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About some problems related to collective expertise

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1 Introduction

The collective process of assessment of difficult objects and situations is based, as is well known, on using of people-experts as measuring instruments. Following this terminology, we should take the selection of suitable instruments as elements of collective expertise, their pre-tuning and coordination, selection of measuring scales, measurement execution by itself, rejection of some instruments according to the results of measurements, also revelation of credible final result by comparing the displayed data of separate instruments.

In spite of the effectiveness of the above shown analogy, it is not, of course, entirely correct. Imperfection of this comparison is revealed particularly while trying the computer to automatize the process of collective expertise. The goal of this article is in determination of possible limits of computer supporting of collective expertise, also in analysis of some paradoxes and contradictions that are met on different stages of the expertise.

For the future there will be taken into consideration some restrictions.

First, as a problem area will be considered the totality of tasks bound with selection of scientific and technical projects announced at contests or tenders(contest of projects). In this problem area the tasks of selection of working team among candidates for execution the project presented to the contest (competition of teams) are included. The

indicated classes of tasks differ by a sufficient high level of uncertainty and poor structuredness.

Secondly, we'll consider that the collective expertise is executed inside the so-called "small scientific community" (SSC), with the Republic of Moldova as a particular example. The phenomenon of SSC, as it will be shown in future, generates a row of specific difficulties and nuances, which are to be considered at the organization and realization of collective expertise.

Table 1.

Stages of expertise	**Possible degree of formalization**				
	Full	High	Middle	Low	No
Forming of contest application					+
Selection of experts and forming of expert team		+	+		
Initial expert rating calculation		+			
Experts orientation			+	+	+
Expert assessments generation	+	+			
Expert assessments analyzing					
Expert assessments aggregation	+	+			
Expertise result interpreting		+			
Current expert rating calculation		+			
Expertise result recording	+	+			

At present there have been elaborated a lot of technologies of collective expertise, also of computer systems supporting such technologies. Some of them are described in [1]. Any technologies include a number of stages, the main of which are presented in the table 1. For every stage its degree of formalization achieved at present is shown. This table discussion constitutes the content of the present article.

2 For whom the applications are composed

The application is a structured description of the project offered to realization with a clear separation and concrete definition of its base parameters. The application is composed for experts and for them only. The standard form of the application is elaborated in the core of the institution that finances the projects and is approved by the person that takes the decisions (PTD). The practice reveals that the quality of the experts work of selection of the best projects or the quality of the working teams for execution of the ordered subjects at a huge degree depends on the degrees of reasoning of this document. Unfortunately, the forms of application used at the contests and tenders do not meet many standard requirements.

- First of all, the form of the application must be clearly structured. According to the requirements of the morphological analysis [2] it is desired to have following columns: WHAT is to be done during the project, WHEREFOR is to be done the project, WHO will do (information about the working team), WHOM the result is to be passed, WHEN the project is to be fulfilled, WHAT is the cost of the project. Of course, these columns are defined concretely with the subcolumns, but the total quantity of the last, as the experience testifies, must not be more than 12-15. As a negative example we can refer to the application forms that contain dozens of questions addressed to the project's initiators. The expert quickly loses interest analyzing such a huge and varied text.

- Secondly, it must be demanded that at filling the application form every answer to be motivated and not to contain general words. For example, the question "Are there analogs of the product to be elaborated during the project?" is almost always answered negatively. Such assessments as a rule cause doubts to the expert. Answers like "Using the result will bring an essential economical effect" or "The project will be executed at a high scientific level" have a low self-descriptiveness.

- Thirdly, in the conditions of SSC not only the expert but the declarant of the project too must be as anonymous as possible. For this goal the application is constituted from two parts – the opened one (designed for the expert) and the closed one (for the manager of the expertise). In the opened part there are missing data about the manager of the project, names of the executors (it is indicated the numeric composition of the working team and its structure), the names of authors publications regarding the theme of the project(there are shown only the tiles and output data of the publications), information about the base organization. Such classification of some information will allow to rise the objectivity of the applications assessment.

- Fourthly, it is desirable the announced projects to be identified on the bases of the criteria related with their belonging to one or another stage of the life-cycle of the scientific-technical problems. In this sense it is possible to use the classificatory brought in the table 2.

Table 2.

Purpose of the project	**Goal of the project**
Fundamental research	New knowledge, adjusted knowledge
Exploratory research	Using methods of the new knowledge, abstract models, common methods
Applied research	Specific models and methods, restrictions, estimations of usability
Elaborations	Technologies, prototypes of final products, algorithms
Implementation	Industry technologies, batch production of the final product organization

It is easy to see, that such identification allows to create competent groups of experts for estimation of specific applied projects. It could be observed that the stage of the structure creation of the contest application can't be formalized in principle, what accentuates its uniqueness.

3 The Expertise: characters and roles

In the process of collective expertise the PTD's, experts and the working team take part. The experts analyze the presented applications and give their appreciations in a special expert chart, the structure of which is in concordance with the columns in the application. Expert charts are included into the supporting computer system by the working team (this can be done by the experts by themselves). Besides, the working team reacts to the possible signals of the system related to the quality of the work of individual experts and prepares corresponding information for the PTD. The role of PTD consists in taking the final contest decisions on the bases of collective expert's conclusions. Besides, the PTD in principle can influence the process of expertise using the totality of his preferences introduced into the base of knowledge of the computer system.

Some non-trivial question appear : how many experts we need to assess every specific application and where do we find them?

There is no a united opinion in the medium of specialists. In the [4,5] it is stated that the number of members of the expert group has to comply with the correlation $m_{min} < m < m_{max}$. The minimum is selected great enough, otherwise the group assessment considerably will depend on the assessment of every expert. Besides, at the selection of the minimum allowed number of experts it is taken into consideration the requirement of the group to be representative, that consists in the fact that for taking the decision on N questions the minimal staff of the group must comply with the inequality $m_{min} >= \alpha N$, where α – coefficient close to 1. The selection of m_{max} is specified by the fact that while the number of experts is too large, the share of noise information, that is introduced by incompetent experts, increases.

In conditions of SSC when the number of experts can be considered relatively small a priori, the shown principles are not working. The number of possible alternatives is sharply limited, and the chose of the optimal variant is obvious. The use of only on expert for assessment of the projects is impossible (monopolism, the risk of gross errors or arbitrariness). The attraction of two experts is highly undesired because of a possible "opposition" of assessments, what can conduct to an unsolvable situation. That's why the optimal and the only one possible way in conditions of SSC is the group structure consisting of three specialists, as it allows reaching the consensus (even by a simple majorization).

In order to create optimal by structure expert groups, preliminarily it is necessary to organize a computer bank of experts, structured by areas of science and technology. The criteria for choosing the experts would be such requirements as high competence in the field, analytical cast of mind and unbiasedness. However this collection can be enlarged and worked out in details. There are lots of methods of expert selection among specialists, many of which are described in [3,6]. However, we will restrict to examination of two of them most of all suitable to SSC.

The "snow ball" method constitutes an efficient and cheap procedure to identify the experts in a certain application domain. Its essence consists in following. The working team that initiates the procedure addresses to one of the leading specialists and asks him to name a fixed number (let it be three) of matching candidates for experts. After getting the list the working team addresses to the indicated candidates with the same request. This iteration procedure is repeated until the growing list doesn't contain new names. Besides, the procedure can be stopped after a certain number of iterations. Certainly, the same names in the final list can be met several times, that allows to regulate the experts by their credibility.

The second is known under the name of documentation method. The experts are selected analyzing the documented data among the SSC. Herewith the documents must contain information about the science status of the specialist, scientific interests, experience and participation in diverse kinds of expertise (work reviewing, attendance at program conference committees, participation at thesis presentation

etc), science activity and so on. Having the respective bank of data, which contains the mentioned information, the task of selecting the experts and forming the expert group can be solved easy enough.

Note, as it is shown in the table 1, the degree of possible formalization of the search of experts among multitude of specialists is high. This can assure an increasing objectivity of the collective expertise.

After selection of the experts according to the science area, it becomes possible to create expert groups in order to assess certain applications for execution the science and technology projects. In this order it is necessary to formulate the common and specific requirements to be met by the expert that is to assess the certain project. It is reasonable to divide these requirements into three groups: mandatory, additional and prohibition. To the mandatory refer: scientific degree, length of service, the experience of expertise execution, narrow science specialization, and rating. As additional can be considered the following: science activity during the last years, experience of result implementation, experience of work in adjacent areas, etc. Prohibitions can be the belonging of the expert and applicant to the same institution or incompatibility of the experts. The concrete set off requirements is formulated by the working team and is approved by the PTD.

The procedure of selection of experts for the creation of the certain expert group is simple. Lets define the criteria according to which the expert k ($k = 1, 2, \ldots m$) can be included into the expert group. Let's introduce the variable X if the expert k meets the requirement i, O in the opposite case. As the criteria of including the expert in the group we'll take the variant, where N is the number of mandatory requirements. The expert is included into the group if $H_k = 1$.

This condition is necessary but not enough because we have to take into consideration some prohibitions and sometimes additional requirements.

4 About the rating

The conception of the expert rating come from recognizing the fact that experts posses different levels of competence. This assumption

brings to the necessity to assign to every expert a coefficient of weight (rate level), to which the estimations made by him are multiplied. By this way the diverse influence on the final result of different members of the expert group is recognized.

We will distinguish the initial and current expert rating. The initial rating is set on the basis of document data immediately after giving him the status of expert. This is executed by the working team in accordance with the PTD. One of the mechanisms of calculation the initial rating consists in following. It is set the list of significant parameters of the expert: science degree, length of professional service, experience of execution expertise of different kind, participation in significant projects of science and technology, scientific activity etc. The respective quality and numeric data are scaled, and to every division of the scale a certain weight is assigned. After that for every expert it is calculated the balanced sum of parameters which forms the rating.

Let us admit that: for example, there are chosen the first three parameters from the list mentioned above and the following scales are set.

Scientific degree	**Weight**	**Length of service**	**Weight**	**Number of expertise**	**Weight**
Doctor of science	2	More than 30 years	2	More than 30	2
Master of science	1	21-30	1,6	21-30	1,6
No	0	11-20	1,3	11-20	1,3
		10 and less	1	10 and less	1
				No	0

The initial rating is calculated as a normalized sum of weights on the multitude of experts:

Experts	**Science degree**	**Length of service**	**Number of expertise**	**Sum of weights**	**Rating**
E1	DS	26	16	4,9	0,41
E2	MS	10	6	3	0,25
E3	No	37	42	4	0,34

Evidently, that the rating of the expert is a subject to change after every expertise according to the success or failure of the expert actions.

5 Experts

The experience of executed expertise attests that at the estimation of certain application by different experts there can be a significant dispersal of assessments. As sources of distortion as a rule are insufficient competence of some experts and lobbing. The last one is specific to SSC, where it is difficult to assure anonymity of experts. From the other hand, we shouldn't confuse the effect with the natural non-homogeneity of expert's actions, which is explained by particular system of preferences of every expert. Usually they try to smooth the non-homogeneity of expert's actions by preventive orientation (instructing).

Another method consists in using of Delphi strategy, when the filled chart of the member of expert group is passed to his colleagues (anonymously). Familiarization with the colleague's actions can influence the expert to change his assessment, which would smooth away the divergence of opinions. Others methods of smoothing the non- homogeneity of results is described in [3]. Let's stop at some heuristic procedures of increasing the reliability of expertise results. We will differ the identification of significant contradictions among the assessments of experts in the group and search for the contradictions among the assessments of different parameters.

Let's consider the following example, where
$e1, \ldots, e5$ are the assessments of the experts E1, E2, E3,
d – the sum of the deviations from values,

σ – the sum of the quadratic deviations,
R – the normalized rating of the experts for given expertise, calculated on the basis of coefficients σ.

Experts	$e1$	$e2$	$e3$	$e4$	$e5$	d	σ	R
E1	5	4	4	3	5	4,3	5,7	0,10
E2	3	4	3	3	3	-0,7	0,7	0,76
E3	3	4	2	2	2	-3,7	3,7	0,14
Middle	3,7	4	3	2,7				

In this example the typology of experts can be traced. So, the expert E1 that gave relatively high assessments can be named "liberal" or ""lobbyist, expert E2 – "equalizer", expert E3 – "terminator". This situation is an "emergency" one. It is easy to formulate the criteria basing on which the computer system will bring the signal to the PTD with a motivated proposal to review the results of the expertise. Besides, the system is capable on the analysis of the work group to identify and assign to the experts the typology markers, what could be useful at the group forming (the group can consist from only "terminators" or "liberals").

The search of contradictions among individual assessments of one expert also is a task of assessed work quality. The main idea is monitoring of expert's logic actions to be brought to an algorithm. In this order a base of productions is introduced into the analyzing block of the system. At the discordance of expert assessments an error message accompanied by a commentary is generated. Examples of two productions:

1. IF the parameter α is assessed not bigger than 3,

   THEN parameter β cannot get an assessment bigger than 3.

2. IF the parameter γ is assessed not bigger than 4

   AND parameter δ got the assessment not bigger than 3,

   THEN parameter ϵ cannot get an assessment bigger than 3.

Here α is the structure of the working team, β – scientific level of project execution, γ – volume of work in the project, δ – working team potential, ϵ – deadline of the execution.

The collection of such productions allows the working team to trace the so called "logical balance" of the experts actions. Moreover, in case of direct inputting of errors by the expert into the computer system he can correct his logical errors.

Experts actions can be analyzed also at the selection of working team for execution of the applied project (contest of teams). Let's admit that every expert is proposed to compare n objects X_i $(i = 1, 2, \ldots, n)$ two by two and rank them according to a certain criteria.

Let's include the expert s answers to a square matrix $G = \|g_{ij}\|$, $ij = 1, 2, \ldots, n$, where n – number of analyzed objects and

$$g_{ij} = \begin{cases} 1, & \text{if } x_i \prec x_j, \\ 0, & \text{if } x_i \succ x_j. \end{cases}$$

Here the symbol $\prec$ means the relation of strict preference, revealed by the expert during the analysis. To the matrix G a full graph can be matched, where the arcs' orientation is influenced by the expert's preferences.

By the definition, there are no cycles in the constructed graph, because their existence would cause the loss of integrity in the judgment of the expert. Let's assess the number of elementary cycles in the graph using next expression [7]:

$$\varphi = 1/2 \left[1/12n(n-1)(n-2) - \sum_{i=1}^{n} \left(\sum_{j=1}^{n} g_{ij} \right)^2 \right]$$

In the case of complete logical consistency in his judgments the number p of elementary cycles would be equal to zero. The maximal number that corresponds to the complete inconsistency of answers will be

$$\varphi_{max} = \begin{cases} 1/24(n^3 - 4n), & \text{if } n \text{ is even } (n \geq 2), \\ 1/24(n^3 - n), & \text{if } n \text{ is odd } (n \geq 3). \end{cases}$$

Let's introduce the coefficient of competence Ψ of the expert:

$$\lambda = \begin{cases} 1/24\varphi/(n^3 - 4n), & \text{if } n \text{ is even,} \\ 1/24\varphi/(n^3 - n), & \text{if } n \text{ is odd.} \end{cases}$$

When having zero or little values for certain experts their assessments must be excluded, since they can distort the result.

6 Conclusion

In this article the problems of aggregation of experts assessments and the result of expertise interpretation are not discussed. They are revealed in details in [1,3,6] and do not cause any difficulties in formalization.

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