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IS THE NOTION OF "CREATIVE METHODS" A LEGITIMATE METHODOLOGICAL CONCEPT?

1. In connection with the rapid growth of the importance of the logical machines the old antithesis of "creative" and "mechanical" revived. Verstand is "mechanical", Vernunft is "creative". The logic is "mechanical", the philosophical method is "creative". The human thinking is creative, the machine "thinks" "mechanically". The chess-playing machine "thinks mechanically", the human chess player thinks "dialectically".

The creative thinking is an object of intensive psychological research. According to one of the psychological characteristics of this type of thinking it "discovers new relationships, achieves new solutions to problems, invents methods or devices ...".[1] Obviously there is nothing illegitimate on this empirical notion of creativity as a possible property of thinking. Sometimes, however, we can hear or even read about creativity as a property of some methods. In this case the mentioned antithesis could be formulated as follows: "the creative methods" vs "the mechanical methods" (we take here into consideration only the scientific methods).

Now, the problem arises whether the general methodology as the science studying the general characteristics of the methods could ever analyze such phenomena as the s. c. "creative methods": according to our linguistic intuition we usually take the formulation "no creative method is analyzable" for a true statement.

Should then the general methodology study only the "mechanical methods", i.e. properly speaking the algorithms? Do besides the "mechanical methods" exist any "creative methods" — independently on what the general methodology does or does not study? Or is the mentioned classification of methods based on an erroneous use of words?

2. To be able to answer these questions we must formulate explications of some terms.

A *method* is a set of regulations ordering to transform "input-data" into "output-data", the relation between the input-data and the output-data being a functional one. (Some other explications are of course thinkable, but they would not essentially differ from this one, if we do not take into consideration some probabilistic conceptions.)

A *problem* we can conceive as a task of finding, constructing a.s.o. the elements of a class which is given by a definition.

Example: The problems of:

a) finding the greatest common divisor of the numbers 16 and 24,

b) finding the greatest common divisor of any two positive integers,

c) determining whether 8 is the greatest common divisor of the numbers 16 and 24,

d) determining whether a positive integer is the greatest common divisor of two other positive integers

we can conceive as the tasks of finding the elements of the following classes (respectively):

a) the class of the greatest common divisors of the numbers 16 and 24 (this class contains of course one element only),

b) the class of the ordered pairs $\{\langle a, b\rangle, c\}$, such that a, b are any positive integers and c is the greatest common divisor of a and b,

c) the class of the correct answers to the question whether 8 is the greatest common divisor of 16 and 24 (containing again one element only),

d) the class of the ordered triples $\{\langle a, b\rangle, c, d\}$, such that a, b, c are any positive integers and d is "yes" if c is the greatest common divisor of a and b, and "no" otherwise.

The problems of the type b) and d) are general problems, the problems of the type c) and d) are decision problems (among them the logical decision problems for provability, for validity, a.s.o. are of special theoretical importance). (From the point of view of the general methodology the general problems are especially interesting.)

We shall say (not very precisely) that the method M *solves the problem* P whenever the class defined in the problem P is a (proper or improper) subset of the class of the output-data of the method M.

It can be proved that for every method there exists a problem which is solved by this method.[2] The "inverse" statement is not valid: it is not true that for every problem there would be a method solving this problem.

From this point of view there exist (always with regard to a definite moment of time) three classes of the problems:

A. Problems which are solved by the already known methods.

B. Problems about which there has been proved that they principially cannot be solved by any method.

C. The remaining problems.

Examples from logic: Into the class A there belong e.g. the decision problems for provability in the classical propositional calculi, into the class B the decision problems for provability in various predicate calculi.

Into the class C all the problems belong which — up to the respective moment of time — were solved neither "positively" nor "negatively". The elements of the class C with regard to the moment of time t_i become elements of the class A or B with regard to the moment of time t_j, $j > i$.

(The problems from the class B are the s.c. (algorithmically) *unsolvable problems.* The conditions under which a problem is or is not unsolvable are analyzed by the theory of algorithms or of the computable functions.)

3. On the basis of the preceding explications we shall now try to explicite the formulations "mechanical method" and "creative method".

What we mean when using the above expressions cannot be meaningfully formulated as a classification of the properties of methods. This becomes evident as soon as we regard our definition of "method". No method can be "mechanical" or "creative". By these terms we really mean some relations, at least some relations between methods and problems.

Let us regard the class A_1 of the ordered pairs $\langle M_i \; P_j\rangle$, $i, j = 1, 2, \ldots$ (the effectiveness of the numbering M_j as well as P_i can be secured e.g. by an appropriate restriction of the universe of discourse) where M_i is a method which solves the Problem P_j (consequently P_j is an element of the class A).

The class A_1 defines a relation R_1 which apparently corresponds to the intuitively conceived meaning of the formulation "the problem P_j can be solved mechanically by the method M_i".

Now a possibility offers itself to us of defining the relation R_2 corresponding to the intuitively conceived meaning of the formulation "the problem P_j can be solved only creatively by the method M_i" as the complement of the relation R_1; this would mean that every ordered pair $\langle M_i, P_j\rangle$ not being element of the class A_1 would characterize a "creative way of solving". This is of course absurd, not corresponding to our intuition connected with the expression "creative way of solving". We get closer to this intuition if defining R_2 by means of the class A_2 of ordered pairs $\langle M_i, P_j\rangle$ such that the class of the output-data of the method M_i is a proper subset of the class defined in the problem P_j. In this case the meaning of the expression "creative way of solving" is given by such pairs method—problem where the method only partially solves the problem.

4. The above explication of the distinction between the expression "mechanical way of solving" and the expression "creative way of solving" is essentially defective: it has been performed on the syntactical-semantical level, the explicated expressions being of a pragmatical character. A more appropriate explication will be based no more on ordered pairs method—problem; we have to consider ordered triples solver—method—problem.

The necessity of the transition on this level is apparent: the syntactical-semantical level of analysis cannot grasp the fact that the word "creative" characterizes a whole situation including a subject, i.e. a problem solver. (In such a situation we solve "problems requiring intelligence and adaptation".[3]

Let us consider the problem whether an expression of the propositional calculus L is provable. Let a solver of this problem be a student who does not know the method of truth-tables and its relation to the decision problem in L, but who knows the axiomatic method, disposes of the axioms of L and of the respective rules of inference. (In the same situation there is a computer solving "heuristic" logical problems in the group of Newell—Shaw—Simon.)[4]

What our student — being of course sufficiently intelligent — makes when solving the given problem we surely can take for "creative way of solving". (His activity could be described as selective using various possibilities of applying the rules of inference to various axioms, eventually theorems.)[4]

Let us however compare with the above situation the case when we forget the general formula for solving the quadratic equations and apply istead of it the formula which is valid only for one type of the quadratic equations. According to our first explication this would mean that our method of solving the quadratic equations is "creative" with regard to this problem. According to our intuition such a conclusion is absurd.

A more natural explication must therefore exclude this case while including the case with the student. Such an explication will be apparently the following pragmatical (or psychological) one:

Let us regard the class B_1 of the ordered triples $\{\langle S_i, M_j \; P_k\rangle\}$ such that the problem solver S_i applies when solving the problem P_k the method M_j which is known to him and which solves the problem P_i. The class B_1 defines what we mean when saying "S_i solves mechanically the problem P_k (by means of the method M_j)".

Analogically, the class B_2 of the ordered triples $\{\langle S_i, M_j, P_k\rangle\}$ such that the problem solver S_i when solving the problem P_k produces himself the method M_j which partially solves or (in extreme cases) solves the problem P_k defines what we mean when saying "S_i solves creatively the problem P_k (by means of the method M_j)".

This explication includes very different cases: when the solver does not know the method solving the given problem although such a method does exist (our example with the student; the given problem is an element of the class A); when the method which would solve the given problem cannot exist (and the method produced by the solver concerns then naturally only a class of subproblems of the given problem: the latter is element of the class B); when the method which would solve the given problem has not yet been discovered (and the method produced by the solver has the same extent as in the second case or it is — in an extreme case — a method solving the given problem and having been just discovered by the solver; the given problem is element of the class C).

Using the expression "creative method" we mean by that most probably a characteristic of the process which takes place whenever a subject is solving a problem not known to him. Taking for the problem-solving-subject the class of all scientists up to a definite moment of time we can accept the classification of researches the author of which is A. Grzegorczyk: "1. The researches performed by means of the effective methods known in the given science; 2. Researches consisting in seeking after new methods and after the solutions of the problems not solvable by means of the existing methods".[5]

5. One new question arises: is the general methodology interested in the distinguishing the "mechanical ways of solving" and the "creative ways of solving" in the sense of the above explications? We have seen that the terms by means of which we have explicated the respective vague expressions belong into the domain of the psychology of thinking. The works of G. Polya[6] concerning the "creative methods" (sit venia verbo) really remind rather of psychological analyses than of the classical methodological monographies.

Our question could be answered in a satisfactory manner only if we applied the explicating procedure to the term "methodology". Not doing so we wish to point out that the methodological character just of the works of Polya cannot be denied as well as the researches of Newell's group, though concerning simulation of the human behavior in the process of problem solving has essentially contributed to the analysis of the structure of methods. There is nothing surprising on these close contacts between the psychology and the general methodology: the pragmatical aspect of the methods is a very important one, and the general methodology cannot avoid studying this aspect empirically, i.e. among others with the help of the psychology.

From this point of view it is wholly legitimate to distinguish in the general methodology between the "mechanical" and "creative" ways of solving the problems. Only we must be aware of the relational character of these expressions the importance of which consists in that they characterize the activity of a problem solver depending on whether the latter applies already known methods or whether he himself produces a "new" method.

6. As a wholly naive and laic opinion we must reject such an interpretation of the expressions "mechanical" and "creative" according to which there exist two groups of methods: one of the mechanical methods, the other of the creative methods. Unless we admit some irrationalistic, romantic ideas we see no possibility how to distinguish between the elements of the first group and the elements of the second group.

Sometimes the following conception is taken for an expression of antiagnostical philosophical "optimism": The mechanical methods are such methods which can be realized by a machine (computer). The superiority of the Man in comparison with the Machine consists in that the Man can realize not only the mechanical methods but also the creative methods which do not deceive us in the cases where the mechanical methods do (apparently this concerns the unsolvable problems).

According to this the (algorithmically) unsolvable problems get solvable by means of the "creative methods".

This conception is unscientific, phantastic. It does not determine in a more precise manner the character of the "creative methods" and concrete reasons for their superiority. Moreover, it cannot show any instance of such a problem that would be unsolvable by means of the "mechanical methods" and would get solvable by means of the "creative methods". We cannot but accept the destroying criticism of this conception as it is contained in A. N. Kolmogorov, *The Automata and the Life.*[7]

NOTES

[1] E. R. Hilgard, *Introduction to Psychology*, 2nd ed., New York 1957.

[2] Cf. P. Materna, *Operative Auffassung der Methode,* Rozpravy Čs. akademie věd, Vol. 75, No. 8, 1965, pp. 17—18, where however the proof is not effective.

[3] A. Newell, J. C. Shaw, H. A. Simon, *Report on a general problem-solving program,* Information Processing, Paris, Unesco 1959, p. 256.

[4] Cf. A. Newell, J. C. Shaw, H. A. Simon, *Elements of a theory of human problem-solving.* In: Psychol. Rev., Vol. 65, No. 3, 1958, and A. Newell, J. C. Shaw, H. A. Simon, *Report on a general problem-solving program.* Information Processing, Paris, Unesco 1959.

[5] A. Grzegorczyk, *Zagadnienia rozstrzygalności,* Warszawa 1957, p. 8.

[6] E. g., G. Polya, *How to Solve It,* Princeton University Press 1945.

[7] In: Rovenskij, Ujomov, Ujomovová, *Machine and Thought,* Praha 1963 (transl. from Russ. to Czech).

Translated by P. Materna

JE POJEM „TVŮRČÍCH METOD" LEGITIMNÍ METODOLOGICKÝ POJEM?

Starý protiklad „tvůrčích" a „mechanických" metod nabyl na významu v souvislosti s růstem úlohy matematických strojů. Soudobá psychologie zkoumá např. intenzívně tzv. „tvůrčí myšlení". Pojem „tvůrčích metod" je však pochybný. Vyjdeme-li z definice metody jako souboru příkazů transformujících „vstupní data" ve „výstupní data" (závislá funkcionálně na „vstupních datech") a z definice problému jako úkolu nalézt, sestrojit apod. prvky třídy zadané definicí, dojdeme k závěru, že pojem „tvůrčí metody" je neudržitelný. Můžeme rozeznávat tři druhy problémů (vzhledem k určitému časovému okamžiku jsou to vždy tři třídy vzájemně disjunktní): problémy řešené již známými metodami, problémy, o nichž bylo dokázáno, že nejsou zásadně řešitelné žádnou metodou, a problémy, které dosud nebyly řešeny, ale o nichž nevíme, zda spadají do prvé nebo do druhé skupiny. Mluvíme-li o „tvůrčích metodách", máme zřejmě na mysli vztah, a to minimálně mezi metodou a problémem. „Mechanické metody" můžeme chápat jako metody řešící problémy prvé skupiny, kdežto „tvůrčí metody" jako metody částečně řešící problémy kterékoli skupiny. Avšak i tato explikace je neuspokojivá, neboť nebere v úvahu třetí člen vztahu: řešitele. Autor proto navrhuje tuto explikaci:

„Mechanické metody" nechť jsou definovány třídou takových uspořádaných trojic $\langle S_i, M_j, P_k \rangle$, že S používá při řešení problému P_k metody M_j, která tento problém řeší a kterou S_i zná. „Tvůrčí metody" nechť jsou pak definovány třídou uspořádaných trojic se stejným označením, kde S_i vytváří sám metodu částečného řešení nebo (v extrémním případě) řešení problému P_k. Psychologický charakter této explikace je vynucen skutečností, že mluvit o „tvůrčích metodách" má smysl pouze na pragmatické úrovni. Naprosto neudržitelný a přímo fantastický je názor, podle něhož existuje zvláštní třída „tvůrčích metod", jež dokáží řešit i algoritmicky neřešitelné problémy.