Modern Science Key Trends: Disunity and Fractionation

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Abstract

Using the examples of physics, mathematics and psychology, traditionally used by philosophers and historians of science to demonstrate different levels of "maturity" and "accuracy" of science, the article shows that at the present stage the differences between "mature" and "immature" sciences fade out. General trends of modern sciences are highlighted: growing disunity and fractionation, a split between different levels of science, as well as the difficulty in defining a criterion for the demarcation of scientific and non-scientific knowledge. Therefore, the stigmatization of the social sciences is inadequate, and the crises of identity of psychologists and sociologists are unfounded. In connection with the fractionation of science, it is possible to predict, along with interdisciplinary research, a greater number of multi-paradigm or multi-approach studies, which, to a certain extent, make it possible to reconcile various scientific worldviews within one science.

Keywords: "mature" and "immature" sciences, social sciences, natural sciences, the criterion of demarcation.

Introduction

Discussions about different kinds of unity and disunity in science last for centuries (Galison and Stump 1996). At the present time, drawing the borderline between the natural sciences and the social sciences is a quite popular position among researchers. In attempts to reflect on the differences between them, scholars actively use T. Kuhn's approach to the history of science. Some researchers tend to consider sociology and psychology as pre-paradigmatic sciences (Benjafield 2019; Noguera 2006; D. Schultz and S. Schultz 2011, 17), their history in this case appears as a “sequence of failed paradigms” (Sternberg and Grigorenko 2001, 1075). However, their images as multi-paradigmatic disciplines are acquiring greater relevance (Cohen 2000; Arcidiacono and De Gregorio 2008; Henriques 2008; Ritzer 1975; Yanchuk 2018; Yurevich 2007a). Many scholars believe that paradigms in social sciences should be considered only research directions set by powerful philosophical approaches, such as the natural-science (aka positivist or quantitative) and humanities (aka qualitative or metaphysical or interpretivist) paradigms (Morgan 2007; Sale, Lohfeld, and Brazil 2002; Vygotsky 1997; Yurevich 2007b). Some scholars add to the list also critical theory, participatory paradigm and postpositivism (Guba 1990; Guba and Lincoln 2005; Lincoln and Guba 2013). Others believe that many powerful scientific schools can be considered paradigms (Buss 1978; Yanchuk 2012). On the other hand, some scientists claim that the concept of T. Kuhn is not applicable to the social sciences at all.

Such uncertainty and the polarity of opinions leads to the fact that social sciences live in a stigmatized state (Noguera 2006), and researchers suffer from crises of identity (Driver-Linn 2003). Are social sciences as “mature” sciences as the natural ones (but “mature” in a different way)? Are they at the stage of “immature” science (“would-be scientific discipline”), and they have yet to develop a single paradigm, as did the more “mature” sciences? Or perhaps they are not real sciences at all? There are many possible answers to these questions, which are more or less justified.

The purpose of this article is to analyze whether modern social sciences (using the example of psychology) are fundamentally different from the most developed or “mature” sciences (for example, mathematics and physics).

The Current Situation in Psychology

The crisis rhetoric. Almost since the beginning of psychology, scholars began to use the term “crisis” to characterize the state of psychological science (Driesch 1925; Willy 1899). Feelings of uncertainty, chaos, and the fragility of the foundations of the emerging science have been emphasized by many psychologists. Although these sensations, apparently, somewhat “blunted” since the second half of the 20th century, certain flashbacks are not uncommon for the current state of science (Kelly 1998; Rieber 2001). Analysis of modern crisis rhetoric shows that discussions of the crisis of psychology, as before, proceed mainly along the line of “unity – disunity” of psychological science (Dvojnin 2016). Researchers identify three key "symptoms" of crisis in psychology (Benjamin 2001; Driver-Linn 2003; Sexton 1990; Yurevich 1999):

a) psychology's disunity and fractionation;

b) deepening split between academic and practical psychology;

c) difficulty in determining the demarcation criterion of scientific and non-scientific knowledge.

Disunity of science. The scholars note that modern psychological knowledge is a chaotic array of incompatible theories, areas of research, models, methods, and philosophies (Hunt 2005; Yanchar and Slife 2000), and that the situation is progressively worsening (Sexton 1990). Moreover, for over a century the statement about the existence of not one, but many different psychologies has been quite popular among scholars (Asmolov and Guseltseva 2015; Koch 1993; Vygotsky 1997, 237, 300-302). Psychology is spoken of as a collection of psychological sciences.

Different approaches in psychology are constantly evolving. They are modified, split up, lose and gain popularity, "fade out" and re-actualize. For example, psychoanalysis has evolved from Freudianism to Object relations theory, behaviorism – from eliminative (or metaphysical) behaviorism to radical behaviorism and behavior analysis. And this evolution continues. In addition, new approaches are constantly emerging. C. Geertz (2000, 188) writes about situation in psychology this way: "Paradigms, wholly new ways of going about things, come along not by the century, but by the decade; sometimes, it almost seems, by the month". As a result, psychologists speak different languages, often not understanding and not accepting the ideas of colleagues. Nevertheless, the most significant results obtained within the framework of one of the approaches are often recognized and used by others, i.e. become the property of psychology as a whole.

Split between different levels. The researchers note that, as in the times of L. Binswanger and L.S. Vygotsky (1997, 305-310), psychological practice and academic psychology do live their parallel lives: they have no mutual interest, but they have different authorities, different systems of education and economic existence in society and also non-overlapping circles of communication (Sexton 1990; Vasilyuk 1996). As a rule, practitioners are not at all interested in the problems of philosophy and methodology of science; they are alien to paradigmatic reflection. Most practicing psychologists use an eclectic set of psychotechnical tools. F.E. Vasilyuk emphasizes the depth of this split with the word "schism" (following K. Popper (1982), who previously applied it to physics). L.S. Vygotsky (1997, 306) in 1927 and F.E. Vasilyuk (1996) 69 years later both suggest the development of the philosophy of practical psychology as one of the ways to overcome this split.

Demarcation criterion. Within the framework of almost every approach, scholars draw a line separating scientific and non-scientific knowledge in their own way. Thus, for radical behaviorists any mental concepts used by most other approaches are fundamentally unscientific. For behaviorists and adherents of cognitive psychology, psychoanalysis is an absolutely pseudoscientific theory. In addition, the vagueness of the demarcation criteria leads to a large-scale expansion of religious, esoteric ideas into psychology (Benjamin 2001). Besides, researchers often unreasonably transfer models developed in the natural sciences into psychology, ignoring the need for their adaptation.

The Current Situation in Mathematics

The crisis rhetoric. Scholars describe the situation with the uncertainty of the foundations of mathematics that developed at the beginning of the 20th century using the term “crisis” (Aleksandrov 1956, 77; Ferrerirós 2008; Weyl 1998). This situation was caused by disagreements between mathematicians about the basics of their science. It led to the loss of scientific unity and the formation of different mathematical schools. Representatives of these schools began to consider quite differently not only the general foundations of science, but also the significance of individual concrete results and evidence. As a result, conclusions that seemed meaningful to some scientists, were declared meaningless by others (Aleksandrov, 1956, p. 75).

Disunity of science. M. Kline (1980, 6) describes the state of mathematical science at the end of the 20th century as follows: “The current predicament of mathematics is that there is not one but many mathematics and that for numerous reasons each fails to satisfy the members of the opposing schools. It is now apparent that the concept of a universally accepted, infallible body of reasoning – the majestic mathematics of 1800 and the pride of man – is a grand illusion”.

The loss of scientific unity in mathematics was associated with attempts to substantiate mathematics by various researchers. The first attempts were made within the framework of three philosophical programs – logicism, intuitionism and formalism (Linnebo 2017; Mancosu 1998). The program of logicism assumed the reduction of mathematics to logic, the program of intuitionism saw as its goal not the proof of "true" theorems, but the development of mathematical ("mental") constructions that organically combine construction and justification, the program of formalism assumed the formalization of mathematics in axiomatic form and the proof of the consistency of such axiomatization by finite methods. M. Kline (1980, 27) writes: "The light of truth no longer illuminates the road to follow. In place of the unique, universally admired and universally accepted body of mathematics whose proofs, though sometimes requiring emendation, were regarded as the acme of sound reasoning, we now have conflicting approaches to mathematics".

These programs were the result of "mathematized epistemology", which involves reasoning about mathematics primarily using the tools of mathematics itself (Lolli 2012, 81). This, apparently, was possible because many of the leading researchers of the early 20th century, as it turned out, combined the talents of both mathematicians and philosophers. Thus, the creation of logicism is primarily due to G. Frege and B. Russell, intuitionism – to L.E.J. Brouwer, formalism – to D. Hilbert (Linnebo 2017; Shapiro 2000). G. Lolli (2012, 81) suggests that this fact was one of the reasons for the particular success of the corresponding programs, "their acceptance on the part of mathematicians, or at least that they were familiar to them and perhaps understood by them".

The adoption by mathematicians of the first programs to substantiate their science led to the fact that, despite the understanding that it was impossible to consistently substantiate mathematics using mathematical means, many scientists did not abandon the epistemological and methodological principles of philosophical programs. Thus, the formalism in its various modern versions remains so attractive to mathematicians that even today many of them proclaim themselves formalists, while accepting the unprovability of the Hilbert hypothesis underlying the formalism (Lolli 2012, 181). G. Lolli (2012, 206) writes about the modern followers of intuitionism: "The panorama of constructive mathematics in action, understood as something other than foundations, appears to be quite variegated. This includes, for example, the Russian school based on Markov's algorithms, constructive algebra, studies of recursive analogues of classical concepts". Sometimes a researcher, without positioning himself as an adherent of one direction or another, nevertheless creates significant works that completely fit into the framework of one of the directions. For example, the contribution of A.N. Kolmogorov and V.I. Glivenko into intuitionistic logic underlies the development of this fundamental school (Lolli 2012, 16), although neither of them, apparently, tried to justify mathematics from the standpoint of intuitionism.

Later these three schools evolved – they were modified, split up, lost and gained popularity, "faded out" and re-actualized (Kline 1980, 320-321; Linnebo, 2017). The constructivist movement within the intuitionist philosophy has many splinter groups (Kline 1980, 275), the key ideas of logicism have come down to the present within the framework of neo-logicism (Shapiro 2000, 133-138).

In modern philosophy of mathematics, a large number of programs are distinguished: in addition to those already mentioned, one can note, for example, structuralism, nominalism, naturalism, phenomenalism, semiotics, deductivism, fallibilism, empiricism, evolutionism, humanistic mathematics (Celishchev 2002; Lolli 2012). Not all of them were accepted by mathematicians and embodied in the paradigms of mathematical science. Some programs remained interesting mainly to philosophers. However, for example, Platonism in its various versions (including different modifications of realism), as well as formalism, is called by modern mathematicians among the most used philosophical programs (Celishchev 2002, 31-37; Lolli 2012, 105-184).

Often mathematicians who adhere to different approaches seem to speak different languages, having difficulty with understanding each other. Japanese mathematician S. Mochizuki published four massive papers online in 2012, claiming to have solved the abc conjecture. “Written in an impenetrable, idiosyncratic style, the papers seemed to be built entirely on mathematical concepts that were completely unfamiliar to the rest of the community – «like you might be reading a paper from the future, or from outer space», wrote Jordan Ellenberg, a number theorist at the University of Wisconsin” (Castelvecchi 2020). The researchers note that in this case, editors and referees handling these papers might have been in a nearly impossible situation: “If the best mathematicians spend time trying to work out what's going on and fail, how can one referee on his own have any chance?” (Castelvecchi 2020). After eight years of peer reviewing Mochizuki's work “has finally received some validation”. “The reason is that Mochizuki's work is so far removed from anything that had gone before. He is attempting to reform mathematics from the ground up, starting from its foundations in the theory of sets (familiar to many as Venn diagrams). And most mathematicians have been reluctant to invest the time necessary to understand the work because they see no clear reward: it is not obvious how the theoretical machinery that Mochizuki has invented could be used to do calculations” (Castelvecchi 2015, 181). “I tried to read some of them and then, at some stage, I gave up. I don't understand what he's doing”, says one of his colleagues (Castelvecchi 2015, 181).

At the same time, as in psychology, the truly significant results obtained in the framework of one of the approaches are valuable for all mathematics: “The achievements of logicism, deductivism, structuralism, logic are a wealth of knowledge about mathematics that is of lasting importance, will never be discredited and should be accepted by everyone, should not become a cause for philosophical disputes. It is not necessary at all to accept the philosophy that accompanied their discovery in order to recognize the significance of these results” (Lolli 2012, 280).

Split between different levels. The researchers note a deep split between scholars who are interested in the basics of mathematics and those who are engaged in mathematical practice (Mancosu 2008). The “working mathematician”, as a rule, is not at all interested in the problems of philosophy and methodology of science, his spontaneous philosophy often does not fit into the framework of one particular approach, but is an eclectic set of elements of various philosophical trends, but at the same time it is not so spontaneous, since important opinions and positions are perceived by him and influence his activities (Lolli 2012, 269). As an example, G. Lolli examines a case study with exploration the philosophical views of the “working mathematician” R. Hamming, which are “an original, sometimes contradictory, mixture of Platonism, naturalism, empiricism and constructivism” (2012, 269-278).

In recent decades, there have been attempts to overcome this split, primarily within the framework of the emerging philosophy of mathematical practice (Baldwin 2018; Mancosu 2008).

Demarcation criterion. M. Kline points out that creations of the early 19^{th} century, strange geometries and strange algebras, forced mathematicians to realize that mathematics proper and the mathematical laws of science were not truths, mathematical design was not inherent in nature, or if it was, man's mathematics was not necessarily the account of that design (1980, 4). That crisis of mathematical science and two other crises allowed researchers to single out such general properties of mathematical theories as their incompleteness, undecidability, impossibility of establishing their consistency, etc. (Mader 1995, 428). “Proof, absolute rigor, and their ilk are will-o'-the wisps, ideal concepts, «with no natural habitat in the mathematical world». There is no rigorous definition of rigor. A proof is accepted if it obtains the endorsement of the leading specialists of the time or employs the principles that are fashionable at the moment. But no standard is universally acceptable today" (Kline 1980, 315).

The potential inconsistency of mathematical knowledge forces modern mathematicians to either reconcile themselves with the possible inconsistency of their science, or look for the criteria for truth outside math: "Mathematics can be firmly, if not absolutely, secured by its applicability even if occasional corrections are required" (Kline 1980, 331); "the truth of mathematical conclusions finds its last foundation not in general definitions and axioms, not in the formal rigor of proofs, but in real applications, i.e., ultimately in practice" (Aleksandrov 1956, 73). Physics is traditionally considered the key application of mathematics in this sense. Some mathematicians, and quite authoritative ones, take a downright radical position, denying the very existence of mathematics as a separate science: "Mathematics is the part of physics. Physics is an experimental, natural science, the part of natural science. Mathematics is the part of physics where experiments are cheap" (Arnold 1998, 229).

The Current Situation in Physics

The crisis rhetoric. As it was shown, they begin to talk about a crisis in the social sciences and in mathematics when researchers are faced with the disunity of knowledge and the fundamental impossibility of combining it. In physics, the crisis, which also presupposes a multivariate description of the reality under study, is ordinarily perceived as a temporary phenomenon that characterizes a certain stage of the development of the paradigm (in the T. Kuhn's sense).

In the history of modern physics, the concept of crisis is frequently associated with the situation that developed in the late 19th – early 20th centuries when researchers faced the inability of classical physics to describe the structure of matter and interactions on a subatomic scale (Darrigol 2002, 341-349). This crisis has been described in sufficient detail by physicists themselves (Einstein 1922), as well as historians and philosophers of science. Moreover, it was used by I. Lakatos and T. Kuhn among other "classical" cases in natural science to illustrate the stages of the regression of scientific research programs and the pre-revolutionary crisis within their models.

A fairly common view is that thanks to the creation of quantum mechanics in its modern form "after a long period of cooperative and competitive efforts, the crisis of physics… had finally been resolved to most physicists' satisfaction" (Darrigol 2002, 348-349). Nevertheless, it would be an exaggeration to say that all the researchers found the solution to the crisis completely acceptable. For example, K. Popper, who had different views on the concept of crisis, wrote in the 1950s.: "Today, physics is in a crisis. Physical theory is unbelievably successful; it constantly produces new problems, and it solves the old ones as well as the new ones. And part of the present crisis – the almost permanent revolution of its fundamental theories – is, in my opinion, a normal state of any mature science" (1982, 1).

Disunity of science. K. Popper singles out a specific aspect of the modern crisis in physics: "it is also a crisis of understanding. This crisis of our understanding is roughly as old as the Copenhagen interpretation of quantum mechanics" (1982, 1). He insisted that "crisis is, essentially, due to two things: (a) the intrusion of subjectivism into physics; and (b) the victory of the idea that quantum theory has reached complete and final truth" (1982, 1).

It is important to note that not only some philosophers, but also some physicists questioned the subjectivist ideas of the emerging theory. The Copenhagen interpretation of quantum mechanics, which was founded by M. Born, W. Heisenberg, and N. Bohr, and which proposed a probabilistic description of processes at the subatomic level, quickly gained popularity among most researchers. However, a small part of physicists, led by A. Einstein, defended materialistic views on reality. A. Einstein strongly disagreed with the statistical description of quantum phenomena (Einstein 1999); he wrote that it "has to be regarded as an incomplete and indirect description of reality, to be replaced at some later date by a more complete and direct one" (Einstein 1948, 323). E. Schrödinger himself did not agree with M. Born's replacing matter waves with probability waves in Schrödinger's wave equation. However, his position was not so categorical and was subject to certain fluctuations.

Until the second half of the 20th century, it was generally assumed that A. Einstein suffered a defeat in this dispute, moreover, his stubborn position on this issue was perceived as marginal and repeatedly caused ridicule from younger colleagues. However, over time, the opinion about the only correct interpretation of quantum mechanics has ceased to be shared by the absolute majority of researchers. Other options were also taken into account. A poll taken at the 1997 UMBC quantum mechanics workshop gave the once all-dominant Copenhagen interpretation less than half of the scholars' votes (Tegmark 1998).

In the middle of the 20th century A. Einstein's ideas about the rejection of probabilistic interpretation were implemented in the original way by H. Everett, who proposed a new strategy for understanding the quantum formalism, which is known as Hugh Everett’s Many Worlds theory (Everett 1957; Saunders et al. 2010). According to this interpretation, every possible quantum state of any system contains infinitely many branches, since it can be expressed as a superposition in infinitely many ways, so Everett’s theory is committed to infinitely many real worlds at all times, no matter what the quantum state of the universe happens to be (Maudlin 2019, 173-175). H. Everett's interpretation is called “one of the great conceptual advances of twentieth-century physics” (Damour 2006, 150), although it has been perceived for several decades as one of the marginal theories. However, the situation has changed thanks to the Hawking's wave function of the universe, which is based on an infinite number of self-contained universes and postulates the possibility of tunneling between them (Kaku 1995, 263-264). It is important to note that modern quantum cosmology not only uses Many Worlds theory, but is largely build on it (Hawking 1988; Vilenkin 2007). D. Deutsch, a pioneer the field of quantum computation, wrote: "The quantum theory of parallel universes is not the problem, it is the solution. It is not some troublesome, optional interpretation emerging from arcane theoretical considerations. It is the explanation – the only one that is tenable – of a remarkable and counter-intuitive reality" (Deutsch 1997, 51). F.J. Tipler talks about a survey of seventy-two leading quantum field theorists about the truth of the Many-Worlds Interpretation. 58% of them said "yes", 18% said "no", 13% said "maybe", and 11% said "no opinion". "In the «yes» column were Stephen Hawking, Richard Feynman, and Murray Gell-Mann, while the «no's» included Penrose. Hawking's letter to Raub stated: « 'Many Worlds' is a bad name for it, but it is basically correct»." (1994, 170).

It can be seen that two such different interpretations lead not only to two different physics, but also to two fundamentally different understandings of the world, touching on the most important philosophical questions of determinism, the existence of many parallel universes, the anthropic principle, the principles of complementarity and uncertainty. Meanwhile, these two interpretations are not the only ones. Researchers use other variants such as Bohmian mechanics (aka de Broglie-Bohm theory, the pilot-wave model, and the causal interpretation) (Goldstein 2017), the Consistent Histories Approach (Griffiths 2019), Modified dynamics (GRW/DRM) (Tegmark 1998) etc.

Disagreements in physical interpretations of mathematical results obtained by modern physics can be called the first level of disunity of knowledge. But the problems don't end there. The second level of disunity is associated with the choice of the most promising areas in which it is advisable to concentrate the efforts of scholars.

The highly popular Superstring theory (or the M-theory behind it) is viewed by many scholars as the main contender for the unification of all fundamental forces, including gravitation. At the same time, even researchers who sincerely believe in the prospects of Superstring theory point out that its experimental confirmation is extremely difficult: “the best we can hope for is indirect tests of ten-dimensional theory into the twenty-first century” (Kaku 1995, 189). In addition, according to some physicists, the possibility of creating a unified theory is questionable: “Nor is there an absolutely *compelling* reason to believe in a unification of gravity with the other forces” (Smolin 2003). A number of researchers who previously actively developed superstring theory have expressed disappointment with it (Smolin 2006, 194).

In this regard, many researchers turn their attention to alternative theories. Although these approaches do not pretend to be a theory of everything, they are aimed at solving actual physical problems that superstring theory is also trying to solve. For example, researchers are trying to build a quantum theory of gravity in the framework of approaches include loop quantum gravity, causal sets, dynamical triangulations, causal dynamical triangulations, twister theory, non-commutative geometry, supergravity, approaches based on analogies to condensed matter physics, etc. (Smolin 2003)

It is important to note that these approaches differ not only and not so much in different interpretations of the same mathematical results, they use a different, only partially intersecting, mathematical formalisms (Smolin 2003), creating de facto different physics. This problem is pointed out by S. Hossenfelder (2018) in his book “Lost in math”. She writes: “Physics isn’t math. It’s choosing the right math”. S. Hossenfelder (2018) draws attention to the problem of the absence of criteria for such a choice within physics. In this regard, she discusses intuition-based assumptions, which are very important for physicists, and suggests paying more attention to the relationship between physics and philosophy.

Split between different levels. As in mathematics, in physics there is a split between those researchers who create and develop theories within existing paradigms or solve applied problems, and those who are concerned with finding the foundations of science (creating new paradigms). L. Smolin (2006, 308-331) called these two groups “master craftspeople” and “seers”.

Physicists in the first group (master craftspeople) are not interested in fundamental questions and problems of philosophy and methodology of science: “In general… most physicists feel uncomfortable talking about philosophy. They are supreme pragmatists. They stumble across physical laws not by design or ideology, but largely through trial and error and shrewd guesses… Most physicists feel that, outside of vague notions of «truth» and «beauty», philosophy has no business intruding on their private domain. In general, they argue, reality has always proved to be much more sophisticated and subtle than any preconceived philosophy" (Kaku 1995, 317). S. Weinberg devoted an entire chapter "Against philosophy" in his book "Dreams of a final theory" to demonstrating that philosophy is almost unnecessary for scholars. He writes: "Physicists do of course carry around with them a working philosophy. For most of us, it is a rough-and-ready realism, a belief in the objective reality of the ingredients of our scientific theories. But this has been learned through the experience of scientific research and rarely from the teachings of philosophers" (1992, 167).

The second group of researchers, who actually who are working on the creation of new paradigm (seers), on the contrary, pays serious attention to the philosophical justification of the results of their activities and the activities of their colleagues (Heisenberg 1959; Planck 1963; Schrödinger 2008). M. Kaku (1995, 317-318) notes: "Nevertheless, although the average physicist is not bothered by philosophical questions, the greatest of them were. Einstein, Heisenberg, and Bohr spent long hours in heated discussions, wrestling late into the night with the meaning of measurement, the problems of consciousness, and the meaning of probability in their work".

Demarcation criterion. In physics, the problem of distinguishing scientific knowledge from unscientific knowledge is also not solved, as in psychology and mathematics. L. Smolin (2006, 308-331) highlights leaders of the "background-independent" approaches to quantum gravity whose scientific views were formed by lifelong reflection on the deep foundational issues: R. Penrose with arguments that the incorporation of gravity into quantum theory makes that theory nonlinear; R. Laughlin, a Nobel Prize winner for his contributions to «the discovery of a new form of quantum fluid with fractionally charged excitations»; T. Jacobson and J. Magueijo with their ideas that special relativity is false; H.B. Nielsen with his antiunification program; G. 't Hooft with holographic principle that assumes that there is no space. Although part of the fundamental ideas of these researchers is sometimes called marginal, some of them have led to significant results, highly appreciated by colleagues and widely used by them in mathematics and physics.

An additional problem of the truth of physical knowledge is the correctness of the use of the mathematical formalism by researchers. As the scholars note, «the number of physicists who write papers that satisfy the usual standards of mathematical rigour is small, perhaps only a few per cent of the total number of working physicists» (Urquhart 2008, 421). A. N. Kolmogorov (1991, 66) points out: "There is still no strict justification for many mathematical methods widely used in modern theoretical physics, where many valuable results are obtained by illegal mathematical techniques, which, for example, sometimes give the correct answer only «with accuracy» to a deliberately erroneous multiplier, corrected from considerations extraneous to this «mathematical conclusion», or by discarding in the sum those terms that go to infinity, etc."[1]. At the same time, the researchers

[1] The old "Problem of Infinities" (Kaku 1995, 140, 150, 326; Weinberg 2014, 1992, 16-17, 108-116, 313) seemed to be solved in Superstring theory by using topology, but in a very specific way. Infinite values seem to disappear, but an infinite number of particles appear (Dowden 2020; Weinberg 1992, 313).

note "the unreasonable effectiveness of mathematics" in understanding the laws of nature (Wigner 1967).

Psychology, Mathematics, Physics: Generalities and Differences

Several key theses can be formulated as a result of comparing the situations in different scientific fields.

1. Crisis rhetoric is quite popular in all three scientific fields. At the same time, there are both general points and specific ones.

1.1. In all three scientific disciplines, crisis rhetoric is resorted to in a situation of disagreement between researchers regarding the foundations of their science, leading to the loss of scientific unity and the formation of different, competing versions of the description of the studied reality.

1.2. The latest global crises in all three disciplines are associated with the period of the late 19^{th} - early 20^{th} centuries. In psychology, the crisis is still considered to have not been overcome; crisis rhetoric continues to be in demand. In mathematics, it is believed that the crisis has not been overcome either, but crisis rhetoric is unpopular at the present stage. In physics, the illusion of overcoming the crisis (in the T. Kuhn's sense) was formed by the middle of the 20^{th} century, however, as can be seen, in reality a single paradigm did not arise. It can be stated that either the crisis in physics has dragged on a bit, or T. Kuhn's idea of the presence of a single paradigm at the "normal" stage of "mature" science has nothing to do not only with psychology and mathematics, but also with physics of the second half of the XX and especially the beginning of the 21st century.

2. The dynamic disunity of scientific knowledge is observed in all three scientific fields. Competing approaches and scientific schools are evolving. The place of the approaches that have lost popularity among researchers is taken by the newly emerging ones.

3. In each of the three scientific disciplines, there is a deep split between the two groups of specialists, related to the degree of importance of philosophy for them. The difference between disciplines in where this gap runs can be demonstrated using the following model.

To simplify the situation, specialists in any science can be divided into three groups.

a) The specialists working at Level 0 develop a new approach (paradigm). For such researchers in all three scientific fields, philosophy is of the utmost importance; new scientific approaches are formed precisely due to the introduction of global changes in the usual scientific understanding of the world.

b) Level 1 specialists are engaged in “pure” science, not interested in its foundations. For them, in mathematics and physics, philosophy is considered unnecessary, completely superfluous, since within the framework of the chosen approach, the researcher is “led” forward by mathematics. It is mathematical rigor (no matter how it is understood within a particular paradigm) that is responsible for the fact that researchers will remain within the framework of the chosen approach and get correct results. Philosophy can be significant at this level only at the time of the initial choice of the approach in which the researcher plans to work, as well as when it is necessary to “translate” scientific models from the language of one approach to the language of another.

The same goes for the natural-scientific paradigm in psychology. Adherents of quantitative psychology believe that they do not need a philosophical understanding of their work. A completely different situation in qualitative psychology. For researchers, there is no mathematics as a “methodological guide”, its role is played by philosophy. Psychologists determine the correctness of their results precisely by checking the results obtained with the chosen scientific world-picture.

c) Specialists working at Level 2 are those who solve applied problems. For such specialists in all disciplines, philosophy is of optional interest.

The considered model, although it represents a significant simplification of reality, nevertheless demonstrates why in mathematics and physics the split is located between Level 0 and Level 1 specialists, and for psychology (most approaches in which are qualitative) – rather between Level 1 and Level 2 specialists.

4. Given the fact that different, competing approaches coexist in all three scientific fields, issues related to the reconciliation of research results and corresponding worldviews will become increasingly important. In psychology, multi-paradigm research is not uncommon. It is likely that such studies will appear

more and more often in physics and mathematics. For this purpose, the basic principles of interdisciplinary research, which have been actively developing since the middle of the last century, can be used. For example, over 70 years ago W. Leontief (1948) developed the concept of interdisciplinary cooperation, which showed the possibility of a pluralistic description of the phenomena under study by various social, natural and exact sciences (for example, anthropology, geography and economics). In particular, he wrote: “The pluralistic character of any single explanation reveals itself not in simultaneous application of essentially disparate types of considerations but rather in the ready shift from one type of interpretation to another. The justification of such methodological eclecticism lies – and this is the principal point of the argument that follows – in the limited nature of any type of interpretation or causation” (1948, 619). In such researches scholars “work out an intermediate language, a pidgin, that serves a local, mediating capacity” (Galison 1996, 14). These ideas are fully compatible with multi-paradigm researches.

5. Generally accepted criteria for the demarcation of scientific and non-scientific knowledge are absent in all three scientific disciplines. The possibility of finding them within a particular science is doubtful today, so researchers are forced to either look for confirmation of validity in other scientific fields (physics - in mathematics, mathematics - in physics, psychology - in philosophy, mathematics and physiology), or set the criterion arbitrarily, as a result of public consensus, or admit the fundamental impossibility of demarcation after P. Feyerabend.

6. Is it possible to assume that mathematics is more accurate than physics, and physics is more accurate than psychology, if in mathematics accuracy is associated with the potential inconsistency of theories, and in physics the results are often accurate, as shown above, up to an arbitrarily discarded term equal to infinity? The answer to this question, of course, is ambiguous and depends on the scientific world-picture of the scholar.

7. Scholars in psychology, mathematics, and physics achieve not only significant scientific results, but also contribute to the rapid development of technology, culture, and society, despite the absence of common truth criteria and demarcation criteria, the impossibility of finding common grounds for science, the potential internal inconsistency of knowledge, and the not always correct use of the tools of other sciences.

8. The application of the described model to the science studies allows us to see that its current state corresponds to general scientific trends. Various approaches coexist and dynamically develop in it (K. Popper, T. Kuhn, I. Lakatos, M. Polani, S. Toulmin, P. Feyerabend, etc.). At the same time, there is no demarcation criterion, there is no single point of view on the degree of “maturity” or “accuracy” of these approaches, there are no internal criteria for choosing one or another of them. The choice can be made only as a result of comparison by the researcher of various approaches with his own picture of the world. There is also a deep split between those who study the laws of the development of science and those who directly develop it. S. Weinberg (1992, 167) wrote about the lack of

interest of researchers in science studies, with some sarcasm: “I do not even mean to deny all value to the philosophy of science, which at its best seems to me a pleasing gloss on the history and discoveries of science. But we should not expect it to provide today's scientists with any useful guidance about how to go about their work or about what they are likely to find. I should acknowledge that this is understood by many of the philosophers themselves. After surveying three decades of professional writings in the philosophy of science, the philosopher George Gale concludes that «these almost arcane discussions, verging on the scholastic, could have interested only the smallest number of practicing scientists.»”. At the same time, the key results obtained within the framework of various approaches to the study of the development of science become the property of the entire scientific community, as a rule, they are highly appreciated and actively used by researchers regardless of their worldview. And, as in the sciences discussed in the article, when studying the development of science, it seems to me promising to conduct multi-aproach research.

Conclusion

The comparative analysis of the situation in three disciplines showed that psychology, mathematics and physics from the point of view of “maturity”, despite their natural specificity, have similar, if not identical, statuses. T. Kuhn (1970, viii) wrote: “the practice of astronomy, physics, chemistry, or biology normally fails to evoke the controversies over fundamentals that today often seem endemic among, say, psychologists or sociologists. Attempting to discover the source of that difference led me to recognize the role in scientific research of what I have since called «paradigms»”. Probably, these words are true when we discuss the situation in science until the 20th century (and partly at the beginning of it). And modern science is characterized by growing disunity and fractionation, a split between different levels of science, as well as the difficulty in defining a criterion for the demarcation of scientific and non-scientific knowledge. At the same time, the differences between “mature” and “immature” science fade out. Therefore, the stigmatization of the social sciences as subjective and imprecise is inadequate, and the crises of identity of psychologists and sociologists is unfounded. In connection with the fractionation of science, it is possible to predict, along with interdisciplinary research, a greater number of multi-paradigm or multi-approach studies, which allow, to a certain extent, to reconcile various scientific pictures of the world within one science.

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