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Rebuilding Research, Education, and Innovation in Ukraine: Proceedings of a Workshop in Brief (2022)

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REBUILDING RESEARCH, EDUCATION, AND INNOVATION IN UKRAINE

Proceedings of a Workshop—in Brief

The Russian invasion of Ukraine in February 24, 2022 has resulted in devastation, including loss of life, massive internal and external migration, and the partial or complete destruction of facilities and infrastructure. This poses urgent challenges for Ukraine’s science, education, and technology sectors. The National Academies of Sciences, Engineering, and Medicine (National Academies) convened a workshop from September 21–23, 2022 to discuss rebuilding research, education, and innovation in Ukraine. The National Academies recognizes that the devastation of the war in Ukraine will make rebuilding particularly difficult and humanitarian aid will remain a top priority for a long time.¹ As a result, while many of the best practices described will be difficult to implement in the short-term, the goal of the workshop was to convene the international scientific community to discuss the importance of science, innovation, and education to Ukraine’s long-term rebuilding and its post-war future.

¹ The National Academies of Sciences, Engineering, and Medicine acknowledges and prioritizes the immediate needs of individual Ukrainian scientists, engineers, researchers, and health care workers, and is providing support through a parallel initiatives. For more information see: <https://www.nationalacademies.org/supporting-ukraines-scientists-engineers-and-health-care-workers>.

To learn how you can help, see: https://host.nxt.blackbaud.com/donor-form/?svcid=renxt&formId=536cf41f-5fc1-42d9-9462-02c7fd1171b5&envid=p-3XLov2OPQUO6JUZI5_HKFQ&zone=usa.

This Proceedings of a Workshop—in Brief provides a high-level summary of the workshop discussions on best practices for managing science, higher education, innovation, and research funding from the international community.

INTRODUCTION

Rita Colwell, University of Maryland, workshop chair, opened by stating that the goal of the workshop is to bring the international scientific community together to raise awareness of the importance of science, innovation, and education to Ukraine’s post-war recovery. Colwell stated that the workshop will provide a comparative review of best practices in managing national research systems. Colwell highlighted that the main components of the workshop—research, education, and technological innovation—are all deeply intersectional.

Anatoly Zagorodny, President of the National Academy of Sciences of Ukraine (NASU), provided introductory remarks. He emphasized that while we should focus on resetting the system of scientific organizations in Ukraine, we should also work to preserve and restore institutes and support researchers, who are working under extremely difficult conditions. Zagorodny

suggested the creation of a state body that would be responsible for implementing science and technology policy and strengthen cooperation between science and business. At the same time, Zagorodny noted, NASU should be preserved, as that is where a majority of research is concentrated. Zagorodny stated that NASU has and will continue to support grant funding in Ukraine, particularly by supporting the National Research Foundation of Ukraine (NRFU), but that funding NRFU should not divert funds from NASU or universities.

Marcia McNutt, President of the U.S. National Academy of Sciences (NAS), stated that following the Russian invasion of Ukraine, NAS established a partnership with the Polish Academy of Sciences to address the flood of displaced persons from Ukraine, and NAS is working to update this strategy to fund research teams that are still in Ukraine. NAS, along with European academies, is developing coordinated plans to continue humanitarian support and look toward longer-term measures to rebuild science in Ukraine.² This includes the creation of a coordinating group for U.S. and European academies to share best practices and connect different initiatives, for which NAS serves as the secretariat.

BACKGROUND ON THE SITUATION IN UKRAINE

Cathy Campbell, CRDF Global (retired), provided some background on NAS's work on Ukraine and how this workshop came to be. Following the Russian invasion, NAS established an informal working group called RESET Ukraine³ to discuss the current situation of science in Ukraine, legal policy and institutional frameworks underpinning it, past efforts to modify the framework, and Ukraine's recovery plans. The group agreed that a modernized science, technology, and innovation system is critical to Ukraine's recovery and path to EU membership. The first step was creating this workshop to discuss four critical and intersecting issues: science, higher education, technological innovation, and financing, with the goal of ensuring that the best and most relevant information is available for Ukraine to make decisions for its own future.

² See: <https://www.nationalacademies.org/news/2022/06/action-steps-for-rebuilding-ukraines-science-research-and-innovation>.

³ The National Academy of Sciences remains committed to this work and has formalized this program, which is now referred to as the "RESET Ukraine Action Group."

Ukrainian Education and Science Reform

Nataliya Shulga, Ukrainian Science Club,⁴ described the series of attempts to reform Ukrainian education and research since its independence from the Soviet Union.

After leaving the former Soviet Union, education and science in Ukraine experienced serious stress due to a lack of funding and the first wave of the mass immigration of highly qualified professional scientists and educators. Many negative aspects of the education and science system became widespread phenomena during the first decade of independence, the most damaging being plagiarism and corruption. Freedom also brought a spirit of entrepreneurship, volunteering and cooperation, international collaboration, and exchange programs, and many NGOs and small companies were successful. Since then, there have been many ideas on how to modernize and advance the research system of a post-Soviet Ukraine, but there was resistance from the ruling elites to move forward. There was no single platform to bring all stakeholders together to plan a future for Ukraine. Shulga stated that the prevailing thought within the Ukrainian community is that increased funding would quickly solve the problems in education and science.

Shulga noted that the past two decades have seen three major steps in reforming Ukrainian education and science that have decentralized management and financing of science and technology. First, in 2005, Ukraine recognized that science should have a stronger presence at higher education institutes. Second, laws on higher education and scientific and technical activities were adopted in 2014 and 2015 respectively.⁵ This led to the creation of science labs and research and education centers which became structural parts of Ukrainian universities, and NASU lost its monopoly on science and R&D. Third, Ukraine adopted conceptual principles of Secondary School Reform, "The New Ukrainian School,"⁶ and a new basic law on education in 2017, which spurred the development of STEM focused interdisciplinary

⁴ See: <https://www.nauka.in.ua/en>.

⁵ See Law on Higher Education: https://www.ilo.org/dyn/natlex/natlex4.detail?p_lang=en&p_isn=105562; See Law on Scientific and Technical Activities: <https://www.rada.gov.ua/en/news/News/120487.html>.

⁶ See: <https://mon.gov.ua/eng/tag/nova-ukrainska-shkola>.

curricula for children. This marked a paradigm shift in education at all levels.

The Revolution of Dignity in 2014 marked a turning point for Ukrainian society to make a final effort toward Euro-Atlantic integration. For the first time, an informal coalition of more than 100 NGOs and independent experts created a platform called the Reanimation Package of Reforms (RPR) to prepare necessary emergency reforms to quickly move the country forward. RPR played a crucial role in the preparation and promoting of all three basic Laws described above and adopted by Parliament. All three new laws recognized the importance of the interdependence of education and research in creating an ecosystem for high quality science and innovation. Shulga explained that international collaboration and internalization of higher education became a trademark of the reform process and the integration of Ukraine into the European science and education area. In 2015, Ukraine became an associate member of the Horizon 2020 program,⁷ which has provided exposure to European standards and best practices. The National Research Foundation of Ukraine, active since 2020, is one of the most important instruments of the reform process. Reforms were also made to secondary education based on scientific methodology. These reforms had a visible effect on the structure and administration of the Ministry of Education and Science of Ukraine, which became responsible for new policies and reform.

Despite these developments, Shulga stated that the reform process has been slow and problematic, and the disruptions caused by the Russian invasion of Ukraine this year have resulted in a large migration of young science students, startup companies, and educators. This mass migration will make the reform process particularly difficult. Shulga underscored the importance of adapting the Ukrainian science sphere to the global challenges of the current world and prioritizing education and science for the next decade.

⁷ See: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-2020_en.

Ukraine Recovery Plan

Yulia Bezvershenko, Stanford University, described Ukraine's National Recovery Plan, which aimed to build a vision of Ukrainian recovery in all spheres and is the only official document of its kind at the national level. The primary goals of this plan were modernization, Euro-integration, and strengthening institutional capacity. Bezvershenko identified several problems with the plan: (1) utilization of science and R&D to aid modernization is rarely mentioned in the plan, (2) policies and instruments are not well-aligned in terms of time or money and there is a lack of capacity, and (3) the stated problems, goals, and actions in the plan are not well-connected. The plan lacks an understanding of the connection between S&T and the economy and the critical role of science in Ukraine's recovery and long-term future. Bezvershenko also noted that human capital is one of the most urgent issues related to scientific research in Ukraine.

Bezvershenko argued that in reality, there is limited capacity to design S&T policies in Ukraine (in terms of number of people, skillsets, and English language capabilities) and very limited capacity and expertise to implement them. Bezvershenko highlighted three actions that are needed: (1) Make science (and technology and innovation) an essential part of the vision of Ukraine's future and strategy for reconstruction, (2) support systemic reforms, and (3) preserve and develop human capital by providing resources and supporting networks and partnerships.

SCIENTIFIC RESEARCH

Cathy Campbell moderated a panel of experts from international Academies and higher education institutes in a variety of countries to provide models and best practices related to managing scientific research.

Perspectives on Best Practices in Managing Scientific Research

Ella Libanova, NASU, described the state of scientific research in Ukraine since the Russian invasion. NASU is responsible for fundamental and applied research (in natural, technical, social, economic, and human sciences) and the expertise and coordination of fundamental research in Ukraine, including research at universities. This comprises 150 institutions, 40 of

which were created after Ukraine's independence, with 28,000 employees. Libanova noted that NASU engages in international cooperation through 140 agreements with other academies, research organizations, universities and private companies in 50 countries.

The invasion of Ukraine has had a significant impact on Ukraine's research system. Missile attacks on research facilities have damaged NASU's scientific infrastructure, and many researchers have been forced to move to smaller towns and villages in other regions of Ukraine where no scientific centers exist, or to move abroad. As of May 2022, 20 percent of NASU's employees had moved to other regions of Ukraine (13 percent) or abroad (7 percent). Damage to NASU Ukraine buildings has cost 14 million euros.⁸

Libanova outlined several problems that must be addressed with regards to NASU's research infrastructure, including reconstruction of damaged buildings and equipment. She highlighted several critical forms of necessary international support, including providing the ability to freely publish scientific papers in journals; providing the minimum necessary salary for scientists to continue their work in Ukraine through various sources; providing grants for joint research where salaries can be paid in Ukraine; special individual grant support; the transfer of scientific equipment to NASU institutes that is already being used but is applicable for modern research; providing equipment to NASU institutes for shared use with universities and other research institutions; providing remote access to international research infrastructures (including computing resources); and providing access to full-text papers in journals included in international databases, which are currently only partially available.

Jerzy Duszynski, President of the Polish Academy of Sciences, discussed the Academy's program to support Ukrainian scholars—227 scientists from Ukraine have been hosted at Polish institutions. They have plans to support research groups (5 members) from Ukraine and provide them with double affiliation at Ukrainian and

⁸ Since May, this migration of NASU employees and damage to infrastructure has likely gotten significantly worse.

Polish institutions so they can operate on Ukrainian territory and members can visit each other's institutions frequently. The goal is to build bridges between the international and Ukrainian communities. Duszynski described Poland's experience with reform, in which substantial funding was provided to science and higher education infrastructure. He noted that instead of infrastructure, investments should be made in human capital and concentrated in the top academic centers instead of equally distributed throughout the country. Support should also be provided to help Ukraine enter European scientific consortiums and programs to support internationalization of a country's science.⁹ Investment in reconstructing Ukraine's research infrastructure can come later. In the meantime, existing infrastructure should be easily and widely accessible to Ukrainian researchers from international academies. The plan for rebuilding Ukrainian science, research, and innovation was adopted in Warsaw by several international academies.¹⁰ Duszynski concluded that it is Ukrainian scholars' responsibility to rebuild Ukraine, and the international community has an obligation to prepare Ukrainian scholars for playing this role.

Tarmo Soomere, President of the Estonian Academy of Sciences, described reforms to Estonia's scientific research and higher education systems after the collapse of the Soviet Union, to serve as an example of potential paths forward for Ukraine. Before the 1990s, Estonia's research system was based on a centralized system in Moscow and the needs of the entire USSR. It was financed by and served the military system. Immediately following the end of the Soviet Union, the correlation between assets and competence on one hand and the needs of Estonia on the other hand were strongly negatively correlated. Soomere listed three major decisions that were made to begin reforms: (1) unnecessary and unsuccessful research fields were cut, (2) high quality and necessary research fields were kept, and (3) research and higher education were highly connected.

The series of reforms that followed occurred in five steps:

⁹ See: <https://marie-sklodowska-curie-actions.ec.europa.eu/>; See: <https://erc.europa.eu/homepage>.

¹⁰ See: <https://www.nationalacademies.org/news/2022/06/action-steps-for-rebuilding-ukraines-science-research-and-innovation>.

1. An inventory was conducted by the Swedish Academy of Sciences of Estonian research groups to evaluate their competence and potential. This provided a general picture of the status of Estonia's research system and provided recommendations based on the data collected.
2. Based on this inventory, the research system was restructured. Major research institutes were moved from the Academy of Sciences and various ministries to the universities.
3. Research financing was restructured based on the principles of quality and importance for Estonia. Each scientist within a research group had to meet certain criteria, and funds were completely under the control of the research group itself, accompanied by small competitive grants. This system weeded out corruption in research financing. Soomere noted that one downside of this system was that universities and research institutes had no funds to make themselves sustainable—the needs of the country prevailed, while the needs of the universities were not met.
4. A more balanced institutional funding system was established by merging the two existing schemes. The number of staff and institutes was significantly decreased. Soomere noted that this system did not work well because it was not clear how to balance the needs of the country and the needs of the university or research institute.
5. Quality-based research grants and “base financing” were separated. This allowed universities to support the work they believed was necessary. Soomere noted that this series of steps created a decent quality assurance system.

Soomere argued for a “policy for science” approach to extract the best knowledge and people from a country, noting that the competitiveness of countries, regions, and whole continents relies on this to stay ahead. The Estonian Academy of Sciences decided that the best way to support the country was not by running the research system and distributing funds, but by providing advice. The four main roles that must be filled at the intersection of scientific research and governance are (1) provide advice, (2) lobby for science, (3) distribute money, and (4) protest if something goes wrong.

Panel: Scientific Research

Oleksii Shkuratov, Deputy Minister of Education and Science of Ukraine (MoES) for European Integration noted that the main problem for the science and innovation sphere in Ukraine is the impossibility of carrying out activities at a high level fully in regions temporarily occupied or experiencing shelling and partially in other regions of Ukraine. This is due to casualties in the scientific and higher education communities, the departure of scientists to other countries, damage to infrastructure, loss of scientific and technical information, low compliance of scientific and technical products with market needs, and falling demand for new technological solutions, with the exception of the military industry.

Shkuratov noted that many scientific institutions have been confirmed as partially or completely destroyed, and the state of much of the scientific infrastructure is unknown due to constant shelling. He added that at the time of the workshop, 17 percent of NASU employees had left Ukraine since the beginning of the war. Shkuratov identified several priority tasks for the MoES including: restore state financial support for scientific research; provide Ukrainian researchers with scientific information; restore damage to research infrastructure; create conditions for the development of the innovation ecosystem; and ensure technology transfer and commercialization of scientific results.

The Ukrainian government's “Plan for the Restoration of Ukraine” has a section dedicated to science and innovation.¹¹ The MoES has launched a program to have professors from international institutions give lectures in Ukraine. They have also established a Telegram channel (“Info Science Bot”), which provides news and opportunities for scientists, innovators, and startups. In May 2022, the Ukrainian Parliament ratified Ukraine's participation in the Horizon Europe Research and Innovation Framework Program¹² and the European Atomic Energy Community's Euratom Research and

¹¹ See: <https://www.president.gov.ua/en/news/plan-shvidkogo-vidnovlennya-ukrayini-peredbachatime-operativ-76433>.

¹² See: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en.

Training Program,¹³ which Shkuratov noted will provide Ukrainian scientists and innovators with additional resources and the ability to apply for grants.

Oleksiy Kolezhuk, Ukrainian National Council for Science & Technology and Development, argued that Ukraine's reconstruction plans should view S&T and innovation as essential, any reforms should be systemic, and human capital should be preserved during the war and developed during the reconstruction period. Short-term measures to preserve and develop human capital, Kolezhuk stated, should include introducing a temporary merit-based system for individual support to keep researchers in their current fields. To develop this capital, Kolezhuk argued for a longer-term program with diverse funding sources that would unfold in several stages. First, he stated, support should be provided to research networks to integrate Ukrainian research into the global science community. Second, joint doctoral schools should be established to cultivate the next generation of scientists. Additional short-term measures could include providing grants and co-funding instruments for specific projects and continued support for Ukrainian researchers outside Ukraine. Kolezhuk emphasized that the goal should be to support Ukrainian researchers' transition back to Ukraine.

On long-term measures for reconstruction, Kolezhuk noted that internal transformations are the responsibility of the Ukrainian government, but that the state's capacity is not currently sufficient to make these strategic decisions. Kolezhuk suggested that the governance of science should be reformed by splitting the policy development (conducted by the Ministry of Education and Science) and implementation functions (conducted by other actors). He recommended training instruments for the Ministry of Education and Science to help them learn from reform processes in other countries and build their own capacity.

Next, Kolezhuk stated that NASU must also be reformed and suggested that the organization and funding structures for basic, applied, and defense-related research be separated because these activities require distinctly different funding mechanisms and evaluation criteria.

¹³ See: https://ec.europa.eu/info/funding-tenders/find-funding/eu-funding-programmes/euratom-research-and-training-programme_en.

He recommended several additional long-term reforms, including: build a multi-layer system of funding to target different types of research, technology readiness levels (TRLs), and researchers at different professional levels; institute a quality assurance system for institutional and project funding; prepare the next generation scientists by prioritizing STEM education; integrate Ukraine within the European research community; and develop a strategy for international cooperation.

Kolezhuk noted that several obstacles for these long-term reforms are the Ukrainian attitude toward science as not a priority, a lack of state capacity and expertise for strategic decisions, and a lack of consensus within the scientific community about how to move forward.

Rick Roush, Pennsylvania State University, described the U.S. land grant system to provide some potential lessons for Ukraine. First established in 1862 through the Morrill Act,¹⁴ the impetus for the land grant system was the need for institutions to educate students in the practical and mechanical arts, particularly agriculture. Each state was provided grants of land in other parts of the U.S. that could be sold and serve as revenue to build a land grant university. Legislation introduced in 1914 formalized cooperative extension at land grant universities, which established partnerships between the Department of Agriculture and universities to partially fund training of the public, particularly farmers. These universities are currently funded by a combination of state and federal sources, as well as competitive merit-based grants, tuition from students, philanthropy, and contracts from industry. Roush noted that this system has seen remarkable economic results—without extension, an additional 28 percent of farmers would have left agriculture in Pennsylvania in the past 10 years. Roush argued that this system is faster and more efficient in linking research advances to applications in the field and allows for a closer linkage to industry.

Ihor Mryglod, NASU, argued that because citizens and politicians prefer quick, concrete scientific results that can be applied, basic research is the most vulnerable in

¹⁴ See: https://www.senate.gov/artandhistory/history/common/civil_war/MorrillLandGrantCollegeAct_FeaturedDoc.htm#:~:text=First%20proposed%20when%20Morrill%20was,law%20on%20July%202%2C%201862.

Ukraine. He said the structure of scientific management and equipment still reflects the demands of the former Soviet Union. He suggested that Ukraine has not developed demand for modern science from the state or industry, and this has led to a decline in the prestige of Ukrainian research and the loss of young researchers. Mryglod recommended developing a specific international fund to address the development of scientific infrastructure and support the most successful research groups by establishing research centers across Ukraine, with help from the National Research Foundation of Ukraine (NRFU) and the Science and Technology Center of Ukraine (STCU), that would operate based on the principles from the best research centers globally. Mryglod noted the importance of growing interdisciplinary research and strengthening international ties.

Discussion

Campbell began the discussion by asking Duszynski and Soomere about the balance between National Academies and universities and how they are handling the intersection between research and technological innovation. Duszynski responded that in the beginning, there were problems of scale and lack of mobility, and it is important to allow researchers to go back and forth between the academies and universities. Duszynski noted that the most successful reform was the creation of the National Center for Science, which was modelled on the European Research Council, but because it was competitive, it was not very popular. Duszynski noted that Poland experienced the same “brain drain” that Ukraine is experiencing, but argued that in the long-run the movement of researchers abroad is beneficial. Poland is building Ukrainian potential that can move back to Ukraine when the time comes. On technological innovation, Duszynski stated that there shouldn’t be discrimination between basic and applied sciences and Poland has separate agencies for each type. Soomere agreed that both basic and applied sciences are important, and former Soviet countries often lack a strong connection between science and innovation. It is critical to have knowledge at private enterprises to avoid the “valley of death” between science and production. Yaroslav Yatskiv, National Academy of Sciences of

Ukraine, added that maintaining a workforce will be the decisive factor in rebuilding Ukrainian science.

HIGHER EDUCATION

Panel: Higher Education

Oleh Sharov, Ministry of Education and Science of Ukraine (MoES), provided background on the MoES’s efforts to reform higher education in Ukraine. From 2014–2021, the MoES’s strategy for higher education reform was to return to the basic concepts of modernization for higher education institutions in Europe, including university autonomy, quality assurance, and mobility. Sharov noted that MoES wants to promote increased autonomy among universities. There are many challenges to these reforms, mainly conservatism, financing, migration of students and teachers, corruption and academic dishonesty, and a lack of internationalization. Sharov emphasized the need to harmonize Ukrainian legislation and practices with European ones. The MoES’s strategic goals for the future are to establish efficient management of higher education; trust among citizens, the state, and business in the activities of higher education institutions; high-quality education; internationalization of higher education; attractiveness of institutions; and recovery of the potential of institutions.

Lidia Borell-Damian, Science Europe, described the work of Science Europe, which serves as a forum for gathering national research funding and performing organizations across Europe to share information. Science Europe has engaged with the NRFU since the beginning of the war, accelerating their membership, and encouraged all of its members to support the NRFU. In particular, the Polish member organizations—the National Research Center and the Foundation for Polish Science—have welcomed Ukrainian researchers to Polish institutions, engaged in humanitarian aid, and issued calls for Ukrainian researchers to continue their work. Borell-Damian highlighted that Ukrainian researchers must be able to go back to Ukraine to rebuild their system, with support from European countries that have hosted them. In order to integrate Ukrainian research policy processes with European ones, we must share research processes in addition to results, and reform research assessments.

Science Europe has a plan, supported by the European Commission and in partnership with the European University Association, to support organizations that want to modernize their research assessment processes.

Yehor Stadny, Kyiv School of Economics, agreed with previous speakers that human capital is the most crucial issue in rebuilding Ukrainian science and higher education. The Russian invasion has had a dramatic impact on higher education institutions (HEIs)—infrastructure has been damaged, there have been budget cuts, and faculty and students have been displaced. Despite this, Stadny stated that Ukraine has continued and almost finished its 2022 admission campaign for universities. Stadny noted that the number of students now is roughly the same as in the early 1990s, but the number of HEIs has more than doubled, meaning that there are too many universities. Stadny emphasized that efforts should be focused on providing a competitive quality of education that will attract young people back to Ukraine.

Stadny described several major problems in the structure of HEIs in Ukraine. First, there is no financial autonomy at public HEIs—these institutions have to confirm all of their decisions with governmental bodies which slows down the decision-making process. Second, private universities do not have equal access to public funding. Third, the number of accepted students who are able to pay for their education is decreasing. Stadny argued that Ukraine should introduce public loan programs for higher education, as no such program currently exists for students. Fourth, there is a lack of awareness among Ukrainian youth about the nature of higher education and the opportunities it provides. Fifth, the structure of degree programs is very rigid, and does not allow flexibility in the duration of study. HEIs, Stadny argued, should allow students to extend their time of study, as many students' studies were interrupted by the war. Sixth, HEIs should not focus their activities purely around research. HEIs should be divided into research-focused, liberal arts, and applied science universities. Finally, the MoES should transform into an advisory body instead of a regulatory body.

Roman Gladyshevsky, University of Lviv, described the structure and activities of that university. While the most popular subjects are economics and law, Gladyshevsky noted that physics and chemistry house much of the research activity, with an increasing focus on materials science. Most of the staff in the departments, including research fellows, are involved in teaching, which allows for basic and high-level courses. Students can also participate in research. Chemistry attracts 50 percent of state funding for research, and biology attracts over 50 percent of international grants. The university has recently received funding from members of industry, with plans to increase industry sources to 50 percent of the university's funding by 2025.

Gladyshevsky also highlighted the importance of encouraging scientific education at all educational levels. The University of Lviv collaborated with NASU to run a competition for young researchers on crystals. The university also hosts an annual innovation program targeted towards young researchers to help them launch their own companies—this year's program is focused on post-war restoration. Gladyshevsky said that research universities should integrate with innovation. Looking ahead, he noted that in order to build a strong and competitive country, research funding must be balanced between fundamental research and immediate needs. He also said that the integration of Ukraine into the international intellectual property protection system is crucial for Ukraine's rebuilding.

Best Practices in Managing Higher Education and Research

Ana Mari Cauce, University of Washington, discussed the importance of university partnerships with local government and industry to grow research funding, provide internship and career opportunities for students, and provide test beds for innovation. For example, the University of Washington works with Boeing to educate engineers in its Aeronautics and Astronautics department. Partnerships with local government are also important. Cauce discussed how to build a strong faculty, noting the importance of beginning with an open and equitable recruitment process. Universities should provide mentorship and professional development tools and support faculty with different needs, such as women

with children. Providing strategic funding for faculty to conduct research, especially those early in their career, is important. Cauce emphasized the value of breaking down silos and building community across the university in an interdisciplinary fashion.

Discussion

E. William Colglazier, American Association for the Advancement of Science, moderated the discussion and began by asking about the mental health of Ukrainian students. Stadny noted that some students suspended their studies in February and March, but many have resumed their education. In response to a question about tuition, Stadny stated that the full tuition fee at the Kyiv School of Economics only covers one-third of the cost, and that the government should introduce public loans for higher education.

In response to a question about advertising available opportunities for funding, Kolezhuk noted that the NRFU has been publishing this information on their website, but some people cannot find it, do not actively seek this information out, are reluctant to use those opportunities, or do not feel like they are in the position to compete for funding. Stadny agreed that potential applicants could be preoccupied or do not have the skills or resources to apply for funding and argued that there should be a central clearing house where information could be coordinated and distributed effectively so it is widely available. Cauce noted that American universities have networks among themselves that work effectively in influencing the U.S. government on higher education issues, and Ukraine could develop their own networks. Shulga added that there are programs to help applicants write grants, but such programs' effectiveness is limited, particularly due to a lack of English language skills

Kolezhuk noted that there are two noteworthy quirks of the Ukrainian system: (1) it is typical that for any announced open professor position, there is just one applicant—this is partially because of low mobility, but mostly due to the traditional mentality surviving from Soviet times, and (2) there is a fundamental division between professors and researchers within the university system.

TECHNOLOGICAL INNOVATION

Alfred Watkins, Global Solutions Summit, moderated a session on best practices in technological innovation. Watkins said that supporting startups via a robust network of national technology incubators, connected to the network of European and international incubators, accelerators, customers, suppliers, and financiers will be critical to fulfilling the Ukrainian government's post-war objectives. This will require industrial technology and upgrading Ukrainian programs to help businesses and their workforces become technologically proficient participants in the EU, U.S., and global markets.

Best Practices in Incubators and Accelerators

Rebecca Taylor, Austin Technology Incubator (ATI), outlined the incubator's history. Founded in 1989, ATI is the U.S.'s longest-running incubator that has supported several hundred companies with an over \$3 billion dollar economic impact. Taylor noted the importance of the relationship between the University of Texas at Austin and ATI. ATI is a unit of the university, but it is not funded by the university. This structure, Taylor noted, pushes ATI to be focused on the external community. ATI's funding changes from year to year and includes a mix of government grants, contributions from state-based organizations, and occasionally economic development organizations in Austin. Taylor stated that the business model for ATI's companies aligns with ATI itself; ATI receives a 2 percent equity position from each startup that it admits to the incubator, and if the company is bought or goes public, some of those funds go to ATI's operating budget. This mechanism, Taylor emphasized, is a key part of the way ATI functions and has been very effective.

Taylor also described some of the ways ATI has collaborated with corporations. For example, ATI hosted a pitch competition for John Deere so that they could integrate new technologies into their products. John Deere chose a company to join an internal year-long program where they plugged the startup into every part of their company to accelerate the rate at which they incorporate new technologies. Taylor noted that working with a company on such an event is a good way to get an incubator off the ground.

Manufacturing USA Institutes

Mike Molnar, National Institute of Standards and Technology (NIST), discussed two of NIST’s programs, Manufacturing USA¹⁵ and the Manufacturing Extension Partnership¹⁶ (MEP), and how they contribute to innovation and the development of new technologies. Manufacturing USA comprises a network of 16 institutes across the U.S. that aim to accelerate the translation of new ideas to technology and manufacturing readiness levels (see Figure 1). Molnar identified four goals of the program: (1) “increase the competitiveness of U.S. manufacturing,” (2) “transform applied research into production,” (3) “accelerate the development of an advanced manufacturing workforce,” and (4) “support business models that help the institutes become stable and sustainable.” Molnar stated that the institutes address the “scale-up” gap by providing a convening ground where a diversity of stakeholders can work together on a project. The MEP is a network of centers in all 50 states and Puerto Rico for technology transfer to small and medium enterprises (SMEs). Molnar noted that public-private partnerships work so well because local governments and local companies know what is needed, and NIST aims to connect them with industry and academia.

A Perspective on Innovation in the Next 20 Years

Andy Hopper, Royal Society and the University of Cambridge, argued that there is a large gap between research and innovation because in innovation it is very hard to be successful and make a profit. There are also major barriers to innovation, including monopolies, patent trolls, the patent system itself, a lack of capital, geopolitics, and individual incentives. Hopper noted that every future product will have a digital representation, and manufacturing will only be the final step. To take advantage of this situation, Hopper described a new national infrastructure, called Digital Common Technology, which could serve as an “industrial Wikipedia” of programs, data, reference designs, tutorials, and examples, and be used as the basis for new products and services. This information source, Hopper argued, would reduce barriers to innovation and provide resources for new startups.

Panel: Technological Innovation

Oleksandra Antoniuk, Kyiv Academic University, stated that all the components of a successful innovation system are present in Ukraine, including legislation, public-private partnerships, investment funds,

Institutes Designed to Transform Technology Collaboration

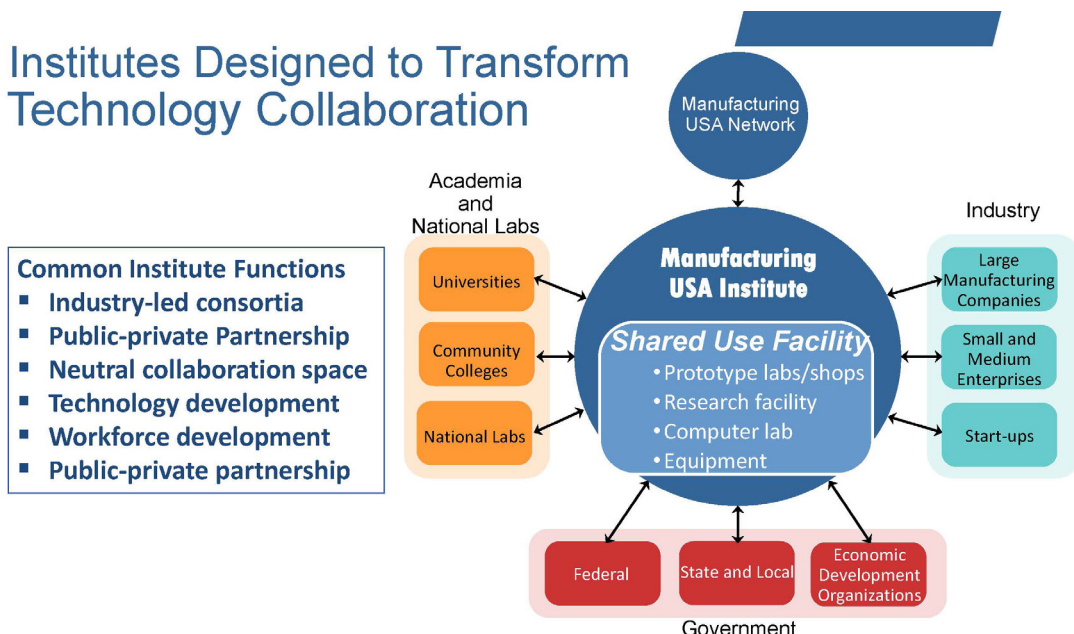


FIGURE 1 The members of Manufacturing USA’s institutes, which include participants from academia and national labs, industry, and government that collaborate at the institutes’ shared use facilities. SOURCE: Mike Molnar, Manufacturing USA.

¹⁵ See: <https://www.manufacturingusa.com/>.

¹⁶ See: <https://www.nist.gov/mep>.

government bodies, and incubators/accelerators, but the system is not working properly. Antoniuk described a study conducted in 2019–2021 in partnership with Humboldt University in Berlin to identify problems and address how to bring best practices to Ukraine.¹⁷ Before the Russian invasion, the study determined that Ukrainian expenditure of R&D as a percentage of the country’s GDP decreased between 2010–2017 to below 0.5 percent.¹⁸ The study also found that there are a large number of companies in the IT and e-commerce sectors, companies founded in Ukraine are moving abroad, and the startup environment is concentrated in the cities. Antoniuk suggested several changes, including: liberalizing the legal system to allow for incubators to operate, simplifying the recent procedure for state R&D institutions, forming an entrepreneurial culture, establishing close cooperation between state R&D institutions and private companies, and financing to support the innovation ecosystem. Antoniuk discussed efforts to create a science park called Academ.City in Ukraine based on the expertise of institutes at the NASU that will include research on artificial intelligence and machine learning, advanced materials, biotechnologies,

nanotechnologies, quantum technologies, and energy. The science park is developing partnerships with local governments and universities.

Pavlo Kartashov, Ukrainian Startup Fund¹⁹ (USF), described the activities of the USF (see Figure 2). The fund, created in 2019, is the main governmental implementing agency working with the World Bank. Its activities include two grant programs for startups (\$25,000 pre-seed and \$50,000 seed funds), an acceleration program (outsourced to U.S. companies), and an innovative voucher program that provides funds for Ukrainian startups to participate in international conferences. The fund recently launched dual-use project grants to support projects in defense, healthcare, cybersecurity, infrastructure, reconstruction, and education, in partnership with Ukrainian ministries. USF also hosted a “drone hackathon” in partnership with the Ministry of Digital Transformation to develop drone technology.

Discussion

Watkins moderated the discussion on technological innovation. Taylor began by noting that ATI has

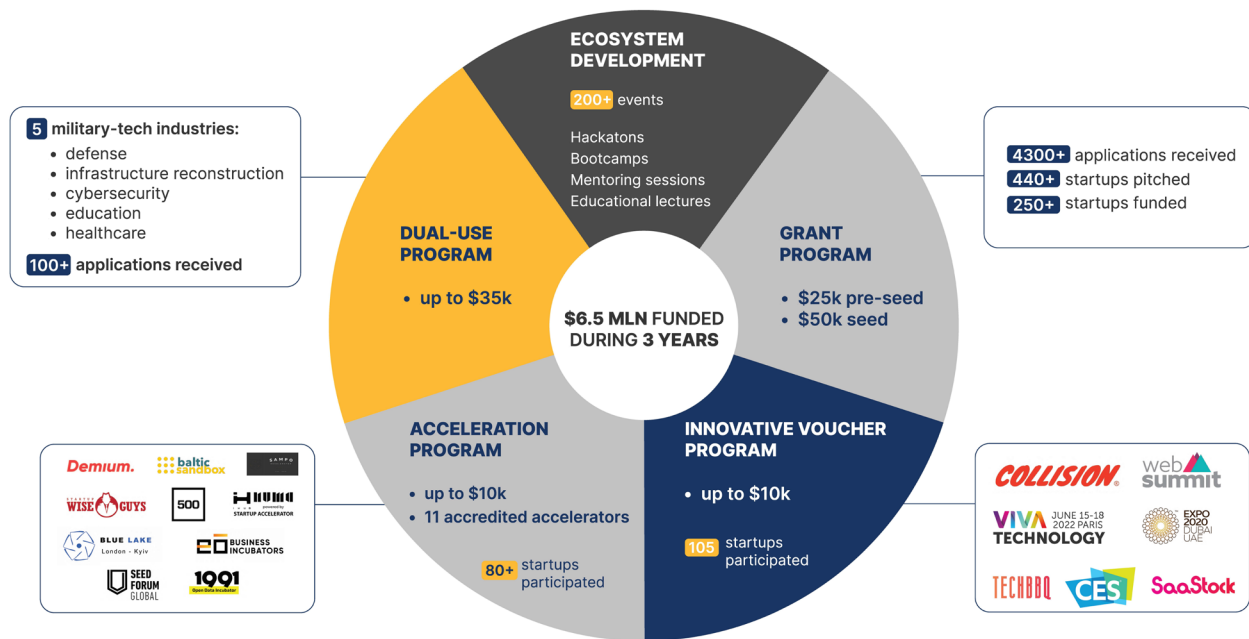


FIGURE 2 The various programs administered by the Ukrainian Startup Fund and their respective funding, including a dual-use program that targets five military-tech industries—defense, infrastructure reconstruction, cybersecurity, education, and healthcare. SOURCE: Pavlo Kartashov, Ukrainian Startup Fund.

¹⁷ See: https://fis.hu-berlin.de/converis/portal/detail/Project/901476666?auxfun=&lang=en_GB.

¹⁸ See: <https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?locations=UA>.

¹⁹ See: <https://usf.com.ua/en/>.

rigorous conflict of interest practices when working with university partners to avoid perceived or actual conflicts of interest—these practices are publically available online to Ukrainians who might want to adapt or draw from them. Molnar added that there is often a dichotomy between “regular businesses” and advanced manufacturers, but innovation should not be thought of just as the highest technology. Every business has an opportunity in the rebuilding process to take advantage of innovative technologies and work collaboratively. Molnar emphasized that there should be a holistic view of rebuilding that is not just focused on technology, but includes all elements that are necessary for rebuilding – workforce skills, access to capital, access to funding for the supply chain, and infrastructure. In response to a question about the role of the Ministry of Defense (MOD) in funding and encouraging applications of technology, Kartashov noted that the USF hosted the drone hackathon in partnership with the MOD, but it is up to the MOD to decide how they will contract companies and startups. Watkins added that the public procurement process is not just for military purposes, and could be a powerful stimulus for Ukrainian innovation.

RESEARCH FUNDING

Best Practices in Managing Research Funding

Mark Ferguson, European Innovation Council, discussed his experience as Director General of Science Foundation Ireland (SFI). SFI²⁰ is one of three enterprise agencies, including Enterprise Ireland, which supports indigenous companies, and IDA Ireland, which attracts foreign companies. SFI identifies priorities for research and links research in higher education. To industry, SFI gives grants to researchers in HEIs in Ireland through a competitive, merit-based review by international reviewers. Ferguson noted that there are 16 SFI research centers that include collaborations across Ireland, meaning that there is excellence in a particular subject spread throughout the country instead of excellence concentrated at a particular university. Each center must win money from industry and competitive, peer-reviewed sources that are not part of the Irish system to ensure that the centers are globally competitive. SFI also runs the Centres for Research Training, a 100 million

²⁰ See: <https://www.sfi.ie/>.

euro investment which supports over 700 postgraduate research students, with industrial collaborations and additional co-funding including 11 higher education institutions and over 90 industry partners. These national collaborations ensure that students and researchers work with, and are trained by, the best, regardless of where they are based. This ensures efficiency, high standards, and teams that are globally competitive.

Ferguson also discussed the European Innovation Council’s (EIC)²¹ work in Ukraine. The EIC launched a program to help Ukrainian startups apply to the EIC accelerator and integrate Ukrainian innovators into the European innovation system. EIC launched another program to create a network of organizations across Europe and Ukraine to support companies that are either established in Ukraine or relocated to an EU country after the Russian invasion. The program delivers 60,000 euros to those companies through individual grants for innovation and business development activities.

Panel: Research Funding

Olga Polotska, National Research Foundation of Ukraine (NRFU), stated that the NRFU is a state budgetary non-profit created in 2018 to provide grant support for both fundamental and applied research. Polotska noted that the NRFU is primarily focused on integrating Ukrainian science into the international scientific area and creating opportunities for Ukrainian researchers to join the international research community. The NRFU holds bottom-up calls for research proposals with quality being the underlying principle for selection. Polotska said that the organization is working to preserve Ukrainian scientific potential by asking international partners for support and identifying additional funding sources guided by a new 2022–2024 fundraising strategy.

Maria Leptin, European Research Council (ERC), outlined some of the ERC’s funding practices. The ERC’s mission is to fund excellent research across the entire range of academic activities in a bottom-up way. The ERC accounts for 3 percent of research funding in Europe, or 2 billion euros per year. Leptin noted that the grants

²¹ See: https://eic.ec.europa.eu/index_en.

are very generous and there are no demands from the grantees in terms of impact. Ukraine is eligible to apply for grants. Leptin said that the ERC has asked all of its grantees to advertise any open positions in research groups on their websites and offer them to displaced Ukrainians, and many of these positions have been filled. The ERC is looking at options for funding researchers to transition back to Ukraine once the war is over. Leptin emphasized that in order to attract ERC grants, a country must be attractive to top-level researchers. This includes having quality research infrastructure, career structure solely based on merit, and an independent granting system that provides individual grants.

Curtis Bjeljic, SCTU,²² stated that while the STCU has transitioned to focus more on CBRN security, it still works to help dual-use researchers and former weapons scientists of Ukraine implement projects that further Ukrainian science. Bjeljic noted the importance of ensuring that Ukrainian researchers and scientists stay in Ukraine, and any programs discussed should help Ukrainians do this.

Discussion

Robin Grimes, Royal Society, moderated the discussion on research funding. In response to a question about the NRFU adopting a center-based, cross-cutting financing structure modelled on Science Foundation Ireland, Polotska stated that the NRFU's funding system is not well-developed, and diversification of financing would make it more sustainable. Not all the funding from the Ukrainian government can be allocated to competitive grants, but the funding should be higher than it is now. Polotska said that the NRFU must identify the top intellectuals in Ukraine, and it is critical to learn about the experience and best practices of other countries. On the role of international reviewers in competitive selection, Polotska stated that both national and international experts are involved, but it depends on each call for applications. If the NRFU expects a call to be particularly competitive, one foreign reviewer is required. Shulga noted that the involvement of foreign reviewers has received pushback from NASU in the past. Polotska noted that there are many legal limitations imposed on

the NRFU as a state budgetary institution, but it can accept donations.

Bjeljac noted that some multinational corporations and Western companies will need to see a security arrangement in Ukraine where their investments are secure before investing, even in the long-term. Bezvershenko added that the NRFU is the best partner for international donors and also has huge outreach within Ukraine. Human capital should be supported not only through direct investment from external actors but also through building the capacity of institutions for long-term reform so they will be effective after the war. Ferguson noted that SFI was created because: (1) the government instituted a national foresight program that recommended the creation of SFI, (2) high levels of government pushed for reforms, and (3) SFI was established before the economic crash. Ferguson also noted that EU membership has been critical for this process and in helping Ireland become a global competitor.

GENERAL DISCUSSION

Gerson Sher, National Science Foundation and CRDF Global (retired), moderated a general discussion on the themes of the entire workshops and next steps for Ukraine. Bezvershenko noted that the Ukrainian government or NASU cannot be persuaded to change how they operate right now, arguing that the focus should be on first addressing the urgent needs of the science system and then attempting long-term reforms. The urgent needs require international experts and donors to be involved in keeping Ukrainian science alive and ensuring they invest in human capital. Bezvershenko stated, in the long-term, communication and collaboration between Ukraine and the international community will be needed to think through a strategy for systemic reform. Kolezhuk agreed that in the long-term, the capacity and expertise for science and technology policy must be developed among policy-makers. Polotska noted that the NRFU needs advice and guidance from international colleagues on how to structure reforms. Bezvershenko noted that while Ukraine has regular dialogue with the EU through the Horizon 2020 program,

²² See: <http://www.stcu.int/>.

there is limited Ukraine–U.S. dialogue on these issues, and argued that direct contact should increase.

Summary and Next Steps

Rita Colwell concluded the workshop by highlighting key points that emerged throughout. She noted that investing in human capital and using a merit-based competitive approach to research selection are two key best practices

that emerged across the discussions. Another key aspect is having the government understand the link between science and reconstruction. Colwell also stated that it is critical for scientists and researchers to remain in Ukraine. Finally, Colwell concluded that the international community must engage in collaborations and partnerships with Ukraine to help institute these best practices.

DISCLAIMER This Proceedings of a Workshop—in Brief was prepared by **Candace Huntington** as a factual summary of what occurred at the workshop. The planning committee's role was limited to planning the workshop. The statements made are those of the rapporteurs or individual workshop participants and do not necessarily represent the views of all workshop participants; the planning committee; or the National Academies of Sciences, Engineering, and Medicine.

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REVIEWERS To ensure that it meets institutional standards for quality and objectivity, this Proceedings of a Workshop—in Brief was reviewed by **Mary Sue Coleman**, American Association of Universities; **Mark Ferguson**, European Commission; **Oleksiy Kolezhuk**, Taras Shevchenko National University of Kyiv; and **Nataliya Shulga**, Ukrainian Science Club

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For additional information regarding the workshop, visit <https://www.nationalacademies.org/our-work/rebuilding-research-education-and-innovation-in-ukraine-a-workshop>.

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