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TRANSDISCIPLINARITY: MARGINAL DIRECTION OR GLOBAL APPROACH OF CONTEMPORARY SCIENCE?

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ABSTRACT

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| Aim/Purpose | The article is designed to contradict the existing opinion that “transdisciplinarity is a marginal direction of contemporary science.” |
| Background | The difficulties of implementing transdisciplinarity into science and education are connected with the fact that its generally accepted definition, identification characteristics, and methodological features are still missing. In order to eliminate these disadvantages of transdisciplinarity, its prime cause and initial idea had to be detected. Then an attempt was made to analyze correspondence of the existing opinions about transdisciplinarity with the content of its prime cause and initial ideas. |
| Methodology | The bibliometric content analysis of the literature reviews on the subject of transdisciplinary was used in order to determine correspondence of the opinions about transdisciplinarity with the meaning of its prime cause and initial ideas, as well as to generalize these opinions. This method allowed detecting and classifying opinions into 11 groups including 39 stereotypes of transdisciplinarity. For substantiation of transdisciplinary approaches consistency with the approaches of the contemporary science C.F. Gauss random variables normal distribution was used. The “Gauss curve” helped to show the place of transdisciplinary and systems transdisciplinary approaches in the structure of academic and systems approaches. The “Gauss curve” demonstrated the step-by-step broadening of the scientific worldview horizon due to sequential intensification of synthesis, integration, unification, and generalization of the disciplinary knowledge. |

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Transdisciplinarity

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| Contribution | Based on rethinking the results from bibliometric content analysis of the literature reviews, the generalized definition of transdisciplinarity could be formulated, as well as the definition for the transdisciplinary and systems transdisciplinary approaches could be given. It was shown that transdisciplinarity is a natural stage for development of contemporary science and education, and the transdisciplinary approaches were capable to suggest the methods and tools to solve the complex and poorly structured problems of science and society. |
| Findings | Many existing stereotypes of transdisciplinarity do not meet its prime cause and initial ideas. Such stereotypes do not have deep philosophic and theoretical substantiation, as well as not suggesting the transdisciplinary methods and tools. Thus, the authors of such stereotypes often claim them to be transdisciplinary or suggest perceiving them as transdisciplinarity. This circumstance contributed to the fact that many disciplinary scientists, practitioners, and initiators of higher education view transdisciplinarity as a marginal direction of contemporary science. Based on the generalized definition of transdisciplinarity, as well as its prime cause and initial ideas, we managed to show that transdisciplinarity is presented in contemporary science in the form of two different approaches: the transdisciplinary approach and the systems transdisciplinary approaches. The objective of the transdisciplinary approach is ensuring science development at the stage of synthesis and integration of disciplinary knowledge. The objective of the systems transdisciplinary approach is ensuring solving of modern society problems using unification and generalization of disciplinary knowledge. |
| Recommendations for Practitioners | The practitioners should consider that the transdisciplinary and systems transdisciplinary approaches have different specific features. Within the limits of the transdisciplinary approach a team of disciplinary specialists forms a new method to solve each new problem every time. As a result, the problem solution is formed based on the consensus formed by compromises. Such a solution is difficult to be risk analyzed. Within the limits of the systems transdisciplinary approach a team of disciplinary specialists uses a universal systems transdisciplinary methodology to solve each problem. In this case the disciplinary specialists don't seek compromises but perform their part of the research using the disciplinary methods and tools. The disciplinary results are unified and generalized by the generalist specialist, who has a methodology of the systems transdisciplinary approach. In this case the problem solution shall be subject to risk analysis, as it is included into the basic research process. |
| Recommendations for Researchers | The researchers should consider that within the limits of the transdisciplinary approach the disciplinary specialists are managed. Within the limits of the systems transdisciplinary approach the disciplinary knowledge is managed. Thus, the transdisciplinary approach is efficient for organization and research with participation of the scientists of complementary disciplines. An example for such research can be a team of researchers of medical disciplines and complementary disciplines from chemistry, physics, and engineering. The systems transdisciplinary approach is efficient for organization and performance of research with participation of scientists of non-complementary disciplines, for example, economics, physics, meteorology, chemistry, ecology, geology, and sociology. |

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| Impact on Society | The prime cause of transdisciplinarity is associated with a desire of economists, politicians, and managers to find a method of efficient control for social and economic development of modern society searching for the solution for current problems accompanying this development. The transdisciplinary approaches formed the methods and tools to solve these tasks. So society can use the advantages of the transdisciplinary approaches, it is necessary to ensure that in the consciousness of the disciplinary specialists “the desire to have such approaches” coincide with “the desire to apply such approaches” for the benefit of the society. |
| Future Research | In terms of the main initial idea, transdisciplinarity is formed as a global approach. The global approach should have a traditional institutional form: it should be a science discipline (meta-discipline) and have carriers with the transdisciplinary worldview. Training for such carriers can be organized by the universities within the limits of the systems transdisciplinarity departments and Centers of Systems Transdisciplinary Retraining for Disciplinary Specialists. Thus, it is reasonable to initiate discussion for the idea to reform the disciplinary structure of the universities considering creation of such departments and centers. |
| Keywords | transdisciplinarity, transdisciplinary research, systems approach, systems transdisciplinary approach, higher education |

INTRODUCTION

In September of 2020 transdisciplinarity turned 50. Over the years many books, articles, and reports were published on the transdisciplinary subject. But it turned out that these publications contained different (depending on the certain situation) definitions of transdisciplinarity. The authors of these publications variously perceive transdisciplinarity and the transdisciplinary approach, as well as variously interpret their intended purpose and identification characteristics. These circumstances allowed for some researchers of transdisciplinarity to make the following conclusions:

Despite its increasing popularity, transdisciplinarity is still far from being academically established, and current funding practices do not effectively support it at universities and research institutions. One reason for this deficit is that a universally accepted definition for transdisciplinarity is not available yet. Consequently, quality standards that equally guide researchers, program managers, and donors are widely lacking. Therefore, a rhetorical mainstreaming of transdisciplinarity prevails, which risks marginalizing those who seriously take the integrative efforts creative collaboration requires. (Jahn et al., 2012)

We are sure that such conclusions are bad advertisement for transdisciplinarity and restrict attention to it on the part of the students and young researchers, who will have to solve the acute problems of the contemporary science. In order to change the relation to transdisciplinarity it is necessary to prove consistency of transdisciplinary approaches with the approaches of academic and system science. Thus, in this article we have classified and generalized opinions about transdisciplinarity, which are given in the literature reviews on the transdisciplinary subject; formed its generalized definition, which can play a role of its expected generally accepted definition; and shown the vital difference between the transdisciplinary and systems transdisciplinary approaches, as well as given recommendations for the researchers, practitioners, and sponsoring organizations concerning targeted use of these approaches. During substantiation of the article’s results, the features of the scientific worldview were considered, which were not always taken into account by the disciplinary scientists and practitioners. It is important to note that the definition for term “transdisciplinarity,” as well as the definition for terms “transdisciplinary approach” and “systems transdisciplinary approach” were formulated in terms of the prime cause of transdisciplinarity and two its initial ideas.

PRIME CAUSE AND INITIAL IDEAS OF TRANSDISCIPLINARITY

The prime cause is an expectation associated with the necessity to solve the current problem, which is assumed to be solved by the transdisciplinarity. The initial idea is a formulated thought, which expresses the essence, objectives, and prospects of transdisciplinarity, and it is an initiator for actions contributing to achievement of these objectives and prospects.

The prime cause of transdisciplinarity was formulated during the Working Symposium on Long-Range Forecasting and Planning (Villa Serbelloni, Bellagio, Italy, 27th October to 2nd November 1968), which was organized by the Organization for Economic Cooperation and Development (OECD). E. Jantsch, Austrian philosopher and astrophysicist, being one of Rome Club founders had a hand in the description of this prime cause. The participants of the symposium unambiguously spoke in favor of the problem solving, long-range forecasting, planning, and control of social and economic development of the society by creation and use of the global approach. The participants of the symposium expressed assurance that within the limits of the global approach a deep synthesis of disciplinary knowledge and different initial data should occur, which allows forming the comprehensive worldview. Thus, the following was recorded in the final symposium declaration:

Many of the most serious conflicts facing mankind result from the interaction of social, economic, technological, political and psychological forces and can no longer be solved by fractional approaches from individual disciplines. The time is past when economic growth can be promoted without consideration of social consequences and when technology can be allowed to develop without consideration of the social prerequisites of change or the social consequences of such change. (Jantsch, 1969, p. 7).

The international presentation of transdisciplinarity took place two years later during the Seminar on Interdisciplinarity in Universities, Paris, September 7th - 12th, 1970. This seminar was organized by the Centre for Educational Research and Innovation (CERI), which was a part of the Organization for Economic Cooperation and Development (OECD) in collaboration with the French Ministry of Education at the University of Nice, France (Apostel, 1972). This seminar is famous because during its preparation and debates the participants formulated two initial ideas of transdisciplinarity: main and additional.

The main initial idea confirmed that transdisciplinarity, as a global approach, had to have traditional institutional form: being a special discipline, more precisely, a meta-discipline. But the scientific approach and discipline cannot exist without carriers – scientists, teachers, students, and specialists having the transdisciplinary worldview. Training of such specialists required reforming of the disciplinary structure of the universities. On this subject E. Jantsch, an author of the main initial idea of transdisciplinarity, stated that, ultimately, the entire education / innovation system can be coordinated as a multilevel multigoal hierarchical system through the transdisciplinary approach implying generalized axiomatics and mutual enhancement of disciplinary epistemology (Jantsch, 1970, p. 403). During the seminar E. Jantsch specified his position in his report:

Transdisciplinarity – the coordination of all disciplines and interdisciplines in the education / innovation system on the basis of a generalized axiomatic and an emerging epistemological pattern. A systems approach as it is proposed in this paper would consider science, education, and innovation, above all, as general instances of purposeful human activity, whose dynamic interactions have come to exert a dominant influence on the development of society and its environment. Knowledge would be viewed here as a way of doing, a certain way of management of affairs. (Jantsch, 1972, pp. 105-106)

However, an idea of global approach creation seemed to be so ambitious that some participants of the seminar perceived a desire to perform the deep synthesis of disciplinary knowledge and different initial data as a basis for an independent (additional) initial idea of transdisciplinarity. The essence of the additional initial idea of transdisciplinarity was formulated by J. Piaget, a French philosopher and

psychologist. According to his opinion, transdisciplinarity would become an efficient method for deep synthesis of disciplinary knowledge. Within the limits of the additional initial idea transdisciplinarity didn't have to be the global approach being capable to perform vertical or external forms of coordination for organization principles, actively modifying disciplinary concepts, limits, and interfaces, as E. Jantsch proposed. Psychologist J. Piaget was interested in the prospects of natural integration (improvement of relations) of disciplinary discourses (verbal, language communication) but not in their external form of coordination. Thus, within his meaning transdisciplinarity was associated with the highest form of such integration. On this subject J. Piaget wrote:

We may hope to see a higher stage succeeding the stage of interdisciplinary relationships. This would be 'transdisciplinarity', which would not only cover interactions or reciprocities between specialized research projects but would place these relationships within a total system without any firm boundaries between disciplines. (Piaget, 1972, p. 138)

A key term "verbal, language disciplinary integration" assumes that for transdisciplinarity implementation it is sufficient to use the services of the experienced facilitator (a specialist ensuring successful group communication) and, thus, reach a consensus of opinions based on compromises of the disciplinary specialists. For verbal, language disciplinary integration, the conditions, which are formed within the limits of interdisciplinary, multidisciplinary research, are required. Thus, it was assumed that within the limits of the additional initial idea transdisciplinarity had to be a skill of the specialist, which was obtained within the limits of a temporary creative team of disciplinary specialists, but not in classrooms of the university.

Since 1970 both initial ideas of transdisciplinarity have initiated two parallel processes of the targeted actions in the area of science and education. Studying the literature on the transdisciplinary subject we came to a conclusion that a major part of Russian and foreign authors preferred to develop and describe a personal opinion about transdisciplinarity not often paying attention to the specific features of its prime cause and initial ideas.

SYSTEMATIZATION AND GENERALIZATION OF THE OPINIONS ABOUT TRANSDISCIPLINARITY

The most suitable primary documents for the task that we are trying to solve in this article are the literature reviews. The authors of such reviews initially select the books and reports that contain the complementary opinions about transdisciplinarity as well as perform primary generalizations of the opinion content. Thus, such reviews contain descriptions of the parameters, characteristics, and properties, which can play a role of identification characteristics of transdisciplinarity. In order to detect these parameters, characteristics, and properties, we performed bibliometric content analysis for 20 literature reviews and 80 analytical articles on the transdisciplinary subject that were published within the period from 1968 till 2021. The literature reviews on the transdisciplinary subject are in free access in the subject section of large scientific social networks: Academia.edu (Academia, n.d.); Researchgate.net (Researchgate, n.d.); Scholar.google.com (Scholar, n.d.).

The literature reviews contain special internet projects: Td-net (Td-net. Network for transdisciplinary research, n.d.); ATLAS (Academy of Transdisciplinary Learning and Advanced Studies, n.d.).

Examples of the literature reviews were articles by the following authors: Alvargonzalez, 2011; Arnold, 2013; Baptista, & Rojas-Castro 2019; Bernstein, 2015; Brandt et al., 2013; Brenner, 2014; Bazhanov, & Scholz, 2015; Darbellay, 2015; Jahn et al., 2012; Kiyshenko & Moiseev, 2009; Max-Neef, 2005; McGregor, 2014; Mobjörk, 2010; Mokiy, 2019a; Montuori, 2013; Osborne, 2015; Pasquier, & Nicolescu, 2019; Rigolot, 2020; Rimondi, & Veronese, 2018. Scholz, & Steiner, 2015a, 2015b; Thompson, 2013, 2014.

This list can be supplemented with the articles on the trans disciplinary subject, which were published within the last years in the specific issues of Informing Science: The International Journal of

an Emerging Transdiscipline (InformingSciJ) (<https://www.informingscience.org/Journals/InformingSciJ/Articles>) and Transdisciplinary Journal of Engineering & Science (TJES) (<https://www.atlas-tjes.org/index.php/tjes>).

The overview of the literature reviews allows focusing on the results of the primary generalization of the literature content, but not on the continuous quoting and discussions of its authors, as it occurs in the traditional literature reviews. The results on generalization of the literature review content allowed making a conclusion that the existing opinion about transdisciplinarity was recorded in the scientific environments in the form of 39 stable stereotypes.

TRANSDISCIPLINARITY STEREOTYPES

The stereotype is a belief or idea of what a particular transdisciplinarity is. This evaluation prevails in the scientific and personal consciousness and forms the prejudiced attitude to the term. Use of stereotypes allows for human brains to save energy spent for mental activity. The stereotypes simplify unordinary and fuzzy image of transdisciplinarity trying to describe it in expressions being simple and common for the authors of the articles and literature reviews. In terms of the certain articles the stereotypes of the transdisciplinarity appear to be convincing. However, it should be noted that authors of some stereotypes use their own perception of transdisciplinarity, which content turns out to be far from its prime cause and initial ideas. Probably this circumstance is one of the main reasons that some researchers consider transdisciplinarity to be a marginal direction of contemporary science. However, during bibliometric content analysis we detected that a major part of stereotypes recorded any certain property, parameter, or characteristic of the transdisciplinarity. This circumstance allowed classifying the detected stereotypes into 11 groups (A-K) (refer to Table 1).

Table 1. Distribution of Stereotypes by Similar Content

| GROUP OF STEREOTYPES | CONTENT OF STEREOTYPES |
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| A) Main prime causes of transdisciplinarity (6): | <ul style="list-style-type: none"> - Desire to have a global approach to the control of social and economic development of the modern society tending to globalization; - Desire to solve the problem for stable development of the modern society; - Desire to overcome division of the scientific disciplines and disciplinary knowledge; - Desire to integrate worldviews of the academic and systems approaches; - Desire to integrate knowledge of science and practice; - Desire to generalize mythological, religious, philosophical and scientific worldviews. |

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| B) Main initial ideas of transdisciplinarity (2): | <ul style="list-style-type: none"> - Transdisciplinarity of higher education as a meta-discipline (systems transdisciplinarity) allowing training the student in the systems transdisciplinary method for wicked problem solving in the modern society; - Transdisciplinarity of scientific research as a special type of transdisciplinary research allowing to the scientists and specialists to form unique methods to solve the certain complex scientific problem. |
| C) Meanings of “transdisciplinarity” definition (5): | <ul style="list-style-type: none"> - Declaration stating and protecting the equal rights of famous and little-known scientists, great and little science disciplines, cultures, and religions, in research of the outside world; - High level of education, versatility, generality of knowledge of the certain person; - Rule of the outside world research; - Principle of scientific knowledge organization providing great opportunities of interaction for many disciplines when solving the complex scientific problems; - Type of systems approach developed within the limits of forming meta-discipline “system transdisciplinarity”. |
| D) Transdisciplinarity forms (3): | <ul style="list-style-type: none"> - Theoretical form relating to research of the proper transdisciplinarity and its methodology; - Phenomenological form being capable to connect theoretical principles with observed experimental data when forecasting the further results; - Experimental form being capable to ensure the level of the experiment procedure reproduction and the results being acceptable for the scientific society. |
| E) Transdisciplinarity kinds (5): | <ul style="list-style-type: none"> - Transdisciplinarity-0 uses the illustrative potential of the artistic metaphor and figurative language as a basis; - Transdisciplinarity-1 designates formal interconnection of several disciplines during transdisciplinary research; - Transdisciplinarity-2 designates internal connection of the disciplinary knowledge with personal experience of the researcher; |

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| | <p>- Transdisciplinarity-3 is associated with use of the general metaphors having fundamental cognitive meaning;</p> <p>- Transdisciplinarity-4 is associated with forming meta-discipline (systems transdisciplinarity), in the basis of which there is a special world view (transdisciplinary reality) and transdisciplinary methodology of its research.</p> |
| <p>F) Transdisciplinarity types (2):</p> | <p>-Transdisciplinarity of ideal type (Mode 1) supposing creation of general cognitive-epistemological structure, by means of which an attempt to combine all disciplinary languages and specific types of causality is made;</p> <p>- Transdisciplinarity of real type (Mode 2) supposing cooperation of science, practice, and society (combining of scientific and empirical knowledge).</p> |
| <p>G) Institutional statuses of transdisciplinarity (4):</p> | <p>- Transdisciplinary approaches as a method for implementation of trends to integrate and generalize disciplinary, interdisciplinary and multidisciplinary knowledge and models of the object;</p> <p>- Transdisciplinary processes as a method for combining of “theoretical severity” of the scientific knowledge and “empirical wisdom” of practical knowledge about the real world;</p> <p>- Transdisciplinary research as a method for creation of different disciplines of new conceptual, theoretical, and methodological innovations to solve the complex scientific problems by researchers.</p> <p>- Transdisciplinary metadiscipline as a way to coordinate knowledge of the unconditional, intuitive, speculative, and empirical types of knowledge.</p> |
| <p>H) Trends for transdisciplinarity activity (5):</p> | <p>- First trend (slogan “Integration”) is a modern version of systematic integration and synthesis of disciplinary knowledge;</p> <p>- Second trend (slogan “Unity”) is a modern version of unification and generalization of disciplinary knowledge and existing world views;</p> <p>- Third trend (slogan “Transgression”) is a modern version of attempts to overcome the borders of academic and unacademic knowledge, borders of class, gender, race, ethnic and other identities, etc.;</p> |

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| | <ul style="list-style-type: none"> - Forth trend (slogan “Holism”) is a modern attempt to move beyond the disciplinary views formulating the integral image, pattern, or model of the research object; - Fifth trend (slogan “Problem Solving”) is a focusing on wicked problem solving in the modern society. |
| I) Potential states of transdisciplinarity (2): | <ul style="list-style-type: none"> - “Weak” transdisciplinarity is associated with transdisciplinary approach in classification of the academic scientific approaches. This approach is based on the natural-science world view and supposes search of unique methods to solve the complex problems of science; - “Strong” transdisciplinarity is associated with systems transdisciplinary approach in classification of the systems approaches. This approach is based on the philosophic picture of a single world (unicentrism) and uses a universal systems methodology to solve the wicked problems in the modern society. |
| J) Consistency of transdisciplinarity to the scientific method (2): | <ul style="list-style-type: none"> - Consistency to academic (classical) approaches in their classification; - Consistency to systems approaches in their classification. |
| K) Associative relation determined as the transdisciplinarity (3) | <ul style="list-style-type: none"> - Transdisciplinarity as an association with some “crossing plays” being capable to describe homogeneity for theoretic activity in different areas of science and engineering independent from the field, where this activity is performed, formulated only in the mathematical language; - The transdisciplinarity as an association with original theoretic concepts, which are outside the scope of one research area only; - The transdisciplinarity as intellectual sophistication associating with the common to humanity culture. |

Rethinking of stereotypes in their group combination in terms of the prime cause and two initial ideas allowed for us to form the generalized definition of transdisciplinarity:

Transdisciplinarity is a method of the intellectual activity intensification in the area of interdisciplinary interactions contributing to maximum broadening of the scientific worldview horizon.

Such definition of transdisciplinarity supposes availability of the tools that ensure broadening of the scientific worldview horizon. A role of such tools in the area of interdisciplinary interactions is played by the transdisciplinary and systems transdisciplinary approaches. Considering the generalized definition of transdisciplinarity the definition of such transdisciplinary approach will be as follows:

Transdisciplinary approach is a method for broadening of the scientific worldview horizon in the terms of natural-science worldview by implementation of integrative trends of disciplinary, interdisciplinary, and multi-disciplinary knowledge and models of the object.

In the classification of the academic scientific approaches the transdisciplinary approach allows maximum integration and synthesis of disciplinary knowledge by the idealized object model. The idealized object is an imagined structure of a real object, which is provided with all possible (real and unreal) properties during mental experiments. The idealized object is used as a basis to construct theories, which allow describing reality laws (Subbotin, 2010).

In its turn the definition of the systems transdisciplinary approach will be as follows:

Systems transdisciplinary approach is a method for broadening of the scientific worldview horizon within the limits of the philosophic picture of a single world by simulation of the object in the form of the transdisciplinary system allowing using the systems transdisciplinary methodology for its research.

In the classification of the systems approaches, the systems transdisciplinary approach allows maximum unification and generalization of disciplinary knowledge within the limits of the transdisciplinary system. The transdisciplinary system is an imagine structure of general order conditioning unity of proper space, information, and time of each object, as well as the proper environment, which elements are these objects (Mokiy, & Lukyanova, 2021). The systems transdisciplinary models of spatial (Mokiy, 2020), informational (Mokiy, 2021a), and temporal (Mokiy, 2021b) unit of the order provide object with strictly certain properties, as well as initially determine the basic parameters for these properties, their values, nature and intensity of their interaction in the object.

CONSISTENCY OF TRANSDISCIPLINARY APPROACHES WITH ACADEMIC AND SYSTEMS SCIENTIFIC APPROACHES

For demonstration of consistency of transdisciplinary approaches with academic and system scientific approaches C.F. Gauss random variables normal distribution was used. The normal distribution law is called the C. F. Gauss random value distribution law (Prokhorov, 2020). Distribution of random values is shown by the Gaussian curve (Gaussian). A part of median (Gaussian center) is executed by some average value of the researched parameter. As a result, the Gaussian can show, for example, distribution of shell burst around the target aim point on “short-long” principle; distribution of blood pressure values in the group of peoples, which doesn’t achieve or exceeds averaged value of 120/80 mmHg; or distribution of height values for these people, which don’t achieve or exceed the average value of 175 cm. The law of normal distribution for scientific approaches differs from distribution of shell bursts around target aim point. Thus, the law of normal distribution for scientific approaches differs from distribution of shell bursts around target aim point. In this case axes of Gaussian will not have numeric (quantitative) but logic (qualitative) characteristics.

In the classification of academic and systems approaches, the continuity is associated with a sequential broadening of the scientific worldview horizon. Thus, it is important to exactly visualize what the stereotype “broadening of the scientific worldview horizon” means. Sight sense of amphibians, for example, frog, is organized so that it sufficiently recognizes moving objects and actively responds on them. It sees and responds to the flag, which is moved by wind. But if the wind goes down, then for the frog the flag turns out to be fuzzy grey spot on the fuzzy grey background of the environment (Zhdanova, 2018). Therefore, a frog will start moving in order to broaden the worldview horizon. At the moment of motion all stationary objects start moving in relation to the frog and it can see and distinguish them! Viewing of the disciplinary specialist has also specific features. The “reality” eyes of the disciplinary specialist see a bent spoon in the glass of water (see Figure 1a), which is actually straight one (see Figure 1b).

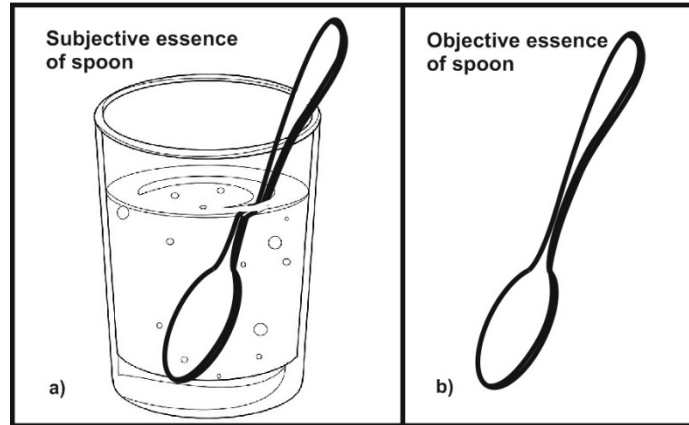


Figure 1. Image of Straight Spoon in Glass of Water

If the disciplinary specialist does not have the possibility of removing the spoon from the glass or does not initially know what it actually is, then the specialist will research and describe what is seen – the bent spoon.

However, if the spoon has a real bend copying its supposed bend (Figure 2b), then the reality eyes of the disciplinary specialist see the straight spoon in the glass of water (see Figure 2a). As a result, the specialist will research and describe the bent spoon as a straight spoon.

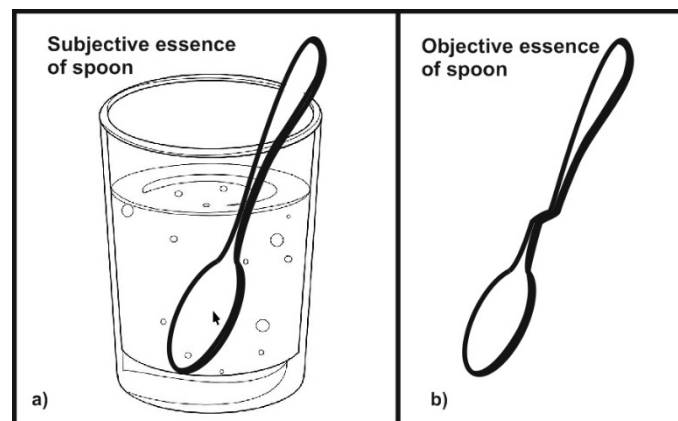


Figure 2. Image of Bent Spoon in Glass of Water

This example prompts asking a question, what are actually the objects and subjects of public (social) sciences that the specialists see in reality? Are these bent spoons that are actually straight ones, or are these straight spoons that are actually bent ones? In this case it is reasonable to ask another question: “What form of social relations (subjective or objective) do economists, sociologists, politicians, and managers use for development of new models of the world social and economic order and control of the local and global processes of the social and economic development?” In order to answer these questions, it is necessary to “take out” the objects of public (social) sciences from the natural environment, as the spoon from the glass of water, and see what they are in reality. Without unambiguous answers to these questions, it is impossible to analyze the risk from implementation of a new model of the world social and economic order. Thus, the specialists of the public (social) sciences should pay attention to the systems transdisciplinary approach, which allows distinguishing the objective essence of the objects, subjects, and their interactions not breaking their connection with the environment.

However, a desire of the disciplinary specialist to achieve a maximum scientific worldview horizon is similar to the desire of a smoker to give up smoking. Theoretically it is possible, but practically it is

difficult; thus, it makes the specialist leave the area of psychological comfort that is formed by the disciplinary worldview. In reality, this desire obtains noticeable support if the smoker sees an X-ray image of their lungs. Possibly, the Gaussian pattern, which demonstrates consistency of the transdisciplinary approaches with the academic and systems approaches, will help the disciplinary specialist. Such Gaussian is given in Figure 3.

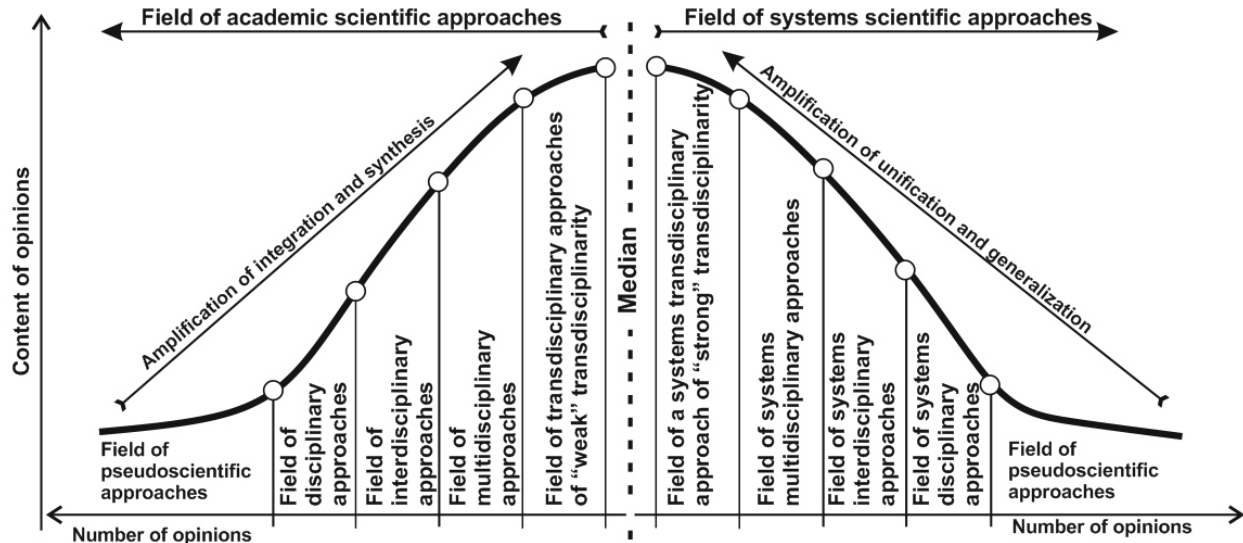


Figure 3. Gaussian Distribution of Academic and Systems Approaches in the Environment of Interdisciplinary Interactions

In this case the median divides the Gaussian into two halves. These halves (areas) are characterized by similar structures of classification for the academic and systems approaches.

AREA OF ACADEMIC APPROACHES

The area of academic approaches is located on the left side of the median. This area is formed with five types of approaches in the direction from pseudoscientific approaches to transdisciplinary ones. The total priority of disciplinary knowledge and disciplinary methodologies in this area does not allow the transdisciplinary approach to form any general theoretical structures. In such a form the transdisciplinary approach calls for greater reflectivity, particularly to humility, openness for interaction with other methodologies and practices, and readiness to give place to other approaches if they are more proper for modern challenges. Such a transdisciplinarity plays a part of weak transdisciplinarity, and its methodology essentially is similar to the methodology and multidisciplinary scientific research (Max-Neef, 2005). However, a weak transdisciplinarity has strong properties. These properties are formed as a result of disciplinary knowledge integration and synthesis. Synthesis is a procedure of imagine connection of the appropriate features, properties, and relations distinguished during analysis of the objects and problem. Integration is a method for maximum filling of the obvious model of the idealized object with knowledge of complementary disciplines. Generally, this knowledge has already been systematized in their disciplines. Within the limits of their own disciplines for knowledge within the standard quantitative and qualitative characteristics, their numerical or logical values are determined. However, the disciplinary knowledge remains indifferent to the process of integration in the integral model of the idealized object (simply stated, they and their numeric values represent only what they present). Thus, the disciplinary specialists often have to make a conclusion and describe the results of interdisciplinary, multi-disciplinary, and transdisciplinary research based on compromise searching. In its turn, the search of compromises results in three negative consequences:

Ambiguousness of Methodological Assurance. Each research of the complex object or solving of the complex scientific problem needs creation of a unique method. The content of the unique method cannot be predicted, as it is newly formed every time during the cooperation of participants from a temporary team. The temporary team of disciplinary specialists is broken apart and a unique method is lost. It should be noted that the unique method requires a unique way for risk analysis due to implementation of the object research results or problem solving. But the proper creation of such analysis ways is a complex scientific problem.

Elitism. Forming of the unique method is available for the specialists, who have formed a scientific world view, but it is unavailable for the students, who are in process of scientific world view forming and training of the scientific method essence. Thus, the rules to form the unique methods cannot be taught in the universities.

High probability of self-reference disciplinary traps. Self-reference occurs in the cases when some notion refers to itself. For example, when the disciplinary specialists have to prove the obvious sense of the straight spoon only on the basis that it is perceived as the straight spoon. But earlier we have shown how false its obvious essence could be.

AREA OF SYSTEMS APPROACHES

The area of systems approaches is located from the right side of the median in Figure 3. Moreover, this area is formed with five types of approaches in the direction from a pseudoscientific systems approaches to a systems transdisciplinary one. Contrary to the transdisciplinary approach in classification of the academic approaches, which use the obvious (subjective) sense of the model for the idealized object, the systems transdisciplinary approach uses the objective essence of the object representing it in the form of the transdisciplinary system (Mokiy, 2019b). Availability of special philosophic substantiation (unicentrism) and the appropriate universal methodology provides the features of strong transdisciplinarity for the systems transdisciplinary approach. The systems approaches of the Gaussian right area are characterized with an increase of disciplinary knowledge unification and generalization degree.

Unification is a process for bringing the disciplinary knowledge and/or their disciplinary classifications to a uniform systems transdisciplinary classification. In other words, the existing classifications of disciplinary knowledge are specified within the limits of isomorphic systems transdisciplinary models for space, time, and information units of the order, which conditions a unity of the world and each object and process. After unification, the disciplinary knowledge becomes an active part of the systems transdisciplinary solution for acute problems of modern society, as well as during solving of the complex scientific problems. Thus, the specialists can forecast change of quantitative and qualitative characteristics of the certain object even concerning condition of the objects, which were located within one area (Mokiy, 2019c).

Generalization is a method of filling of the systems transdisciplinary models of the order units with the disciplinary knowledge, which describes the objective essence of the object or problem. It should be noted that the systems transdisciplinary unification and generalization do not break the disciplinary classifications of knowledge and do not cancel their disciplinary criteria, indices, and parameters. It allows interpreting these criteria, indices, and parameters in terms of the order conditioning a unity of the environment, as well as the objects and processes, which are its elements. Moreover, relevance, reliability, scientific severity, and efficiency of the disciplinary tools and methods used for the process of systems transdisciplinary research are retained.

The systems transdisciplinary unification and generalization of the disciplinary knowledge results in six positive consequences:

- allows excluding the practice of compromise search between the disciplinary specialists;

- allows for the specialists of the transdisciplinary team to focus on their professional competences, but not the compromise search: in particular, provide the required volume of disciplinary information, organize and perform the required experiments, control and comment the process of disciplinary knowledge generalization in the direction of wicked problem solving;
- contributes to substantiation for selection of the disciplinary specialists in the temporary teams, as well as the disciplinary knowledge, that will be used in the systems transdisciplinary research;
- contributes to use of the universal research method and universal method of risk analysis due to research results implementation; the rules for use of the universal method of research and risk analysis can be studied in the universities;
- reduces the part of facilitators in the transdisciplinary teams of the disciplinary specialists, as a result management (coordination) of the disciplinary knowledge, but not disciplinary specialists, is performed;
- allows avoiding dead end with self-reference, as the specialists of the transdisciplinary team use the objective and uniquely determined philosophic, conceptual, and methodological categories excluding use of the corrupted or incorrect research object pattern and solved problem.

CONCLUSION

The results of the overview of the literature reviews witnesses that the prime cause of the transdisciplinary is a desire of politicians, economists, managers, and other disciplinary specialists to solve the problems of control for global and regional social and economic development of modern society, which include the social and political problems and problems of international relations by means of the global approach. Thus, for the last 50 years the main initial idea has contributed to forming transdisciplinarity as a global approach, within the limits of which several important problems are solved.

- develop the global approach within the limits of the independent meta-discipline (systems transdisciplinarity);
- develop a single (universal) method to solve the acute problems of the modern society based on the meta-discipline.
- organize studying of the students in this meta-discipline partially reforming the disciplinary structure of the universities;
- present the social and economic development as natural fragment for development of planet nature within the limits of this meta-discipline. In this case development of the society and management risk analysis is evaluated with regard of objective laws of nature and society uniformity conservation.

The systems transdisciplinary approach, as one of the main pretenders for the global approach title, supposes control (coordination) of disciplinary knowledge. In this case the systems transdisciplinary specialist (generalist) performs unification of disciplinary knowledge at the first stage of research. This specialist organizes the proper research: determines composition of the disciplinary specialists and scientific disciplines; specifies the list of parameters to be considered; forms several scenarios of research development in the direction to the determined objective, etc. Moreover, the part of the disciplinary specialists in the research results in traditional professional activity by means of strict disciplinary methods. The generalist specialist corrects the research scenario, which will cause the certain objectives and results, at the subsequent stages of research. At the final stage, together with the disciplinary specialists, it generalizes the results; forms the final conclusions of the research; describes them with a language that is understandable by the specialists and administrative workers; and analyses the risk due to implementation of the systems transdisciplinary research results. In such a role the systems transdisciplinary approach allows solving the poorly structured problems of the science and society.

It should be noted that T. Kuhn (1962) stated in his famous book “Structure of Scientific Revolutions” that almost always people, who successfully provided the fundamental development of a new paradigm, based on which the global approaches were constructed, were either very young or beginners in this area. Thus, we attach important significance to partial reforming of the disciplinary structure of the universities allowing creating the Systems transdisciplinary departments and the Centers of systems transdisciplinary retraining of disciplinary specialists. Moreover, T. Kuhn warned that the change of tools in science was a last extreme measure, which was taken only in case of actual necessity. Significance of social and economic and social and political crises of modern society consists particularly in that they speak about the relevance of such tools change. Little remains – it is necessary that disciplinary specialists want to use the tools of a global approach to solve global problems.

Why is the transdisciplinary approach, which is formed by the additional initial idea, more known in science and education this day? This occurred due to the overlapping of the subjective desire of practitioners to eliminate subdivision of the disciplinary approaches on the objective desire of scientists to synthesize and integrate the disciplinary knowledge, with which the modern stage of the science development is characterized. Such overlapping contributed to transformation of multi-disciplinary research into a special form of transdisciplinary research, which was associated with the transdisciplinary approach or transdisciplinarity. The distinctive feature of the transdisciplinary approach is forming a unique method for each complex scientific problem. Such method is based on the experience of facilitation, consensus, and compromise of disciplinary specialists being participants of the temporary transdisciplinary team. Thus, within the limits of the transdisciplinary approach, the global and regional social and economic development is interpreted as stable development based on subjective laws of the human being and society development, stage standards of morality and ethics.

It should be noted that the effectiveness of the transdisciplinary approach and, thus, transdisciplinary research is negatively affected by objective and subjective interpersonal, world vision, ideological, psychological, methodological and other problems of interdisciplinary interaction (Lotrecchiano, & Misra, 2018). In this case, the problem solving concerning interaction of specialists from different disciplines does not depend on objective scientific methodology. It depends on practical experience of the facilitators to a greater degree. As a result, many problems of modern society, which expect its solution and in which the social and political aspects appear, are declared to be acute problems. It should be noted that such problems are excluded from the list of problems that could be solved by means of science (Rittel, & Webber, 1973). Therefore, the transdisciplinary approach allows solving sufficiently structured scientific problems in which knowledge of the complementary disciplines takes part.

In view of the above, we can conclude that transdisciplinarity is not a marginal direction of contemporary science. Transdisciplinarity is a method of intensification of intellectual activity in the area of interdisciplinary interactions contributing to maximum broadening of the scientific worldview horizon. The transdisciplinary approach and the systems transdisciplinary approach play the role of tools that expand the horizon of the scientific worldview.

Considering the above mentioned information, it can be concluded that the transdisciplinary approach and systems transdisciplinary approach have a different initial idea, a different intended purpose, and a different research potential. We hope that the initiators of higher education currently discussing the problem of university disciplinary structure reforming will pay attention to differences of the transdisciplinary and systems transdisciplinary approach. In this case they should take timely actions for exact designation of the purposes for such reforming and start moving to achieve these objectives (Mokiy, 2019c).

The customers and sponsoring organizations trying to obtain the solution form the problem of long-range forecasting, planning, and control of the global and regional social and economic development of the society, which include the social and political problems and problems of the international relations, should pay attention to these differences. Thus, to solve such problems, firstly it is necessary to

involve the teams of specialists who have skills in knowledge of the systems transdisciplinary approach and who are able to conduct a risk analysis of the proposed solution.

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