towards the center of the graph, we can see four key defining features of engaging science classroom environments. These are the 4Ps of engagement in creative science education (8):

- pluralities: opportunities for students and teachers to experiment with many different places, activities, personal identities, and people
- possibilities: opportunities for possibility thinking, transitioning from what is to what might be, in open possibility spaces
- participation: opportunities for students and teachers to take action, make themselves visible on their own terms, and act as agents of change
- **Playfulness**: opportunities for students and teachers to learn, create and self-create in emotionally rich, learning environments.

![CREATIONS Approach](image)

*Figure 1. CREATIONS Approach: The graph demonstrates how the CREATIONS scenarios support the development of a research culture in science classrooms.*

We then come closer to the heart of the CREATIONS graph and find WHC (wise humanizing creativity) and LDS (living dialogic space). The WHC that is being sought in CREATIONS is not only an individual activity, but also happens in collaboration with fellow learners, teachers and other adult professionals (artists, researchers). These individual and collaborative creative activities form part of a wider web of ethically-guided communal interaction geared towards both helping children and young people become more creative scientists and assisting teachers in becoming more creative in how they teach science. For this reason WHC is positioned very close to the heart of the CREATIONS graph as it is one of the core aims of the CREATIONS pedagogic principles. Alongside and integrated with WHC, is LDS, always a partner to WHC in terms of conceptualizing ideas and developing practice. Again LDS is at the heart of the CREATIONS graph because its methods (participation, emancipation, working bottom up, debate and difference, openness to action, partiality, and acknowledging embodied and verbal modes of knowing) are fundamental to allowing WHC to happen. Chappell et al (9), have evidenced the importance of dialogue at the heart of engaged, creative learning in the arts and it is this kind of dialogue that has been highlighted and applied within the CREATIONS approach. Via these processes the aim is to develop creative young scientists and creative science teaching pedagogies. Embedded within this is the vitally important notion that students and teachers are creating wisely and humanely, and that cyclical developments occur between their creativity and their identity. As they generate new
ideas; this in turn generates change in them as ‘makers’; they are also developing or ‘becoming’ themselves. Slowly, small changes accumulate to contribute to ‘journeys of becoming’ (shown developing across the layers in Figure 1). These individual journeys accumulate together, embedded within an ethical awareness of the impact of creative actions on the group. Through this process small-scale creative changes or ‘quiet revolutions’ can take place for the group as a whole (shown as emerging from the heart of the CREATIONS activity).

1.2 CREATIONS Demonstrators

The implementation of the described pedagogic approach highlights and promotes best practices in introducing scientific work in science classrooms. The aim was to offer to the teachers, who will be involved in the project activities, a variety of resources that is arranged so that it does not impose a fixed curriculum, but instead supports the development of a model that can be customized to reflect location, culture and ideology. These initiatives are implemented the last years in CERN, but also in numerous schools in Europe and they have proven their efficiency as practices that introduce the scientific methodology in the science classroom.

In the framework of the project we enrich these initiatives with the proposed creative approach in order to increase the utility of them through coordination, systematic dissemination and effective teachers’ community building. The CREATIONS Demonstrators that emerged are treated as case and will be disseminated in different environments (teachers’ preparation and professional development institutions, schools, science and research centers) across Europe during the life cycle of the project, in order for this pedagogic approach to be tested. The process of observing and reflecting on teachers actions, and on students' learning and thinking, can lead to changes in the knowledge, beliefs, attitudes, and ultimately the school everyday practice. A short description of demonstrators which lying on the core of the CREATIONS pedagogic approach follows:

Art@CMS is an education and outreach initiative of the CMS experiment at CERN that seeks to act as an inspiring springboard for engaging the public in general, and youth in particular, in the excitement of scientific research in High Energy Physics. In 2014 Art@CMS events and workshops have been taken place in 7 countries involving more than 700 students.

CERN virtual visits. CERN in cooperation with the European initiative Open Discover Space (portal.opendiscoveryspace.eu) is offering the opportunity to school students to perform a virtual field trip to CERN experiments. Students virtually guided through the research infrastructure, communicate with scientists in their mother language, ask questions, and learn about the research work at CERN. More than 50 virtual visits were organized in 2014 involving more than 10,000 students from different European countries.

HYPATIA analysis tool enables high schools students together with their teachers to study the fundamental particles of matter and their interactions, through examining the graphic visualization/display of the products of particle collisions at LHC world's most powerful particle accelerator. These products are "events" detected by the ATLAS experiment.

Write a Science Opera (WASO) is a creative approach to inquiry-based music and science education in which students of different ages, supported by teachers, opera
artists and scientists are the creators of an educational performance. The WASO concept was developed at Stord/Haugesund University College (Norway) as well as the Royal Opera House (London)'s Education department.

Taking into consideration the described framework in this study we investigate:

Can creative teaching scenarios, such as CREATIONS Demonstrators, improve the motivation and interest in learning science?

2. Setting of the study

A common framework was created for the design and development of a series of demonstrators that introduce effectively scientific methodology and culture in science classrooms. For each one of these demonstrators an on line created in the Open discovery space platform (http://www.opendiscoveryspace.eu/), in order to support users of the demonstrators. Moreover it is requested for every new demonstrator, an on line support community to be developed. Such communities act as a context of cooperation within and between schools, universities, research institutions, artists and encourage development and evaluation of instruction, exchange of ideas and best practices, providing at the same time support and stimulation from research.

![Figure 2. The map of the support online communities of the initial CREATIONS Demonstrators](image)

The CREATIONS Project includes large-scale pilots of a variety of activities to be implemented in local, national or international level in numerous countries.

2.1 Implementation activities

The first implementation activities witch based on a set of different CREATIONS demonstrators are the 6-days teachers international training course held in Marathonas and the students 5-days national summer school held in Messini Greece, both during July.

In teachers training Course, 17 teachers took part from from 6 European countries (Greece, Estonia, Sweden, Croatia, Finland & Switzerland). The course aimed to
present to the teachers innovative approaches and activities that involve students in Scientific Research through creative ways that are based on Art. The course included lectures, workshops and activities concerning: The CREATIONS pedagogical framework, creative approaches to teach and communicate science, the science concept of neutrino particle detection particles which had to be communicated via the Science Operatic performance, composition/use of music in a learning activity, how to write a Science opera, the management of a large scale learning activity involving art and science, etc.

Concerning the case of students summer school, 50 high school students participated from all over Greece. Main aim of the summer school was to introduce the students in complex science topics such as universe evolution, Higgs boson, gravitational waves, neutrino telescopes and in the same time by using art enhance the creative thinking of students. To this end the students visited NESTOR institute at Pylos, as well as make a virtual visit to ATLAS experiment at CERN. Furthermore they conducted lab exercises which simulated the detection techniques of elementary particles etc. Participate in science café. Moreover they learn to use creative approaches in order to communicate science concept All this acquired knowledge from the activities mentioned above, was used by the students in order to design 5 science stories and perform relevant short plays.

2.2 Data collection and analysis

2.2.1 Teachers training course

A quantitative approach with questionnaires was implemented, as well as qualitative approach with interviews was realized. Specifically 15 out of 17 teachers completed a pre-test before participation and a post-test afterwards. The questionnaires included questions concerning demographical data, participants’ science motivation and technology interest. More over 14 participants were interviewed about their expectations of the training course and their personality as a teacher during the course.

2.2.2 Students summer school

The methodology employed to analyze scientific data gathered from the theatrical performances in the summer programme of Messini, constitutes a merging of qualitative and quantitative analysis (10). The data were analyzed and classified into categories. This categorization took into consideration the theoretical framework of the analysis along the empirical evidence gathered from the theatrical plays performed by students. Student representation of scientific concept and the production of scientific meaning was studied using 3 categories.

- Embodied Learning
- Multiple representational systems (verbal, embodied, digital, kinesthetic representation, elements of Art)
- Analogical Reasoning

Each category is further divided into subcategories/ properties which are connected to basic features of embodied learning, of multiple systems of symbols, of analogical reasoning.
3. Initial results and discussion

Preliminary findings based on a data analysis from Creations 6-days teachers training course show that the creative approach of the course and the new ways of teaching and learning were inspiring for them and increase their interest in learning science. Furthermore the participants stated that they want to take part again in training like this, in order to learn new innovative learning methods and different demonstrators.

Concerning the findings from the students’ 5-days summer school, we can reach the conclusion that students’ interest and motivation in science was quite increased after the summer school. Indicatively, one of Student that participated in the course a student who completed the first year of senior high school stated: “My participation in the summer school was one of the best experiences in my life!” Students employed scientific concepts in all of the plays. As far as the representation of scientific concept and the creation of meaning are concerned, students seemed understand all sub-elements and basic characteristics of each concept. They managed to render the general meaning of the concepts and to explain simple scientific terminology. It is significant to mention that students were able to use simple language to explain scientific terminology at the same time they were using this terminology provided they had understood the scientific concept in question. In most cases, they used simple everyday objects, which verify that they gained, built and appropriated knowledge. This means that they managed to successfully connect newly gained knowledge with everyday life and to use it in an everyday environment.

Furthermore both training courses seems to managed to combine teaching about Science with creativity and Art, offering a new way of approaching these cognitive areas. Overall the first findings from the existing data and the positive reactions so far of the students and teachers involved, allow us to estimate that the whole process will enhance students’ motivation in science and also their creativity. We will be able to provide more details on this subject mutter during the conference.

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