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CONDITIONS AND FEATURES OF UNITY CONCEPTS IN SCIENCE[1]

1. UNITY CONCEPT IN TERMS OF SCIENTIFIC KNOWLEDGE SYSTEMS

There are many phenomena in different areas of human intellectual life that have been subsumed under the concept of unity and its relatives: integration, generalization, synthesis, unification and so on. Numerous authors have lobbied for one or another variety of the unity within traditional scientific disciplines (in mathematics, physics, psychology, etc.). Other have argued for the unity between the different natural sciences (for example, physics and biology) or between the natural sciences and mathematics. Still others have focused on forms of the unity between science and humanities. It seems that the scrutinizing these unity forms is a precondition of considering any meaningful form of the unity between science and art, science and other spiritual types of human activity.

The concept of unity may be investigated with reference to various phenomena and at different levels of generality and formality. Keeping in mind set-theoretical or/and categorical foundations of mathematics, one may speak of, correspondingly, the set-theoretical or/and categorical unity of mathematics. One may also speak of the unity of contemporary physics created by the ideas of relativity, complementarity, and self-organization. In these cases the unity is treated in terms of some particular concepts and ideas. It gives a room for scientific-like speculations that are sometimes very interesting and plausible, especially when they have been produced by outstanding experts in the field.

There is also a possible alternative to such a consideration of the unity concept in science. It is connected, first, with taking into account not the whole science, but only scientific knowledge. Second, it recognizes as some empirical fact that scientific knowledge has been split in various and interrelated systems. These have not been remained stable and constant. The development of science has been producing new knowledge systems as well has been leading to elaborating old ones and establishing fruitful and original relations between different systems. The supersystem of scientific knowledge systems is in a permanent state of flux. The unity here may be treated as some property defined on pairs of elements from this supersystem. From such a point of view the unity concept in

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science may be investigated in terms of scientific knowledge systems and relations between them.

To put it more definitely, one of the important forms of the unity in science is connected with the consideration of common structures that two distinctive knowledge systems possess. Examples of such unity may be found among different theories of classical physics; the nonrelativistic quantum mechanics and wave mechanics, quantum relativistic mechanics and special relativity theory; current programs of unification of theories of fundamental physical interactions; different models of concepts in contemporary cognitive psychology, etc.

It is necessary to note, that considering the unity concept in terms of scientific knowledge systems would be more efficient if one explicitly uses a certain methodological model or reconstruction of scientific knowledge systems. The modern methodology and philosophy of science has produced many such models. Among them are cognitive [1], erotetic [2], standard [3], semantic [4], structuralist [5], structure-nominative [6], etc. They put forward different pictures of the nature and composition of scientific knowledge systems. This has immediate consequences for methodologically possible modes of the unity of various knowledge systems.

Indeed, if one separate a specific list of structures in knowledge systems, then it means that she or he may speak of their unity in more concrete and detailed terms. Simply stated, if knowledge systems include a single type of structure, then one may describe their unity only in terms of this type. If knowledge systems include two different and interrelated types of structure the number of possible modes of unity grows essentially. As a first approximation, we may have two types of partial unity connected with either types of structures. Then, we have also the type of unity associated with both structure types. In each case there are some constraints on the unity arising from ties between both types of structure.

As compared with others, the structure-nominative reconstruction has separated inside of scientific knowledge systems much more various types of interrelated structures. From this it follows, that it has provided more opportunities for the analysis of the concept of unity of scientific knowledge systems and for the classification of possible types of unity.

2. THE STRUCTURE-NOMINATIVE VIEW OF COMPOSITION OF SCIENTIFIC KNOWLEDGE SYSTEMS

Let us suppose that we consider a variety of functions realized in scientific practice with the help of a scientific knowledge system (SKS). Among them are the naming (assigning special and manageable names), attribution (imposing properties and relations), description, explanation, classification, prediction, understanding, generalization (establishing patterns of behavior and changes) of entities, events, states, and processes in the domain of a SKS, etc. An SKS must have some structures by means of which these functions have been fulfilled. Including only logical structures in SKSs is not sufficient for their realization.

The very idea of an SKS presupposes that its structures are ordered in a way. Further still, there are many kinds of these structures and many methods of their ordering. On closer examination one may conclude that these structures create a huge system with many hierarchies and subsystems. The numerous case-studies of mathematical, physical, economical and social SKSs have shown the justifiability of such an approach [6].

It is possible to separate five subsystems at the highest hierarchy level of an SKS. These are logico-linguistic, model-representing, problem-heuristical, pragmatic-procedural subsystems and a subsystem of links between them. Their careful study shows that any of them may be represented in others only partially. These subsystems are not totally reducible to each other.

All kinds of knowledge associated with an SKS are expressed and logically ordered by means of its logico-linguistic system. Among resources of this system are concepts, alphabets of languages, word construction rules, vocabularies of assertoric languages, expression construction rules, assertoric languages of an SKS, selection rules for basic expressions. Evaluating some of them as true, we obtain a system of initial propositions (axioms, laws, postulates, principles) and enter to the logical part of a logico-linguistic subsystem. It includes also a system of rules of transformation (deduction, inference, argumentation) of initial propositions, and derivative propositions (statements, consequences, theorems).

With only a few exceptions, practically all experts in the current philosophy and methodology of science and many philosophically minded scientists identify an SKS with its logico-linguistic subsystem. Only adherents of the structuralist approach connect systematically an SKS with the kind of structure different from logico-linguistic ones. The elaboration and further development of their arguments led to the separation of a model-representing subsystem inside an SKS. Its constitutive structures are abstract properties and models. To a first approximation, the model-representing subsystem includes levels with the following subsystems. These are systems of: names of supposed entities from the domain of an SKS; names of properties and relations of entities from this domain; scales for properties and relations between domain entities; abstract properties as models of properties and relations of entities; model scale of an SKS; model forms of the representation of domain regularities; hierarchies of such forms.

In addition to these subsystems of an SKS, there are reasonable arguments for separating others. Indeed, numerous case-studies of SKSs (as they exist in scientific monographs, textbooks, papers, manuals and lectures) show that an SKS also includes other kinds of constitutive structures above concepts, languages, propositions, properties, models, and laws. These are problems and tasks specific for a given SKS, methods and operations of problem solving and model building. An important part of an SKS is associated with its various axiological structures. Among these are traditional logical estimations like the truth of propositions and the completeness of their system. Above this there are variety of other estimations as the adequacy of models, the complexity of problems, the universality and efficiency of methods used, the beauty of a whole SKS [7]. These constitutive elements are naturally distributed between the problem-heuristical and pragmatic-procedural subsystems. In turn, either of them consists of two subsystems.

The problem-heuristical subsystem of an SKS contains problem and heuristical systems. The basic constitutive structures of the first are problems, questions, puzzles and tasks as well solutions of problems, answers to questions, guess-works about puzzles and results of fulfillment of tasks. The basic structures of the second are hypotheses, ideas, effective but not well grounded assumptions.

It should be stressed that any set of structures associated with a given SKS alters during its development. For a problem-heuristical system it means that employing any nontrivial SKS, one is able not only to solve some known problems, but also to formulate and resolve new and original ones.

The constitutive structures of an SKS mentioned above may be called constructive or static ones. The introduction of so-called dynamic structures is caused by the following reasons. In scientific practice an SKS exists as a large and complex system of transformations, actions and operations with constructive elements. Possessing and applying an SKS, scientists are doing something with concepts, language expressions, models, problems, etc. In the framework of a given SKS these actions are not arbitrary and chaotic. Each kind of constructive structure corresponds to a specific system of operations over them. Operations over concepts include abstraction, idealization, combination, etc. Operations over propositions contain their truth estimation, deduction of some propositions from a certain set of them, confirmation, falsification of propositions, etc. When one deals with properties he or she connects operations of determination of property values with them. In an empirical SKS the realization of this determination frequently presupposes the use of the calculation and measurement operations and procedures.

There is a widespread tendency of reducing all kinds of operations and methods associated with an SKS to deductive and inductive ones. However, besides them, there are many other kinds of operations and methods in it. For example, the methods of solving mathematical equations in any SKS with mathematical apparatus are not reducible either to deductive or inductive ones.

The operations appropriate to the various constructive structures of an SKS are the main constitutive structures of the operational subsystem of a pragmatic-procedural subsystem of an SKS. It also contains the descriptions of these operations (procedures and algorithms), the rules of construction of new operations from the known ones, etc. It may be shown that methods are systems of some basic operations and the rules indicating the sequence of their fulfillment.

The second system of the pragmatic-procedural subsystem is an axiological one. Its main constitutive structures are estimations and evaluations of other structures of an SKS. Examples are the effectiveness and universality of methods used in an SKS, the practicality of scientific theories [7].

There are many important and poorly investigated relationships within any subsystem mentioned above. Along with this, all subsystems of the highest hierarchy level have many interdependencies and ties. By way of example one may take links between the logico-linguistic and model-representing subsystems. Languages used in the former essentially determine the types and nature of models that may be constructed by means of these languages. If a scientist uses only ordinary language, then she or he is not able to construct rather sophisticated and experimentally testable models. We mention in passing that (from the point of view of ties between the logico-linguistic and model-representing subsystems) the importance of mathematics in SKSs is connected not only with a need of conducting complex calculations and statistical processing of experimental data. Mathematical languages are also used for constructing models that could be experimentally tested. Only after such testing the models may be provisionally estimated as more or less adequate depiction of the domain of an SKS.

Similar considerations lead to the separation of the subsystem of links among other four subsystems of the highest hierarchy level of an SKS.

3. THE UNITY AS A FUZZY DICHOTOMOUS PROPERTY

Having rather detailed reconstruction of SKSs, we need some formalization of the concept of unity between them. Usually this concept has been considered as dichotomous one. It means that pairs of SKSs subsumed under it have been treated as possessing the unity or not. In reality there are many types of the unity between SKSs as well many degrees of the unity of a certain type. For instance, it seems that the types of unity between two mathematical theories are different from the types of unity between sociological theories. Moreover, the degrees of the definite type of unity between mathematical theories may depend on the pairs of theories chosen.

First of all, we consider a way of expressing an idea about the unity degrees. Then, we propose an idea of the unity sorts connected with different measures of the unity.

The unity under study may be studied as some abstract property [8; 9] denned on pairs of compared SKSs. It allows us to speak of the unity not only in terms of its presence or absence, but also in terms of its degree.

In more formal way, any sort of the unity of SKSs may be defined as follows.

Definition 1. The unity U(S)of the sort S of SKSs is a triple (M, p(S), L(S)) where M is a set of all possible pairs of SKSs, p(S) is a unity function of the sort S and L(S) is a scale of the unity of the sort S.

More specifically, L(S) is a set of values of the unity of the sort S, p(S) is the function that assigns some value v e L(S) to a given pair of SKSs. For dichotomous concepts of unity, one takes the set {0,1} as the scale L(S). The assigning of the value 0 to the pair of SKSs means that there is no unity between them. The assigning of the value 1 means that there is the unity between them.

It seems more realistically to take the interval [0,1] as the scale L(S). In this case we may give some numerical characterization of the degree of unity between SKSs and may compare various degrees.

The unity function p(S) assigns some numerical value from [0,1] to any element from M. It allows us in principle to compare the degrees of unity between SKSs. For example, the SKS(l) may have the numerical value of unity equal to 0,8 with SKS(2), while the appropriate value may be equal to 0,5 for SKS(3). The way of determining value of p(S) on a given pair of SKSs is depended on the definition of the measure of unity at hand. Under this treatment it is naturally to interpret the value (1 - p(S)) as the degree of deviation of SKSs.

Definition 2. The deviation D(S)of the sort S of SKSs is a triple (M, d(S), L(S)) where M is a set of all possible pairs of SKSs, d(S) is a deviation function of the sort S, L(S) is a scale of the unity of the sort S and d(S) = 1 - p(S).

Let SKS(l), SKS(2) and SKS(3) be three SKSs. Their possible coupling includes pairs designated as (1,2), (1,3) and (2,3). We can assign or determine definite values of p(S) for these pairs: p(l,2), p(l,3) and p(2,3) and analyze various numerical relations between them. It is interesting to investigate how different measures of unity are comparable with our intuition about the unity of knowledge.

There are variety of possible measures of unity connected with the appropriate definitions of the unity function and the scale of unity. Our ideas about the compositions of SKSs play here the crucial role. Each of the possible measures introduces a specific sort of the unity between SKSs. Some of them may be found below.

Definition 3. The measure of nonspecific structural unity of two SKSs is the ratio of the number of their common structures to the sum of numbers of all their structures.

Definition 4- The measure of specific structural unity of two SKSs in relation to specific sort S of their structures is the ratio of the number of their common structures of this sort to the sum of numbers of all their structures of this sort.

In many cases it is more convenient to discuss the unity of SKSs in terms of sorts of their structures, but not in terms of their structures themselves. It gives the nonspecific and specific sortal measures of unity.

Definition 5. The measure of nonspecific sortal unity of two SKSs is the ratio of the number of their common sorts of structures to the sum of numbers of all their sorts of structures.

Definition 6. The measure of specific sortal unity of two SKSs in relation to specific sort S of their structures is the ratio of the number of their common subsorts to the sum of numbers of all subsorts of this sort.

These definitions are rather flexible and their application depends on many conditions. First of all, it is an objective splitting SKSs into subsystems and structures. Then, our ability to recognize and identify these components should be mentioned. These conditions are correlated with each other. However, there may be various contradictions between them. For example, an SKS may have very rich hierarchies, but we could not recognize their existence.

The deepness of our possession of SKSs is the next condition. Usually only a few scientists are well aware of both SKSs compared. It is possible that the deeper understanding of SKSs may reveal the unity lacking in the case of their superficial treatment. At least, but not last, one should mention the objectives during the study of unity of SKSs. They extend from general talking about SKSs to attempts to unite them in order to solve real scientific problems.

Because there are many reasonable measures of the unity, the problem of their compatibility and consistency appears. Its preliminary analysis revealed many inconsistencies in the common scientific intuition about the unity of SKSs. The results of this analysis will be given in the future author's papers.

It should be noted that to achieve the fuller presentation of the unity between two SKSs we may use the construction of composition of the measures of unity mentioned above. This construction is a partial case of composition of abstract properties [8].

Besides the idea of different measures and sorts of the unity between SKSs, we introduce an idea of types of this unity. This idea deals with internal splitting of SKSs.

4. THE STRUCTURE-NOMINATIVE CLASSIFICATION OF UNITY TYPES

One may use the structure-nominative reconstruction as some methodological frame of reference for discussing the unity concepts. From stated above about the structuring of an SKS it follows that one may speak of, at least, two major presuppositions of the unity of two SKSs.

First, they should reveal all their subsystems in distinctive form. In this sense all SKSs demonstrate the unity connected with their systematic and structural similarity.

From such a point of view, it is rather difficult to separate any nontrivial mode of possible synthesis of art and science or scientific and common knowledge. Under trivial modes we mean the usage, for example, the same alphabet of natural language and a huge list of the same words from its vocabulary by many SKSs and literary texts. These kinds of the unity may be called, correspondingly, the alphabetic and lexicographic. However, the proper specifics of SKSs began from the usage of artificial languages, especially mathematical languages with their symbolic alphabets and vocabularies of terms. As a rule, these languages have semiotic, syntactical and semantic rules that are different from those of natural language. Nevertheless, they may intersect. It gives the natural grammatical unity between SKSs and written and spoken arts.

Second, SKSs under comparison should possess about the same level of development of their corresponding subsystems. There is no sense to consider the unity between mathematical category theory with its highly developed logico-linguistic and procedural subsystems and some social theory that used ordinary language in its logico-linguistic subsystem and elementary rules of argumentation in its pragmatic-procedural subsystem.

Generally speaking, one may introduce the following principal types and subtypes of the unity of SKSs.

The logical-linguistic unity.

The compared SKSs possess the logico-linguistic unity when they share some structures from their logico-linguistic subsystems. The main subtypes of this unity are conceptual, language, logical and axiom unity. We may speak of them when SKSs share some structures from, correspondingly, conceptual, language, logical and axiom systems of SKSs. Let us consider briefly some illustrations. We may speak of the conceptual unity between geometry and most scientific theories that using the concept SPACE. Classical field theory and wave theory of light possess the language unity arising from the use of the language of the theory of differential equations in partial derivatives. Some scientists say that there is the logical unity between all classical theories because these theories use logical systems with two truth values. According to this view, the logical unity of quantum theories arises from their common many-valued logical systems. We may speak of the axiom unity of intuitionistic and non-intuitionistic logical systems having in mind that they share many axioms but not the law of the excluded middle.

The model-representing unity.

The compared SKSs possess the model-representing unity when they share some structures from their model-representing subsystems. The main subtypes of this unity are nominal, attributional, model and nomic unity.

The nominal unity takes place when compared SKSs use the same names of objects under study. There is a great degree of nominal unity between atomic physics and chemistry, especially in the field of naming atoms, chemical elements and their atomic structure.

The attributional unity emerges between SKSs by means of which the "same" properties are studied. In spite of all discrepancies of classical and relativistic mechanics these theories have a great value of attributional unity. This follows from their usage of such properties of investigated objects as mass, momentum, energy.

The model unity appears when SKSs use some common models. There is the model unity of most contemporary theories of elementary particles due to their usage of quark model.

The nomic unity appears when SKSs share some laws and principles. Practically all contemporary natural sciences share the law of energy conservation. There are varieties of modern theories of fundamental physical interactions that share the same supersymmetry principles. In both cases we may speak about the nomic unity of corresponding SKSs. In the last case the laws of SKSs may be different and simultaneously may obey the same supersymmetry principles.

The pragmatic-procedural unity.

The compared SKSs possess the pragmatic-procedural unity when they share some structures from their pragmatic-procedural subsystems. The main subtypes of this unity are operational, methodical and axiological unity.

The operational unity is connected with a usage of the same operations by SKSs. Having in mind such operations as abstraction, generalization, idealization, one may speak of operational unity of science and humanities. The subtypes of this unity are connected with using arithmetical, geometrical, topological operations, etc.

The methodic unity is connected with an application of the same methods. All contemporary natural sciences use experimental methods and methods of measuring. On this ground one may introduce the concept of experimental and measuring methodic unity of some SKSs. The methods of solving differential equations give the way for the corresponding subtypes of the methodic unity.

The axiological unity is associated with sharing the same collection of estimations by different SKSs. The best-known estimation is the truth evaluation. If we agree that one objective of any SKSs is the truth attainment, then we may assert the truth unity of science in the whole. The extraordinary important roles in the social sciences and humanities play some hermeneutic estimations. Among them is a requirement to provide the understanding of reality under study. In view of this, one may consider many types of the hermeneutic unity between various social and humanistic knowledge systems.

The problem-heuristical unity.

The compared SKSs possess the problem-heuristical unity when they share some structures from their problem-heuristical subsystems. The main subtypes of this unity are problem and heuristical unity.

The problem unity is associated with common problems formulated and resolved by SKSs compared. There are many kinds of problem generality. If we agree that one of the main problems of science is to obtain adequate and testable explanation and prediction of phenomena studled, then we may speak of the appropriate problem unity of all SKSs. On more concrete consideration, problems are separated by nature (mathematical, physical, social, spiritual, etc.) and forms (precise, formal, fuzzy formulated, etc.). Taking this into account, one obtains appropriate subtypes of the problem type of unity. In spite of widespread opinion even highly formalized mathematical and physical theories use many plausible assumptions, efficient but not well grounded methods, some general and empirically unverifiable ideas, heuristic argumentation, etc. In this sense there are many subtypes of heuristical unity between all SKSs.

Studying the real life cases of the unity of SKSs, one may meet practically all possible combinations of these basic sorts and types of unity. Frequently researchers concentrate only on some of them. This generates different opinions about the unity of any given pair of SKSs, because researchers consider only one or two unity aspects. Applying different concepts of unity, they may obtain different conclusions about concrete realization of the unity. For instance, keeping in mind the nature of mathematical concepts and basically deductive character of mathematical argumentation, some eminent mathematicians find only a low degree of unity between mathematics and natural science. In contrast to them, others point out the fact of using mathematics in physics and conclude that there is a great degree of unity. This may be explained as a result of the application of the different unity concepts.

5 UNITY AND UNIFICATION OF PHYSICS

Let us consider briefly the problem of unification of physics from the view point of the above analysis of the unity concept.

Almost always this problem is investigated as follows. It is supposed that in the future it will be possible to invent such an axiom and law system from which one may obtain axioms and laws of any other physical knowledge system as particular cases. This program rests obviously only on two types of unity: axiom and logical ones. Even though the building of this system will be possible, this would lead only to the partial, but not to the total unification of all physical knowledge systems. These contain not only common problems, models, methods, etc., but also specific ones. This means that the unity of the appropriate types with degrees close to 1 is practically unattainable. The lack of the complete reduction of any subsystem of SKSs to other means that all types of unity are irreducible to the axiom and logical unity.

The unification itself is not an ultimate goal of science development. It is only one of the tools of this development. It strengthens human power to solve new and more complicated scientific problems. It also gives us the interplay of different methods that leads to inventing more powerful and universal methods. It also reveals deeper and more fundamental structures, patterns and regularities of nature. It creates more effective and universal forms for nature understanding. From this point of view, one may conclude that only with the help of the axiom and logical unification, this tool cannot be put into action.

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