System for Assessing the Socio-Personal Competence for Certification Qualifications of Specialists-Managers in the Nuclear Industry

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Abstract: This article presents the results of research for the expert and methodical centre of assessment and certification of qualifications of specialists in the nuclear industry, which was established on the basis of the National Nuclear Innovation Consortium. A series of new professional standards for the nuclear industry has shown that the value of social and personal competence steadily increases with the skill level of employees. The objectives of the study were to identify latent personality factors that have a significant impact on the performance of various types of management activities and to create a model for assessing the socio-personal competence of managers of the nuclear industry. The study was conducted among a large sample of undergraduate MEPhI students specialising in training management, economics and business informatics. On the one hand, students have well-formed competence in team management, teamwork and conflict management, on the other they are taught to work in the nuclear industry and responsibly assess the technological and environmental risks which are specific to nuclear energy.
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1. Introduction

Improving the system of assessment and certification of qualifications of specialists is one of the priorities of not only the nuclear industry, but also higher education in general. According to the national system of certification, specialists with higher education correspond to the sixth, seventh and eighth levels of qualifications. The difference in the functions performed by specialists in levels is that at the sixth level specialist participates in the execution of work; on the seventh level they organise the implementation of the work; and on the eighth level they determine the strategy of the enterprise.

National Research Nuclear University 'MEPhI' was one of the leading universities of the country in 2011-2013. It successfully completed a number of projects related to the creation of a network of centres of qualifications and certification and an expert and methodical centre of the nuclear industry. Development objectives and implementation of a joint system (with 'Rosatom' corporation) for the certification of university graduates' qualifications are included in the roadmap for the implementation of the program to improve the competitiveness of MEPhI [1].

The system of employee certification in the nuclear industry is built so that at the sixth level of qualification a specialist without experience is mainly tested for knowledge. On the seventh level the tests are completed by checking skills in dealing with complex and unusual problems – the specialist must demonstrate his or her responsibility and ability to act and think on their own. On the eighth level it is necessary to comprehensively test the skills and abilities needed to process management activities within large enterprises, the ability to shape development strategy and readiness to bear responsibility for the results of the company. When certificating qualifications the level of development of work functions is measured by competence. Each function corresponds with several competencies, and each competence is a part of more than one job description.

The scale of assessment of each competency is [0-1]. A 50% result corresponds the basic level of competencies development, 75% is the advanced level. Otherwise, the competence is considered unformed.

Typically, evaluation of the competence of engineers mainly focuses on engineering competence. Several authors propose criteria and methods for assessing professional competence [2-5]. However, it is necessary to assess social and personal skills for the certification of qualifications, in addition to professional competence. Unlike professional competence, 'social skills' and 'social competence' are normally paid much less attention. Since social situations are an inevitable aspect of any

working relationship, whether one-to-one or within a group context, social skills should be one of the key skills for employees in the nuclear industry.

Paper [6] introduces the notion of a unified social competence. Its structure consists of three units: an intellectual, a personal and a competence-based component. There is a need to evaluate each of the blocks according to the model of the integrative approach. The intellectual component is evaluated through an intelligence test; personality (responsibility, independence, focus, organisation, social activity and creative activity) is evaluated using a table of expressions; the competence-based component is evaluated with expert marks.

The current paper introduces the concept of a unified social-personal competence of the nuclear industry employee as an integral feature of his professional activities. The concept reflects the ability to interact with various parties in the most effective manner depending on the situation. The chosen manner should be based on socially appropriate norms, standards, regulations and rules of conduct inherent to the organisation. Social and personal skills are perceived through the prism of knowledge, experience, value-meaning attitude, emotional and volitional regulation and readiness for implementation.

2. Methodology for assessment of socio-personal skills

The generalisation of professional standards within the nuclear industry has allowed for the selection of key components: willingness to solve problems and make decisions, team-working, ability to manage conflicts, team management ability, leadership skills and self-motivation. The manifestation of social and personal skills as well as the stage of their development is associated with latent qualities of a person. The objective was to conduct a preliminary study in order to identify a set of latent qualities that affect approach to various tasks. The other objective was to prove whether the denoted effect is statistically significant.

This is how the study was conducted. Latent traits, that affect a number of components of social competence were identified with the help of standard tests of Eysenck, Thomas and Belbin. The following traits were selected as latent: extraversion/introversion, neuroticism/stability, preference in team roles and preference in behavior strategies in conflict.

Eysenck's bifactor model of personality allows the assessment of a person's orientation to an internal or external world using basic indicators (extraversion-introversion). It also allows the determination of levels of emotional stability through neuroticism-stability indicators. It is generally accepted that personal traits affect the execution of one's duties, including professional activities [7]. The combination of extraversion-introversion and neuroticism-stability features creates a unique identity of the person, resulting in the type of temperament (sanguine, choleric, phlegmatic, melancholic).

As a rule, the prevalence of certain temperament traits is taken into account. In real life pure types are very rare. Paper [8] considers not four, but nine personality types: one normal and eight accented. In addition to the four 'pure' types, the authors introduce four intermediate ones: choleric-sanguine, sanguine-phlegmatic, phlegmatic-melancholic and melancholic-choleric. The current study uses the Eysenck test to determine latent personality traits based on this classification.

Belbin's test is intended to identify the roles which the subject prefers when working in a team [9]. There are eight roles and each one is necessary for the successful work of the team: 'Co-ordinator' (Co), 'Shaper' (S), 'Plant' (P), 'Monitor Evaluation' (ME), 'Implementer' (I), 'Resource Investigator' (RI), 'Teamworker' (T) and 'Completer Finisher' (CF). An efficient working team must include people whose personal traits cover a range of qualities necessary for all eight roles. This does not mean that the group should consist of eight people as some employees can combine roles. It is however essential that all the functions be covered.

Thomas's test is used for allocation of one's latent properties of behavior in a conflict situation. There are two general strategies in conflict resolution. They are cooperation and compromise. In a compromise one party wins, and the other loses; or both parties lose (strategy B). In cooperation both parties of the conflict win (strategy A). One's aspiration to choose one of the strategies above the other to resolve a conflict defines latent traits of social and personal competence [10].

Preliminary study was conducted among a large sample of undergraduate MEPhI students specialising in management, economics and business informatics. On the one hand, students are focused on work in the nuclear industry; on the other hand they have well-formed competence in team management, teamwork and conflict management.

The students were given 15 tasks for situational analysis. The tasks served to assess the relevant components of social and personal skills specific to the sixth level of qualification. There were two types of assignments. The first type was analytical, the second type required making decisive solutions by force in extreme situations. Conceptually, the tasks were divided into three parts

aimed to access the subject's abilities in team management, abilities to work in teams and to manage conflict. This is how the level of formation of socio-personal skills' components was measured.

3. Research results

The results obtained by Eysenck test for the main indicators of extraversion-introversion and neuroticism-stability are as follows. The majority of students are normal (25%), melancholic and choleric (28%) and choleric (11%) as type.

Cluster analysis on the scales of 'stability' and 'introversion' was performed based on the results of research at the first step.

The results of cluster analysis for the value 'stability' are shown in Figures 1a-1b. Z-variables were transformed, i.e. normalised by subtracting the arithmetic average of the variable and dividing the result by the mean square deviation estimate. Three classes of 'stability', 'average values' and 'neuroticism' were defined. Students who obtained scores from 2 to 8 by the scale of 'stability', coped very well with 10 analytical tasks and 5 decision-making tasks.

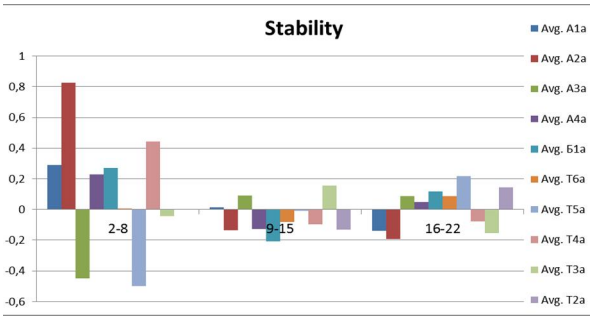

Figure 1. (a) Results of analytical tasks for three clusters in terms of 'stability'

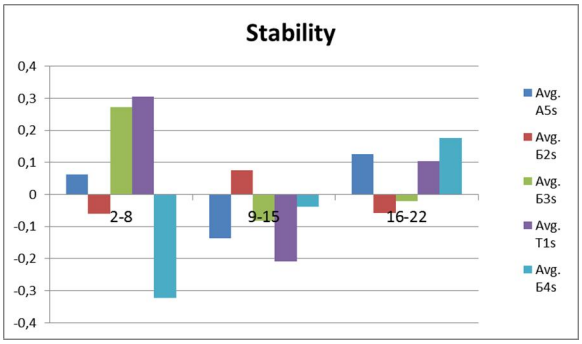

Figure 1. (b) Results of decision-making tasks for three clusters in terms of 'stability'

The cluster of students who demonstrated average results (9-15) by the scale of 'stability', mostly failed at analytical and decision making tasks. The cluster of students who scored between 16 and 22 points mostly coped with both types of tasks. Thus, increase in the stability scale corresponds with a slight increase in the complexity of the tasks, while the complexity of decision-making tasks stays unchanged.

Fig. 2a-2b shows the results of cluster analysis for the value 'introversion'. The cluster demonstrates opposite values for different kinds of tasks. Students of the 'Introvert' cluster (3-9 points) did very well with analytical tasks and did not cope with decision making tasks. Students from 'Ambiverty' cluster (10-16 points) coped more or less well with analytical tasks and did very well in decision making tasks. Students from 'Extroverts' cluster (17-23 points) failed analytical tasks, and coped more or less well with decision making.

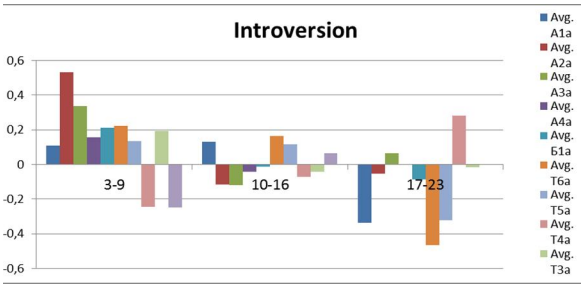

Figure 2. (a) Results of analytical tasks for three clusters in terms of 'introversity'

With the increase in introversion scale the performance of the subjects in analytical tasks increases significantly. The complexity of analystical tasks proves to be minimal for the introverts cluster, while the complexity of decision-making tasks proves to be too high. When the value on the scale of introversion increases, the complexity solving decision-making tasks becomes less. However the decrease is slight.

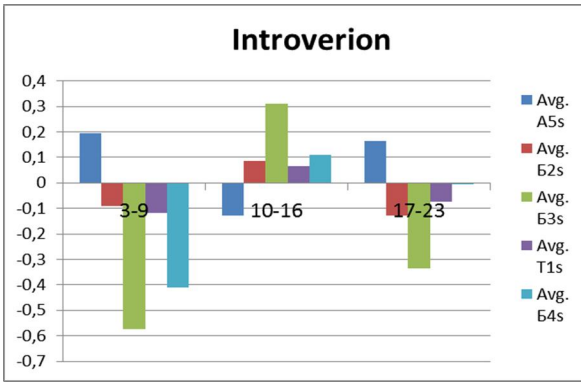

Figure 2. (b) Results of decision making tasks for three clusters in terms of 'introversity'

Cluster analysis based on 'stability', 'introversion', strategy A and strategy B factors was conducted in order to define latent factors at the second step of the research. Four clusters were identified as a result (Fig. 3a and b).

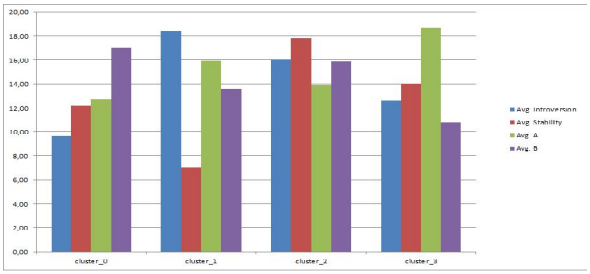

Figure 3. (a) Results of cluster analysis for behaviour choice in conflict resolution (personality traits)

Average values for the selected variables in original (untransformed) scales were found for each cluster. The data shows that in each cluster the results of the analytical tasks are opposite to the decision-making tasks: if some are done well or very well, the others are done badly or very badly. Classes 0 and 3 contain ambiverts, classes 1 and 2 contain extroverts.

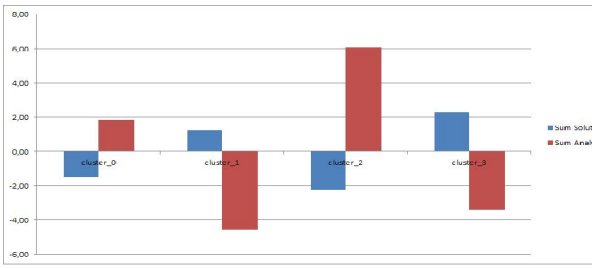

Figure 3. (b) Results of cluster analysis for behviour choice in conflict resolution (results of task-solving)

Clusters 0 and 2 demonstrated preference for the strategy of 'compromise' (B) in the test over the strategy of 'cooperation' (A). For the subjects of these two clusters the results of analytical tasks are significantly better than decision-making. In general, the choice of strategies in conflict resolution has a greater impact on the results of an actual job than the values obtained in scales of 'introversion' and 'stability.'

Clusters 1 and 3 prefered the strategy of 'cooperation' (A) over the strategy of 'compromise' (B). Their results for tasks on decision-making are also significantly better than those for analytical tasks. Cluster 1 includes extroverts and they are really bad with analytics. Cluster 3 includes ambiverts and their analytical skills are also poor, but still they did better than extroverts. Cluster 1 (extroverts) did better in decision making than Class 3 (ambiverts). SumA and sumS (sum of analytics and decision-making, respectively) variables were defined for the mentioned clusters.

The third step of the study refers to cluster analysis of the twelve traits: introversion, stability, behavior in conflict strategy A, strategy B and the roles 'Co-ordinator' (Co), 'Shaper' (S), 'Plant' (P), 'Monitor Evaluation' (ME), 'Implementer' (I), 'Resource Investigator' (RI), 'Teamworker' (T), 'Completer Finisher' (CF).

Clustering was carried out for different numbers of clusters (from 2 to 10). Average values of the variables in the initial scales were identified for each cluster, as well as average values of the variables sumA and sumS, identifying success in analytical and decision making tasks. If the number of points given to a role is less than 5 the role is considered undesirable; if there are more than 10 points the role is considered preferable.

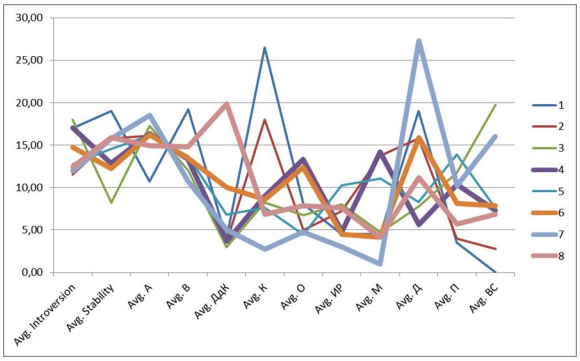

Figure 4. (a) Cluster profiles by roles, personal qualities (introversion and stability) and the use of strategies (A and B)

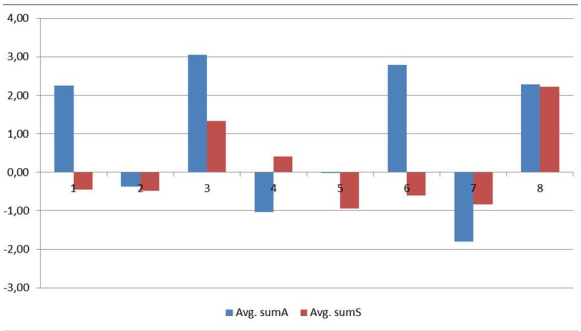

Figure 4. (b) Cluster profiles by s sumA (analytics) and sumS (decision-making) variables

Starting from four clusters, two main clusters, in which the subjects coped well with both analytical and decision-making tasks, became clearly distinguished. In fig. 4a-4b they are clusters 3 and 8. Regardless of the strategy of behaviour in conflict, the subjects of these classes are ambiverts and extroverts and have average marks on the stability scale. They prefer test roles of 'Implementer' (I),

'Shaper' (S) and 'Co-ordinator' (Co) and avoid the roles of 'Plant' (P) and 'Completer Finisher' (CF). Cluster 8 prefer the roles CF and I, and avoid the role of S.

For clusters 7 and 2 in Fig. 4 both types of tasks were not feasible. Cluster 7 preferred the roles of I, S, and Co and avoided roles P, ME, S and T. Cluster 2 preferred T, P and I and avoided S, CF and ME. Clusters 1, 5 and 6 coped well with analytical tasks, but performed poorly at decision-making. Cluster 1 tends to be neurotic, prefer strategy B in conflict resolution, prefer the roles of K, M, L and avoid S, CF and Co. Cluster A prefers strategy A. The dominant roles are Co and P and there are no avoided roles. Cluster 6 preferred the roles of CF, ME and I and avoided roles RI and P.

The cluster in which subjects performed poorly at analytical tasks but well at decision-making is mostly composed of extroverts with average stability, and preferred the A strategy for conflict resolution (cluster 4 in Fig. 4). They have preference for roles P, ME and Co and avoid roles CF and RI.

The clusters were transformed into five independent classes: 'Analysts', 'Solvers', 'Successful', 'Losers' and 'Neutral'. Decision rules, allowing subjects to be placed in a specific class, were derived for each of the classes.

4. Decision rule development

The obtained results were reviewed in more detail. Table 1 describes the classes in terms of the complexity of tasks and the rules by which they can be attributed to subjects.

Table 1. Decision rule for assigning subjects to classes

Class	***Analytical tasks***	***Decision-making tasks***	***Rule 1 (features)***	***Rule 2 (features)***
Analysts	Easy	Difficult	Neuroticism, preference for B strategy	Ambivert, medium stability, preference for A strategy, roles P and Co, no undesirable roles
Solvers	Difficult	Easy	Extravert, medium stability, preference for A strategy, roles Co, P, and ME, undesirable roles RI and CF	
Successful	Easy	Easy	Average stability, preferrence for CF and I roles, undesirable role P	Ambivert, medium stability, preference for roles S, Co and I, undesirable role P
Losers	Difficult	Difficult	Ambivert, medium stability, preference for A strategy, roles S, Co and I, undesirable roles P, ME, RI and T	Ambivert, medium stability, preference for A strategy, roles I, P, and T, undesirable roles S, ME and CF
Neutral	Average	Average	All other cases	

Rules for deciding on referring a subject to each of these classes were identified. The rules are combined using the logical exclusive disjunction. Each rule consists of a set of features that reflect latent factors. One can be referred to a class if he or she has all the necessary features that correspond to either rule 1 or rule 2 Classes are independent, so that each subject can be assigned to only one of the classes.

The complexity of the tasks for the test is determined by experts on the basis of analysis of the preliminary study. It is generally agreed that the complexity of all tasks is average (1), and each subject must demonstrate at least a basic level of development of social and personal skills, i.e. $f \geq 0.5$.

The assessment was carried out for six components: the ability to solve problems A, the ability to make decisions B, the ability to manage a team C, teamwork D, the ability to manage conflicts F and self-motivation E (Table 2). When the inclination (I) to perform certain activities, i.e. latent properties, and acquisition of skills, achievements in completing assignments A (achievements) are also estimated. The value of development of the corresponding component is defined as the length of the vector $f = \sqrt{A^2 + I^2}$.

The F component value is formed when evaluating five other components based on the correspondence between the identified latent properties of the subjects and results of their achievements $f_f = \sqrt{D_a^2 + D_b^2 + D_c^2 + D_d^2 + D_e^2}$.

If the difficulty of the task for a subject is 1, i.e. average, then $I_k = A_k$. If his or her achievement amounts to $A_k \geq 0.5$, then the value f_k of the corresponding component is calculated as $f_k = \sqrt{2A_k^2}$.

The corresponding component amounts to D_k=0.5, if $K_k \in [0.5; 0.75)$ and D_k=0.75, if $K_k \in [0{,}75.1]$.

If the task is difficult and the achivements of the subject are [0.5; 0.75], then I_k= 0.75, $f_k = \sqrt{A_k^2 + 0.57}$, a D_k= 0.75. If the results of achievements are [0.75; 1], then I_k= A_k, $f_k = \sqrt{2A_k^2}$, and D_k= 1.

For easy tasks and if the achievements are [0.5; 0.75), то I_k= 0.5, $f_k = \sqrt{A_k^2 + 0.25}$, and the corresponding component D_k= 0.25. Otherwise, I_k= A_k, $f_k = \sqrt{2A_k^2}$, D_k= 0.75.

Table 2. Decision rule to estimate the components of social and personal competence

Difficulty of the task	***Achievements of the subject A_k***	***Latent properties I_k***	***Effectiveness function f_k***	***Dk component***
0 - easy	[0.5; 0.75)	I_k= 0.5	$f_b = \sqrt{A_b^2 + 0.25}$	D_k= 0.25
	[0.75; 1]	I_k= A_k	$f_a = \sqrt{2A_a^2}$	D_k= 0.75
1- average	[0.5; 0.75)	I_k= A_k	$f_b = \sqrt{2A_b^2}$	D_k= 0.5
	[0.75; 1]			D_k= 0.75
2-difficult	[0.5; 0.75)	I_k= 0.75	$f_b = \sqrt{A_b^2 + 0.57}$	D_k= 0.75
	[0.75; 1]	I_k= A_k	$f_a = \sqrt{2A_a^2}$	D_k= 1

5. Conclusion

The methods for assessing the social and personal competence for managers proposed in this paper have been accepted in the expert and methodical centre of the nuclear industry for the certification of employees' qualifications in the nuclear industry. But work in this field continues. The proposed estimation model is planned to be implemented in a software simulator. The simulator will be used by senior students of the Faculty of Technical Physics of MEPhI who study engineering areas and are trained for the State Corporation 'Rosatom'. After getting sucessful results from testing, the software simulator will be introduced for the assessment of socio-personal competence amongst nuclear industry employees on the sixth level of qualification.

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