THE INNOGRAPH TECHNICS

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Summary

The main goal of the innograph technics is to disclose and to systematize the development possibilities, and the problems impeding the correct operation of complex industrial systems. The procedure combines the brain-storming and the nominal group technics with special graph methods. It makes possible structurized working process in groups. It eliminates nearly the conformity, at the same time offering participation equality. A rapid and effective creative work activity in groups, supported by computer, can be achieved by applying graph methods.

Purpose and Main Points

While solving problems one can face conditions when a *simple* enumeration of the problems is not satisfactory. In this case it can be essential to know from several points of view of the relations among problems, which can be solved by the analysis of these relations. Our aim is to increase the effectiveness and the efficiency of the problem-solving by means of methods stimulating the *intuition* of teamwork and by means of the systematic "pragmatism".

The method to reach this goal is the so called *innograph technics* (its name comes from the joint application of innovation and graph technics) developed and resulted from our departmental work. The main point of this technics are: the participants of the teamwork applying the brain-storming method disclose their thoughts about the topic under discussion and define first individually the relations among the thoughts by means of a graph, later they discuss the disputable details of the graph. The graphs made individually and discussed mutually are to be organized in a matrix form. So the system matrix is obtained. The relations among the most essential thoughts can be defined by a suitable analysis of this matrix. Based on the disclosed relations the team will be able to improve their results by searching for the so called *circles and paths of thoughts.*

Resulted from this technics, in case of problems the critical, in case of suggestions the successful circles and paths of thoughts are obtained.

In fact the innograph technics accumulates several other innovation technics in such a way, that elements of brain-storming will dominate when

disclosing thoughts, elements of nominal group method with "graph" are used when defining relations, the method of co-operation of large and small groups is used in case of a staff of 20 people and the elements of causal technics increasing efficiency will dominate when analysing the circles and paths of thoughts.

The most advantageous feature of the innograph technics is its graph-based representing method that inspires the review of the relations of the given thoughts and stimulates to disclose new ones. It is a structured teamwork process, the variability among groups is minimal, building-up of interpersonal relations is less than the task-orientation. The teamwork is featured by the proactive searching because there is a considerable increase of time allocated to the concentration on the task. The conformity factor is almost zero, because the individually defined relations are "unrecognizably" built into the synthetized graph. Thus the equality of team members in participation is of high degree, and it cannot be effected by the discussion periods. This technics is very effective, its use needs relatively short time and can be processed by computers.

The definition of circles, paths of thoughts and its analysing possibilities

It is a well-known fact, that there may exist many kind of goals to disclose thoughts and to define their relations. These goals depend on the real content of the thoughts. We have one intention if we want to define a problem and have another one if we strive for working out propositions from different ideas.

In the given example the thoughts disclosed should be problems, that must be divided into causes and effects for the reason, that ceasing the causes, the consequences will be presumably ceased as well.

For presenting the main points of this technics, let us start from the set of the most important problems:

$$P = \{P_1, P_2, P_3, \ldots P_{13}\}$$

The cause-effect relations are shown in the graph of Fig. 1.

Generally it can be stated, that the number of cause-effect relations among problems defines the complexity of the problem-system. In our example there are 31 directed relations among the 13 thoughts. The bidirectional relations of this graph consisting of 13 points number 156. It means that the graph presented here has a system relation complexity of 20%. This is not a complicated graph. The high number of relations can refer to the similarity of the revealed problems, which indicate in some extent the possibility of reduction. For example P_1, P_2 and P_5 are reducable. The new problem will be marked as P_{125}.

After the reasonable reductions the examination of the cause-effect characteristics of the problems may follow. α_i as measure can be introduced that shows how many times a given problem turns to be a cause (outgoing arrows) or an effect (incoming arrows). In case of a given problem it is advantageous to express this condition as the number of effects per causes. Based on the value of α_i problems can be separated into two groups: causes and effects. If a given problem has only outgoing arrows and has no incoming ones, it can be handled as a *fundamental cause.*

If a given problem has got only incoming arrows, it can be considered as *fundamental effect.*

On the basis of our graph the *fundamental causes* are: P_4, P_8 and P_{12}, whereas the *fundamental effects* are: P_1, P_7 and P_{11}. The other problems can be

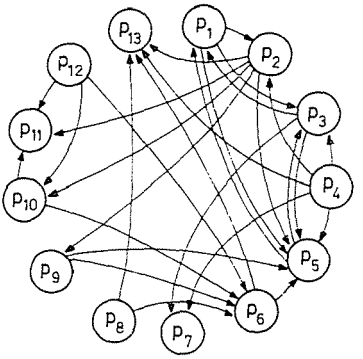

Fig. 1

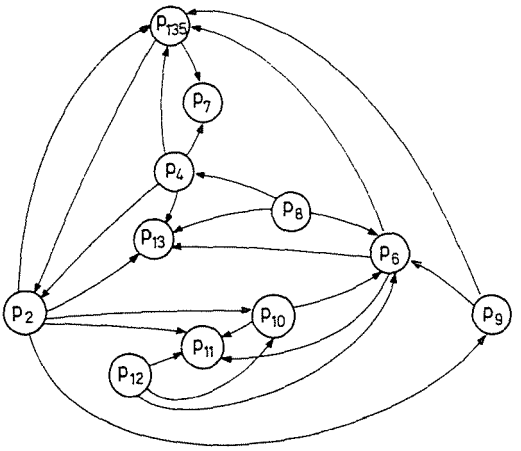

Fig. 2

regarded as cause or effect according to their characters. The α_i values are:

$$\alpha_{135}=\frac{4}{2}=2; \quad \alpha_2=\frac{1}{5}; \quad \alpha_6=\frac{4}{3}; \quad \alpha_9=\frac{1}{2}; \quad \alpha_{10}=\frac{2}{2}=1$$

Based on the above mentioned, according to their character, if $\alpha_i<1$, the problem seems to be much rather a cause, than an effect, if $\alpha_i>1$ then it is much rather an effect than a cause.

Thus the additional *causes* are: P_2, P_3 and P_{10}, the effects are: P_6 and P_{135}. Figure 2 presents another graph, which shows the relations among problems much better than the previous one. Based on this graph the so-called *matrix of minimum distances* can be set up:

$$P_{min}=\begin{matrix} 0 & 1 & 0 & 3 & 1 & 0 & 2 & 2 & 2 & 0 & 2 \\ 1 & 0 & 0 & 2 & 2 & 0 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 0 & 3 & 1 & 0 & 2 & 2 & 2 & 0 & 1 \\ 1 & 2 & 0 & 0 & 2 & 0 & 3 & 3 & 3 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 2 & 0 & 1 & 2 & 0 & 0 & 2 & 2 & 0 & 2 \\ 2 & 3 & 0 & 1 & 3 & 0 & 4 & 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 2 & 3 & 0 & 1 & 3 & 0 & 4 & 1 & 1 & 0 & 2 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{matrix}$$

The "0" values show the lack of relations among elements. At first sight it can be read out of this matrix, that non-zero values reflecting relation exist, and their values are the smallest—that means, their distances from the other points are the shortest—these points represent the *central thoughts*. In our example they are: P_2, P_4, P_9 and P_{135}.

One can see from the above mentioned, that both the graph and the matrix representations offer several kinds of analyzing possibilities. As for the problems it is possible to place them in the centre or in the periphery according to their importance. The judgement of a given problem can only be really unambiguous, if it is put to a consistent place with regard to its relations and its importance as well.

By means of the graph in Fig. 2 *starting from a given thought* we can go continuously along a series of paths until we reach another thought or get *back to our starting point*. With this method we include the thoughts situated on the paths, in fact the interdependent ones, in groups, in part sets. As an example let us see any series of paths of the Fig. 2. *Let us start* from P_4. We can go to several directions from here. Let us pick up the following direction: P_2, P_9, P_{135}.

Looking for the *circles of problems it is practical to start from the previously determined centre of problems*, in our case from P_2. We can start from here into 4 different directions and can arrive from 2 directions. Where to go? Covering up the graph has to be done systematically. Before doing it let us "go round" an optional circle of thoughts. Let us start from the determined point P_2. The elements of this circle are: P_2, P_{10}, P_6 and P_{135}.

The read-out of the graph can be started in another way as well. We can start from the fundamental causes, from P_4, P_8 and P_{12} in our case. According to the graph they do not depend on each other. There is no path back, so circles of thoughts cannot be disclosed. Let us see another example.

Let us start from P_{12}. We can have three different directions to pass along. Let us go on to P_9. Passing through the paths of the innograph our stops of thoughts are the following: P_{135}, P_2 and P_{11}. In our route we were given many times a choice between alternatives by the graph "directing" our thoughts, e.g. our route could have led to P_7 from P_{135}. It is practical to summarize the results together with the weight-numbers of thoughts in a table form, where the main paths of the graph should be presented besides the circles. When determining the paths the starting point should always be a fundamental cause (source of thought). It is advantageous to examine *separately* the paths coming into effects as well.

Based on the above, the advantage of the innograph technics can be seen: *proposals can be made to solve not only individual problems but related ones.* At the same time the relations of the previously disclosed problems can be controlled. This feedback makes possible to revise and to complete the problems. "Reading" the innograph inspires a profound causal thinking.

The main characteristics and advantages of the application

This technics seems to be applicable for such fields, where relations exist among the disclosed thoughts. The number of such cases is significant so this technics is applicable in several fields.

The innograph technics backs the teamwork exclusively. Staff number of the team shall be 5 as a minimum. When disclosing and solving problems need the co-operation of more experts, then it is possible to establish and operate more teams simultaneously. The upper limit of staff number for a successful application is 20. (It is justified by the effective use of brain-storming method.) The main characteristics are:

It is intuitive and causal at the same time

This technics unites the advantages of both ways of thinking. When disclosing thoughts it is intuitive, when looking for relations it is causal. The latter can be made intuitive by the application of proper procedures.

Representation with graph and matrix gives many-sided analysing possibility

It seemed that an intuitive and at the same time systematical approach could only be reached by a representation based on graph and matrix. The great advantage of the graph-theory is due to the fact, that it makes possible to handle problems by means of mathematics. Thus the previously mentioned intuition and causal thinking can be promoted by the tools of mathematics. In fact a helical process is set up, in which association and logics are harmonized, supported by the graph-theory. In this process computing technics can play an active role, especially by applying microprocessor-based computers which give a *direct* support for the work of the team. It is imaginable, that the related thoughts resulted from the computing appear on the screen. Analysing and completing these thoughts the computer can help in disclosing new ones.

Inductive and deductive phases of thinking are founded on each other

It is well-known, that thinking in a given period is inductive, later it is deductive. This technics is inductive in disclosing thought, and it is deductive when the innograph-based paths and circles of thoughts are looked for. On this latter informative level thinking can become inductive again, e.g. new thoughts will be disclosed by means of brain-storming, and they will be built into the system of the former results. The reinforced interaction of inductive and deductive thinking can go on until a given goal is achieved.

It can be built up and expanded with modules

The graph-based representation makes possible the modular processing. It means that the result of our thinking can be represented mosaic-like, so they can be completed any time at will i.e. they are expandable.

Activities of several innovative groups can be united

The other significant advantage of this technics derives from its modular structure: it is possible to integrate and unify the results of the work of *several groups*. Above all this feature gives methodical help when solving problems of large systems.

Supplemented with other methods of innovation it can be organized to be a problem-solving process

This technics can be used for disclosing problems and preparing proposals to solve the problems. For example: test sheets, ranking method etc. are used for preparing problem-maps. When making proposals from roughly detailed immaginations the Delphian method is used to set up the problem-solving process supported by innovation graphs.

Application of innograph technics for disclosing the factors impeding innovative activities

The efficiency of a company's innovation process can be increased by forming the attitudes, raising the level of management and organization, not to mention many other factors. In this field the *first step* may be the initiation of the experts to disclose and abolish factors impeding the creative work. Taking into consideration there can be a lot of important goals:

— to disclose all factors impeding innovation,
— to look for the relations among the disclosed factors,
— to collect into groups the most important problems according to the necessary expenditures to their solution.

The above goals can be reached by organizing a procedure consisting of several different technics. Selected from the developing staff of the company we have established an *innovative team* and a result of their work we have got thoughts listed below.

The activities of the innovative team for disclosing the situation are e.g.:

a) Determining in a brain-storming meeting factors impeding the creative work

b) Selecting and weighting the most important, the most easily and most heavily solvable problems out of the disclosed factors
c) Looking for causal relations among the selected and grouped factors
d) Summarizing the opinions of those participating in the teamwork and improving the results achieved
e) Discussing and completing the disclosed relations by means of the interview method.

The presented process was realized step by step. Besides the well-known brain-storming and ranking technics the innograph technics was applied to disclose the cause and effect relations making possible to draw up the situation in a causal way and to analyse it systematically.

The innovative activity can be effected by different conditions and problems. One part of these is objective the other one originates from subjective causes. It is important to provide the necessary conditions and circumstances for performing the creative activity. The most important problems impeding the innovative activity are listed in Table 1.

The weighting numbers of the table show the importance of the problems. Based on those the most significant factors impeding the innovative activity can be summarized as follows: the lack of objective conditions, the disorganization, the attitude of people, the lack of the proper working power, the insufficient knowledge of the method, "fire-fighting in production" etc.

The sum of weighting numbers given to the most important factors achieves 70% of the sum of all weighting numbers. It indicates unambiguously, that the opinions of the participants concentrate to some problems only.

During the survey information was collected according to causal relations of the above disclosed problems. The use of this information made possible to compose Table 2. In the table problems are listed in the direction of both the rows and the columns. Their causal relations are represented in such a way that problems appear as causes in the direction of rows and as effects in the direction of columns. Number "1"-s in the table indicate a relation between cause and effect. In the table a "cause sum" appears, a number that shows how many times a problem appears as cause. The sum of a column indicates how many times a problem turns to be effect. E.g. "attitude of people" appears as a cause 13 times. Taking into consideration the "importance" scores of the problems and the "cause sum" we receive a measuring number from their product that helps us to select the most significant problems. This is shown in the "ranking column" of Table 2. These are the following: disorganization, the attitude of people, the lack of objective conditions, the lack of the proper working power, the insufficient knowledge of methods, etc.

Based on the above factors the matrix of most important problems impeding the creative work can be constructed. The matrix is shown in Table 3. From this the causal relations of problems can be easily read out. So it can be

Table 1

The most important factors impeding the innovative activity

Problems	The opinion of the participants in teamwork (wieghting number)							Total	ranking order
	A	B	C	D	E	F	G		
1. Lack of exchange of foreign experiences									
2. Patent difficulties									
3. Difficulties of import									
4. Material-moral interest									
5. Lack of objective conditions									
6. Attitude of people									
7. Lack of proper working power									
8. Returning tasks									
9. Definition of target									
10. Disorganization									
11. Lack of cooperation									
12. Lack of education and post-graduation									
13. Lack of market (non-technical) information									
14. Long transit time of process									
15. Lack of method (knowledge)									
16. Difficulties in introduction of new technologies									
17. Fire-fighting in production									
18. Lack of up-to-date data storage and processing									
19. Lack of basic research									
20. Degree of mass production									
21. Tasks non-concerning the merits									

Table 2

Problems	Effect identifier	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Cause sum	weighting number of importance	weighting number	ranking order
1. Lack of exchange of foreign experiences																										
2. Patent difficulties																										
3. Difficulties of import																										
4. Material-moral interest																										
5. Lack of objective conditions																										
6. Attitude of people																										
7. Lack of proper working power																										
8. Returning tasks																										
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13. Lack of market (non-technical) information																										
14. Long transit time of process																										
15. Lack of method (knowledge)																										
16. Difficulties in introduction of the new technology																										
17. Fire-fighting in production																										
18. Lack of the up-to-date data storage and processing																										
19. Lack of basic research																										
20. Degree of mass production																										
21. Tasks non-concerning the merits																										
Total effect																										

Table 3

Cause-effect relations of the most significant problems

Problems	Effect identifier	1	3	4	5	6	7	10	11	15	17	21	Total	Ranking order
1. Lack of exchange of foreign experiences														
3. Difficulties of import														
4. Material-moral interest														
5. Lack of material conditions														
6. Attitude of people														
7. Lack of proper working power														
10. Disorganization														
11. Lack of cooperation														
15. Lack of method (knowledge)														
17. Fire-fighting action in production														
21. Tasks non-concerning the merits														
Total:														
Ranking order:														

proved that the *most significant causes of the factors* impeding the innovation are: disorganization, the attitude of people, the lack of method (knowledge), the lack of material and moral motivation. Important effects as the lack of the proper working power, the lack of objective conditions and the tasks non-concerning the merits derive from the above causes.

Table 3 helps to draw up the *innograph* outlining roughly the relations of the problems. Of course the innograph needs a further thinking through and improving the problem-system. Reaching this goal was carried out by the discussion, completion and correction of the innograph. So the causal relations of problems can be featured by the number of relations and the sum of "votes". The analysis of the results shows, that the first-ranking source of problems is the "attitude of people". It is interesting that though "the material and moral motivation" according to the numbers of relations ranks second, it was pushed into background because of the number of votes. The survey indicates that the "attitude of people" and "disorganization" together are the sources of all the troubles.

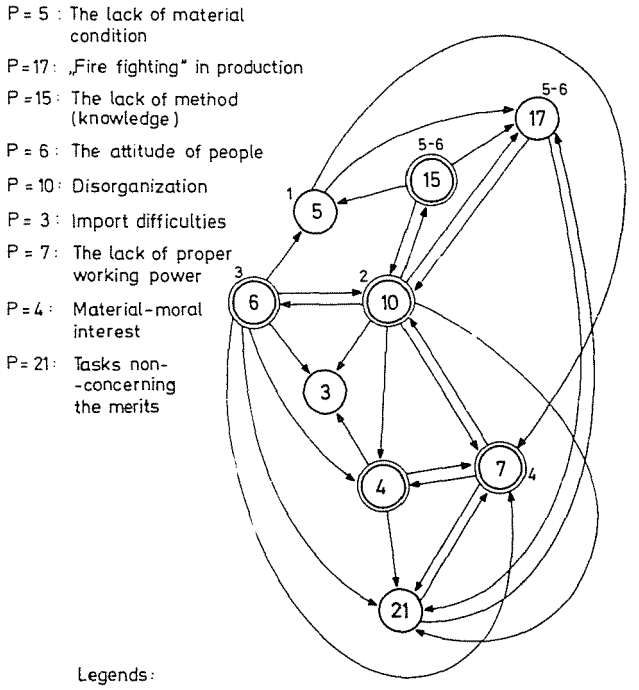

Fig. 3

The above thoughts are supported and clearly demonstrated in Fig. 3. Here all the causal relations of problems are shown in such a way, that opinions of those participating in the work are marked on the graph. The figure characterizes the problem-approaching method of the team.

Major conclusions from the application of the innograph technics

Information from the survey and the graph showing the relations serve as starting points. Factors impeding the creative activity, their weighting numbers and their causal relations give a sufficient basis for the analysis.

The figure clearly demonstrates, that "disorganization" interconnected to "the attitudes of people" and to "the lack of methods" (knowledge) is placed in the centre of the factors impeding the creative work. In some respect "the lack of proper working power" can also be ranged to the centre area.

It was a characteristic feature of the survey, that though "material-moral interest" appeared as a factor influencing the creative work, but it did not play an important role either in its weight or in its relations. Other surveys do not support this, so a special analysis ought to be done. Analysing the relations of the problems it can be stated that "fire-fighting in production" and "tasks non-concerning the merits" appear as effects of the problems. The "fire-fighting in production" is a direct effect of the "disorganization", the "lack of material conditions" and the "lack of methods (knowledge)". These "fire-fightings" involve "tasks non-concerning the merits". The "lack of proper working power" is partly caused by the "tasks non-concerning the merits", but it originates from the "attitude of people" and from the "lack of material-moral interest" as well.

The knowledge of the causal relations of the most important problems makes possible to walk along the so called *problempaths*. Let us analyse some of these relations:

1) Let us start from P = 6: "attitude of people". This concept involves very complex thoughts. From the non-innovation centered management to the employee liking the convenience of routine each subjective factor, that impedes to disclose and to create the "new idea", belong to this concept. For example some of these are: Aversion from the new idea, managerial behaviour, the fear of responsibility, the lack of innovative organization, etc. Starting from the non-innovative attitude of people we can proceed seemingly along several graphpaths. One of the most important paths is:

P = 6: the attitude of people (85)
P = 5: the lack of objective conditions (130)

P = 17: "fire-fighting" in production (60)
P = 21: tasks non-concerning the merits (25)
P = 7: the lack of proper working power (65)
P = 10: the disorganization (120)

Let us look through this list. (Weighting number featuring the importance was put in brackets.) Though it is obvious that this list could be started with "the lack of material conditions" and all the other factors in the list could be derived from that, up to the non-innovative attitude originating from the disorganization. Nowadays it would be a causeless start, first of all because creation of the material conditions is a matter of attitude. In yearly planning viewing the basis, when the urgent money-spending is not rare at the end of the year, an "objective structure" could be formed that will be very unfavourable if innovation is considered. From this viewpoint getting a start from the non-innovative attitude of people is reasonable. This circle of problems involves nearly 70% (485 weighting numbers) out of the total of the weighting numbers (700). Therefore it would be justified to cease the above circle of problems.

The other path still starting from the "attitude of people" is listed below:

P = 6: the attitude of people (85)
P = 4: the lack of material-moral interests of people (135)
P = 7: the lack of proper working power (65)
P = 10: the disorganization (12)

It can be seen, that it is a much "shorter" path. It could also be started with the lack of the formation of the "material-moral interest" which means that there is not enough proper working power. Disorganization originates from these factors as well. The creation of proper material and moral interest has now mainly obstacles of attitude.

2) When analysing the situation we can start from "*the lack of method (knowledge)*" as well. A lot of circles of thoughts can originate from here, since it is a "source of problems". E.g.:

P = 15: the lack of methods (knowledge) (6)
P = 17: fire-fighting in production (60)
P = 10: disorganization (120)

This circle of problem seems to be short and logical. The thought could be enlarged according to the following:

P = 15: the lack of method (knowledge) (60)
P = 17: fire-fighting in production (60)
P = 21: tasks non-corcerning the merits (25)

P= 7: the lack of the proper working power (65)
P=10: the disorganization (120)

This problem-circle is a result of the non-sufficient education and post-graduation, and gives more than 30% of the total weighting numbers of the problems. Looking through the latter problem-circle it can be said, that the lack of proper working power could be managed as an independent source of problems influenced primarily by the unsolved factors of the material and moral interest.

3) A starting point of the analysis can be "*the lack of proper working power*" (65) from where originate:

P=21: tasks non-concerning the merits (25)
P= 4: the lack of material-moral interest (35)
P=10: the disorganization (120)

It can be seen that this circle of thought effects deeply the whole problem-system like the above discussed factors: "the attitude of people", "the lack of method (knowledge)" and "the disorganization".

Based on the survey it can be *summarized:* first of all the formation of the innovative attitude has to be forced. From one hand it can be supported by ceasing the drawbacks of the everyday disorganization, from the other hand it can be promoted the creative management and organization of the innovative process. Of course this process will only be really effective if the participants have real material and moral interests.

An application of this method in the process of production development can be found in the following paper about functional analysis written by Sándor Bálint.

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