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THE IMPACT AND DYNAMICS OF INTERDISCIPLINARY RESEARCH IN CONTEMPORARY SCIENCE

Given the growing impact of interdisciplinary research on various fields of science, there is a need for a deeper understanding of how these processes work, what indicators to use to measure their effectiveness, which disciplines are involved in the process of interdisciplinarity and which are not. Therefore, the purpose of this study is to identify the place, role, and prospects of an interdisciplinary approach in science. To achieve this goal, the author considered the results of empirical study conducted by leading researchers in this field over the past 35 years. Using the methods of analysis and generalization, the article classified data by indicators of publications, research centers, the level of funding, and the use of new methods. As a result of information analysis, it was found that without the development of clear indicators for measuring the interdisciplinary component of research, it is extremely difficult to determine its place in science. Although interdisciplinarity is one of the main trends in modern science, the number of publications and research methods of monodisciplines have a significant advantage. However, interdisciplinary inquiry has higher rates for research centers and funding programs. At the same time, the data indicates that the highest level of interdisciplinarity is inherent in the medical and natural sciences, and the lowest - in the humanities. Hence the obvious need to abandon the approach of «dominant-auxiliary» disciplines, which is common in cooperation between the natural and socio-humanitarian sciences. It is also obvious that the communicative model of cooperation within the natural sciences is better developed than in social, and especially in the humanities. The solution to such imbalance is the encouragement of the synthesis of disciplines in the form of the creation of interdisciplinary journals and the recognition of these forms of work by the scientific community.

Key words: *discipline, interdisciplinarity, publications, methods, research centers, natural sciences, social sciences, humanities, scientific researches, communication.*

Articulation of the issue. In recent decades, the growth of scientific and technical knowledge has prompted natural scientists, engineers, and socio-humanitarians to join in the consideration of complex problems which are possible to solve only through the ability to attract knowledge from various fields of science. Among the many types and forms of integration of scientific knowledge, interdisciplinarity occupies a leading position. The value of interdisciplinarity is not only in opening new horizons for scientific work but also in providing an opportunity to rethink old problems that could not be solved using old approaches.

The study of the relationship between disciplinary and interdisciplinary research is still debated. In particular, there is a lack of infrastructure for such research, the need to formulate a regulatory framework for interdisciplinary work, and the development of communication tools. Another problem is the asymmetry of interdisciplinary research in different fields of science. There is a common tendency when representatives of natural sciences or engineering disciplines refuse the help of colleagues from the socio-humanitarian fields, appealing to the fact that they can do the layer of work that is usually assigned to the latter.

A particular challenge is the lack of clear indicators by which to measure the level of interdisciplinarity or its effectiveness. At the same time, it is obvious that the number of interdisciplinary studies increases every year. However, this indicator manifests itself differently in the natural, social and humanitarian fields of science. In particular, the level of communication between representatives within these fields,

the contribution of interdisciplinary research to the overall development of science, and the possibility of publishing the results of such research are taken into account.

Research objectives setting. The purpose of this article is to determine the place of interdisciplinarity in the leading fields of science, using such parameters as scientific publications, research methods, the possibility of obtaining grants or other forms of funding, and the creation of research centers.

Research methods. The author analyzed the empirical researches conducted by scientists and philosophers of various universities around the world from 1980 to 2015 on the place of interdisciplinarity in the natural, social and human sciences and classified these data by publications, methods, research centers, and funding. The article also used historical and systemic approaches, as well as methods of synthesis and generalization.

Research results presentation. Interdisciplinary research is dominant among other types of knowledge integration, as it is based on finding ways to bring together researchers who would not otherwise meet. At the same time, to better understand how the synthesis of knowledge occurs, it is necessary to take into account the different types of the motivation behind it. This can be an educational factor, a reaction to criticism, the development of integrative skills, a pragmatic approach to solving problems, or an identification of new interdisciplinary areas of knowledge [11, 156]. Therefore, most interdisciplinary connections are responses to the various challenges that a scientist faces in the course of his work.

There are several criteria for measuring the level of interdisciplinary impact on research. First, the relationship between the interdisciplinary project and previous disciplinary knowledge. Disciplinary canons remain relevant, as they are used to measure the performance of interdisciplinarity. Second, the balance of the perspectives of different disciplines, even if the disciplinary norms contradict each other. And third, the contribution of interdisciplinary work to understanding the essence of the study [8].

The success of interdisciplinary research depends on many factors: organizational structure, funding, support of the institution in which they are conducted, the staff of the research team, and the nature of the problem [12, 187-195]. A survey of 1,353 colleges and universities found that about 70% of scientists in all fields of science consider interdisciplinary knowledge to be better than monodisciplinary [5, 46]. Therefore, to better understand the place and role of disciplinary synthesis in science, several indicators should be taken as a basis.

Scientific publications. Since the 1980s, citations of publications from other disciplines have increased significantly. Such dynamics are observed in both natural and social sciences. There are various bibliometric methods used to analyze quantitative and qualitative indicators of scientific publications. The use of such methods in the natural sciences is quite common, but in the case of the social sciences and the humanities, the situation is ambiguous. The methodological value of indicators is in providing quantitative information on publications or results of interdisciplinary research and in facilitation the interaction between theories, terms, sources, and communication among scientists. Therefore, the creation of indicators that would take into account the place and role of interdisciplinarity in science could help to understand whether this process is a powerful tool for acquiring new knowledge.

In general, there are three types of journals with elements of a combination of several fields of science: inter-field, interdisciplinary and multidisciplinary. According to another classification, there are disciplinary, interdisciplinary, and multidisciplinary journals. The main indicators that determine the level of interdisciplinarity in scientific publications are the use of the same or similar terms in publications from different disciplines, «migration» of citations from one scientific field to another, or joint publications of representatives of different disciplines.

The methodology commonly used to determine the level of interdisciplinarity of journals is based on indicators that may reveal a link between disciplines or research topics. All branches of science are divided into categories, and then determine which categories are presented in publications in specific journals. The division of journals into different categories within one field of knowledge is called «internal», and that which covers remote areas of science is called «external» [10, 203-205]. There is another methodological approach that analyzes citations. It is similar to the previous, but has an important nuance: the interaction between scientific areas is found in citations that are made

within a particular discipline, but at the same time point to other research domains [17, 19]. I. Rafols proposed to use a network-analytical approach to determine the contribution to the interdisciplinarity of research that is cross-field or marginal-disciplinary [13, 10]. The importance of taking this approach into account is that usually these types of researches find no place in various classifications. Thus, it is unclear what their real contribution to the development of an interdisciplinary paradigm of knowledge.

According to a study of interdisciplinary citations as of 1995, it was found that 69% of scientific publications use citations from other fields of science. In particular, 97% of articles on medical informatics refer to biomedical disciplines. In total, in about 14 disciplines, interdisciplinary citations account for more than 90%. At the same time, in such scientific fields as astronomy and mathematics, intradisciplinary citation predominates [15, 184].

Another study conducted in England in 2007 found that the most cited interdisciplinary publications were equated to the average cited disciplinary publications [2]. Most of these researches use a methodology that calculates the level of interdisciplinarity by the percentage of citations published by representatives of different disciplines. This figures vary in different fields of science. In medical disciplines, it is 79%, in natural sciences - 61%, in social sciences - 37% and in the humanities - only 5%. Narrowly disciplined or too interdisciplinary publications are least likely to be cited. [6, 127]. At the same time, interdisciplinary articles usually have a larger number and variety of citations than monodisciplinary ones. On the other hand, they are also more likely to be either an actively cited article or not cited at all [7, 118]. Some studies suggest that moderate interdisciplinarity has better citation rates than a combination of very distant branches of science [16, 306].

In the modern scientific community, there is a significant increase in co-authored publications in all disciplines, while the correlation of such publications per the field of knowledge is different. According to some studies, the number of collective socio-scientific publications increased from 17.5% to 51.5% between 1955 and 2000 [18, 1037]. In the humanities, the co-authorship rate is the lowest, however, in general, the trend indicates a significant increase in this process. In the period 2001-2010, the most interdisciplinary areas of science were medicine and biology, the average level of integration were shown by physiology, chemical physics, anthropology, archeology, statistics, and the least interdisciplinary were nuclear chemistry, nuclear physics, astronomy, astrophysics, clinical medicine [16, 307].

At the same time, it remains unclear why some scientific disciplines have a stronger connection than others. There is also a need to determine (if possible) the optimal level of interdisciplinary citation. This is necessary to prevent two extremes in scientific work: narrow specialization, when research is so local that it is of no value to science, or scientific dilettantism when a scientist appeals to disciplines in which he does not have a sufficient level of knowledge.

Methods. The problem of interdisciplinary methodology is one of the weak links in knowledge integration. The lack of clear methods of interdisciplinary work creates many obstacles for this type of research. At the same time, the question of whether such a methodology can exist in principle remains unanswered, as disciplinary methods can differ radically. W. Newell and J. Klein noted that «cross-fertilization of research methods and concepts» began to be actively implemented in science in the 1980s. This was facilitated by the «hybridization of scientific practices» and the fact that knowledge has become «heterogeneously complex and hybrid» [11, 155].

The main methodological challenge for interdisciplinarity is how to combine quantitative methods (natural science and mathematics) with the interpretive (social and human sciences). For example, a statistical method of survival analysis, which determines the probability and duration of a particular process is commonly used by many branches of science. In particular, in engineering, it is known as «reliability analysis», in economics – «duration analysis», and in sociology «event history analysis» [1].

Another methodological approach is a constructive assessment of differences of opinion. N.Marres argues that in the natural science methodology, the lack of agreement on methods can be regarded as a negative phenomenon, as a lack of stability in the study. However, for social sciences and the humanities, differences are sometimes seen as «components of the empirical phenomenon being studied». So the dispute, in this case, should be seen as an element of transformation rather than degradation. [9, 1047].

Funding. Financial institutions have great potential to promote both disciplinary and interdisciplinary research. The number of scientific disciplines is growing, therefore, the number of laboratories, research centers, university departments, and faculties increases, too. Therefore, it is advantageous to combine highly productive scientific fields with low-productive ones. Secondly, scientific fields and methods are becoming increasingly interdependent. Thus, to achieve the result it is not enough to finance a separate industry. On the contrary, there is a common tendency to solve problems in one discipline by engaging in related disciplines. For example, such fields as biology, mathematics, chemistry, computer science, and engineering are often funded to work within the life sciences. The first serious joint research began in the 1950s and 1960s in the form of educational programs. The Whitaker Foundation, established in 1975, played a crucial role in the development of bioengineering. It launched large funding programs designed to assist institutions in establishing or developing biomedical engineering departments and programs. [4, 132-133].

At the same time, some studies indicate that interdisciplinary projects are less likely to receive funding than disciplinary ones. In particular, within integrated research projects, «close» interdisciplinarity is more likely to receive funding than «distant» interdisciplinarity [14, 314].

Research centers. For the first time, research centers, private and public foundations began to fund interdisciplinary researches in the interwar and postwar periods. Funding was largely public and focused primarily on solving social problems. However, private foundations also played an important role in this process with Russell Sage (1907), Rockefeller (1913), and Spellman (1968) pioneering in this area. Such cooperation created the preconditions for expanding the boundaries of the disciplinary structure of science. In the Cold War, interdisciplinary projects were reoriented toward the problems of security, information, and social behavior.

Since the 1980s, interdisciplinary centers, institutes, and schools have become an integral part of the world's leading universities, where they typically perform a communicative function to bring together different majors, departments, faculties, and colleges. In the late 20th – early 21st centuries, public funding began to significantly dominate and determine the central themes and areas of interdisciplinary research. One of the most famous examples is the Minerva Initiative (2008), sponsored by the US Department of Defense. It provides grants to support academic research in the social sciences that are of strategic importance to US national security policy. The importance of non-governmental and non-profit organizations in promoting interdisciplinary projects increases [3].

In 2007, the U.S. National Institutes of Health funded nine interdisciplinary research consortia to bring together different disciplines to address health issues that were resistant to traditional research approaches. Similar projects have been implemented in other universities and research institutes. In particular, it is the International Center for the Study of Terrorism, the Center for Information Support of Computer Systems and Security Technologies, the Center for Protection of People and Infrastructure from Terrorist Attacks, etc. [5, 60].

However, some researchers draw rather disappointing conclusions in their analysis of the role of research centers in the interdisciplinarization of science. In particular, there is an opinion that such centers are usually organized around «trendy» («fashionable») or too general topics, which in reality do not create opportunities for real cooperation between disciplines [5, 54].

Conclusions and research perspectives. Analyzing the research, we can conclude that the success of an interdisciplinary project (publications, centers, funding, etc.) requires several factors. First, the understanding by all participants of the purpose and final results of the study. In addition to the methodological role, it also has a psychological component. In case a project result is unsatisfactory, it motivates participants to further work. Second, the rejection of the approach which determines the «leading» and «serving» discipline. This is important for the social sciences, and especially for the humanities, which are usually not equal partners in interdisciplinary projects, but play a supporting (advisory) role. Third, it is important to either create a new system of criteria for evaluating interdisciplinary research, which will go beyond the disciplinary standard and will differ significantly, or to maintain disciplinary autonomy and alternate criteria of one discipline with another according to the specifics of the study. Fourth, interdisciplinarity should develop not only

horizontally (involve as many disciplines as possible in research), but also vertically (to delve into the essence of partner disciplines for a better understanding of their tools, methods, and terms, etc.). Fifth, the presence of constant communication between the participants of the research, especially in the field of the humanities. Sixth, communication with stakeholders in the form of government projects and collaboration with various industries. The practical value of the study significantly increases its demand both within the scientific community and beyond.

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ВПЛИВ ТА ДИНАМІКА МІЖДИСЦИПЛІНАРНИХ ДОСЛІДЖЕНЬ У СУЧАСНІЙ НАУЦІ

Зважаючи на зростаючий вплив міждисциплінарних досліджень на різні галузі науки, виникає потреба глибшого розуміння того, як ці процеси працюють, які показники використовувати для вимірювання їхньої ефективності, які дисципліни досить жваво включилися у міждисциплінарне співробітництво й активно залучають його у своїх дослідженнях, а які майже не приймають участі у цих процесах. Тому метою даного дослідження є виявлення місця, ролі та перспектив міждисциплінарної роботи у провідних галузях науки. Для досягнення цієї мети автором проаналізовано результати емпіричних досліджень, що проводилися провідними фахівцями у цій галузі впродовж останніх 35 років. Використовуючи методи аналізу та узагальнення, у статті класифіковано дані за показниками публікацій, дослідницьких центрів, рівня фінансування та використання нових пошукових методів. У результаті аналізу інформації виявлено, що без розроблення чітких індикаторів вимірювання міждисциплінарного складника дослідження визначення її місця в науці є вкрай складним. Хоча міждисциплінарність є однією з головних тенденцій у сучасному науковому пізнанні, за кількістю публікацій та дослідницькими методами монодисципліни мають значну перевагу. Однак міждисциплінарні дослідження мають вищі показники щодо наукових центрів та грантових програм. Водночас дані вказують на те, що найвищий рівень міждисциплінарності притаманний медичним та природничим сферам, а найнижчий – гуманітарній. Звідси випливає очевидна потреба у відмові від підходу «домінуюча – допоміжна» дисципліна, що є поширеним у співпраці між природничонауковими та соціогуманітарними напрямами науки. Також очевидним є те, що комунікативна модель роботи у межах природничих дисциплін краще розроблена, ніж у соціальному, особливо в гуманітарному пізнанні. Важливим чинником є заохочення до синтезу дисциплін у вигляді створення міждисциплінарних журналів та визнання таких форм роботи науковим співтовариством.

Ключові слова: *дисциплінарність, міждисциплінарність, публікації, методи, дослідницькі центри, природознавство, соціальні науки, гуманітарні науки, наукові дослідження, комунікація.*