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Principles of Open Science in the Activities of a Technical University

Abstract

The *purpose* of the article is to analyse and present the use of Open Science principles and their implementation in the activities of Lutsk National Technical University. *Methodology.* The main provisions of the Open Science concept and their implementation in European and Ukrainian official documents are analysed. It has been found that at Lutsk National Technical University (LNTU) the principles of Open Science are implemented in three main areas: in the educational process; in research activities; in informal promotion among students and other stakeholders. As a result, the authors found that participation in international projects, in particular ERASMUS+, causes changes in educational and scientific activities towards the creation of a fair and competitive educational space. New disciplines, such as Open Scientific Foundations and Information Management Practice, have been introduced into the educational process of masters and postgraduate students. The implementation of the policy of openness of scientific research is mainly limited to open publications in scientific journals and public discussion of research results at conferences and seminars. Informal trainings on academic integrity and Open Science involving students and teachers help to promote the principles of Open Science. The effectiveness of the training for LNTU students has been experimentally established. After the training, most students understood the basic principles of Open Science and were able to give examples of their use at LNTU, but they are not yet ready to apply them in their first scientific or academic achievements. *Practical implications.* These examples of implementation of Open Science principles in educational and scientific activities of LNTU illustrate an important vector of development of the technical university towards joining the European higher education area. At the same time, the authors came to the conclusion that it is necessary to conduct a broad information campaign among research and teaching staff for their further implementation.

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1 Introduction

The future of the civilisation in general and of each individual in particular is determined by scientific and technological progress. Science plays a key role in this, which is why the discourse on the creation and dissemination of scientific knowledge does not lose its relevance. The term "Open Science" is gaining popularity (Google Scholar search engine gives more than 36 thousand links in Ukrainian and more than 9 million in English). Among the numerous long and short interpretations of this concept, this paper uses the one presented in the review by R. Vicente-

Saez and C. Martinez-Fuentes: "Open Science is transparent and accessible knowledge that is shared and developed through collaborative networks" (Vicente-Saez, 2017).

Open access to knowledge, as well as peer review and evaluation of research, are irreversible trends in the modern scientific world. Another aspect is bridging the gap between research and society, as well as developing accessible tools for collaboration between scientists. As noted by (Fecher, 2014) As Fecher (2014) notes, "...openness could refer to pretty much anything: The process of knowledge creation, its result, the researching individual him-

Keywords

education, research, open educational resources, Open Science, Open Data

JEL: I21, I23, O33



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or herself, or the relationship between research and the rest of society." Ukrainian higher education institutions are striving to become part of the European educational and scientific space. That is why the implementation of Open Science principles is so important.

The application of Open Science principles has great potential to accelerate the research cycle on global human problems in the 21st century. This is recognised in a number of recent documents from global intergovernmental organisations such as the European Commission, the European Parliament, the European Council, the Organisation for Economic Co-operation and Development, the United Nations and the World Bank (European Commission, 2016; Open Science, 2020). Experts from the Organisation for Economic Co-operation and Development (OECD) interpret Open Science in its broadest sense as an activity that transforms the scientific process through digital technologies, making it more open and inclusive for all stakeholders within and outside the scientific community (Dai, 2018).

The UNESCO Intergovernmental Expert Meeting noted the impact of existing Open Science practices and infrastructure on innovation, research dynamism and economic partnership, and pointed to strong evidence of economic benefits and significant returns on investment in this direction (Recommendation, 2021; Towards, 2020). Open Science should help to reduce inequalities in access to scientific development, infrastructure and opportunities between different countries and researchers, regardless of gender, nationality or level of financial security.

For example, Open Science is changing approaches to scientific publication through the use of Open Access platforms, access to research data according to the FAIR (Findable, Accessible, Interpretable and Reusable) principle, and the distribution of educational resources, software and hardware with open licences (Bronner, 2022).

Despite the hostilities, the Ukrainian scientific and educational space is also implementing the Open Science implementation strategy (Resolution "On Approval of the National Plan regarding Open Science" of October 8, 2022 № 892-p). The Institute of Higher Education of the National Academy of Educational Sciences of Ukraine is engaged in a systematic reflection on the theoretical foundations of enhancing the research potential of Ukrainian universities in the context of the Open Science concept (Theoretical foundations for increasing the research capacity of universities of Ukraine in the context of implementation of the "Open Science" concept: preprint (analytical materials), 2021).

The purpose of the article is to analyse the ways of introducing the principles of Open Science into the educational process of Lutsk National Technical University.

2 Theoretical Background

The concept of Open Science is implemented through a number of core practices, such as (Dijk, 2021): Open Data (free access to all empirical data that serve as source material for scientific research); Open Analysis (demonstration by scientists of the full way of data processing); Open Materials (access to protocols, techniques and procedures necessary for successful replication research); Preregistration (the need for researchers to outline all parameters of their study, clearly describing their own hypotheses, methods of data collection and a plan for analysing these data); Open Access (providing free access to scientific publications).

It is becoming common practice to publish all raw data used in scientific work, as opposed to presenting only summary data in the form of averages and standard deviations (Kraker, 2011; Nuijten, 2019). In this way, the authors of the publication ensure that anyone can reproduce the research procedures using all the materials used in the study.

Guided by the principles of FAIR (Findable, Accessible, Interoperable, Reusable), it contributes tools to train and motivate honest researchers to improve their scientific practice and promotes greater transparency at all stages of the research process (Allen, 2019; Banks, 2019). Through an open demonstration of the scientific process and its results to the scientific community and the general public, scientific behaviour and communication will be optimised (Besançon, 2021).

However, promoting the principles of Open Science also raises a number of concerns. The discovery of scientific publications can accelerate forms of dishonest behaviour such as plagiarism, the theft of ideas, the development of predatory journals (Finance, 2023). Hasty and unverified conclusions can have serious unintended consequences, in particular misinformation (Besançon, 2021). It is also difficult to implement the principle of "as open as possible, as closed as necessary". Obviously, implementing the concept of Open Science requires abandoning some of our old habits and acquiring new skills (Dienlin, 2021).

The university as an educational and research environment is the cornerstone of high-quality scientific research. In order for Open Science practices to become widespread, it is important that they become an integral part of the training of future researchers (O'Carroll, 2017). Open Science has become a relevant trend in European higher education in recent decades. It is not just about using open educational resources (so-called MOOCs) or information from digital libraries. T. Heck et al. argue that "...empowering students through open educational practices increases their awareness of

the future goals of open science and teaches them the skills needed to achieve these goals" (Heck, 2020). Educators encourage students to adopt Open Science practices as part of the guidance and mentoring process.

In leading European universities, there is a shift from a narrow understanding of Open Science as Open Access to scientific sources, data and software to a view of it as a special environment in which partnerships between scientists, society and business are combined. As an example of good university practice in implementing the principles of Open Science, see the illustration from (Boon, 2022) (Figure 1).

Improving the availability of research data, publications and ideas about research methods helps to increase trust in science and the university as a public institution. The implementation of the Open Science concept allows citizens to participate in scientific projects and scientists to consult with stakeholders in society, thereby broadening and sharpening their views on problems, issues and possible solutions (Boon, 2022).

In recent years, there has been a theoretical understanding and active implementation of the principles of Open Science in the Ukrainian educational environment. For example, researchers at the Institute of Information Technologies and Learning Tools of the NAES of Ukraine have identified the principle of Open Education (Bykov, 2018): the principle of mobility of students and educators in the labour and educational markets; the principle of equal access to educational systems to meet the need for lifelong learning; the principle of quality education that meets the individual educational needs of students and the requirements of society; the principle of market mechanisms for shaping the structure and implementation of educational services.

The means of implementation of Open Science is the cloud educational and scientific environment

of higher education institutions (Bykov, 2018). It is determined that the wide involvement of the means and services of cloud-oriented scientific and educational networks in the educational and scientific process contributes to the improvement of qualitative and quantitative indicators. The use of new forms and models of organisation of educational and scientific activities positively affects both learning outcomes and the effectiveness of scientific research. The principles of Open Science have also become the subject of reflection in academic disciplines.

Given the relevance of this issue, the analysis of the implementation of Open Science principles in Ukrainian higher education institutions requires additional attention.

3 Results and Discussion

The active implementation of the principles of Open Science at Lutsk National Technical University is associated with participation in the ERASMUS+ KA2 project "Open Practices, Transparency and Integrity for Modern Academia" (OPTIMA) 618940-EPP-1-2020-1-UA-EPPKA2-CBHE-JP. The main goal of the project is to introduce the ideas and practices of Open Science to improve the quality of educational services in Ukraine. The project will result in the creation of online peer review platforms that will bring together international virtual communities of expert scientists to transparently evaluate the results of repeated research at scientific conferences at Ukrainian universities. From 12th to 16th of June, 2023 Université Côte d'Azur (Nice, France) hosted a seminar of the OPTIMA project, in which the LNTU team participated. The International Open Peer Review Platform for Ukraine was presented there. Before the end of the project, researchers from LNTU and other Ukrainian universities should test it in their own scientific activities.

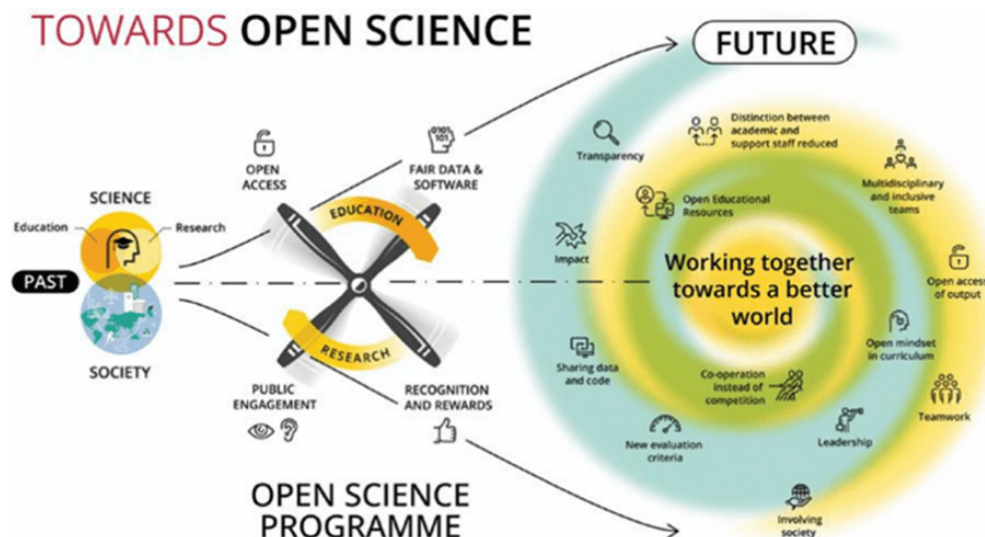


FIGURE 1 Mission and vision of the Open Science Programme at Utrecht University
Source: (Boon, 2022)

Another aspect of the project is to raise awareness of academic integrity and Open Science, to improve Open Practices and skills in Open Science in Ukrainian universities and society at large by introducing new subjects on Open Practices within modernised training courses and an open public online course.

The result of the combination of Open Science and Open Education are Open Practices, the components of which are tools (blogs, wiki, learning platform, editing pad), activities (sharing, communicating, discussing, evaluating) and resources (data, book, article, presentation, multimedia) (Heck, 2020). Analysing the educational and scientific activities of the LNTU, examples of each component are given in Table 1.

When considering the use of Open Science principles at Lutsk National Technical University, three main areas are highlighted:

- Educational process;
- scientific activity;
- promotion of Open Science.

The openness of the educational environment is demonstrated by the LNTU website <https://lntu.edu.ua/en>. The e-portal tab focuses on the most important educational and information resources. The LNTU repository contains pedagogical and methodological developments of teachers, scientific articles and monographs, texts of bachelor's and master's theses. Educators' and students' electronic cabinets provide all relevant information about the educational process and its evaluation.

The main educational platform is LSM MOODLE (Modular Object-Oriented Dynamic Learning Environment). The tab "Platforms for Skills Improvement and Self-Development" contains links to educational resources that offer formal and informal learning in the public domain (Coursera, Udemy, Prometheus, EdEra, etc.). Anyone can join the Ukrainian Global Faculty, which provides advanced educational content from the world's leading scientists in various fields of knowledge (economics, ecology, history, artificial intelligence, etc.). The educational process includes the main aspects of the Open Science concept. This is a separate topic in the discipline "Methodology of Scientific Research" for masters

and postgraduate students or a special discipline (elective or normative, depending on the major).

In 2023, the LNTU updated the Master's programmes by introducing a new academic discipline "Open Scientific Foundations and Information Management Practice" in the compulsory part of the general cycle (5 ECTS credits). In the autumn semester of the 2022/2023 academic year, the discipline was studied by 84 applicants for the "Software Engineering" programme and 41 for the "Applied Mechanics" programme. The elective "Open Scientific Foundations and Practice in Ecology" (5 ECTS credits) is being prepared. In the academic year 2021/2022, 23 applicants studied the discipline and in the spring semester of the academic year 2022-2023, 34 applicants were selected to study the discipline.

The educational and scientific program PhD "Economics" with a new subject of choice "Open Science" (5 ECTS credits) was updated. The discipline was chosen by 7 applicants in the spring semester of the 2022-2023 academic year.

The aim of the course is to master the principles of using the concept of Open Science in students' research activities. The course content includes 2 modules: Module 1. Fundamentals of Open Science; Module 2: Institutional Support and the Open Science Environment.

The article discusses the methodology and applied methods of conducting scientific research in an open manner, as well as the theoretical and practical aspects of implementing the Open Science paradigm in both Ukrainian and international scientific spheres. It also clarifies the peculiarities of publishing scientific and technical results in Open Access and working with open and transparent research data. Particular attention is given to the application of open licenses and methods for open evaluation of scientific results, as well as modern information and communication technologies in the scientific field. The principles of building a business based on open innovations are also discussed.

The openness of assessment is illustrated by open student performance ratings and the results of a survey on the quality of the educational process, which are regularly conducted by the Department for Quality Assurance, Licensing and Accreditation.

TABLE 1 Aspects of implementation of Open Science principles at LNTU

E-tools	Resources	Activities
E-portal	University website	Project OPTIMA
MOODLE	https://mdl.lntu.edu.ua/	Academic discipline
Zoom	Library repository lib.lntu.edu.ua	Academic mobility
Google Meet	Scientific journals of LNTU in Open Access	Open quality assessment results
Classroom	Platforms for skills improvement and self-development	Reviewing graduation works
Viber	(Coursera, Udemy, Prometheus, EdEra et all)	Popularization among students and schoolchildren
Telegram	Ukraine Global Faculty	
Labster		

Source: compiled by the authors

Openness in the scientific aspect is demonstrated by scientific journals of LNTU, publications of which are in the Open Access. These are scientific journals "Computer Integrated Technologies: Education, Science, Production", "Economic Forum", "Technological Complexes", collections of scientific papers "Economic Sciences" and "Scientific Notes". The texts of doctoral dissertations are posted on the university website for public discussion. Every year, LNTU holds more than 10 national and international scientific conferences, the materials of which are also publicly available.

An important aspect of implementing the principles of Open Science is their wide popularisation. Informal trainings on academic integrity and Open Science are periodically held with the participation of students and educators. For example, on 25 May 2023, as part of the international OPTIMA project, students and schoolchildren talked to scientists from leading Ukrainian universities and members of the 28th Antarctic expedition, who are currently at the Faraday Station.

The principles of Open Science are at the heart of the work of the National Antarctic Centre's specialists, and the results are sent to leading research centres, where specialists around the world can use them to compare or combine with their own developments.

Interactive trainings are an effective way to promote Open Science. In April 2023, the experience of master's students who had taken courses in Open Science was shared with undergraduate students. The aim of the training was to broaden the understanding of the concepts and terms used in the educational and academic environment regarding Open Science, integrity and transparency. 68 students from the Faculty of Digital, Educational and Social Technologies, 65 students from the

Faculty of Transport and Mechanical Engineering and 35 students from the Faculty of Agricultural Technologies and Ecology participated. The coordinator of the OPTIMA project at LNTU, the Dean of the Faculty of Digital, Educational and Social Technologies, Halyna Herasymchuk, acquainted the participants with the main aspects of Open Science, and the master trainers conducted an interactive training.

Before the training, a survey was conducted, the key questions of which were as follows:

1. "Do you understand the term 'Open Science'?"
2. "Can you provide examples of the use of Open Science principles at LNTU?"

The results of the survey are shown in Figures 2 and 3.

Most of the bachelors who participated in the training did not know about the term "Open Science" and could not give examples of the spread of this direction in the activities of LNTU. However, after the training, only 3 students (1.8%) did not understand the basic principles of Open Science at all, 12 (7.2%) answered "rather not" to the first question. Only 2 students (1.2%) answered "rather no" to the second question, 98 (58.3%) confidently gave examples of the use of Open Science principles at LNTU, 68 (40.5%) answered "rather yes" to the second question.

The training was attended by senior students, who annually choose 4-5 disciplines to form an individual learning trajectory. To the question "Will you choose a discipline for in-depth study of the principles of Open Science in the future?" 38 (22.6%) students answered "Yes", 56 (33.3%) – "Rather yes", 50 (29.5%) – "Rather no" and 24 (14.3%) – "No". The main argument of those who were not interested in Open Science practices was that they were focused on acquiring practical skills for their future profession, rather than on scientific research.

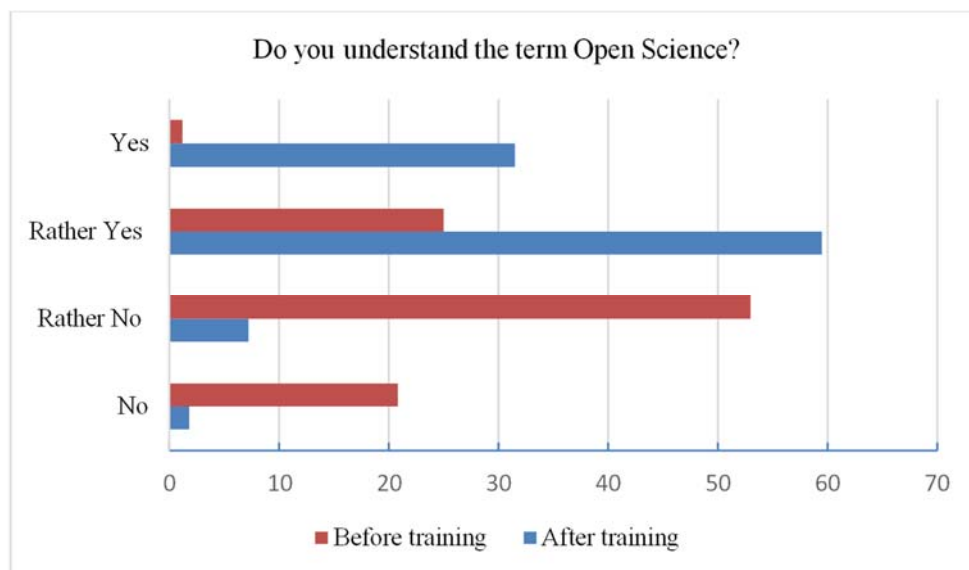


FIGURE 2 Histogram of answers to question No. 1

Source: compiled by the authors

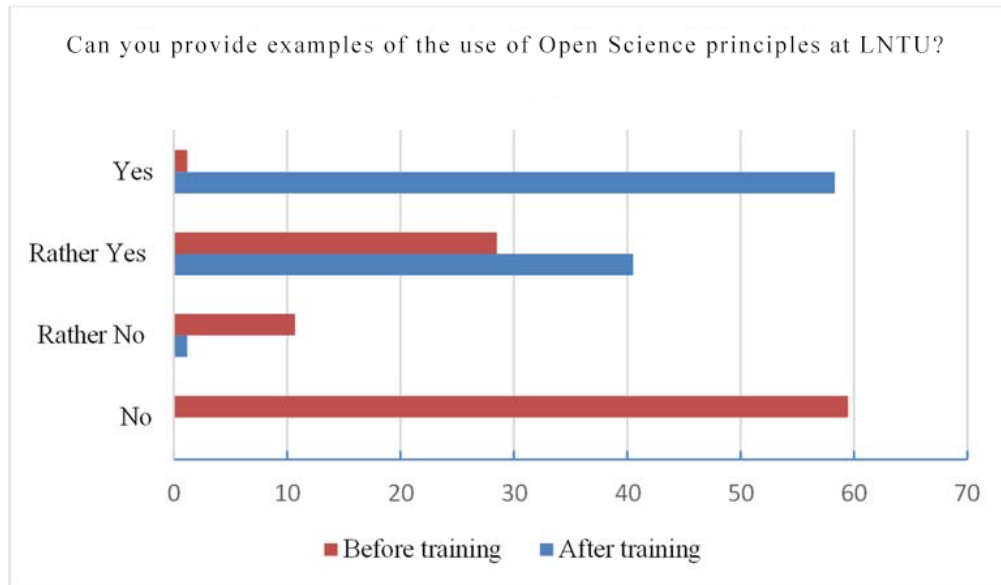


FIGURE 3 Histogram of answers to question No. 2

Source: compiled by the authors

To the question "Are you ready to submit your future bachelor's thesis for public defence?" 18 (10.7%) students answered "yes", 26 (15.5%) – "rather yes", 100 (59.5%) – "rather no" and 24 (14.3%) – "absolutely no". Among the reasons for negative answers, the most common were the following: "I am not sure of the quality of my own work", "I am afraid of criticism", "I am afraid that my work may be copied" and others.

Thus, it can be concluded that most students have understood the principles of Open Science, but they are not yet ready to apply them to their first scientific or academic achievements.

4 Conclusions

These examples of implementation of Open Science principles in educational and research activities of LNTU illustrate an important vector of development of the technical university towards joining the European Higher Education Area. Open Science and Open Education are both founded on high standards of transparency, collaboration, and communication. It is agreed by European researchers (Cronin, 2017; Heck, 2020) and Ukrainian researchers (Bykov, 2018; Drach, 2022; Marienko, 2021) that the implementation of Open Science enhances the value and effectiveness of science and improves the quality of education at universities. However, this text also highlights the challenges associated with implementing the principles of Open Science. As noted by Drach (2022), European universities face several obstacles in implementing Open Science policies, including insufficient motivation and readiness among researchers to embrace scientific openness, as well as legal and financial support issues. These challenges are also present in the Ukrainian educational space.

The analysis of LNTU's experience allows for the following conclusions:

- The implementation of the principles of Open Science in higher education institutions is directly related to digital cloud technologies, in which the university website plays a leading role;
- the experience of European universities in the field of Open Science is studied and implemented through participation in ERASMUS projects and academic mobility;
- coordination and advice on certain aspects of Open Science is provided by various university departments (scientific, project, quality assurance, licensing and accreditation);
- the implementation of the policy of openness of scientific research is mainly limited to open publications in scientific journals and public discussion of research results at conferences and seminars;
- events are held to popularise the principles of Open Science for both students and academic staff.

The principles of Open Science contribute to the creation of an innovative, open, virtuous, and competitive educational space. Broad information on the use of open access and research data management is needed to promote the Open Science policy on university websites. It is worth promoting the best practices of open research.

Special attention should be given to the principles of Open Science as a component of the disciplines for future researchers, including masters and graduate students. Further research will focus on the implementation of the principles of Open Science in the educational process. Another area of scientific work will be assessing the readiness of students, scientific and pedagogical staff, and administration of educational institutions to implement the principles of Open Science.

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