

The Place of Academia in the Knowledge Triangle: How Students Recognize the Role of Scientists for Building an Innovation Ecosystem

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Abstract: Universities traditionally play a central role in building a thriving knowledge and innovation ecosystem. However, in many Central and Eastern European (CEE) countries, universities and research centres are hardly recognized by students as attractive places for career development or as partners for successful business endeavours. Many factors can explain why the public image of scientists in countries like Bulgaria is underestimated: from low investments and under-financed research to old research infrastructure, poor media coverage, low international mobility and lack of interest from local businesses. At the same time, new opportunities and investments remain hidden for students and young people who remain sceptical about pursuing a research career. Considering this, the paper aims to explore the main challenges for positioning Academia back in the centre of the innovation ecosystem. Starting with a short overview of the main pillars of the knowledge triangle, it further enlarges the analysis with the role of the new national institutions (such as Centre of Excellence and Centres of Competence) within the modern innovation ecosystem. Focusing on the researchers' role, the paper summarizes how universities can further help to strengthen the knowledge sharing within the society. The paper is structured as follows. The literature review identifies the main components of the thriving innovation ecosystem, considering some of the pressing national and international challenges, recent technology opportunities and public expectations. Then, it presents the EU-level initiative – the European Researchers Night (ERN) role in boosting public awareness and interest in science. More specifically, it explores the K-TRIO project activities in Bulgaria from a knowledge-sharing perspective. In the next part it analyses the opinions of about 107 ICT students who took part during the last year in surveys and round tables dedicated to the role of researchers, research careers and research opportunities for building a sustainable innovation ecosystem. The outcomes of the surveys and round table discussions are presented along with the main conclusions and lessons learned, summarizing their perceptions, prejudices and recommendations. The last part highlights how working with young people and attracting them to Academia can boost its importance for the innovation ecosystem.

Keywords: Innovation ecosystem, European researchers night, Knowledge triangle, Research career

1. Introduction

Adapting business and society to the challenges of the digital transformation requires substantial efforts for strengthening the role of Academia in the knowledge triangle. Policy initiatives and public investments in research and innovation (R&I) are increasing, but many of these efforts remain unrecognized for the young generations and the general public. For example, several actions are taken recently for making Europe a modern, resource-efficient and competitive economy, and the first climate-neutral continent and empowering people with a new generation of technologies. Research and innovation are considered crucial for the economic recovery, and are in the centre of the industrial transformation for Green and Digital Europe (European Commission, 2020a). Recent actions for Deepening the European Research Area (ERA) consider how to translate R&I results in the economy, and contribute for sustainable development and to the common European efforts for bridging global challenges, building Green and Digital Economy, Smart Cities and Smart Factories, and take full advantage of Clean Technologies, Internet of Things (IoT), Artificial Intelligence, BIG Data, Cloud computing, etc. In addition, the synergy of ERA and the European Education Area (EEA) are essential for the European competitiveness, dual transformation and knowledge-based growth (European Commission, 2020b). Several policy instruments have been in place to facilitate the knowledge transfer between academia and industry: university-industry research contracts, internship schemes, innovation vouchers or tax credits for industry-university collaboration, technology transfer offices, innovation centres, business incubators, science/technology parks, innovation platforms, etc. As outlined in Cervantes (2017) the institutionalisation of knowledge transfers from academia to industry have been not successful in most cases. Among the factors are considered *“the tacit nature of knowledge, and the cost of network building and the difficulty of pricing knowledge.”* At the same time, as a general failure of innovation policies is considered the push on academia to transfer knowledge to industry, and underestimating the multidirectional flows in the knowledge triangle (Cervantes, 2017).

The changes in the economy and society towards higher knowledge intensity have created new demands on higher education institutions (HEI) to develop the human capital to better respond to the labour market needs, and support the industry research and competitiveness with its competencies. Moreover, the need for “nourishing talent for excellence” and developing the next generation of researchers and innovators, is related to new educational methods and emphasis on Science, Technology, Engineering and Maths (STEM) at an early age. At the same time, young people should be equipped with competencies facilitating their engagement as citizens in Open Innovation and Open Science (Gourova et al 2021).

Bulgaria as a European Union (EU) Member State (MS) has followed the trends in ERA and EEA, and has aligned its national strategy, regulations and funding schemes to the EU actions in the areas. For example, recent legislation aimed at modernising universities ensured a framework for enhancing the research excellence in the leading research universities. At the same time, the Innovation Strategy for Smart Specialisation (ISSS) outlined regional priorities for industrial development. The funding mechanism for developing Centres of Excellence (CoE) and Centres of Competence (CoC) clearly emphasised the need for building research excellence in the ISSS priority areas, and thus, the centres to better serve the economic and societal needs (Gourova et al, 2021).

Sofia University (SU) as a leading research university in Bulgaria has been involved in some consortia for developing CoE and CoC. In the paper will be presented the role of the CoE UNiTe (Universities for Science, Informatics and Technologies in e-Society) in Information and Communication Technologies (ICT) ecosystem, and its approach towards building the next generation of researchers and innovators within the K-TRIO project. The paper initially focuses on some concepts related to the innovation ecosystem and the role of universities in the triangle of knowledge. Next are presented the UNiTe role in supporting the digital society, and the approach of the K-TRIO project for attracting talents to research. Within K-TRIO activities is carried out a survey among young people which results are discussed in the paper as well.

2. Universities in the Triangle of Knowledge

2.1 Role of Academia in the Innovation Ecosystem

The concept of the knowledge triangle emerged in the works of Etzkowitz and Leydesdorff (1995) and Leydesdorff and Etzkowitz (1998), exploring the relationships between universities, industry and government and naming them “triple helix”, focusing on the importance of coordinating their efforts for strengthening innovation and knowledge economy. As a “fourth helix” was added the civil society by Carayannis and Campbell (2009) in response to the changing nature of the knowledge society. As highlighted by Cai and Lattu (2022), both models are very popular in innovation systems research, and they are complementing each other to a large extend.

The innovation ecosystem is an evolving concept in the research literature. Several studies (Gu et al, 2021; Granstrand et al, 2020; Scaringella et al, 2018; Tsujimoto et al, 2018) have focused on the understanding of innovation ecosystem dynamics, structure, components and positioning. As stressed by Granstrand et al (2020), the ecosystem concept has its origins in ecology, and is related to the flows of resources to living systems, their relations with non-living systems, etc. Furthermore, one of the first definitions of innovation ecosystem is given by Adner (2006) and focused on firm ecosystem. Generally, different types of ecosystems have been discussed by scholars. For example, in (Scaringella et al, 2018) are presented the specifics of business, innovation, entrepreneurial and knowledge ecosystems. Tsujimoto et al (2018) consider four streams of ecosystem research: industrial ecology, business ecosystem, platform management, and multi-actor networks. In a review of innovation ecosystem (Gu et al 2021) are considered five research streams:

- Technology innovation – investigating the creation, evolution, orchestration and inter-organizational collaboration in technological innovation ecosystems;
- Platform innovation ecosystems – focused on their organization, cooperation and competition, and diffusion of platform technologies and services;
- Regional development – considering innovation ecosystems of clusters, national, industrial, or smart and sustainable cities;
- Conceptualization and theorization of innovation ecosystems;
- Entrepreneurship and innovation – including entrepreneurial university or firms, and individual entrepreneurs.

Despite the differences in theory and practice, some important characteristics of the innovation ecosystems could be outlined: It is a dynamic system of various stakeholders who interact among them with a specific purpose. In most cases, the system purpose determines the rules of its functioning, the actors involved, the internal processes and relations (cooperation or competition), and the input and output flows (tangible and intangible resources, products and services, etc.). For this paper the main focus is on the national/regional innovation ecosystems, and the interactions between academia and other public or private institutions of the ecosystem.

As outlined in (Scaringella et al, 2018), in the knowledge ecosystem the universities or research organizations are in its centre of a network of companies, and focus on knowledge generation and its transfer to industrial stakeholders. Etzkowitz and Leydesdorff (2000) considered that the university model is changing towards an “entrepreneurial university” and application and exploitation of the research results. In fact, a large share of the research activities is performed at HEIs, and they have an essential role for increasing the knowledge capital. Universities are positioned in the centre of the knowledge triangle due to their role in generation of knowledge, on the one side, the knowledge transfer to the future labour force in education, on the other, and last but not least, their involvement in innovation with companies. As outlined by Cervantes (2017), knowledge generated by universities is a result of the interactions among education, research and innovation, and “*the bi-directional or circularly-caused knowledge flows between the three core elements of the knowledge building process constitute the Knowledge Triangle.*” This concept shows also that the knowledge production is not a linear process, and is based on various paths of learning, knowledge gathering and exchange. At the same time, it is essential that universities position themselves not only in the centre of the knowledge triangle, but also in their specific innovation ecosystem. The successful model for universities requires contribution to the knowledge demands of their environment – local, regional or national, taking into account industrial or regional specialisation.

2.2 The UNITE Innovation Ecosystem

The main goal of the UNITE project is to build a Centre of Excellence as a highly competitive, internationally recognized scientific research complex, that satisfies the requirements of the modern research infrastructures and the excellent scientific level in the ISSS research priority Informatics and ICT. In the project participate five universities: Sofia University “St. Kliment Ohridski” (as a leading organization), Technical University - Sofia; University of Rousse “Angel Kanchev”; University “Prof. Dr. Assen Zlatarov” - Bourgas; University of Shumen “Konstantin Preslavski”. As guiding principles for formation of partnerships within the project were defined: high scientific quality, synergy and complementarity, knowledge transfer experience, wide regional collaboration and established networks with R&I actors. The existence of trust and tradition in cooperation were also considered as essential factors for development of a sustainable partnership and prevention of possible risks associated with the collaboration within the project.

The project goals required the UNITE partners to enhance their collaboration in R&I with various interested stakeholders, both at international, national and regional levels. The consortium considered its role in the centre of the ICT ecosystem and the collaboration opportunities for each individual stakeholders’ group. As illustrated in Figure 1, the cooperation with the different types of organizations has different goals, determined by the research program of the UNITE. They are targeted at supporting ICT innovations, the digital transformation of industry, the extensive use in industry, science, government and society of Big data, the development of a new generation equipped with new values, skills and abilities to participate in the digital society and economy, as well as to achieve higher integration in the ERA.

- **Partnership with the ICT industry:** In order to reach the project research objectives, and to support the ISSS through research excellence, it is essential to achieve a greater integration of the research and innovation systems in Bulgaria. The CoE UNITE aims primarily to strategic partnerships with the ICT industry, which suggests launching joint projects for new scientific knowledge generation and its implementation by the ICT industry for design of new products and offering them in the market. These projects facilitate closer integration between universities and industry related to staff exchange, joint supervision of PhD students and mentoring of young researchers working on the joint projects, optimal use of the CoE research infrastructure and the created scientific databases. Within the project, the main directions of cooperation with the ICT industry are outlined by the scientific work packages and the aim to overcome the challenges associated with cybersecurity, optimal use of Big Data, real-time virtualization, digitization and visualisation objects, prototyping, and supporting the development of Cyber-physical systems, Factories of the Future and smart cities.

- *Partnership with small and medium enterprises (SMEs) and non-ICT industry:* The main collaboration form with this group is related to knowledge transfer and provision of services for research and technological development (RTD), supporting the digital transformation of the industry and the more extensive use of ICT for build the Factories of the Future. This is also a prerequisite for the formation of a greater demand for ICT services and products, which on its turn to stimulate related research and innovation activities of the CoE and the ICT industry. Within the project, partnerships have been sought for joint pilot projects for testing the research results in a real environment.
- *Partnership with innovation intermediaries:* The knowledge transfer from the CoE to the industry is carried out mainly in collaboration with intermediaries in the innovation system (clusters, innovation centres, technology transfer centres, branch organizations, etc.), with which have been undertaken joint activities according to the specific regional industrial needs. A special attention is paid to organizations supporting start-ups and building innovation and entrepreneurship competencies of young people and employees.
- *Partnership with state bodies and local authorities:* The CoE UNITE has been collaborating with local authorities for the development of e-municipalities, and offering advanced electronic services to citizens and businesses, as well as for development of smart urban environment. Within the project as a main collaboration form is considered launching joint pilot projects to test the research results in a real environment.
- *Partnerships with schools and other educational organisations:* The wide ICT penetration in the economy and society, and the creation of R&I attitudes critically depends on the formation of the human capital – future researchers and innovators, ICT professionals and ICT teachers. Major roles in this area have the educational organizations that create the basis for the development of future citizens and professionals. Despite that the partners as universities have significant contribution for preparing the workers demanded on the labour market, at local level has been launched collaboration with schools and other educational organizations (incl. for training and life-long learning) in order to integrate new teaching methods and ICT in education, as well as raise the awareness on science among the younger generation.
- *Partnership with non-governmental organisations (NGOs):* In order to overcome the digital divide, expand the e-participation and create prerequisites for e-democracy, the UNITE partners have collaborated with NGOs for enhancing the e-skills of citizens, and to identify their demands for new ICT products and services. With these organizations have been organized joint activities for raising the awareness on the contribution of science to the development of the economy and society, and to form a more attractive image of researchers and attract young people to research careers.
- *Partnerships with other research performing organizations (RPO) and universities:* Of particular importance for UNITE CoE is to expand the collaboration with other research organizations and universities in the country, so as to provide them opportunities to benefit from the research results of the project and the established research infrastructure and scientific databases of the CoE. The partner universities have collaborated for years with research organizations and universities in the areas of Communication and Computer techniques, and in Informatics and Computer sciences. Within the project are discussed joint initiatives for knowledge transfer and new projects.
- *Partnerships with the international community:* The goal is to establish strategic collaboration for joint projects and use of the UNITE research infrastructure, knowledge sharing through mobility and specializations of UNITE researchers and PhD students, in order to achieve higher integration of the CoE in the ERA. The UNITE CoE aims at building long-term collaboration for the development of ICT science and innovation with leading universities, research organizations and scientific networks in the EU.

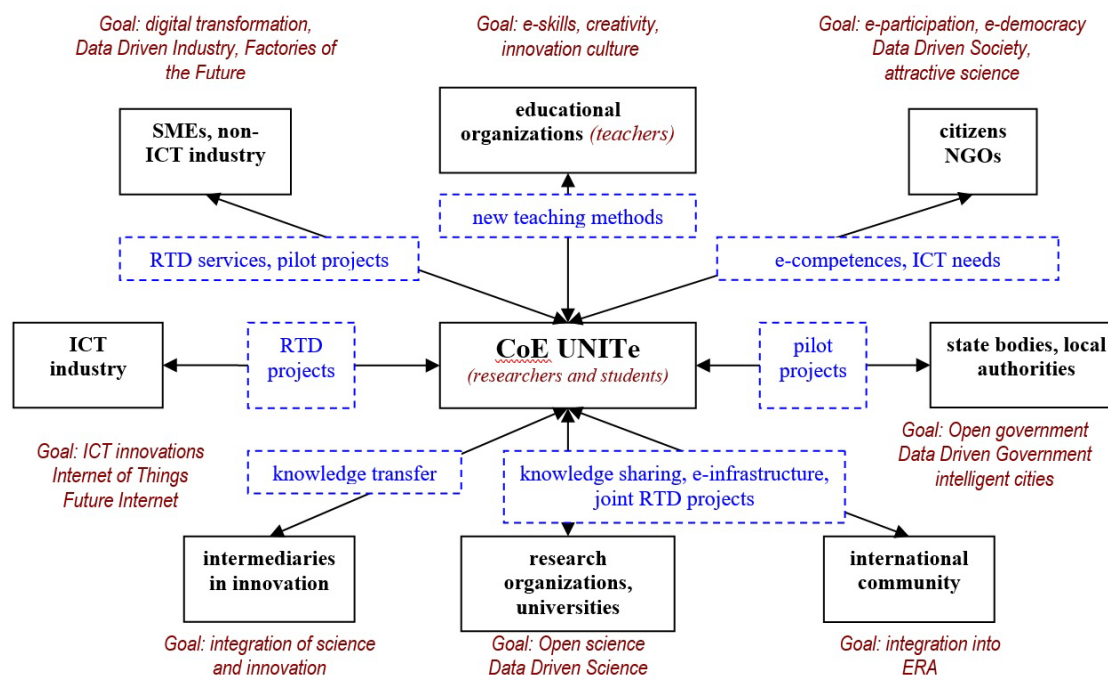


Figure 1: CoE UNITE Positioning in the ICT Ecosystem

3. Researchers in the Knowledge Triangle – the K-TRIO Concept

The difficult transition of Bulgaria caused a serious decline in education and in building real values of the new generations. The image of science and researchers, teachers and educational institutions was also damaged. Despite recent public attention to the impact of online education on building knowledge and skills of students, and the increased awareness of teachers' role, the challenges of Bulgarian R&I system remain (Gourova et al 2021). The UNITE Consortium has recognised that there is a need for cultural change and nurturing a new culture of creativity, scientific curiosity, innovative spirit and environmental responsibility. Subsequently, by designing the K-TRIO project, the partners considered how to address the human resources challenges of the national R&I ecosystem: How to encourage young people for research career? How to grow new talents? How to engage citizens with Open Science and Open Innovation? How to foster R&I and increase their role in Green and Digital transformation? There is no clear approach, however, the K-TRIO consortium followed a concept that universities should play a leading role in the knowledge triangle and facilitate:

- building the next generation of researchers by educating students to respect the principles of research integrity during their education, and involving them at an early stage in solving real problems and focusing on the needs of the economy, environment and society;
- integration of new teaching methods and tools in higher education of future teachers, and thus, facilitating changes in teaching styles in secondary education; nurturing creativity, innovation spirit and environmental responsibility, as well as Open Science and entrepreneurship attitudes at an early age;
- achieving scientific excellence and turning it into innovation by using the Open Innovation paradigm to engage the citizens in a dialogue on R&I agendas, valorisation activities, and subsequently, changing the attitude of the general public towards science and researchers;
- accelerating the change towards higher innovativeness and knowledge transfer by providing researchers with complementary skills and competencies to work with industrial stakeholders and better understand the role of academia for turning knowledge into innovation.

All partners collaborate with a large number of national or regional stakeholders, and have engaged more than 30 associated or supporting partners (the Ministry of Education and Science and its regional departments of education, several municipalities, schools, NGOs, etc.). This consortium composition has facilitated the smooth involvement of various target groups (Figure 2) in the K-TRIO activities.

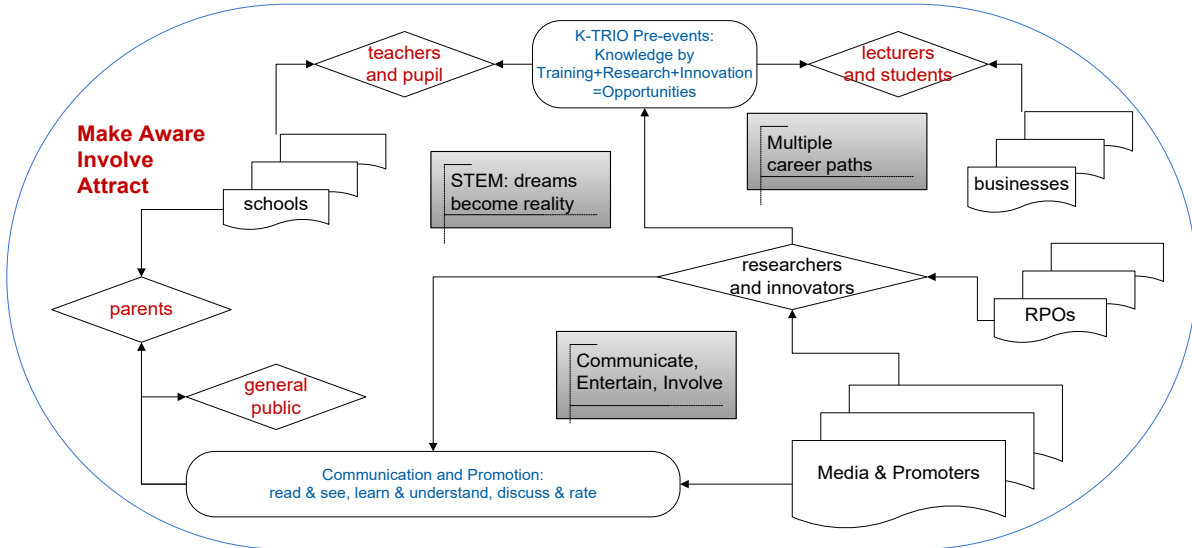


Figure 2: Stakeholders Engagement in K-TRIO Project

The K-TRIO project has engaged the most stakeholders of the UNITE ecosystem in the process of building the next generation of researchers.

- *Researchers and innovators*, both from industry, HEIs or RPOs, are placed in the centre of all activities as they can serve as role models for the youth with their R&I experience, and their multiple career paths.
- The K-TRIO partners involved researchers and innovators in joint activities with *schools and teachers* in order to raise the awareness of students and pupils on the R&I profession, involve them in STEM centres and research activities, thus, attracting the youth to a possible research career path.
- In the Open Labs or Open doors of partners universities and museums *students and pupils* (and the general public during the ERN) had opportunities to be involved in scientific experiments, learn and understand the real work of researchers, and discuss with them on various topics.
- At the same time, the K-TRIO partners focused on *teachers as multipliers* of the project messages, but also as essential actors for attracting students and pupils to STEM. Therefore, several seminars were organised to train teachers to use innovative teaching methods, or better use the available STEM centres infrastructure.
- Another essential target group are the *university students* who are involved in discussions about the R&I system and the respective career, involved in research projects or industrial internships. For talented students (both in schools and universities) have been organised also competitions (e.g. “Young and Energetic Scientists”) whereas researchers were involved as their mentors or supervisors.
- *Civil society actors – NGOs, media and science promoters* have an essential role for attracting the young generations to research. The K-TRIO consortium used several communication channels (web sites, Facebook, YouTube, LinkedIn, traditional media) and formats (interview, podcast, short video, etc.) in order to present to the general public the contribution of individual researchers, research projects or RPOs to the economy and society, regional development and growth.

The K-TRIO model for collaboration with stakeholders facilitated the awareness raising and debates related to sustainable recovery, increasing the knowledge intensiveness of industry through R&I services or R&I projects, as well as focused on preparing of citizens for Open Innovation. The role of research for smart specialisation and regional; growth have been the focus of debates with public bodies and local authorities. In the centre, however, have been educational organisations and HEIs with their role for preparing the next generation of researchers and innovators, and facilitating a cultural change towards Open Science and Citizens Science.

4. Young People Attitude to Research and Innovation

4.1 Methodology of the Study

Within K-TRIO project, a short survey was made among the students in the ICT bachelor programs of SU in order to explore the perceptions and attitudes of young people toward the role of academia in the knowledge triangle. The students are an important part of the UNITE target groups, as ICT talents are among the most critical resources for further success of the research infrastructure. More specifically, the survey was completed anonymously as part of the seminars of the elective course “Knowledge Management”, followed by a round table discussion on the role of science in the modern society.

The aim of the proposed approach was first to put students in the position to formulate their initial perceptions, and then, to openly discuss their concerns. Thus, students can prepare more carefully their arguments, considering evidence and examples for the round table and at the end they can summarize some common visions. The survey was organized in four parts:

- impact and role of the Bulgarian science in the society and the attitudes toward scientists in general;
- role of the science and technology transfer for the economy, business and social development;
- new perspectives and general attitudes for the role of the science in the society;
- statistical data.

4.2 Analysis of the Results

In total 107 students filled the questionnaire in 2022 and 2023. The demographic data shows that students are 45% females and 55% males, most of them (87%) aged between 21-22. To summarize the results, the answers are grouped in two main areas: the role of science in the modern society and economy and the attitudes of students towards research career.

- The role and the impact of science in the economy and society

The survey comprises 48 questions that directly or indirectly explore the role of science in the knowledge triangle. From this perspective, students recognize that Bulgarian research institutions significantly contribute to the progress of the economy and society. For instance, almost 80% of the students emphasize that research institutions promote knowledge discovery, and 77% consider its positive impact on the educational system and on national culture. At the same time, 61% of students find that research institutions contribute to a limited extent to the practical implementation of research discoveries in the business and society.

Almost 20% of the young people have concerns that science is underestimated in the last years, and students find that Bulgarian society in general is not really interested in new scientific endeavors. As identified on Figure 3, students find that Bulgarian science contributes very significantly for cultural heritage protection, for increasing the national prestige and for environment protection. At the same time, students don't see the role of Bulgarian scientific institutions for making better social regulations/strengthening institutions, for improved decision making on strategic company or government level and in general for innovative products and services.

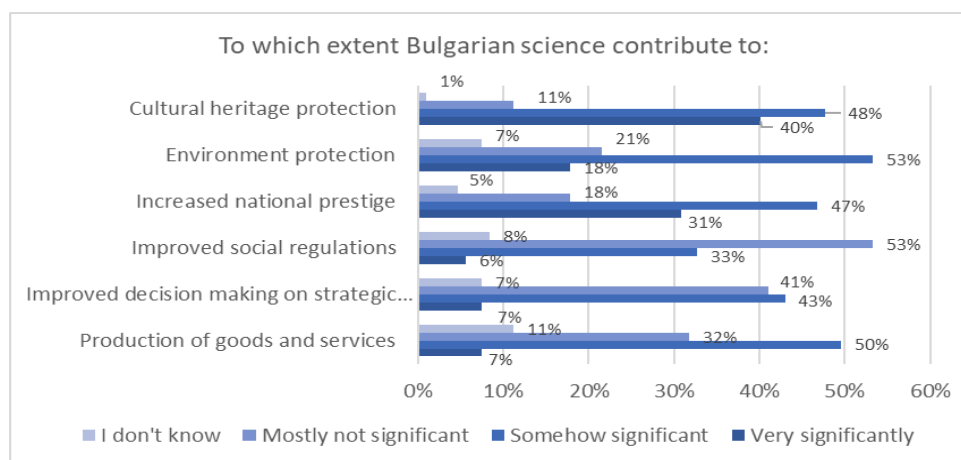


Figure 3: To Which Extent Bulgarian Science Contribute for the Economic and Social Development

Concerning the new challenges in front of the knowledge economy, most of the students agree that science should be supported as a national priority (68%). In the same time, the respondents find that the role of science is underestimated by the public authorities (62%) and by the businesses (35%). However, most of the students find that research institutions need to improve the visibility of the research career.

- The role and the impact of the scientists and the scientific career

In general, 86% of the students find that researchers and scientists have good reputation and about 60% find that research profession has a positive social image. However, considering the social status, almost all of the students (90%) claim that at least in the Bulgarian society, researchers receive low or very low remunerations comparing to their efforts. Concerning the personality of the researchers, most of the students find them to be smart and intelligent people (93%), good in theoretical knowledge (79%), mostly old (66%) and mostly men (30%). Some general (mis)conceptions for scientists are still recognized, viewing researchers as difficult for understanding (26%), with low communication skills (21%), and in general very distracted people (19%).

On the question whether students would like to become a scientist, 45% of them directly respond NO, 18% said YES, and 36% had never thought about research careers opportunities. On the Figure 4 are presented some data how students recognize the main stimulus for attracting young people for research career.

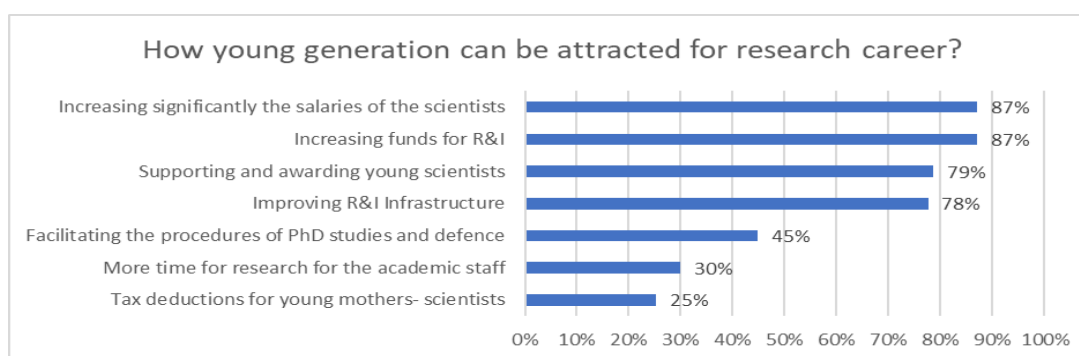


Figure 4: What are the key Factors to Motivate and Attract Young Generation for Research Career

5. Conclusions

Although the significant efforts and public investments in R&I, young people still do not see the role of Academia as crucial for thriving research and innovation ecosystem. The team of Sofia University regularly take part in similar surveys for measuring the attitude and perceptions of different target audiences. However, this survey is focused to investigate more specifically the attitudes of young talents in ICT. The survey results demonstrate that students still do not understand the multiple perspectives offered by the research careers. Many popular misconceptions for science and for the research profession are still dominating among young students and they hardly recognize the opportunities for becoming scientists.

All this show that the team of UNITE needs to pay more attention to raise the next generation of talents in science, actively involving and explaining various R&I initiatives. Researchers and lecturers have to openly communicate and discuss real-world examples, case studies and research evidences how ideas emerge and progress, nurtured in the academia environment. In plus, more dissemination activities orientated specifically to students and young people have to present how Academia strengthen the knowledge ecosystem.

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