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A Comprehensive Program of activities to develop sustainable core skills in novice scientists

To cite this article: K V Vlasenko *et al* 2021 *J. Phys.: Conf. Ser.* **1946** 012017

A Comprehensive Program of activities to develop sustainable core skills in novice scientists

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Abstract. This paper is aimed at studying scientific communication as an integral part of a scientists activity. The authors of this article analysed the development of informational technologies, which gave rise to a new paradigm of scientific communication Research 2.0. In the present study the analysis of research papers, describing models of scientific communication is done. The findings allow to define the structure and content of a comprehensive program of activities, connected to scientific communication in compliance with the Scientific Communication Life Cycle Model. In order to implement the program, aimed at developing core skills through scientific communication of scientists, a target audience, comprising postgraduate students and young researchers in Mathematics and Teaching Methods was engaged. A five-stage program of activities, which was developed, prompted scientific activity of young researchers and gave them an opportunity to learn about means of presenting research results, elements of management, mechanisms for applying the findings. A constructive description of each module of the program is done, actions and a strategy are described, communication between participants and tutors through the platform Higher School Mathematics Teacher is arranged in this research. In order to assess the efficiency of implementing the program, Researcher Development Framework (RDF) is used. The study also presents the results of the activity of young researchers, who were engaged in the program. Following the change in the phase of the development of researchers characteristic features and in compliance with RDF, a conclusion is made about a positive impact of the program on the development of career skills of young scientists, their interaction skills, awareness of professional behavior procedure.

1. Introduction

Career development of young scientists is an attribute of sustainable development of the society. Preparing young researchers for independent scientific activity, the development of intellectual and psychological qualities of a scientist, correlation between the process of thinking and creativity, phenomena of scientific discovery and genious were always of high interest for psychologists, educators, science historians. Numerous researches were done into specific attributes of a scientist, considering them from different theoretical perspectives. Attempts to identify personal qualities, which are central to the professional activity of a scientist, were made late 19th century in papers by Terman [1], Hollingworth [2], Guilford [3] and others. In the 20th century classical research by Roe [4] stated, that scientific communication (a complex of processes and mechanisms of transmitting scientific ideas inside a scientific community) is an integral part of a scientists activity. Fast-paced development of modern science and the level of scientific achievements prompted scientists to search for new means of scientific communication.

The first aspect meant integrating skills of scientific communication into a basic set, which is identified by educators, employers and scientists (Brownell et al. [5], Gray et al. [6], McInnis et al. [7], West [8], Vlasenko et al. [9]) as critical for any scientist. Hence, courses in communication are introduced into curricula for postgraduate students in many countries, among which are the following: Great Britain (Quality Assurance Agency [10]), the USA (American Association for the Advancement of Science [11], [12]), Canada (Ontario Council on Graduate Studies [13]) and Australia (Australian Qualifications Framework [14]). In turn, in educational literature there are numerous papers by Levine [15], Mulnix [16], Gillen [17], Kozeracki et al. [18], Jones et al. [19], Cameron et al. [20], which state, that such components of scientific communication as reading scientific papers by other scientists and promoting own scientific concepts can help budding researchers to develop core skills of a scientist and boost their confidence in scientific thinking. So, inspired by this idea, the authors in the present paper did an overall review of the history of communication in science. A paper by Vickery [21] presents detailed means and attributes of oral and written communication in pre-digital era and shows a picture of prerequisites for modern methods of scientific communication. Special attention is given to the development of scientific communication in the 20th century, resulting from industrial research, occurrence of Big Data, computer networks and Internet communication. Early in the 21st century, in his papers Hurd [22, 23] offers a new paradigm of communication in science and shows that digital media offer new roles and functional opportunities to the participants. Thus, the development of information technologies changed the mode of scientific communication. The conventional system based on printing, which relied on a referred scientific journal as a key mechanism for presenting scientific findings, underwent transformation and turned into a system, dependent on digital means of transmitting information. As Hurd [23] stated, scientometrics bases replaced conventional libraries and publications turned to electronic formats; communication in science evolves to the process, which counts more on on-line resources. This transition from printed to digital format changed the roles of all the participants of the scientific communication system. The challenges, prompted by these changes stay topical nowadays.

2. Literature review

In educational literature, dedicated to academic education, scientific communication is considered from a point of view of positive impact on the process of developing a personality of a would-be scientist. In papers by Levine [15], Mulnix [16], a correlation between the skills level of processing scientific literature and efficient scientific activity is stated. Research by Gillen [17] proves that though a majority of postgraduate students are able to understand and absorb informative aspects of scientific articles, they often face difficulties interpreting the findings and analyzing them critically. As young researchers lack in strategies, necessary for building up credible criticism, then developing the skills of scientific communication becomes critical for engaging them into active scientific process. Research papers by Kozeracki et al. [18], Vlasenko et al. [24] highlight, that designing courses, aimed at the critical analysis of articles in scientific journals and presentation of own research increases scientific literacy and self-confidence.

Researching the problem of developing a skill in scientific communication, Cameron et al. [20] came to a conclusion, that behavior and attitude to scientific writing, speaking and presenting findings are prior to the intention to pursue academic research career through scientific identity. As the main factor of this process is its fulfillment in all the academic stages from a postgraduate student to a scientific advisor, it is indicative of a potential for engaging means of scientific communication for enhancing career perseverance. Research papers by Smyrnova-Trybulska et al. [25], Kuzminska et al. [26], look into this issue and allow to state that introducing the learning environment in scientific communication into educational process ensures developing and improving in young researchers such a skill as undertaking scientific communication; contributes to developing digital competencies and building up an image of a scientist, thus integrating into a single scientific community. The researchers [27–38] confirmed that digital competencies concerning scientific competencies allow researchers to search for scientific and professional information more efficiently, to work with open systems of scientific research support, to analyse data and visualize them with the help of up-to-date informational computer technologies (ICT), to create and manage personal educational environment, a portfolio, etc.

Studying the problems, connected to developing professional skills in a young scientist, experts emphasized the necessity to build models of scientific communication. One of the earliest models of scientific communication is the UNISIST model [39] (the United Nations Information System in Science and Technology), offered by the United Nations Educational, Scientific and Cultural Organization (UNESCO) with the aim to improve scientific and technical communications. Taking into account ever-growing impact of the Internet technologies on communication between scientists, Søndergaard, et al. [40] presented an extended and revised UNISIST model. One more model by Garvey and Griffith [41] means to describe the communication process in science, but it lacks informational technologies support. In studies by Hurd [22, 23] this model is revised in order to consider the impact of ICT, such as electronic publications, self-publications and electronic libraries.

Kling et al. [42] offer a model of scientific collaboration STIN (Socio-Technical Interaction Network), which allows to understand better the character of professional relationships inside scientific communities. In a paper by Swisher [43] they offer a linear step-by-step model which defines the stages that a new concept goes through in the system of scientific communication. In a cycle of research by Björk [44–48] a model of SCLC (Scientific Communication Life Cycle) is presented. It describes the process of communication from the beginning of a research up to using the findings for the benefit of the society. This model covers both, formal and informal communication, but the main focus is on the life cycle of publications as well as readers activity aimed at getting access to those publications. A systematized review of the characteristics of these and other models of scientific communication can be found in a study by Lugović et al. [49]. The scientists put focus on the development of technological innovations of Web 2.0 that resulted in occurrence of a new paradigm of scientific communication Research 2.0.

The analysis of papers by Luzon [50], Ullmann et al. [51], Procter et al. [52], Koltay et al [53] shows, that the term "Scientific communication Research 2.0" determines new approaches in creating scientific knowledge, based on the notions of unity and collaboration. The scientists describe how generating and managing collective knowledge brings about new structures and systems of scientific communication. Kuzminska et al. [26] consider that scientific blogs, social networking sites for the collaboration of scientists ResearchGate and Academia.edu, applications for managing and sharing publications (Mendeley, Qiqqa, EndNote), services Open Peer Review, international and national bibliometric systems (in Ukraine – Open Ukrainian Citation Index, "Bibliometrics of Ukrainian science") and other make part of such structures. Though the main channel for publishing the research findings is still an article in a journal with a peer review, Research 2.0 provides wide opportunities for the improvement of research processes and can lead to changing the principles of research activity in future.

The present study is dedicated to developing a comprehensive program of activities, concerning scientific communication in compliance with the SCLC Model and the principles of Research 2.0.

One of the objectives is to confirm that the introduction of the developed program into the process of advanced training of young scientists contributes to improving their skills in scientific communication and confirms their role as a catalyst for developing core skills of young researchers.

3. Method

3.1. Participants

Throughout 2019–2020 a comprehensive program of activities, aimed at developing a scientist score skills through the means of digital scientific communication, was introduced into the educational process of advanced training of young scientists at Ukrainian universities. 67 postgraduate students and young researchers under 40 participated in the experiment (figure 1).

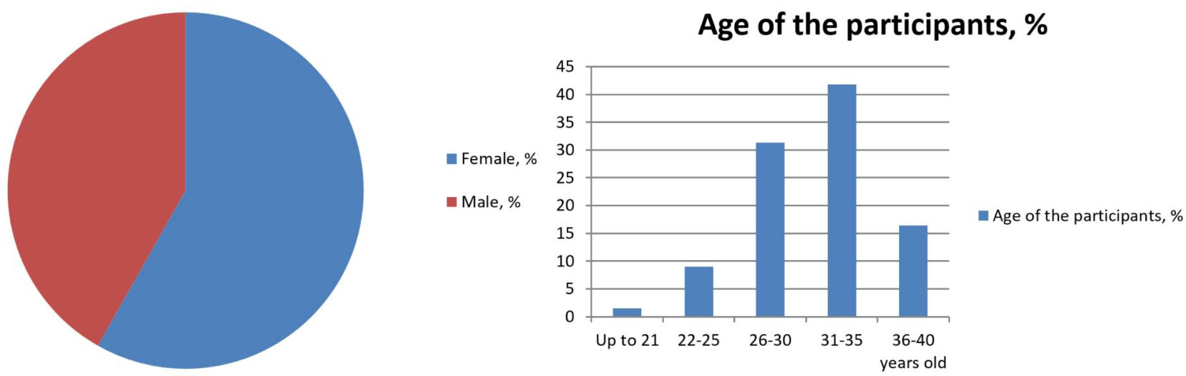

Figure 1. Gender and age sampling frame, % of the total number of participants.

According to targeted selection, the sampling frame must comprise researchers working in the same area of knowledge. It was done, taking into account the specifics of the scientific communication system for different mathematic disciplines. The experiment was done at scientific schools, where the researchers work in the domain of Mathematics and Teaching Methods. The quality composition of the program participants in accordance with specialization and professional attributes is presented in figures 2–3.

Development of a comprehensive program of activities in scientific communication in compliance with SCLC Model. In the first stage of the program development with the help of the deductive content analysis of the research papers (Søndergaard et al. [40], Kling et al. [42], Swisher [43], Björk [47, 48], dedicated to the models of scientific communication, the authors of this study defined the structure of the program and the key aspects of the content, designed to provide its compliance with the paradigm of Research 2.0. Compared to other models, the SCLC Model Björk [47, 48] is more comprehensive, detailed and contains more constituents that reflect activity, findings, elements of governance, mechanisms, etc. when developing the program of activities, connected to scientific communication, the SCLC Model serves as a roadmap for positioning all the components of the system of scientific collaboration as a global interconnected informational system. The developed comprehensive program consists of five stages of different duration from 0.5 to 2 credits ECTS, each of them contains 2–5 modules (table 1).

In the second stage, when doing analysis concerning the nature of Research 2.0, Koltay et al. [53], Sheombar [54] gave a constructive description of activities and projects, as well as actions

Table 1. The structure of the comprehensive program of activities, concerning scientific communication in compliance with the SCLC Model.

Stage	Activities concerning scientific communication	Content of the activity
Creating the information environment	An on-line course in scientific communication	Watching video lectures, chatting
	Practical assignments	Doing practical assignments on searching information, quoting, preparing presentations, designing a manuscript, etc.
	Presentation of University programs, events by the Ministry for Education and Science and businesses, aimed at supporting young scientists	Electronic mailing of video materials and samples of documents; meetings with management, representatives of the Ministry for Education and Science representatives of business, program alumni
Doing the research	Searching for ideas, defining a topic for research	Getting acquainted with social networking web-sites for scientists; creating profiles and micro-networks.
	Searching the information resources	Searching publications in databases, archives, bookmarks, getting (saving) the publications, paid and free subscriptions
	Reading publications	Reading summaries, full texts
	Doing the research itself	Communication with an advisor, communication in collaborations
	Integrating the results into the context of a general problem	Work with references, quoting
Presenting the findings	Non-formal communication	Seminars, conferences, mailing colleagues, microblogs, subscriptions to the projects in social networking web-sites
	Publication in a reviewed edition	Preparing a manuscript, searching publishing houses. Designing the manuscript, communication with an editor and a reviewer
	Promoting sharing and search	Promotion in blogs, social networks for scientists, open libraries, University resources
	Tracking the publication	Indexing, bookmarks, tags
	Secondary publications	Monographs, publishing in mass media
Applying the findings	Promoting the improvement of the standard of living (application in industry, IT, healthcare)	Getting acquainted with the process of standartisation, filing an author certificate/a patent
	Education	Passing on knowledge through workshops, educational videos, one-to-one counselling
	Feedback for science	Forecasting benefits for the future of science
Contests for scientists, grant programs	Contests for young scientists by Universities and the Ministry for Education and Science	Filing documents
	Contests organized by businesses	Preparing presentations, participation in startup-schools

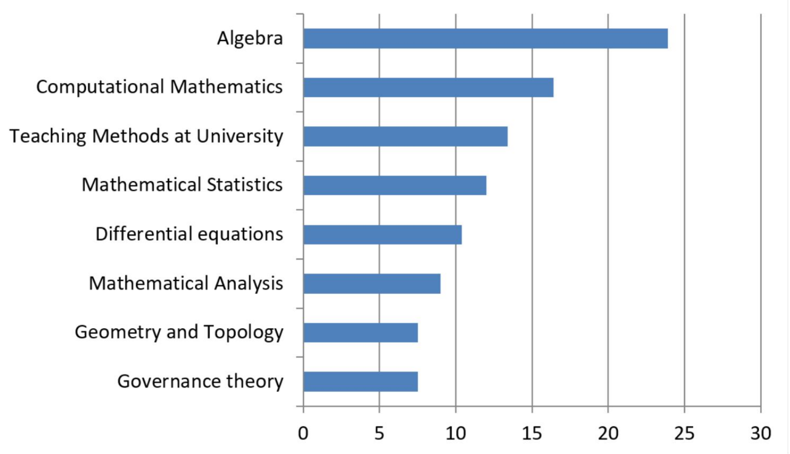

Figure 2. Specialisation of the participants of the experiment, % of the total number.

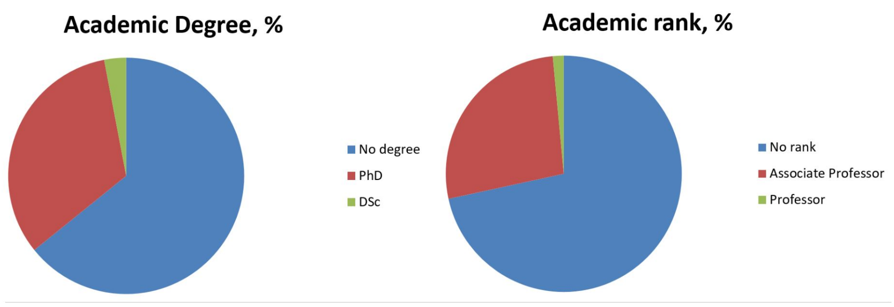

Figure 3. Qualitative composition of the participants of the experiment in accordance with professional attributes, % of the total number.

and strategies which contribute to developing scientific research skills in young scientists and which are based on the principles of openness, collaboration, conversation and connectedness.

Communication between the program participants and tutors took place on the platform Higher School Mathematics Teacher [55–57]. Forum, on-line chatting and electronic mailing were chosen as the means of communication. Through their personal accounts the participants got access to the description of events, activities and strategies for each of the stages of the program, listed below.

3.2. Developing topics for the informational environment

In the early stage of their activity as scientists, most young specialists have no proper information database on scientific communication, which is explained by the fact that scientific communication is a specific activity, which postgraduate students did not face before. Even some years later, the knowledge of the scientific communication tenets is fragmentary. The main goal of this stage is developing in young researchers a systematic knowledge concerning scientific communication, its key components, new trends and technologies, basics of efficient work with information, research data management. Watching video-lectures allows the participants to understand how scientific communication happens nowadays, how open access, open science and licenses, research data management impact the life cycle of a research. Participation in seminars, trainings means applying best updated practices and search techniques in order to work with scientific sources, to use universal and specialized information resources, new web-applications for various types of research, etc.

The authors of the present study believe, that in the informational environment, dedicated to the problem of scientific communication, it makes sound sense to highlight the following topics:

1. General overview of key components and strategies of scientific communication, usage of new web-applications in all the stages of the research life cycle, especially when searching for information and spreading the findings. Social networks for scientists ResearchGate, Mendeley, Academia.edu.
2. Scientific information: main types of sources. Specialized search systems such as Google Scholar, ScienceDirect, DOAJ and databases (Web of Science, Scopus, ZbMATH, MathSciNet), strategies for efficient search on the Internet.
3. Tools for monitoring new publications on the research problems. Subscriptions (Mendeley Groups, ResearchGate). Scientist's profiles (Scopus Author ID, ResearherID, ORCID iD).
4. A scientific article in a reviewed journal as the main element of scientific communication. Academic publishing houses (Springer, Elsevier, Pleiades Publishing).
5. Studying various aspects of scientific papers and publication strategies. OJS/PKP journal systems.
6. Management of bibliographic references (applications Mendeley Web Importer, EndNote, BibTex, Zotero).
7. Key notions of scientometrics. Scientometric indices Web of Science, Scopus, Google Scholar, Open Ukrainian Citation Index et al.
8. Copyright. Creative Commons license.
9. Archiving the research data. Repositories DOAJ and ArXiv.

When creating the informational environment, educational materials published on the platforms Prometheus [58], EdEra [59, 60], YouTube channel [61–63] and own materials by the authors of this study were used [64]. As an illustrative basis for scientometric and bibliometric techniques, a cycle of research by Rovenska et al [65–68] were used.

As the main indicator of the efficiency of scientific work is receiving accolades and financial rewards, the authors of this paper believe it pertinent to share relevant links to grant programs and awards with the program participants, announced by university management, businesses and professional unions. Receiving an accolade by a young researcher can serve as one of the criteria of developed skills in scientific communication and core skills in general.

3.3. Doing research

The firs module, which is to define the topic, initiates the research. Review of ideas is the main function of this module. Social media offer useful communication channel for finding new ideas and communicating with the world. Participants register and create own accounts in the main social networks for scientists, such as ResearchGate, Academia.edu and Mendeley. According to a research by Nentwich and König [69] on academic use of social networks, the function "Profile" comes top among eight most popular functions of social media for scientific purposes. The profiles created can be filled with publications that the participants already have. In this module the participants also create micro-networks with the representatives of a certain scientific school. When the topic is defined, social networking sites for scientists become an additional tool for searching partners for collaboration.

Since the research process is based on the competencies, related to searching, assessing and applying information, the second module is dedicated to developing skills in searching information resources. The development of Web 2.0 brought about easy and accessible means of receiving information. Still, access to information does not necessarily mean expanding knowledge. Research 2.0 resources allow to make changes in the methods of assessing information sources on their topic. The participants are offered to focus on the assessment of the accessible information, based on bibliometric indicators. The module gives an opportunity to master the specifics of work with both, interdisciplinary (Scopus, Web of Science, Google Scholar), and specialised (ZbMATH, MathSciNet) scientometric databases.

It is necessary to draw the participants' attention to the opportunities which subscriptions (both, free and paid) give as well as risks arising out of it. Not only using social media for private purposes, but also for academic ones requires preventive measures from spam and harassment from unscrupulous communities. Participants can also face challenges when receiving publications, for instance, if the publication is not accessible any more, or the publication was not digitalized. When such situations happen, it prompts finding alternative ways of receiving the publication, such as buying a hard copy, search in archives or among colleagues.

The third module is dedicated to the development of practical skills in reading publications. The participants work on the constructive methods for reviewing the content of a publication with the help of key words, summaries, reading full texts, creating bookmarks, comments and annotations in Mendeley, applications for tracking quotes EndNote, BibTex.

When doing own research, the need for expanding own scientific horizon through communication with single-minded scientists increases, and most of the young scientists enhance live communication etiquette. However, the challenges of the time require mastering on-line modes of communication with colleagues. According to a recent research by the Ministry for Education and Science of Ukraine [70] the most common reasons that hamper the development of scientific communication among young scientists are: psychological unpreparedness for new types, modes of scientific communications and underdeveloped network of personal connections and communication channels. For remote communication the participants are recommended (but not limited by) such means of communication as Zoom, e-mail, Viber, Facebook Messenger, Telegram, Skype, WhatsApp. As the survey shows [70], these channels are the most widely used in professional communication among young scientists.

The final module of this stage is dedicated to improving the practical skills in working with reference-messengers, such as Mendeley Web (functions Web Importer and Citation Plugin), EndNote (adding information about sources from Web of Science, from on-line libraries, websites of publishing houses, and own notes), Zotero and others.

3.4. Presentation of findings

This stage comprises five modules, which are – informal communication, presentation of findings through publishing, sharing promotion, tracking and secondary publications. The main difference from communication within the first module is that an author has a complete control over those who become the receivers of the information about the findings. On top of conventional presentations at conferences, seminars, the participants also learn about informal communication channels which are accessible tools of Research 2.0, such as blogs, subscriptions for ResearchGate projects, tags and opportunities for joint work in Mendeley Groups. Using the resources of Research 2.0 increases the efficiency of scientific communication, as researchers receive a feedback (on-line comments) much earlier and can fix the errors, complete the article and send it for publication.

In the module, dedicated to presenting the findings through publication in a reviewed journal, the participants can learn about the proper formats of articles for academic publishing houses Springer, Elsevier, Pleiades Publishing (mastering AMS-LaTex is an obligatory prerequisite) and acquire the practices for communication with the editor and reviewers through open journal systems OJS/PKP. An important nuance of the module is that some participants experience communication with predaceous publishing houses and for the first time face academic plagiarism. Taking it into account, maintaining academic reputation becomes profoundly valuable.

Modules, dedicated to sharing, promoting search and tracking publications, encompass the whole spectrum of practical skills in using bibliometric means – from identifying the indices universal decimal classification (UDC) and Mathematics Subject Classification (MSC) to using descriptors (DOI, ISSN). The basics of information search and scientometrics, which the participants learnt during lectures and seminars in the first stage, are now acquired through personal experience in using scientometric databases (Scopus, Web of Science, Google Scolar), archives (arXiv), etc. The participants are recommended not only to create formal profiles Scopus Author ID, ResearcherID and ORCID, but also de-facto analysis of absolute and normalized indicators, namely h-index and impact-factor of the publication.

The final module of this stage concerns secondary publications of scientific findings. As a rule, writing a monograph or a popular science article is not common among young researchers. This module significantly falls behind the previous ones and is optional. Secondary publications make sense in terms of sustainable impact on the development of science, when they give other scientists or external experts an opportunity to learn more about the findings in solving a certain problem. Among the communication norms, which are also mastered in this stage are copyright for scientists, open access and research ethics.

3.5. Application of findings

This stage highlights practical skills in transferring scientific knowledge in several directions in parallel – improving the quality of life through its application in industry, IT, healthcare; integration of the knowledge into education and learning; feedback in science. The participants are recommended to select a direction of application, depending on the kind of scientific research. Thus, in order to commercialize scientific knowledge, the participants are advised to register a patent or an author certificate. Application in education and learning means running classes and workshops for students in their first years of studying, one-to-one counselling, creating educational videos, etc.

The specifics of scientific communication in Mathematics is to use the findings broadly in order to amass theoretical knowledge. The research findings, as well as the methods of receiving them can be used for further studying various issues of Mathematics, including Applied Mathematics, prognostication, hypothesizing and other. Secondary publications, for instance sections of monographs or a popular science article allow the participants to acquire the skills in communication with the audience outside their own scientific school.

3.6. Contests for scientists and participation in grant programs

According to Björk [47], the global system of scientific communications performs two functions – the first is to pass on scientific knowledge, the second is to contribute to decision-making in supporting research from the side of University leadership, business, non-governmental organisations. This stage must be introduces into the program, as lack of understanding concerning the mechanisms of grant participation is a strong communication barrier in the general system of science and innovations support. Participation in contests is not obligatory, but is recommended to all the program participants. This stage allows to develop skills in preparing contest papers, presentations, startup projects.

3.7. Method of assessing the findings during the experiment

The assessment of the program implementation was done with the help of Researcher Development Framework (RDF) (Vitae [71]), offered by a world leader in supporting professional development of researchers, the Research and Advisory Centre “Vitae”, Cambridge, UK. RDF is made of the empiric data, collected through surveying experts in order to identify characteristic features of researchers, defined in RDF as descriptors. Descriptors are structured into four domains and twelve subdomains that cover knowledge, intellectual abilities, methods and professional standards of doing a research, as well as personal qualities, knowledge and ability to ensure efficient collaboration with others, and a wider impact of research (figure 4). Each of sixty three descriptors contains three to five phases, that are separate development stages or the efficiency level within the descriptor [71].

Figure 4. The Researcher Development Framework by Vitae [71].

3.8. Findings

The comprehensive program of the activities, which is aimed at developing core skills of a scientist with the help of scientific communication means, was introduced into the educational process of advanced training of young scientists in 9 scientific schools of and Teaching Methods of Donbas State Engineering Academy, Kryvyi Rih State Pedagogical University, Sumy State Pedagogical University, Berdyansk State Pedagogical University.

The assessment of the results of the program implementation was done through surveying 25 stakeholders, namely heads of scientific schools, leading scientists, who are directly concerned with scientific collaboration with the program participants, University management and business representatives. Every participant of the program was assessed by at least 2 stakeholders through an on-line surveying. The goal of the survey was to identify the skills level in the participant attributes that encompass professional qualities, methods and standards of doing research, personal communication skills that prompt the progress in scientific activity and academic career.

The data concerning changes in the descriptor development or the level of efficiency within the descriptor in the program participants can be found in table 2 (Domain A: Knowledge and intellectual abilities; Domain B: Personal effectiveness) and table 3 (Domain C: Research governance and organisation; Domain D: Engagement, influence and impact).

Positive results of implementing the program (marked as "+") are confirmed by deepening of the development phase or the level of efficiency within 15 descriptors in 30–50% of the participants, 16 descriptors in 50–75% of the participants and 21 descriptors in more than 75% of the participants of the program. The program has the most significant impact on the development of career skills, necessary for responsibility and control over professional development (B3); awareness of the standards, requirements and procedures of professional behavior, necessary to manage research efficiently (C1, C3); skills, necessary for interaction, management and influence on academic, social, cultural and economic context (D1, D2).

Forming such skills as financial management of research, understanding of academic and commercial systems of financial support becomes an additional factor for the impact that the program has, which is proved by the data concerning the program participants' involvement in contests and grant programs for young researchers (figure 5).

Hence, it can be stated, that the structure of the program encompasses knowledge, behavior and attributes, which are defined by the sector of tertiary education as critical for a researcher. The content, identified by the research environment is also validated by expert stakeholders – employers and sponsors.

4. Discussion

In connection with the present research it makes sound sense to mention the papers, dedicated to defining skills of researchers that characterize them as scientists in a volatile informational environment. Davies et al. [72] define a set of central skills of an efficient researcher that are linked to the adaptive nature of thinking. These authors consider that scientists do cognitive activity filtering information according to its importance, using various tools and methods for it. Such an activity is defined by a certain type of thinking, which allows to use these tools and methods in the working processes, aimed at achieving the desired outcome. As Koltay et al. [53] mention, researchers have to acquire skills, linked to innovative thinking and problem-solving. They also believe that the research process nowadays is defined by comprehending and justifying data, as the ability to find deeper meanings is more important than formal reading. Moreover, due to globalization and increased international cooperation a practical skill of working in social networks as well as cross-cultural communication skills are becoming more and more vital.

Comprehension, justifying, adaptive thinking, problem-solving and innovative activity depend on the information and define the circle of skills, necessary for a modern scientist. Contemporary resources of Research 2.0 have an impact on all the stages of the life cycle of a research, which

Table 2. Changing the development phase of a descriptor or the level of efficiency inside a descriptor in the program participants.

Descriptor/Subdomain	in 30-50% of the participants	in 50-75% of the participants	in more than 75% of the participants
A1 Knowledge base			
Subject knowledge	+		
Research methods – theoretical knowledge	+		
Research methods – practical application		+	
Information seeking			+
Information literacy and management			+
Languages			
Academic literacy and numeracy	+		
A2 Cognitive abilities			
Analysing			
Synthesising	+		
Critical thinking			
Evaluating		+	
Problem solving	+		
A3 Creativity			
Inquiring mind		+	
Intellectual insight			
Innovation		+	
Argument construction	+		
Intellectual risk			+
B1 Personal qualities			
Enthusiasm		+	
Perseverance	+		
Integrity		+	
Self-confidence			+
Self-reflection			
Responsibility	+		
B2 Self management			
Preparation and prioritisation	+		
Commitment to research			
Time management		+	
Responsiveness to change			+
Work-life balance			
B3 Professional and career developmen			
Career management			+
Continuing professional development			+
Responsiveness to opportunities			+
Networking			+
Reputation and esteem		+	

Table 3. Changing the development phase of a descriptor or the level of efficiency inside a descriptor in the program participants.

Descriptor/Subdomain	in 30-50% of the participants	in 50-75% of the participants	in more than 75% of the participants
C1 Professional conduct			
Health and safety			
Ethics, principles and sustainability		+	
Legal requirements			+
IPR and copyright			+
Respect and confidentiality			
Attribution and co-authorship			+
Appropriate practice		+	
C2 Research management			
Research strategy	+		
Project planning and delivery		+	
Risk management			
C3 Finance, funding and resources			
Income and funding generation			+
Financial management		+	
Infrastructure and resources			+
D1 Working with others			
Collegiality			+
Team working			+
People management		+	
Supervision			
Mentoring	+		
Influence and leadership		+	
Collaboration			+
Equality and diversity		+	
D2 Communication and dissemination			
Communication methods			+
Communication media			+
Publication			+
D3 Engagement and impact			
Teaching	+		
Public engagement		+	
Enterprise		+	
Policy			
Society and culture	+		
Global citizenship	+		

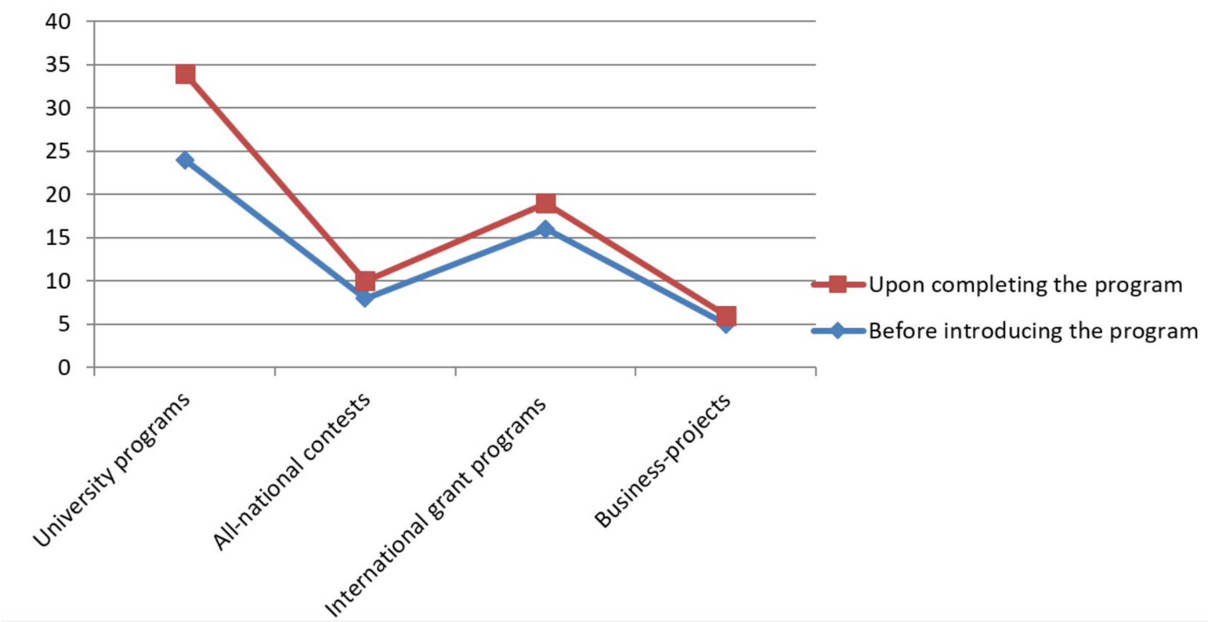

Figure 5. The number of co-participation in contests for young researchers among the program participants.

are connected to information, starting with identifying an idea to spreading the results. Thus, Research 2.0 gives a wide spectrum of opportunities for personal growth of scientists, who nevertheless are reluctant to use these opportunities and excuse themselves by lack of time or experience. According to conclusions by the Social media and research workflow (CIBER [73]), Nicholas and Rowlands [74], Sheombar [54], Vlasenko et al. [75] only a few researchers make the most of all the tools that social media provide.

The authors of this paper believe that creating in young researchers a quality experience of using Research 2.0 resources in professional communication could become a solution to this problem. As Mogull [76] states, novice scientists often follow bad communication practices, reiterating typical mistakes. The most typical problems are: lack of ideas because the content is inadequate when the information is processed (inability to read summaries, incorrect application of search techniques); lack of clearly defined conclusions because of inability to integrate the findings into the structure of the general problem; poor choice of the edition for publications; ignoring the process of managing the publication, etc. By the present research the authors join such experts as Mogull [76], Albert [77], Szklo [78], Vlasenko et al. [79] who consider, that clear and transparent communication practices can make a difference to scientific thinking and improve the quality of scientific advancement. Thus, the suggested program of activities is based on acquiring by novice scientists some personal experience in research work through the usage of the means of digital communication.

The constituents of the program are aimed at improving core skills of young scientists through their scientific communication. Each stage of their activity (from developing topics for the informational environment to presenting the research findings) is ensured by a program of activities, divided into several modules. Every module focuses on developing certain skills. The program means, that postgraduate students and novice researchers, who advance their qualifications, will master the basics of efficient work with information, research data management, and will get an insight into scientific communication, its components, new trends and technologies of scientific communication; they will learn how to use contemporary practices and search techniques when working with information resources. The attendees also master constructive means of reviewing the publications content, acquire the skills of creating bookmarks, comments and summaries as well as communicating with editors and reviewers through open journal systems. Communication between the program participants and tutors takes place on the forum and via an on-line chat on the platform Higher School Mathematics Teacher [55].

The assessment of the results of the program implementation was done with the help of Researcher Development Framework (RDF) [71], as the latter was created based on the empiric data, collected to identify characteristic features of researchers and for that purpose methods and professional standards of doing research were applied. This assessment showed that combining means of digital scientific communication on a certain system and ensuring personal experience in using those means contributes to the development of career skills, necessary for responsibility and control over professional development; awareness of the standards, requirements and procedures of professional behavior, necessary for the efficient research management; development of the skills, central to interaction, management and influence on academic, social, cultural and economic context, for instance, skills in financial management of research, understanding of academic and commercial system of the financial support of science.

5. Conclusions

Fast-paced development of informational environment, opportunities for researchers to communicate with their colleagues and the whole scientific world via the Internet ensured new opportunities in strengthening the global system of scientific communication. This fact made it possible for novice researchers to improve their core skills through promoting scientific knowledge, ensuring mechanisms of participation in contests, interaction, collaboration, personal development and justified the timeliness of developing the program of activities in scientific communication among young scientists, based on the principles of Research 2.0.

Analysing the research into the models of scientific communication and considering the experience of mature scientists, working in Mathematics and Teaching Methods, allowed the authors of the present paper to define the structure of a comprehensive program of activities, aimed at developing skills in scientific communication and core skills of novice researchers, as well as to devise educational and methodological materials for its implementation in compliance with the SCLC Model, which ensures acquiring personal user experience through the practice of using the means of digital scientific communication.

The abovementioned program of activities was structured in accordance with certain stages of a novice researcher's activity and involves scientific communication through the means of digital learning environment. Among such activities were: on-line courses in scientific communication, presentations of programs for supporting young researchers, workshops, educational videos, one-to-one counselling. These activities prompted young researchers to seek informational sources and integrate the results into the context of the general problem; learning about social networking sites for researchers; creating profiles and micro-networks; informal communication through seminars, conferences, mailing with colleagues, publications in reviewed editions. When doing those activities, the participants were aimed at creating systematic comprehension of scientific communication; skills in communication with colleagues and presenting the research findings in a remote mode; skills in practical usage of bibliometric means; skills in using up-to-date practices and search techniques when working with informational sources; practical skills in transmitting scientific knowledge; skills in preparing startup projects.

Stakeholders, namely managers of scientific schools in Mathematics and Teaching Methods, leading scientists, who are directly concerned with scientific collaboration with the program participants, University management and business representatives assessed the results of implementing the program with the help of Researcher Development Framework. Through an on-line survey they defined the participants' level of a researcher characteristic feature in such domains, as: A – Knowledge and intellectual abilities; B – Personal effectiveness; C – Research governance and organisation; D – Engagement, influence and impact. Positive changes in the stages of the descriptor development or changes in the level of its efficiency prove the efficiency of implementing the program and its influence on the development of young researchers' skills in scientific communication. It was also confirmed, that the latter became a significant catalyst for the development of career skills of novice scientists, their awareness of standards, requirements and procedures of professional behaviour, developing skills, necessary for interaction. The analysis of the information on the participants involvement in contests and grant programs for young scientists proved the skills level of in financial management of research and understanding of the system of financial support.

The authors of this paper see the perspective for further research, which is developing on-line support of such a discipline as Methodology and Arranging Scientific Research in overall preparation of Philosophy Doctors.

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