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SCIENTIFIC CREATIVITY RELATED TO RRI - PSYCHOLOGICAL AND PRACTICAL IMPLICATIONS FOR STUDENTS

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Abstract

In any field of activity, the progress involves research, experimentation, trial, success or failure, but also people with innovative vision, passion and unconditional dedication. The premises for undertaking applied research and scientific development, in many cases, begin very early, in the time of the primary school, when the interest of some young students for research and innovation is materialized in small projects that could be real starting points for their future evolution and career, with possible potential to be implemented in the society for solving several issues or problems. Thus, the scientific creativity represents the ability to find new problems and the ability to formulate hypotheses, involving additions to the prior knowledge, being associated with ethical principles and norms, due to the fact that science, technology, research, innovation do not always have positive, desirable moral and social consequences. In this respect, the paradigm of *Responsible Research and Innovation* (*RRI*) and its specific frameworks proposed by the EU (starting with 2010) asked for a close cooperation between society and research. At the same time, RRI exploited the premise which sees the intrinsic connection between science and ethics, considering *ethics* as a clear dimension, near *engagement*, *gender equality*, *science education*, *open access* and *governance*. This paper seeks to identify the young students' interest in several RRI activities (in formal and non-formal contexts), organized in the IRRESISTIBLE project, but also their perception related to the ethical dimension of research.

Keywords: Scientific creativity, Responsible Research and Innovation, ethics, Science, students' feedback, IRRESISTIBLE Project.

1. Introduction

In a general sense, the *creativity* is characterized by a multitude of attributes: novelty, originality, productivity, ingenuity, utility, efficiency, value (Roco, 2004). From a narrower and more specific psychological perspective, the creativity occurs in 4 important concepts: as a *product*; as a *process*; as *human availability* (the *human potential* as a *creative ability*); as a *complex personality dimension*. The creativity depends on a unitary set of cognitive factors: fluency, flexibility of thinking, originality, imagination and intelligence, and non-cognitive factors: innate, motivational, attitude and temperamental factors.

Going further, the scientific creativity represents the ability to find new problems and the ability to formulate hypotheses, involving additions to the prior knowledge; thus, scientific creativity represents "a kind of intellectual trait or ability producing a certain product that is original and has social or personal value, designed with a certain purpose in mind, using given information" (Hu, & Adey, 2002, p. 391). The characteristics of the scientific creativity are: the need to liberate rules (flexibility), openness to experience, problem sensitivity, problem-solving (Roco, 2004); in simple terms, the scientific creativity involves the discovery of *scientific truths*.

But how creativity can be linked to *Responsible Research and Innovation* dimensions, which its particular frameworks have been proposed by the EU, since 2010, asking for a close cooperation between society and research? *Responsible Research and Innovation* (*RRI*) exploited the premise which seen the intrinsic connection between science and ethics, considering ethics as a clear dimension, near engagement, gender equality, science education, open access and governance. In fact, RRI includes, in a general sense, aspects of the ethical dimension of science, research, technology and innovation, but also responsibilities in scientific creativity to lead to positive moral and social results. RRI represents an approach that anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation. 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 societal expectations.

In this respect, there are definitions of RRI which try to make clear the meaning of this paradigm. The first one was stated by Rene von Schomberg (2011) - policy officer working for European Commission - in which RRI represents a clear and interactive process through which the societal actors and innovators can respond to each other for ethical acceptability, sustainability and societal opportunity for the innovation process and for its marketable products, allowing so an adequate integration of the scientific and technological progress into the society. The second definition was formulated by Stahl (2013) and defined RRI as a higher level of responsibility or even meta-responsibility, which targets to form, keep, enhance, coordinate and range extant and new research and innovation processes, actors and liabilities, in order to ensure desired and accepted research results.

2. Problem Statement

Creativity and responsibility are core values for societal development. The *creativity* is defined as a complex feature of human personality, related to the ability to achieve something new, original - a highest

valence of the human activity. *Responsibility* represents a social construction that contributes to the regulation of human relationships from the ethical, moral, legal point of view, being also associated with research and innovation. From the etymological point of view, the term originates in *response*, so responsibility involves a communicative structure. The subject, who has the ability to respond, must answer for his actions based on a set of pre-existing rules or guidelines. RRI has its starting point from the expected positive impacts of technology and seeks what can be done to operationalize them in practice Thus, RRI involves the interaction of three components or dimensions: *actors*, *activities* and *norms* (figure 1).
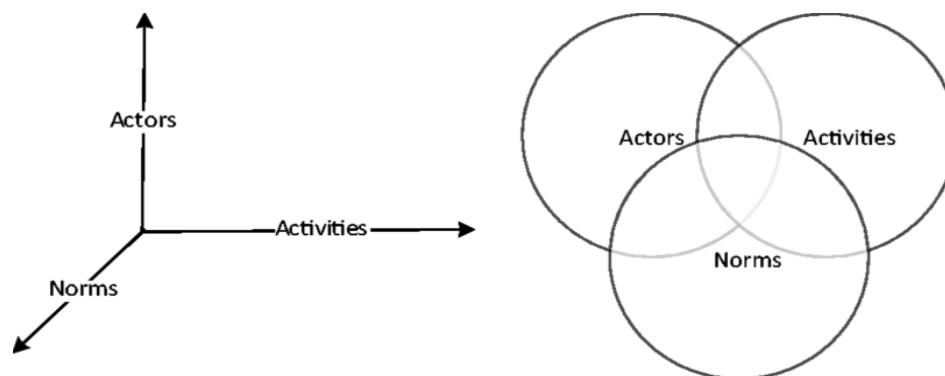
Figure 01. Graphical Representation of the RRI space (Stahl, 2013)

The *actors* may be researchers, research organizations (even public or private), research ethical committees and their related members, research and innovation users, policy makers (at different levels), professional bodies, legislators, civil society, educational organizations (like schools or higher education institutions), but also public bodies - from local authorities to regional structures (Stahl, 2013).

A multitude of *activities* refers to a number of different actors from the abovementioned enumeration. As example, *education* requires the engagement of each individual researcher, requiring in this sense legal frameworks, often supported by professional bodies and introduced in practice by the educational structures (institutions or organizations). It is evident that there is a strong relationship between the RRI actors and their related activities. In practice, there is a large palette of possible activities which promote research in many areas and, in this respect, RRI requires a series of basic *normative principles* with the view to assess if a specific type of research or innovation is really desirable or acceptable.

As example, in the European FP7 IRRESISTIBLE Project (*IRRESISTIBLE - Including Responsible Research and Innovation in Cutting Edge Science and Inquiry-based Science Education to Improve Teacher's Ability of Bridging Learning Environments*) proposed a frame in which the contact between the different stakeholders are encouraged. In this respect, in each of the project partner institutions, a *Community of Learners* (*CoL*) was set up with the aim to develop thematic learning modules. The *CoL* involved school teachers, educational experts from universities, researchers, experts from museums/science centers.

The Learning Module designed in the project, was used by the teachers together with their students. Additionally, the students visited relevant research labs / science centers, museums and transposed the learning module results into exhibits, offering an example for developing a proper relationship between research and society, with major emphasizing on exploiting the creativity. As results, some of the best

exhibits produced by the students were shown during the *RRI Festival* (March, the 3rd, 2017), organized in Targoviste, Romania.

3. Research Questions

During the RRI Festival, questionnaires were applied to 112 students in order to analyse how much they are interested in RRI activities, in what measure the ethical principles are understood and respected, how much the proposed experiments - in which students were involved - contributed to the development of their creativity, and how did the students feel comfortable in the festival activities.

4. Purpose of the Study

This work seeks to identify the young students' interest as expression of scientific creativity, for the RRI activities (in formal and non-formal contexts), organized in the IRRESISTIBLE project, but also with the occasion of RRI Festival. More, it is interested to see the students' perception related to the ethical dimension of research, taking into account that in the IRRESISTIBLE project, it is raised the awareness about the relation between research and society among young people, with a special focus on school students and their teachers as intermediates.

5. Research Methods

The proposed investigation involved a *survey questionnaire* applied on a sample of 112 subjects, 48 students from primary education and 64 from secondary education. The obtained results provide the students' feedback on RRI activities, a starting point for such projects and an indicative landmark in non-formal education. The results were processed involving statistical methods, in correlation with qualitative analysis, based on the data gathered from discussions with the participating students.

6. Findings

The first question was oriented on obtaining the feedback related to the extent to which students are interested in learning more about the main topics proposed in the project, all of them including debates and discussions in connection to the RRI dimensions: nano-world, renewable energies, climate change, smart cities etc.

Figure 2 illustrates graphically the distribution of the level of students' interest in the project activities having topics that can be linked to RRI issues. It can be noticed that at primary and secondary level there is a *great* and *very great* interest for such activities. Information on nano-world, renewable energies, climate change, smart cities and others has received with great interest and enthusiasts for the questioned students.
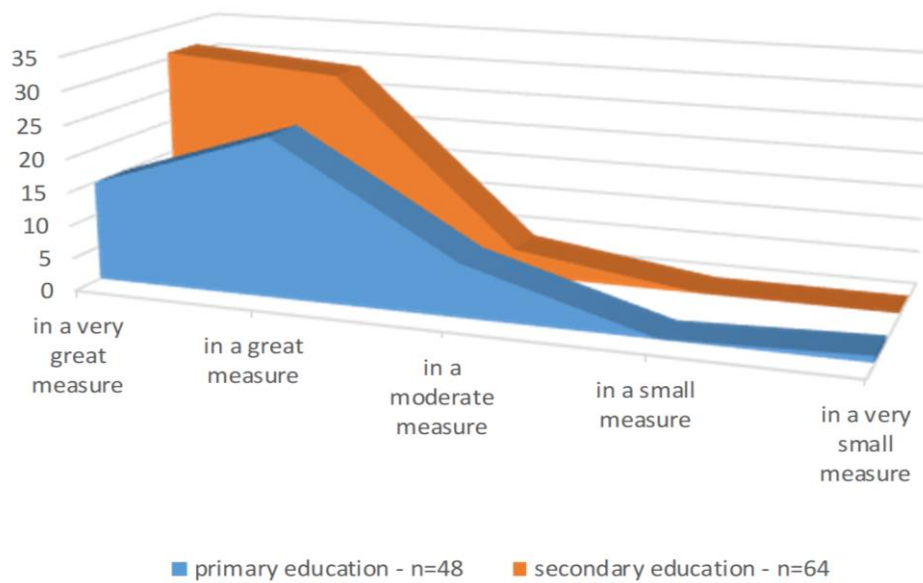
**Figure 02.** The degree to which students are interested in topics which can be linked to RRI issues

The second question explores the students' vision regarding the ethical dimension of research, the need to apply and respect it from the societal actor point of view. Figure 3 shows the high degree in which students believe, that ethics is a very important dimension of research, students from primary and secondary education being aware of the research importance for the society. Ethical issues are essential elements that support and validate high-level research and innovation.
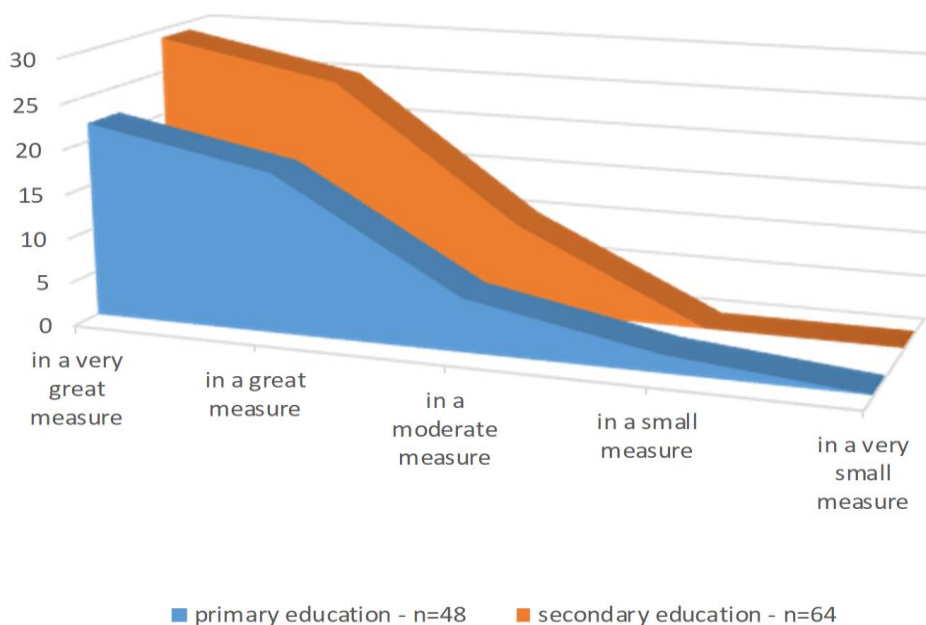
**Figure 03.** The value of ethical principles in research, perceived by the students

In the same questionnaire, students were asked whether they consider that the experiments they have realized, or have they attended/assisted contributed to the development of their creativity. By definition, the RRI activities largely involve a developed level of scientific creativity. Figure 4 shows that students

consider the proposed activities in which they participated, played an important role in the development of their creativity, an important dimension of the researcher's personality.
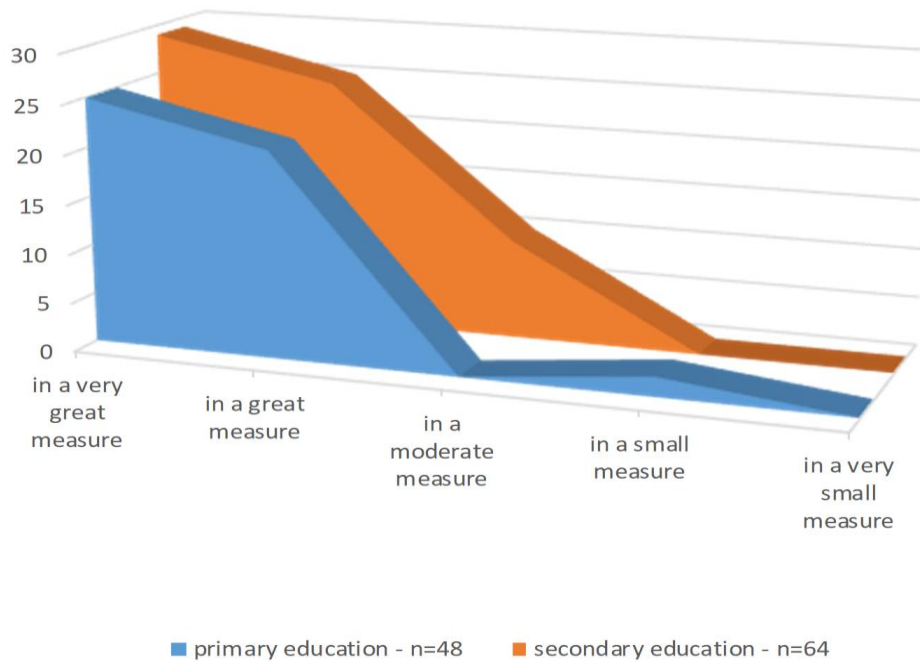
Figure 04. Contribution to the development of scientific creativity through RRI activities, from the participated students' point of view.

Last, due to the fact that in any activity the affective component has a decisive role, the students were asked to appreciate and describe in three words how did they feel as participants, in the RRI festival.
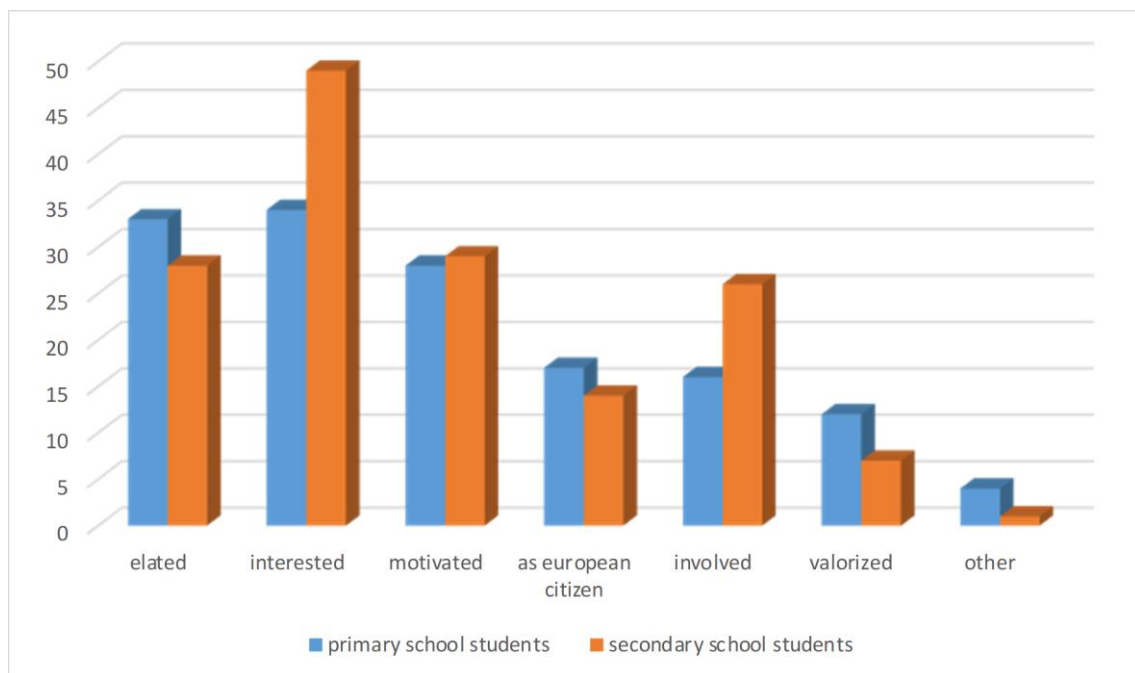
Figure 05. Students' impressions and feelings related to the activities held during the RRI Festival

Figure 5 shows what students who participated in the RRI festival activities felt - most of them expressed great interest in those activities, but they felt themselves also: elated, motivated, involved or treated as European citizens.

Concerning the manifested interest and involvement, the secondary school students recorded a higher level of confidence, the difference from the primary school students being attributed to their age and level of understanding, more developed for those types of activities.

7. Conclusion

Scientific research and scientific creativity are two important parameters of education in the actual contemporary society. The results confirm the attractiveness and the high interest of the dimensions promoted by Responsible Research and Innovation, for students. Considering their specificity, the activities that include RRI features, indirectly imply the development of scientific creativity, an important dimension of the students' personality. At the same time, students are aware (mostly) of the ethical dimension of RRI and assumed responsibility arising from less conventional and experiential activities. In accordance with Stahl, Eden, & Jirotka (2013), RRI is best understood as a meta-responsibility, that includes, for example, the responsibility of the scientist or researcher for the integrity of her or his work, as well as the responsibility of the innovator for the potential users.

In this context, encouraging initiative, research and innovation, but also creativity, using science and technology in formal or non-formal educational contexts, become more and more important, being relevant indicators of social and human progress.

Acknowledgments

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