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PROMOTING INQUIRY-BASED SCIENCE EDUCATION THROUGH TWO CONTINUOUS PROFESSIONAL DEVELOPMENT PROGRAMS

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ABSTRACT

In the context of permanent and complex changes recorded at the level of the global social system, the education system - through its teachers as its other actors - has to make an effort to continuously adapt to the various problems that appear generally and specifically in educational activities. As such, the teachers' concerns related to their own professional development, through a variate typology of continuous professional development programs, becomes a constant of the contemporary educational environment. Those training programs are designed to equip the teacher with new skills, mainly related to: understanding and developing the psycho-social knowledge of the students, solving the problematic situations in which some of them are involved, training / designing efficient student-centered demarches by using inquiry methodology, designing problem solving demarches, introducing responsible research and innovation, exercising the students' metacognitive capacities etc. Those are the coordinates on which a number of European programs were built, emphasizing also on developing activities or even programs for teachers continuous training. The paper intends to present some issues concerning two continuous professional development programs, proposed in two European projects, in which Valahia University of Târgovişte was partner. Both programs (entitled "PROFILES - Education through Science" and "Applications of Nanomaterials") proposed training models that considered inquiry-based science education as one of the best methods for the teaching and learning of Science nowadays.

Keywords: *Science education, Inquiry-based Science Education, Responsible Research and Innovation, Dissemination, Networking, PROFILES Project, IRRESISTIBLE Project*;

INTRODUCTION

In the last decade, a number of important changes have been registered in the Romanian primary and secondary education, being focused essentially on ensuring an

adequate endowment of the educational units, providing the necessary resources for the teaching process, as well as the continuous training of the teaching staff. At the same time, specific actions related to quality assurance in education, lifelong learning, and professionalization of teaching career have also become a priority. In this sense, at national level, following the trends recorded at European level, a multitude of projects have been proposed and implemented which aimed at the continuous professional training of teaching staff, promoting theoretical and pedagogical knowledge, in order to acquire transferable skills and rethink the teaching strategies, in a great measure.

Some of those kind of projects - implemented by Valahia University Targoviste - had particular objectives dedicated to the continuous professional development of Science teachers - in essence, Chemistry, Physics and Biology teachers -, in the format of presenting and implementing of new teaching and learning methods and techniques in the formal curriculum, but also in non-formal activities. In the context of the knowledge-based society, such integrated approaches related to teaching Science represent a necessity, due to the fact that current top scientific areas are practically interdisciplinary, located at the border between Science and Technology, being successfully enriched with particular issues from Information and Communications Technology area.

1. THE PROFILES PROJECT

The FP7 Project entitled: "*PROFILES - Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science*" (2010-2015) - international web page: http://www.profiles-project.eu/, national webpage: http://profiles.ssai.valahia.ro/ - promoted the students' instruction by exploiting the features of IBSE method (*inquiry-based science education*), having the aim to improve the students' scientific literacy. In fact, the project partnership, initially formed by 22 institutions from 20 participating countries, proposed a specific approach for teaching Science, based on students' socio-scientific motivation.

The project introduced to science teachers teaching materials based on IBSE, offering so a series of reflection issues that aim to develop creative skills, but also to solve problems in socio-scientific environments, stimulating the intrinsic motivation of students, with the view to learn science, develop the students' skills specific to scientific research, and those ones related to taking optimal decisions. Thus, the elements of success were configured both by determining the self-efficacy of the teachers who embraced the PROFILES approach, as well as the students' attitude towards Science and Science Education (Bolte et al., 2014).

The dissemination of the PROFILES project results, the feed-backs offered by the educational actors involved in the project, the related research perspectives opened by the project, but also the evaluation of the whole project, results and processes represent - in fact - key targets for the success of this important project, in the long term. Its ultimate goal is dedicated to science education, making it much more important to students, more strongly linked to current scientific and technological development, much more associated with general education, and in particular, more oriented on promoting and strengthening IBSE methodology in modern education.

Basically, the PROFILES project aimed to ensure the enlargement of students' scientific education, by offering new opportunities for teacher professional development. This objective became tangible through (Bolte et al., 2012):

• providing a training program for teachers, in which IBSE methodology were introduced and presented, accompanied by the development of new teaching modules, with the perspective to be implemented in classrooms;

• establishing mutual cooperation and networking between the actors and the involved educational institutions;

• developing the concept of professionalization of the teaching career and strengthening the teachers' self-efficacy;

• evaluating the results of the classroom implementation process and highlighting the students' feedback;

• disseminating the ideas, materials and results of the PROFILES project, as well as its potential to create teachers' networks who interact with other regional, national and even international networks.

Those interactive networks influenced the promotion of science teaching using IBSE, and thus, allowed and increased self-efficacy in innovative student-centered teaching. In fact, the teachers' self-efficacy represents what motivated the PROFILES teachers to evaluate their own professional development, as well as to advise other colleagues to analyze and consider teaching activities oriented on IBSE.

In Romania, the teachers' continuous professional development program entitled: "*PROFILES - Education through Science*" had the objective to improve the activity of teachers, trying to contribute to the modernization and improvement of the quality of primary and secondary education, through a training offer dedicated to science teachers.

The program had as objectives the following issues (Petrescu et al., 2014):

• training and developing teachers' didactic competences by promoting the exploitation of IBSE method in formal and non-formal activities;

• considering integrated approaches of topics related to the scientific fields;

• capitalizing the students' potential and individual experience;

• designing educational demarches, in accordance with the principles of the constructivist paradigm;

At the same time, the teachers who participated in the continuous professional development program were expected to train and develop solid scientific skills for future graduates, providing them with opportunities for:

• building and improving their own scientific knowledge and understanding;

• understanding various fields of application of the contents related to Science;

• conducting a series of investigations using various materials and appropriately capitalizing their own experience;

• solving problems or problem situations, encountered mainly in the real life;

• training and practicing the ability of "learning to learn".

The continuous professional development program "*PROFILES - Education through Science*" totalized 60 hours (18 hours - courses, 36 hours - practical applications and 6 hours - evaluation) being accredited at national level, and granted with 15 transferable credits.

2. THE IRRESISTIBLE PROJECT

The FP7 project entitled: "*IRRESISTIBLE - Including Responsible Research and innovation in cutting Edge Science and Inquiry-based Science education to improve Teacher's Ability of Bridging Learning Environments*" (2013-2016) - international web page: http://www.irresistible-project.eu, is a European Commission funded project, whereby 14 partners from 10 countries, including academic institutions, science centers and museums, collaborated through a Science-in-Society activity, having the goal to bridge formal and informal/non-formal education by developing Training Modules that introduced actual and cutting-edge scientific topics through inquiry-based science education (IBSE), in order to raise the awareness of students and public in *Responsible Research and Innovation* (RRI).

RRI implies that societal actors (researchers, citizens, policy makers, business, third sector organizations etc.) work together during the whole research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of society (http://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation)

In Romania, the teachers' continuous professional development program was developed around a didactic Module entitled: "*Applications of Nanomaterials*", that proposed a series of activities which tried to address RRI issues via related societal and environmental implications and ethical issues (Petrescu, Gorghiu, & Lupu, 2015). The didactic Units contain guidelines for teachers and additional materials related to the proposed topics, according to the current typical recommendations and formats. Each Unit is proposed to be taught in 4 hours, approximately. This means that the entire Module can be covered in 40 hours.

The Units and the related activities are addressed to primary school level (some of them), and lower and upper secondary school students, proposing the following topics (Gorghiu, & Petrescu, 2016):

(1) *Natural Nanomaterials* - the experiments proposed in this unit direct students to acknowledge the nanoparticles in natural nanomaterials. The activities are planned to make students think about maintaining people's health and responsible use of food-related nanotechnology.

(2) *Lotus Effect* - the students approach the effect from a nanoscience innovation perspective. The purpose is to form a responsible attitude towards using nanomaterials in various industries. The experimental activities highlight the structural and functional properties of super-hydrophobic nanomaterials.

(3) *Nanoscience - A Facilitator Background for a United Group* - the students are introduced to the concept of nano-metals and learn green methods for obtaining colloidal nanoparticles (Au and Ag) from plant extracts, with a responsible attitude concerning the use of nanoparticles in practice.

(4) *Magnetic Liquids Technology - Ferrofluids* - ferrofluids are a special class of nanomaterials that combines the usual properties of a liquid and a magnet. This unit involves students to study the properties of such unusual materials before proceeding to search and design several applications. The unit claims some previous knowledge related to magnets.

(5) *Applications of nanomaterials in Medicine* - the activities designed in this unit aim to the formation of a conscious and responsible attitude towards the importance of using the properties of nanomaterials - either natural or synthesized - in the medical laboratory.

(6) *Applications of nanomaterials in Solar Energy Systems* - the envisaged activities target to enrich the students' knowledge concerning the renewable energy, but also to specific RRI issues related to solar energy technologies.

(7) *Industrial applications of nanomaterials* - the activities proposed to be carried out by the students lead to know general notions about nanomaterials and their applications in industry.

(8) *Applications of nanomaterials in Museum Research* - the envisaged unit activities - strengthening the whole knowledge gained till this moment - propose to carry out also a series of experimental / practical work specific to museums.

(9) *The World of Nanomaterials* and (10) *Biomimicry / Nanobiomimicry* - those two multimedia units are designed in order to fundament the concepts and notions learnt by the students during the entire Module. In this respect, a movie (in the first activity) and many images (in the last one) are used to explain - in details - various applications of nanomaterials and introduce also the concept of biomimicry.

The big challenge was strictly related to the national curriculum for Science (Physics, Chemistry, Biology), where no reference concerning RRI had been included. That challenge led the IRRESISTIBLE Community of Learners to analyze the introduction and adaptation of the RRI specificity in the proposed activities. That was the reason for approaching the RRI dimensions in conjunction with the curricular science education activities.

3. DISSEMINATION ISSUES

The dissemination of results and good practices recorded in both projects, was made taking into account the needs of the educational actors who acted in the Science area. As normal, the main dissemination channels were represented by: national web page, leaflets, posters, newsletters, participation in workshops, seminars, conferences, but also in several important events.

As example, the Community of Learners built up in the frame of IRRESISTIBLE project organized a series of workshops and exhibitions, as a point of meeting and discussion between academic staff, teachers, students and even general public. In this respect, the workshops thematic were anchored around the topics of nanomaterials and RRI (Măntescu, Gorghiu, & Gorghiu, 2017):

- "*Nanosciences and responsible research*" - at History Museum of Dambovita County;
- "*Multimedia Instruments for Promoting the Concept of Responsible Research and Innovation in Museum Practices*" - at Prahova Natural Science Museum;
- "*Responsible Research and Innovation in the Area of Nanotechnology*" - at "Ion Heliade Rădulescu" Dambovita County Library;
- "*Nanobiomimicry and Responsible Research*" - at National College "Constantin Cantacuzino" Targoviste;
- "*Applications of nanomaterials in industry*" - at Valahia University Targoviste;
- "*Applications of nanomaterials in renewable energy technologies*" - at Multidisciplinary Scientific & Technological Research Institute of Valahia University Targoviste;
- "*History of nanomaterials. Applications of nanomaterials in practice*" - at "Ion Heliade Rădulescu" Dambovita County Library;

- "*Applications of nanomaterials in museum research*" - at Prahova Natural Science Museum;
- "*World of Tomorrow and the Future Energy*" - at Technical College "Elie Radu" Ploiesti.

More, the IRRESISTIBLE students - together with their teachers - designed several exhibitions, some of them being opened in two important museums from Dambovita and Prahova Counties (Petrescu et al., 2016):

- *Local Exhibitions* (in schools) - starting with March 2015 (schools involved in IRRESISTIBLE Project);
- *Exhibition 1*: "*The World of Nanomaterials and Solar Energy*" - August - November 2015 - at History Museum of Dambovita County;
- *Exhibition 2*: "*The Sun & The <Nano> World*" - March - July 2016 - at Prahova Natural Science Museum.

A valuable presence of the IRRESISTIBLE Community of Learners was recorded with the occasion of *European Researchers' Nights* public events, such large meetings being dedicated to gather researchers closer to the general public, expressing the diversity of research and highlighting the impact of research on our daily lives (Gorghiu et al., 2017):

- in September 2015 - at History Museum of Dambovita County;
- in September 2016 - at History Museum of Dambovita County / Museum of the Romanian Police Targoviste;
- in September 2016 - special event in Kiel, Germany.

On the other hand, the concept of *Networking* was introduced, being referred to the network paradigm and implemented step by step, in the format of a communication system based on reciprocity. In this respect, all the involved educational actors were able to exchange opinions and information, but also cooperate on various issues of interest.

As example, in the PROFILES project, the establishing of specific networks was fulfilled, with the aim to maximize the dissemination efforts and make the teachers more aware of the project objectives, activities and results (Rauch, & Dulle, 2012):

• cooperation networks between Science teachers from one school - as *teachers' network*, for disseminating the PROFILES modules for the school and school community educational actors;

• cooperation networks between Science teachers from 2-3 schools - as *school network*, for disseminating the PROFILES modules for the educational actors from the particular county / region;

• cooperation networks between Science teachers from local / regional structures - as *local / regional networks*, for disseminating information for educational actors at regional level, and subsequently, national one.

Creating such kind of networks was not a simple process, but it had a constant activity. During the project lifetime, the PROFILES networks played crucial roles for sharing the teachers' experience into the educational communities and valorized the best practices, spreading them at local, regional and national levels (Gorghiu, & Gorghiu, 2014). But it is clear that special attention had to be paid to the sustainability of those networks, so efforts were constantly done for keeping them alive, in order to maintain their dynamics, flexibility and democratic actions.

CONCLUSION

It is obvious that, in the frame of various European projects, Science teachers had the opportunity to participate in a multitude of continuous professional development programs, which offered proper environments for improving the quality of science education by developing their pedagogic knowledge, in strong correlation with the actual European requirements. At the same time, such programs have all the advantages, being able to promote socio-scientific learning environments based on the exploitation of IBSE methodology, with direct impact on the development of students' creative and scientific thinking. In addition, the process of dissemination - through traditional and modern channels, and its possibilities of maximization using the networking power - offer the possibility to extend the number of targeted educational actors, offering various ways for collaboration, both in real and virtual spaces.

Inside the networks, the teacher has to be ready to communicate, cooperate and share experiences and best practices. But for defining an optimal picture, the teacher has not to forget to work as a reflective teacher, to be responsible, to be aware of the importance of his/her mission, ready to learn permanently, respect the child and the teaching profession, and constantly invest in his/her own professional development (Stăncescu et al., 2019).

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