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Responsible Research and Innovation in the Context of Educational Partnership - A Case Study Oriented on a Training Module Related to Nanomaterials

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Abstract

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The paper illustrates the results of a research which aimed to perform a diagnosis made in the frame of the FP7 project called IRRESISTIBLE, being oriented on the training module related to *Nanomaterials*, concerning the results recorded in specific activities carried out in educational activities organized by formal and non-formal educational partnership - university, schools, research institute, museums. In order to achieve the goal of promoting *Responsible Research and Innovation* in educational activities, the abovementioned project proposed a series of activities involving the participation of a large number of teachers and students. The research targeted the following specific objectives: (a) the analysis of the perception related to learning experiences, made by direct beneficiaries who acted in an active way in the educational activities (students, teachers, researchers, experts) - *OS1*; (b) the identification of representations expressed by the educational actors related to the impact of performed activities on their own professional development - *OS2*; (c) the analysis of the feedback concerning the benefits of their direct participation in the project activities - *OS3*; (d) the measure of the project added value based on a set of quantified indicators (baseline indicators) - *OS4*. The research was a mixed-type: qualitative and quantitative, and its methods and tools were based on questionnaire surveys and semi-structured interviews. The target group consisted on: students, teachers, researchers and educational experts. The quantitative research enabled the measurement of the interest level of the beneficiaries involved in the IRRESISTIBLE project, related to the dissemination of the learning results.

Keywords: Formal education; non-formal education; Responsible Research and Innovation feedback analysis; IRRESISTIBLE project.

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1. Introduction

The present orientations in the paradigm of teaching underline a displacing of the accent from the normative, passive didactics, towards a descriptive, explicative didactics with a powerful prescriptive character. Within this framework, we are thus able to refer to a new paradigm of didactics: the psychological-active paradigm. The modern didactics demand the permanent improvement and adaptation of the learning activities as a consequence of the scientific evolution, development, research and progress, the correct understanding of the human behavior, the accurate understanding of the human organism psychical functionality, understanding the actual environment factors and their influence upon human development, progress in the neurosciences research field, the individual's expectations reported to life, the individual's normal functioning as a social integrated whole. Many researchers were preoccupied of identifying explanations regarding the correlation between different learning structures. According to Thorpe & Schmuller (apud Neacșu, 2015), we identify the following learning principles and laws: learning must begin from the establishing of a purpose; any learning begins with different means of using the subject's experience; learning has a neurophysiological basis, thus a material substrate; learning is strongly influenced by the affective states generated by the situations and conditions which appear during the process; learning develops and is also positively influenced by a socio-cultural system of stimulation which is called *instruction*; learning is more efficient whilst developing an action; learning is influenced by the ageing general and partial processes; learning is directional and determined by knowledge. In the teaching paradigm, the act of "teaching" has the following steps: to present facts, examples, models, exponents, offcuts from reality; to lead pupils towards their analysis, to compare them, to explain; to draw the essential which to be focused in definitions, laws, rules, principles; to organize the act of learning; to activate knowledge in exercises, applicative activities (Ionescu & Bocoș, 2009). Within this frame, the formal and non-formal educational partnerships converge towards achieving a sustainable education. We define educational partnership as the explicit and implicit accord between formal and non-formal type of educational actors, active on developing educational activities with an important role on forming and developing cognitive, attitudinal, instrumental applicative and reflexive competences, demanded by the need of functioning confronted with the new social and progress realities.

2. Research methodology

The present research proposes to accomplish a diagnosis within the European FP7 project named IRRESISTIBLE, taking into evidence the dedicated Training Module on Nanomaterials, concerning the results obtained during the specific activities accomplished in the frame of project educational partnership (university, schools, museum, Research institute). For this purpose, there were formulated specific research objectives: (a) analyzing the perception of direct beneficiaries learning experiences concerning the active involvement in the project (students, specialists, teachers) - *OS1*; (b) identifying the representation of the actors involved in the project concerning the impact of the activities on the personal professional activities - *OS2*; (c) analyzing the direct participants' opinions regarding the benefits identified by the means of the activities accomplished during the project - *OS3*; (d) measuring

the project added value based on a set of quantifiable indicators (baseline indicators) - *OS4*. The research is mixes: qualitative and quantitative, and the proposed instruments are: specific questionnaires and semi-structured interview. The participants to the research were: students, teachers, researchers from the pre-university and university educational environment. The quantitative research allowed the measurement of the beneficiaries' level of interest in the project, towards disseminating the products of learning. The structure of the sample is: (a) students (200 - from pre-university educational levels: primary (50), lower secondary (75), upper secondary (75); (b) members of the Community of Learners (35 - Science teachers - Physics, Chemistry, Biology, educational experts, researchers, specialists from museums and libraries) - set up in the frame of the project. The whole group took part at the formal and non-formal educational activities during the project. The distribution of the sample is illustrated in figures 1 and 2.

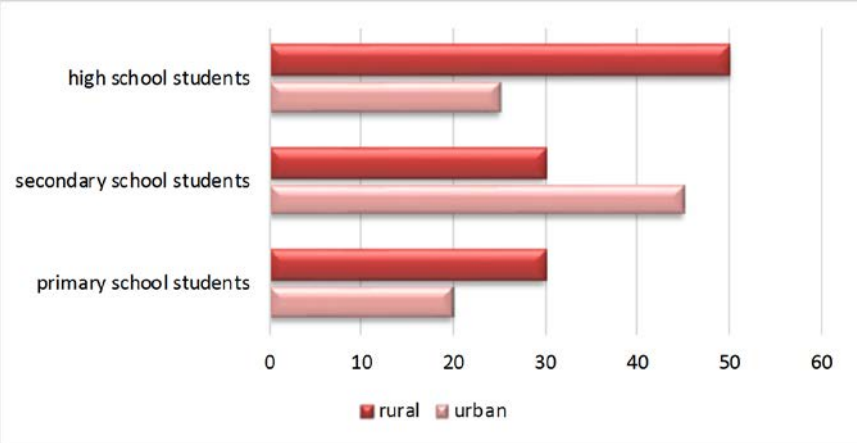

Fig. 1. Distribution of the questioned students in project educational (rural / urban provenience)

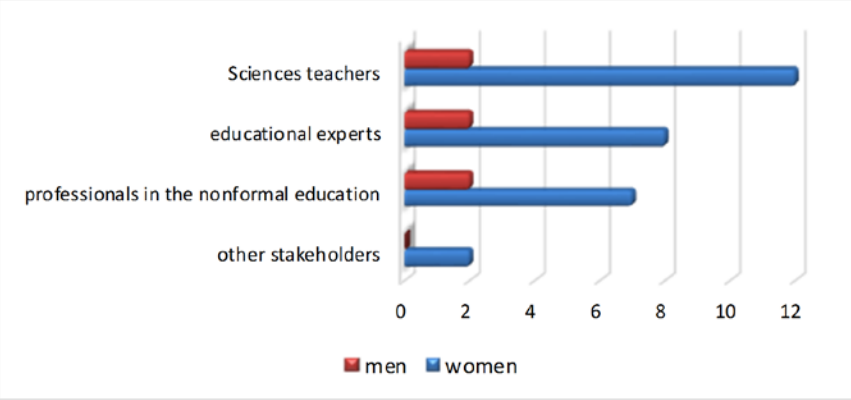

Fig. 2. Gender distribution of the Community of Learners members

3. Results and discussion

The formal and non-formal educational activities aimed to the implementation of the knowledge concerning the acknowledgement of the importance of valorizing the benefits offered by the Nano-world, together with the advantages of nanotechnology / nanomaterials, all of them being enrich with Responsible Research and Innovation issues. The thematic included in the *IRRESISTIBLE Romanian*

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Teaching Module named: "*Nanomaterials and its applications*" consists of the following subjects*: "Natural nanomaterials"*, *"Lotus effect"*, *"Nanoparticles"*, *"Ferrofluids"* (formal educational activities), and *"Applications of nanomaterials in medicine"*, *"Applications of nanomaterials in solar energy systems"*, *"Applications of nanomaterials in industry"*, *"Applications of nanomaterials in the museum research"* (non-formal education activities). At the students' level, the Module aimed to develop cognitive competences: knowing, understanding and using the specific language, interpreting the knowledge, but also educational competences: applying, transferring and problem-solving, critical and constructive reflecting, creative-innovative behaviouring. The non-formal type activities allowed the formation at the students' level of transversal competences: role competences and also personal and professional development ones. To each competence, it corresponds a series of descriptors. In this respect, there were projected research instruments which allowed the measurement of the level of the gained competences, using a Likert type-scale. The following working hypothesis was considered: if in the formal and non-formal educational activities, the teachers use the experiential pedagogy in the didactic process, then the students will easily understand the knowledge related to nanomaterials and the projected competences will be developed. The operationalization of the cognitive competence dimensions aimed to: minimal knowledge about each topic, knowledge related to the concept of nanotechnology, acknowledging the importance of using nanotechnology, possibility of giving examples related to applications of nanomaterials in various areas, knowing the importance of nanotechnology for the human progress, expressing some value judgments regarding the need to know the importance of using nanotechnology in the everyday life. At the level of the functional action competences, it was especially pursued the perception of the manner in which students can apply, transfer and solve certain problems in the context of valorizing information regarding nanotechnology, have a creative and innovative behaviour about particularizing in several life contexts the learning results, have a critical and constructive reflection reported to the decisions taken about selecting information and its use in the personal space. In this respect, figure 3 shows that students appreciated on a large scale all the topics, but mainly those connected to the *"Natural nanomaterials"*, *"Lotus effect"*, *"Applications of nanomaterials in medicine"*, *"Applications of nanomaterials in solar energy systems"*, and *"Applications of nanomaterials in the museum research"*, the last three ones probably to the fact that during the non-formal activities, the students took part actively, being involved in direct activities like observation, experimentation, asking for information from other specialists (researchers). Those ones were able to facilitate the students' access to the information derived from valid experiments and have exemplified the manner in which this can be valorized in the everyday life. In conclusion, the identification and correlation of the gathered knowledge related to its use in the students' everyday life, increased their interest for learning and representing a fundament for sustainable education.

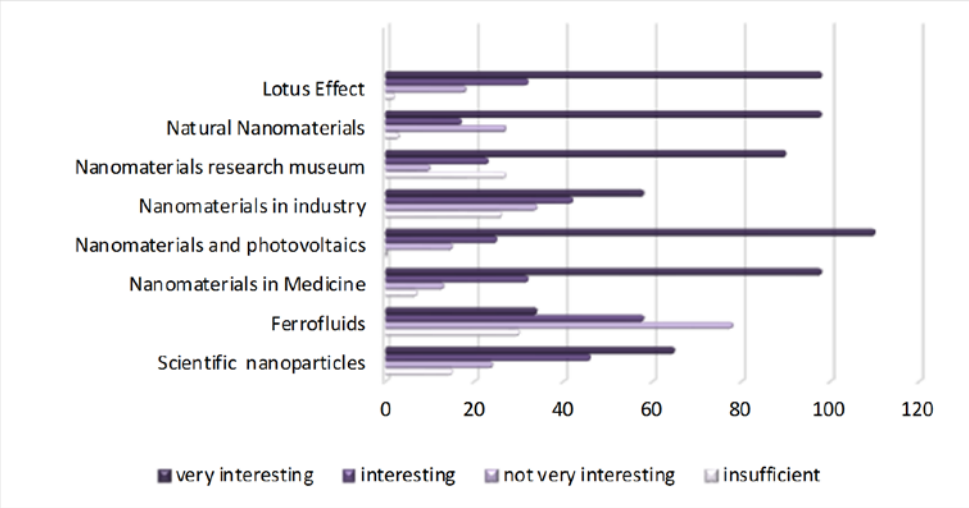

Fig. 3. Students' perceptual level related to the cognitive competences dimensions

At the teachers' level, it was measured their perception regarding the didactic strategies used on building competences for each theme from the module: "*Nanomaterials and its applications*". Within this framework, it was considered the following explicative paradigm: the field is hard to be understood by the students, due to the lack of adequate resources, and the didactic strategies must aim to design learning activities based on the models which to aim to: observation, experiment, explanation, reflexive approach, debate. The perception of the learning activities, as perceived by the Community of Learners members, is illustrated in figure 4.

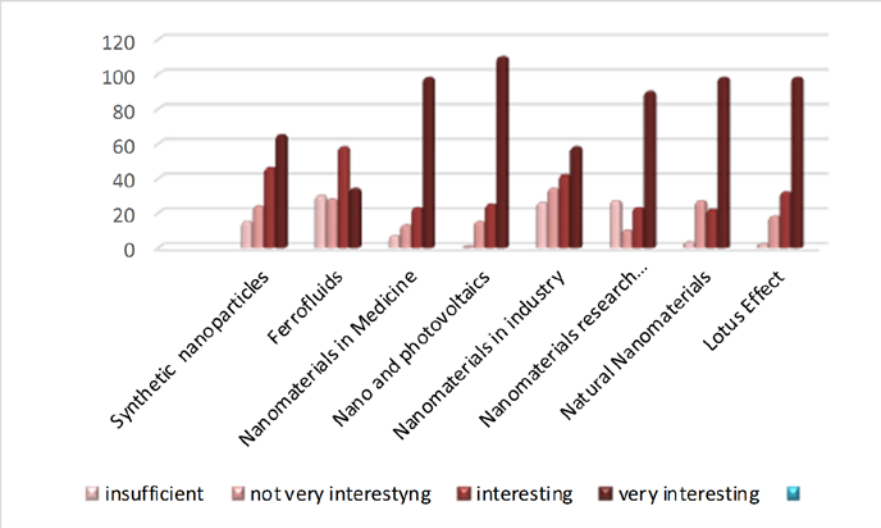

Fig. 4. The perception of the learning activities by the Community of Learners members

In conclusion, we may assert the fact that, at the perceptual level, from the perspective of the high degree of didactic availability on implementing the presented thematic, the teachers' opinion converge with the perceptual level of the competences gained by the students, which leads to the following fact: the didactic demarche, the multidisciplinary approach and the presence of the team of specialists/experts in formal and non-formal education activities, condition the success on gaining of new competences by the students (OS1, OS2, OS3). Presenting information from the perspective of its

use in the personal life, enhance the students' curiosity, interest and active participation to the learning process. Those aspects represent precursors of sustainable education.

Regarding the measurement of the project added value, based on a set of quantifiable indicators (baseline indicators) - OS4, it was considered the following explicative paradigm: the discoveries from the nanotechnology field represents an issue frequently used by the society and valorized by the science, in the benefit of all the citizens, by respecting the principles of governance, equality and accessibility. A form of an education dedicated to "nano" world represents a successful key on acknowledging the importance that nanotechnology has in the societal progress, environmental protection, health and increasing the quality of life, preserving the natural and environmental resources. In this way, the project added value is justified: beyond the importance of the field, the students proved to be an active part because they were actively involved in the experimental part, in making samples, in organizing exhibitions, in building investigation demarches based on the problems solving models and learning by discovery, in valorizing the available material resources, all of those facts governed by the dimensions of Responsible Research and Innovation: implication/engagement, gender equality, ethics, governance, accessibility, scientific education, sustainability and social justice. Education in the non-formal space, can valorize the dimensions of RRI by the adequate use and exploitation of the methods of stimulating learning at the trainees' levels (Anghel, Gorghiu, & Măntescu, 2015).

4. Conclusion

We observe that the educational activities developed within the IRRESISTIBLE project led to a successfully learning demarche. Experiential pedagogy made the students manifest an increased interest towards learning, given the conditions they are the direct beneficiaries of some concrete learning activities, based on experimentation. The education made especially in non-formal settings adds real values and complement the formal one. The consolidation and building of students' educational competences within such modules (like "*Nanomaterials and its applications*") is possible in the context of a mixt-type educational design, in which the formal educational models are completed by non-formal educational activities.

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