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CRISIS MANAGEMENT DURING THE IMPLEMENTATION OF SCIENTIFIC PROJECTS ON CRITICAL TECHNOLOGIES DURING THE WAR: THE EXPERIENCE OF A DISPLACED UNIVERSITY

ABSTRACT

The article presents the experience of Berdyansk State Pedagogical University in the implementation of crisis management of scientific projects during the war and under the conditions of occupation. Based on experience, the authors show the problems and challenges Ukrainian scientists to face in occupied cities and territories where active hostilities are taking place. Based on the analysis of the current situation and the survey of scientists of the BSPU participating in the scientific projects' implementation, the main factors that prevent scientific research implementation have been established. The authors present their own vision of crisis management during wartime, identify risks, and offer tools for their minimization. Next, the authors analyse the effectiveness of the measures taken. The article is useful for managers of all levels, because it raises important questions about the stability of the functioning of the science and education system in force majeure circumstances.

KEYWORDS

scientific projects, crisis management, scientific research, researchers, risks, displaced university, occupation, war

Introduction

The science, education, and cultural functioning depend significantly on the available conditions and resources. For the successful operation of these institutions, the presence of the following is necessary:

- material and technical resources,
- human capital,
- adequate level of financing,
- sustainability and stability of the current situation.

The experience of the Covid-19 pandemic has shown the world that the usual mechanisms for organizing activities do not work. And it is necessary to develop new schemes and tools. During the two years of the pandemic, humanity has adapted to new challenges. Most organizations and institutions have demonstrated the ability to organize their work remotely and online. The war launched by Russia against Ukraine on February 24, 2022, exposed some obstacles to the implementation of the activities of higher educational institutions and scientific institutions.

At the same time, before the beginning of the large-scale invasion of Russia on the territory of Ukraine, the state understood the importance of implementing military scientific programs aimed at the introduction of critical technologies. State target programs and state budget funding of scientific projects demonstrated an emphasis on the development of dual-purpose technologies. Such technologies have a pronounced applied nature and conduct both fundamental and experimental research. Of course, experimental research requires more resources, including [1, 2]:

- powerful material and technical base,
- access to modern equipment,
- availability of components and materials,
- close connection with business and production, etc.

At the time of writing the article (4 months of active hostilities on the territory of Ukraine), many Ukrainian universities and scientific institutions suffered significantly from the armed conflict unleashed by Russia. Many institutions were almost destroyed, some partially lost their educational and scientific premises, and a few universities and scientific institutions ended up in the territories occupied by the Russian invaders. In these conditions, even the most progressive institutions are unable to continue full-fledged activities. Ukraine, like the whole world, was not ready for such challenges.

Berdyansk State Pedagogical University is located in the city of Berdyansk, Zaporizhzhia region. The city was occupied on February 27, that is, from the very first days of the war. Occupation has its characteristics. Active hostilities do not take place in such cities, institutions and institutions are not destroyed. However, it is impossible to conduct educational and scientific activities.

Military events negatively affect all areas of life, business, infrastructure, etc. [3]. In the situation of occupation of part of the territories, Ukrainian universities cannot carry out educational activities in the legal field. The occupation of part of the Donetsk and Luhansk regions, as well as the annexation of Crimea, led to the relocation of most universities from these territories to the territory under the control of the Ukrainian authorities [4]. However, several studies show the positive impact of a displaced university on a host city [5-7].

In this article, based on our own experience, we demonstrate the peculiarities of the implementation of scientific projects during the war and occupation, we present the established mechanisms of crisis management and tools for overcoming existing obstacles. We show what challenges higher education institutions of Ukraine face today and try to answer the question - Is it possible for educational and scientific institutions to function in the conditions of the active phase of the war? Understanding the factors that influence the activity of scientists and the ways of possible overcoming crises will make it possible to develop effective emergency response mechanisms in the event of force majeure and insurmountable circumstances.

Retrospective analysis of the current situation

According to the Law of Ukraine, the priority directions of the development of science and technology are defined, in particular:

1. fundamental scientific research on the most important problems of scientific-technical, socio-economic, socio-political, and human potential development to ensure Ukraine's competitiveness in the world and sustainable development of society and the state
2. information and communication technologies
3. energy and energy efficiency
4. rational nature management
5. life sciences, new technologies for the prevention and treatment of the most common diseases
6. new substances and materials.

At Berdyansk State Pedagogical University, state budget financing projects are carried out in the following directions (Table 1).

Tab. 1. State-budget scientific projects currently being implemented at Berdyansk State Pedagogical University

#	Project name	Project type	The corresponding priority direction of the development of science and technology	Project implementation period	Implementers
1	Theoretical and methodological principles of systematic fundamentalization of training future specialists in the field of nanomaterials science for productive professional activity	Fundamental research	1) fundamental scientific research on the most important problems of the development of scientific-technical, socio-economic, socio-political, human potential to ensure Ukraine's competitiveness in the world and the sustainable development of society and the state;	2021 – 2023	Doctors of Science – 3, Candidates of Sciences – 1, researchers without a scientific degree – 1, technical staff – 1, graduate students – 2
2	The search for optimal conditions for the synthesis of nanostructures on the surface of semiconductors A3B5, A2B6 and silicon for photonics and solar energy	Scientific work of young scientists	6) new substances and materials	2022 – 2024	Doctor of Science – 1, Candidates of Sciences – 2, researchers without a scientific degree – 1, technical staff – 1, graduate student – 1

Source: compiled by the authors

Fundamental research

Fundamental research «Theoretical and methodological principles of systematic fundamentalization of training future specialists in the field of nanomaterials science for productive professional activity» aims to develop and experimentally test the theoretical and methodological principles of systematic fundamentalization of professional training of future specialists in the field of nanomaterials science for productive activity, and as well as the creation of innovative nanomaterials and nano technologies by students of higher education in the process of this training. The project is aimed at solving the urgent problem of improving the quality of professional training of specialists in the field of nanomaterials for productive activities in the context of business requirements, technology transfer, commercialization of scientific research, national security, society, and the state. The research assumes that the quality of professional

training of future specialists in the field of nanomaterials science will increase if they engage in productive activities in the creation and application of innovative samples of nanomaterials based on their fundamental philosophical, natural, and mathematical principles. The project is interdisciplinary and has a dual purpose. As a leading approach to conducting research under the project, a systematic approach is defined, which includes theoretical substantiation, creation, and correction of a functional model for the systematic fundamental training of specialists in the field of nanomaterials and the organization of productive practical activities of future specialists as an experimental object for checking the functional suitability, adequacy, and adaptation capabilities of the model. Practical activity here means the activity of future specialists in the fields of development, design, synthesis, and use of nanostructures, research of their properties and quality indicators, verification of compliance with a functional purpose, etc. The project is aimed at determining ways to modernize the existing nanotechnology training model in connection with the urgent need to implement the strategy of training highly qualified specialists in the most demanded and promising sectors of the future, considering the requirements of a business, national security, defence technologies, society, and the state. Theoretical substantiation and experimental verification of the effectiveness of a certain approach in teaching nanoengineering for the formation of the necessary general and professional competencies of the future is also necessary.

Scientific work of young scientists

The goal of the scientific work of young scientists «The search for optimal conditions for the synthesis of nanostructures on the surface of semiconductors A3B5, A2B6 and silicon for photonics and solar energy» is the development of a reproducible and effective method of synthesis of nanostructures on the surface of semiconductors of the A3B5, A2B6 group, silicon, research of their optical, electrochemical and structural properties, as well as establishing the effect of defects on the morphology of the surface layers. The problem of improving and ensuring the high quality of nanomaterials, researching the composition and properties of nanostructures to create samples of a given level of quality that are stable over time, and establishing the technological foundations of the synthesis of nanostructures is urgent. The scientific and practical results of the project will become the basis to produce these materials on an industrial scale and a prerequisite for their mass use as a material for photonics and solar energy. The proposed approach to the implementation of the tasks set in the project is based on the development of a unified approach to the synthesis of nanostructures on the surface of semiconductors with specified properties. In turn, nanostructures will be formed by simple and cheapest methods – electrochemical and photoelectrochemical etching, electrochemical and thermal deposition. This approach will make it possible to unify the synthesis technologies of high-quality nanostructures on the surface of semiconductors GaAs, GaP, InP, A2B6 ZnTe, CdTe, CdS, CdSe, ZnS, ZnSe, Si. Such an extensive class of semiconductors was chosen to establish the general laws of the synthesis of various types of nanostructures by electrochemical methods. This opens prospects for the industrial production of nanostructures on the surface of these semiconductors, which are expedient to use for photoelectric energy converters and photonics devices. In addition, the development of a criterion apparatus for controlling the synthesis of nanostructures, processing conditions, and post-processing (passivation) of nanostructures will allow minimizing the rejection of nanotechnological products, which will significantly increase the technical and economic indicators of nanostructures synthesized on the surface of semiconductors.

Project execution peculiarities

From the information presented above, it follows that the implementation of projects involves [4-8]:

- conducting experimental research
- involvement of experts in the nanotechnology field
- availability of powerful material and technical base
- access to up-to-date high-tech equipment
- availability of materials for research
- the need for cooperation with real sectors of the economy and organizations for the research results' implementation.

Before the start of the war, the university had material and technical resources for conducting relevant research. Based on the Department of Physics and Teaching Methods of Physics, the laboratories of optics, spectroscopy, and vacuum technology functioned. In 2019, together with the Zaporizhzhya National University, the Centre for Collective Use of Scientific Equipment „Structure" was opened. The University had a Research Institute of Nanotechnology. In 2020-2021, scientific and laboratory equipment was purchased for the necessary experimental research. In 2022, the opening of the Nanomaterials Synthesis Laboratory was planned.

This ensured the stability of the implementation of projects, in the implementation of which students of higher education were actively involved (Fig. 1). Students had the opportunity to take an active part in scientific activities, work in scientific laboratories and participate in the publication of articles in leading publications as co-authors [9].

Fig. 1. Involvement of educational programs „Secondary education. Physics" and „Applied Physics and Nanomaterials" students to the scientific projects' implementation

During the temporary occupation, the physics and mathematics building of the university, in which the laboratories functioned, was shot by the Russian occupiers. They also stole the server of the university on which the site is located. In such conditions, the successful implementation of scientific projects was at risk, so it was necessary to introduce crisis management.

Methodology

The basis of the study is the analysis of risks and the ways to prevent or solve them, which were considered during the preparation of applications for receiving funding. In parallel, the situation of project executors and their ability to perform scientific research was monitored. Next, an assessment of the current situation and new risks was carried out. At the next stage of the research, several measures were developed that allow moving to high-quality crisis management. Then the effectiveness of the proposed tools was evaluated. A feature of the research is the direct participation of the authors in the researched environment.

Analysis of risks present at the project implementation beginning

Figure 2 shows the main risks and logical connections between them, which were considered when writing the projects. So, the main risks include:

- risks of non-compliance with the implementation schedule and exceeding the project budget
- technical risks
- personal or human risks, which include internal conflicts in the team, burnout of team members, lack of cohesion in the team, incorrect distribution of roles, etc.
- economic crises and force majeure circumstances
- epidemics and lockdowns caused by them.

The developed ways and methods of overcoming risks are listed in Table 2.

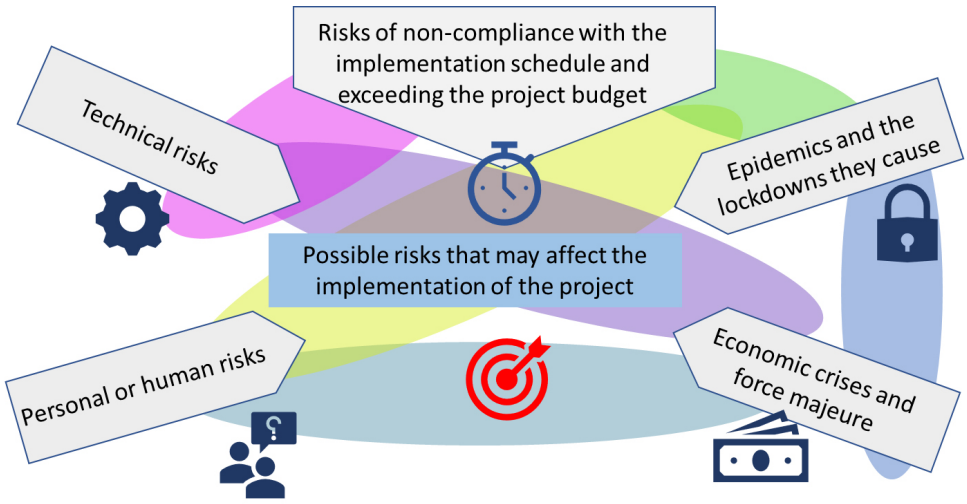

Fig. 2. Possible risks that may affect the implementation of the project

Tab. 2. Possible risks that may affect the implementation of the project and ways to overcome risks

Risks	Ways to overcome risks
Risks of non-compliance with the implementation schedule and exceeding the project budget	The reasons for planning and financial risks can be objective (change in legislation, delay in the work of contractors) and subjective (insufficient processing and inconsistency of work on the project). In our case, this risk is minimized, as the basis for project implementation is well-developed. The excess of the project budget may occur due to rising equipment prices and currency volatility. We consider the minimization of this risk in attracting additional sources, if necessary (own funds, crowdfunding, special university fund, etc.).
Technical risks	This type of risk can occur in cases of equipment failure, insufficient hardware, and software for the project, etc. The project team has extensive experience in debugging technical devices, developing software applications, and statistical processing of results. The risk of equipment failure is minimized by attracting proven contractors with a stable reputation.
Personal or human risks	The project team has been working together for many years. It is with this team that several large-scale projects have been implemented. No internal conflicts arose during the implementation of previous projects. Burnout as a personal risk is more typical for teams whose members are of respectable age. Our team is balanced in terms of young professionals who are enthusiastic and ready for challenges. High professionalism of team members also minimizes personal risks.
Economic crises and force majeure	This type of risk is the worst predictable and minimized. However, taking into account the previous large-scale projects, we have developed several precautionary measures: the clause of force majeure in contracts with contractors, transition to crisis management (by redistribution of roles in the team), and so on.
Epidemics and the lockdowns they cause	The current situation has shown humanity the instability of functioning in the usual forms, the variability of work organization, recreation, and more. Each member of our team has skills to work with online platforms, social networks, and more. This will ensure the implementation of the project regardless of whether a new lockdown is introduced or not.

Source: compiled by the authors

As we can see, such an approach can ensure the sustainability of projects and the fulfilment of all tasks to achieve the goal of each scientific study.

The current situation analysis and survey of project participants

The survey and analysis of the situation were carried out according to the following categories:

- security situation
- location
- availability of stable Internet
- the possibility of conducting scientific research.

Surveys and analyses of the current situation took place every week during the four months of the war.

Security situation and location

During the first month of the war, all the researchers were in the city of Berdyansk, but 50% considered the possibility of moving due to the danger of being in the occupied city. The other 50% saw greater danger in the relocation itself, since leaving the occupied territories is only possible through places of active hostilities.

In the third month of the war, 2 participants moved to the territory controlled by Ukraine, and 60% of the project executors left Berdyansk within another two months.

In general, the percentage of displaced research and teaching staff at the university is 45% of those who remained in Berdyansk.

Internet availability

During the first month of the war, more or less stable Internet was available in Berdyansk, but access to the university buildings was limited, which made it impossible to use the electronic libraries, repositories, databases of scientific publications, and the university website.

Those scientists who left had the opportunity to work with unlimited access to the Internet. In Berdyansk, the situation with the Internet connection was unstable. Internet and mobile communication could be unavailable for several weeks. At the time of writing, Berdyansk has no mobile communications and limited access to the Internet (only 2 providers are operating in the city). So, 40% of executors of scientific projects have problems accessing the Internet within four months.

The possibility of conducting scientific research

A survey of scientists regarding the organization of scientific research revealed several problems that hinder effective activity (Fig. 3). Thus, the survey showed that stable Internet and access to electronic libraries and scientometric databases are most important for scientists. In addition, access to the material and technical base, of scientific equipment, is fundamentally important for the effective conduct of the scientific activity.

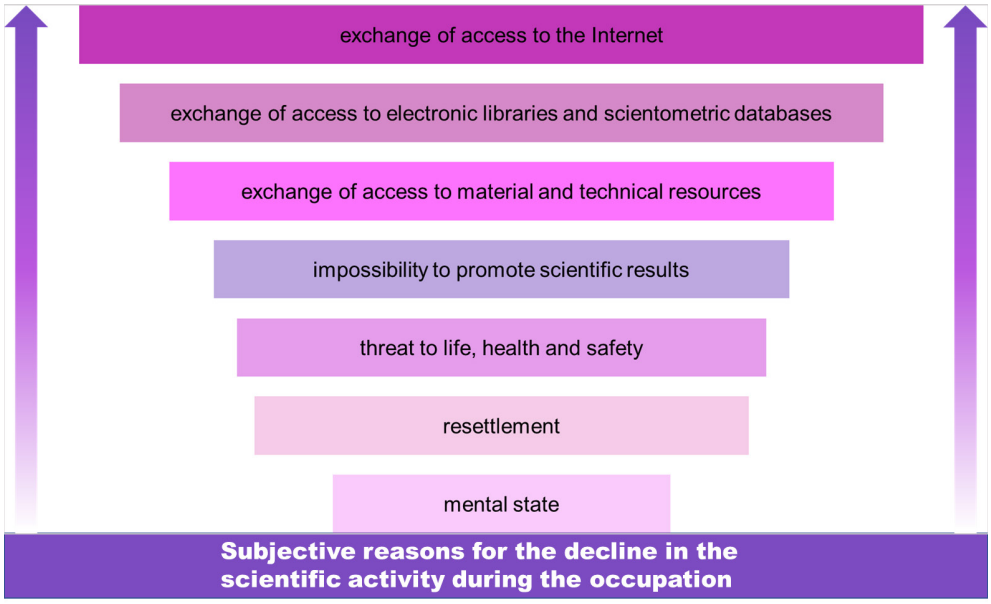

Fig. 3. Subjective reasons for the decline in the scientific activity during the occupation

Crisis management

The Russian-Ukrainian war demonstrated new challenges faced by scientists. In the conditions of occupation, it is almost impossible to carry out scientific activities effectively. Therefore, to solve the issue of blocking scientific research, balanced but very urgent actions are needed. It was decided to move to crisis management and optimization processes to overcome existing obstacles (Table 3) fully or partially.

Tab. 3. Existing problems and ways of solving them in the crisis management mode

Problem	Solution
Access to the material and technical base and scientific and technical equipment	Conclusion of agreements with other universities of the country and the world on the implementation of scientific
Access to scientometric databases	Providing scientists with "home" access
Blocking the work of the university website	Transferring the site to the cloud
Access to electronic libraries	Connecting to the Research4Life system
Decrease in publishing activity	Withdrawal of fees for publication in university anthologies
Difficult financial situation due to relocation	Constant information about available opportunities and support programs for Ukrainian scientists

These and other actions made it possible to intensify the work of scientists in the implementation of scientific projects. Today, the projects demonstrate a high pace of execution. Already during the war, several scientific works were published, which are indexed in scientometric databases [10, 11], project executors participated in international scientific conferences, and strengthened cooperation with foreign colleagues [12, 13]. Obtaining 10 patents for inventions and registering 10 technologies for methods of synthesis of nanostructures testifies to the practical orientation and wide implementation of project results during the war.

It should also be noted that this is facilitated by the dedication of Ukrainian scientists, confidence in the future of Ukraine, and awareness of the need to work for the reconstruction of the country.

Conclusions

The article considers the need to introduce crisis management for the implementation of scientific projects in the event of force majeure. No one was ready for war in Ukraine. And this war affected every Ukrainian, and its consequences are felt in every country. Such wars should never happen again, but every conscious manager should have a set of crisis tools to deal with the insurmountable circumstances that are wars.

Based on their own experience, the authors demonstrate how timely and external actions can „revive" the implementation of scientific projects, and ensure stability and high results of scientific activity. Science is a vulnerable institution. But it is also necessary to understand the great role of science in the development and prosperity of every state. Therefore, in the future, it is necessary to improve the technologies of crisis management of scientific projects and to develop tools, mechanisms, and roadmaps for managing scientific research in crises.

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- No. 0121U109426 „Theoretical and methodological principles of systematic fundamentalization of training future specialists in the field of nanomaterials science for productive professional activity".

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ZARZĄDZANIE KRYZYSOWE PODCZAS REALIZACJI PROJEKTÓW NAUKOWYCH DOTYCZĄCYCH TECHNOLOGII KRYTYCZNYCH W CZASIE WOJNY: DOŚWIADCZENIA UNIWERSYTETU PRZEMIESZCZONEGO

STRESZCZENIE

W artykule przedstawiono doświadczenia Państwowego Uniwersytetu Pedagogicznego w Berdiańsku, dotyczące wprowadzania kryzysowego zarządzania projektami naukowymi, w czasie wojny i w warunkach okupacji. Bazując na własnym doświadczeniu, pokazujemy problemy i wyzwania, przed którymi stoją ukraińscy naukowcy w okupowanych miastach i na terytoriach, na których toczą się aktywne działania wojenne. Na podstawie analizy obecnej sytuacji oraz ankiety przeprowadzonej wśród naukowców Państwowego Uniwersytetu Pedagogicznego w Berdiańsku, uczestniczących w realizacji projektów naukowych, ustalono główne czynniki uniemożliwiające realizację badań naukowych. Przedstawiamy naszą wizję zarządzania kryzysowego w czasie wojny, identyfikujemy zagrożenia i oferujemy narzędzia do ich minimalizacji. Następnie analizujemy skuteczność podjętych działań. Artykuł jest przydatny dla menedżerów wszystkich szczebli, ponieważ stawia ważne pytania o stabilność funkcjonowania systemu nauki i edukacji w warunkach siły wyższej.

SŁOWA KLUCZOWE

projekty naukowe, zarządzanie kryzysowe, badania naukowe, badacze, zagrożenia, przesiedlony uniwersytet, okupacja, wojna.