Qualitative Analysis of the Structure of 107 Demonstrators

Smyrnaiou, Z., Sotiriou, M., Georgakopoulou, E.

National Kapodistrian University of Athens (NKUA)

1 CREATIONs European Research Programme

The framework of the European Project CREATIONS (http://creations-project.eu/), 16 partners from ten European countries develop creative approaches based on Art for an engaging science classroom. CREATIONS will establish a pan-European network of scientists, teachers, artists and students with the aim to improve the skills of young people in STEM (science, technology, engineering, mathematics) and to pool talent to scientific careers. This initiative follows the principles of the Science Education Declaration, of creativity, of effective and efficient research and aims at enhancing creativity in class-room (http://www.opendiscoveryspace.eu/community/culture-creativity-curiosity-413201) in the context of STEAM. The aims of CREATIONS Program are:

i. giving students and teachers opportunities to experiment with many different places, activities, personal identities, and people
ii. simulating the work of the scientist and researcher in the classroom
iii. promoting a better understanding of how science works
iv. enhancing students' science related career aspirations
v. encouraging and empowering science teachers to affect change
vi. implementing and promoting inquiry-based science teaching and learning
vii. learning and (self)creating in emotionally rich learning environments
viii. disseminating and exploiting the results

2 Qualitative Analysis of 107 Demonstrators as Innovative Ideas

2.1 *Worldwide challenges- A need for a renewed approach on Science teaching models*

Over the last few years, there is a need both from political decisions and scientific paradigms to redefine teaching methods and reform educational systems. This change from traditional ways of teaching to a new way of educating students seems to establish a new pedagogy and to be a deep change of world's, countries' and people's philosophy of teaching and learning. In fact, it is considered that a better future of Europe can be designed only if new theories, practices and scientific approaches start to take place on educational communities. Nowadays educational systems but also all the members of a school community face lots of challenges. These challenges are firstly relevant to the educational practices and the purposes of school education. One of the main problems of the most school systems is the students' lack of motivation. Another relative problem is scientific outflow. In addition, although most school curriculums have managed to simplify scientific knowledge to school knowledge, they have failed to deal with modern scientific notions according to the global, new findings on science. The teaching methods are, also, old or inappropriate for their acquisition of knowledge, as these are not creative and challenging. At the same time, it is observed that there are some efforts of introducing news methods on educational practice, but these efforts finally do not have any support, as actual science teaching keeps existing. In addition, the difficult scientific notions acquire a different way of thinking and teaching, where modern pedagogical framework is taken into account and is adjusted to basic principles, such as the use of different cognitive semiotic systems of the representation of scientific knowledge. Since the origins of the declining interest among young people for science studies are found largely in the way science is taught in schools, we have to try not only to establish new ways of teaching, scientifically acceptable.

2.2 *Best practices and principles promoting a new philosophy on Science*

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 "weakest" to the most "capable" (Rocard, 2014), as it enhances students' comprehension (Chu, 2011) and a variety of skills. Over the last decades many efforts have tried to reduce the distance between science and society, leading to a European wide approach in Horizon 2020 called Responsible Research and Innovation. Responsible Research and Innovation (RRI) seeks to bring issues related to research and innovation into the open, to anticipate their consequences, and to involve society in discussing how science and technology can help create the kind of world and society we want for generations to come. Education and innovation are yet another key aspect. Educational practices have to characterized by creativity, innovation, scientific learning objectives derived from an interdisciplinary approach and new initiatives so as future researcher be equipped with knowledge, capability, responsibility and engagement to use science for a better society.

2.3 Methodological Procedure

107 Demonstrators have been delivered according to Principles of CREATIONS EU Program. This number is a significant number of new scenarios, new ideas and innovative suggestions to be followed and be implemented on everyday school life. Generally, the procedure of evaluating the quality of the demonstrators has started from February 2016 till now. This long-term procedure is necessary for understanding the qualitative categorization and high scientific process of the structure of the demonstrators. As far as the analysis of demonstrators concerned, this was enriched by both qualitative and quantitively scientific methods so as a better and deeper understanding will be succeeded. The methodology employed to analyze scientific data gathered from 107 demonstrators, constitutes a merging of qualitative and quantitative analysis in combination (Gobo, 2005). The data were analyzed and classified into categories. This conceptual categorization takes into consideration the theoretical framework of demonstrators along with empirical evidence gathered from comments and discussion during these months. Content- Analysis of 107 demonstrators were consisted by two main categories with subcategories.

a. The first category refers to the structure of demonstrators.
b. The second category refers to the qualitative analysis according to the Pedagogical Framework of Demonstrators (CREATIONS Features, IBSE approach, RRI principles, Effective Learning Environments)

The analysis of demonstrators was enriched by both qualitative and quantitively scientific methods so as a better and deeper understanding will be succeeded. Some demonstrators, such as “The Learning Science through Theatre Initiative”, gave the appropriate stimulus for the organization of more than 200 theatrical performances with over 2500 students and over 200 teachers during the years of the Program. This demonstrator can actually be considered a model of synergy and a generator of more than 100 possible demonstrators.

2.3.1 Qualitative Analysis according to Structure of Demonstrators

2.3.1.1 Demonstrators Identity

As far as **subject domains** concerned, there is a variety of different cognitive aspects. These subject domains are the heart of Science studies and Humanistic and Social Studies linking to Art field. Some Subject Domains are part of National Curricula, such as Mathematics, Science or Biology. However, others are not part of formal Curricula, such as Geology or Astrophysics. This means that there is a deep need on all members of educational communities to research modern subjects and fields with new, adorable developments on lots of them. The negotiable notions of each subject domain are not easily understandable. The level of difficulty is really high, especially for modern notions. Students deal with both traditional and modern scientific ideas and notions. About 1422 scientific notions are examined through scientific procedures and are represented with scientific and artistic way. Most of the activities are **Educational Activities based on Creativity- enriched Inquiry Based Approaches (school- based)**. Some of them promote Educational Activities based on Creativity- enriched Inquiry based Approaches and Educational Activities that promote school- research center collaboration, while some of them refer to Educational Activities that promote Professional Development. According to the **Duration** of Demonstrators, long- term activities can establish a better way of understanding and acquiring the knowledge. When a school activity last not only more time during the year, but also it is repeated during months, it can lead to students’ conceptual change. As far as the **Setting** of Demonstrators concerned, some of them refer to formal setting, as the activities are school- based, others refer to informal setting, as the activities took place out of the school environment, but most of them combine formal and informal setting. It is important to mention that even the demonstrators that suggest only one type of setting, they try to specify that in some cases school activities can be reorganized, so as formal setting can be on first stages of learning process, and informal setting on last stages of this procedure. All of the Demonstrators use almost **the majority of Effective Learning Environments** or at least three of them. In Communities of practice Learning Environment students can make presentations about their projects or group discussions between teachers, students and mentors are hold. Simulations refer to the visualization of learning outcomes. Visual semiotic systems refer to systems whose basic characters are not verbal but they actually have an aesthetic similarity to what they represent. Visual representations also include every type of picture, diagrams, maps, computational images, but also, they are linked to analogies and models, diagrams and graphs, three-dimensional models, computational modeling and simulative activities, which they compare structures between different domains. In Dialogic space and argumentation Learning environments students discuss and give evidence about different sides of an issue, they try to give answers to ethical issues or they try to link the scientific data and provide arguments about possible use of Science in everyday life. In Experimentation setting (science laboratories, eScience applications) the hand- on activities divided into pre-lab and lab phases and help students to base on true and real data in order to find answers to scientific questions. Visit to research centers (virtual/ physical) is an effective learning environment which is strongly related to the collaboration between schools and research centers. Communication of scientific ideas to audience is also a learning environment which is common in the majority of the demonstrators, as in Phase 6 of Inquiry- based Approach students deal with different ways of thinking and possibilities and prove their ideas by providing justifications through dialogue with other students, educators and professional scientists. Art based activities is the central part of Effective Learning Environments, as all the demonstrators have to link scientific activities to artistic representations. **The "Challenge"** part to categorize the demonstrators is really interesting, because we can realize the main educational problems of each country in the European Union. 10 Categories of challenge are derived from the analysis, which makes these educational suggestions more necessary for educational systems. Domain specific objectives and general skills objectives are in accordance to "Challenge" Section. They are categorized into the following categories: a) Cognitive objectives, b) Emotional objectives, c) Communicative/ cooperative/ Social objective, d) Lifelong objectives, e) Artistic objectives, f) RRI and research related objectives, g) Metacognitive objectives. Twelve different types of fostering motivation are noticed during the learning procedures proposed by these demonstrators: a) challenging/ scaffolding question, b) Questionnaires, pre- tests, c) societal challenge or dealing with a problem- solving situation, d) Searching and collecting data, e) Cooperative methods Texts, f) Audiovisual means (a video, a film, a picture) and g) websites, h) Outside activities, i) Discussion with scientists, j) An early representation of a science topic, k) Games, l) Brainstorming techniques. **Motivation/ Sparkling Interest** and Excitement means that students should have the opportunity to experience excitement, interest and motivation about phenomena in the natural and physical world. Learning (CBL) provides the appropriate ideas for that, as teachers should first understand the main challenges of the world and then determine the whole learning process of helping students to acquire helpful knowledge. Twelve different types of fostering motivation are noticed during the learning procedures proposed by these demonstrators: A challenging/ scaffolding question, A societal challenge or dealing with a problem- solving situation, Searching and collecting data, Cooperative methods, A text, Audiovisual means (a video, a film, a picture) and websites, Outside activities, Discussion with scientists, A game, Brainstorming techniques, An early representation of a science topic. All demonstrators have described **potential art activities** and they propose learning procedures embedded with creativity and imagination Potential Art Activities give the opportunity to school community to learn and use new pedagogical theories. Research centers have the ability to develop new techniques and therefore art activities which are technologically sophisticated. In most cases more artistic activities are combined. we have to accept that the students could not represent scientific notions without the interaction between different subject domains and the contribution of Arts. Therefore, it is really crucial to promote the interaction between all types of cognitive systems from different scientific aspects and the Arts, coming from STEM to STEAM: Science, Technologies, Engineering, ARTS or ALL SUBJECTS, and Mathematics. All demonstrators have described potential art activities. A variety of art activities are described. The use of ICT tools is really helpful during these procedures. In most cases art activities are completed with art exhibitions lots of students used sample material.

2.3.2 Qualitative Analysis according to Pedagogical Framework of Demonstrators

2.3.2.1 CREATIONS Key Features

As far as CREATIONS features concerned, the process enables the dialogue between students, teachers, researchers and stakeholders so as to analyze an aspect interdisciplinarity. Therefore, there has to be a variable range of didactical approaches and different representational, cognitive systems so as to be in accordance to Dialogue, Interdisciplinarity, Individual, collaborative and communal activities for change, Balance and navigation, Empowerment and agency, Risk, immersion and play, Possibilities, Ethics and trusteeship.

2.3.2.2 Inquiry- Based Approach

As far as Inquiry- Based Learning concerned, learners and teachers collaborate in seven different phases of Inquiry- Based Learning (Question, Evidence, Analyze, Explain, Connect, Communicate, Reflect) so as to be engaged by scientifically oriented questions. Students give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.

2.3.2.3 Responsible Research and Innovation (RRI)

Fostering Responsible Research and Innovation is the next big step in the methodological teaching of Science. This is the solution towards an open classroom and innovation system of learning that tackles societal challenges.

2.3.2.4 Reflecting on Science

Reflecting on Science is the last part of Inquiry- Based Approach (PHASE 7). Activities are individual or collaborative and community- based and enables students and teachers to balance their educational tensions. This mental ability is consisted of:

a) Following inquiry- based processes: All the demonstrators follow these approaches, according to new pedagogical theoretical frameworks.

b) Multiple representation of scientific and artistic activities: The combination of Science to Art lead students to renew and reconsider scientific notions.

c) Collaboration: The majority of activities are collaborative and even when a student has to at individually, discussion and communication with others always exist after each procedure.

d) Duration always help the establishment of metacognitive skills, long- term activities give the appropriate time for the formatting of cognitive frames.

2.3.2.5 Identifying with the Scientific Enterprise

Scientific enterprise humanizes the sciences and connect them to personal, ethical, cultural and political concerns. There is evidence that this makes science more attractive to many students, and particularly girls, who currently reject them. Moreover, it can contribute to the clearer appraisal of many contemporary educational debates that engage science teachers and curriculum planners**.** The whole science community act as an ecosystem. There are a series of concrete design patterns that helps educational members to collaborate and set common- based approaches for creating a new dynamic scientific enterprise. Trying to fixing the gap between societal needs and scientific careers, these demonstrators can influence both boys and girls to follow scientific careers. This motivation is in accordance to new needs of European Union, more and more challenges are coming but not so many young people are interested in Science. The collaboration between all members of educational and research communities and policy makers and stakeholders is a new system- based approach that allow science to adapt more quickly and link it to everyday societal, socio- political and economic context of today reality.

3 References

Atkinson, P., Watermeyer, R., & Delamont, S. (2013). Expertise, authority and embodied pedagogy: operatic masterclasses. British Journal of Sociology of Education, 34(4), 487-503.

Bamber, J. (2014). Developing the creative and innovative potential of young people through non-formal learning in ways that are relevant to employability. European Commission Youth: Expert Group Report.

Glaser, B. G., & Strauss, A. L. The discovery of grounded theory: Strategies for qualitative research. Transaction publishers, 2009.

Gobo, G.. The renaissance of qualitative methods. In Forum Qualitative Sozialforschung/Forum: Qualitative Social Research, Vol. 6, No. 3, 2005.

Hazelkorn, E., Ryan, C., Beernaert, Y., Constantinou, C. P., Deca, L., Grangeat, M., .& Welzel-Breuer, M. (2015). Science Education for Responsible Citizenship: Report to the European Commission of the Expert Group on Science Education. Retrieved from: http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf

James K. H., & S. N. Swain, “Only self-generated actions create sensor-motor systems in the developing brain” Developmental Science, Vol. 14, No. 4, 2011, pp. 673–687. doi:10.1111/j.1467 7687.2010.01011.xRocard, M., Csermely, P., Jorde, D., Lenzen, D., Walberg-Henriksson, H., & Hemmo, V. (2007). Science Education NOW: A renewed pedagogy for the future of Europe, Brussels: European Commission. Luettu: http://ec. europa. eu/research/science-society/document_library/pdf_06/report-rocard-onscience-education_en. pdf (21.10. 2016).

Maschi, T. and Youdin, R. (2012), Social worker as researcher — Integrating research with advocacy, Peachpit Press.

Smith, J. A. (Ed.). Qualitative psychology: A practical guide to research methods, Sage, 2015.

Smyrnaiou Z., Georgakopoulou E., Sotiriou M., Sotiriou S. (2017). The Learning Science Through Theatre initiative in the context of Responsible Research and Innovation. Journal on Systemics, Cybernetics and Informatics (JSCI), vol. 15, n 5, pp. 14-22, http://www.iiisci.org/journal/sci/Contents.asp?var=&Previous=ISS1705

Smyrnaiou Z., Sotiriou M., Sotiriou S. & Georgakopoulou E. (2017). Multi- Semiotic systems in STEMS: Embodied Learning and Analogical Reasoning through a Grounded- Theory approach in theatrical performances. WSEAS transactions on Advances on Engineering Education, vol. 14 pp. 99-114.

Sotiriou M. (2017). The Learning Science Through Theatre Implementation, Step by Step,http://www.scienceview.gr/wordpress/wp-content/uploads/LSTT/20172018/MENELAOS_SOTIRIOU_PRESENTATION.pdf.

Strand R. Rapporteur: Jack Spaapen, Members: Martin W Bauer, Ela Hogan, Gema Revuelta, Sigrid Stagl, Contributors: Lino Paula, Ângela Guimarães Pereira. (2015). Indicators for promoting and monitoring Responsible Research and Innovation. Report from the Expert Group on Policy Indicators for Responsible Research and Innovation. European Commission B-1049 Brussels.

Thomas, L. E., & Lleras, A. (2009). Swinging into thought: Directed movement guides insight in problem solving. Psychonomic bulletin & review, 16(4), 719-723

Vergnaud, Gérard. (2009). "The theory of conceptual fields."