

APTITUDE TESTING OF ENGINEERS, AS EVALUATION ON PERSONALITY TRAITS FOR A SUCCESSFUL PROFESSION

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The current importance of aptitude testing for the purpose of evaluating specific personality traits along with reasons for its marginal importance has been given motivation to develop a new personality test. By assessing hard facts as well as soft skills, manifold results could be derived from the collected data by developing and applying a new aptitude testing model. This is leading to specifying typical traits as well as the most important development areas for engineers to develop a successful profession. The present paper develops and reveals important matters associated to a new aptitude testing of engineers mainly focused on soft-skills evaluation.

Keywords: aptitude testing, hard facts, soft skills, candidate selection, personality traits.

1. Introduction

The requested personal skills and attitudes in reality are rather a side note and seem always to be derived from a rigid template. More or less, the same criteria without weighting are used regardless of the industry. By far, the more problematic part about the soft skills is that no notable acquisition takes place. In Germany, for instance, 41.532 million employees were in 2012 (37.63 million: in 1997) [1], with an assumption about 7 million staffing decisions per year [4, p. 29]. 5,000 HR consultants nationwide can cover about 50,000 occupations every year. Only a few HR consultancies use aptitude assessment methods. Even in the best case, a very small proportion of less than 1% of all staffing decisions are made using aptitude testing methods. This is due to two main reasons: the acquisition is time-consuming, i.e., costly, which is why this point gets a raw deal during aptitude testing, mostly because interviews to assess the candidate are used; these interviews tend to be low in terms of objectivity [2, p. 45].

Although aptitude testing methods base on a self-evaluation as well, there are the following differences: such a personality test lacks the audit character, also

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it is made clear to the person in advance that only truthful information leads to a realistic and therefore for the person useful test; the psychological personality tests are neglected because they are openly little valued [2, p. 2].

The fact of this little valuation and just recent change towards more consideration can be visualized via figures derived from the tool Ngram Viewer [3, p.11]. Relative frequencies of certain terms as “personality test” or “aptitude test” occurring in a corpus of books over the last century are shown in Figs. 1 and 2, where the considered relative frequency, RF%, is the percentage ratio between number of instances of the n-gram in a given year, I, and total number of words in the corpus in that year, W, i.e., $RF\% = 100 I/W \%$. For instance, in 1966, the 1-gram ‘Persönlichkeitstest’ appeared in the corpus 65 times in 29 books; the corpus contains 531,063,307 words; thus, the frequency is 0.000012%.



Fig. 1. Relative frequency of the term “Persönlichkeitstest”, i.e. “Personality test” in between 1900 and 2008 from the corpus “German” (derived from the tool Ngram Viewer [3, p.11])



Fig. 2. Relative frequency of the term “Eignungsdiagnostik”, i.e. “Aptitude testing” in between 1900 and 2008 from the corpus “German” (derived from the tool Ngram Viewer [3, p.11])

Frightening is that the so underrated personality assessment actually represents an existential part of the suitability assessment as a statement of an experienced HR manager of a large enterprise shows: . . . we hire people because of their knowledge and experience, but we fire them because of their personality [2, p. 1].

The following induces also to the same conclusion: there is a systematic relationship between personality and managerial competence; there is a systematic relationship between personality and managerial incompetence; certain kinds of

people with identifiable personality characteristics tend to rise to the tops of organizations and these people are potentially very costly to those organizations [2, p.1].

The acquisition of information about candidates is carried out from three sources (Fig. 3): the objective information, such as education or previous jobs, so the facts; the perception of external observers that emerges from impression of the conversation or observation of behavior; self-perception, which is composed of the presentation in the cover letter and resume, the self-description in the interview and beyond personality tests [2, p. 53].

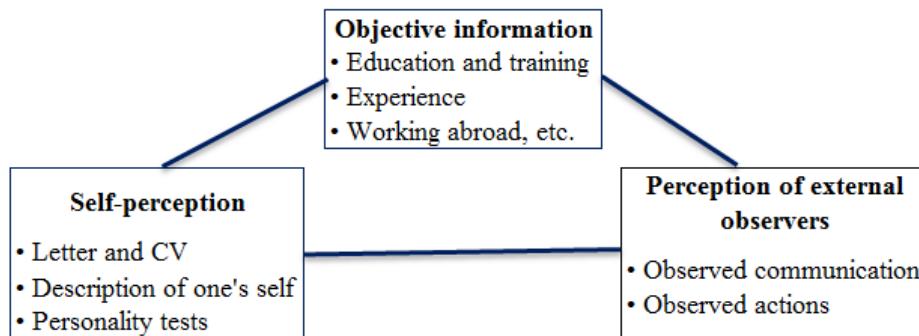


Fig. 3. Information sources in professional aptitude testing [2, p. 53]

Personality is thus both the main reason for exemptions as well as a basic requirement and driver for success and thus an important criterion for the suitability determination. Even more surprising is the low status of personality tests to assess this distinct characteristic of the candidate and therefore to indicate the suitability for an advertised position.

The focus is always on the desire to optimally fill a vacancy.

It is legitimate to question whether there are measurable and recurring factors that are understandable that a person must bring to be able to fill a position suitable.

The classification of people into categories regarding their personalities is thousands of years old. For example, the theory of humors split people according to their nature into phlegmatics, sanguines, choleric and melancholics. This doctrine is outdated as now. In contrast, there are new methods that capture refined, new characteristic values. For now, the "Big Five" should be mentioned.

It is obvious that an employer has a picture on a potential employee regarding his technical abilities and personality.

While the functional requirements may be quite clearly defined and demarcated, the same is difficult for the individual requirements. The personality, as mentioned before, is rarely covered in filling vacancies. Moreover, the personality requirements are defined inadequately or even not at all.

A personality test largely along the lines with “a test someone who applies for a graduate role in engineering is likely to get” [5] is based on the following topics: critical thinking; analysing and detecting systematic themes in data; attention to detail; planned, structured and analytical approach; interpersonal and teamwork skills; self-confidence; stress tolerance; risk management; taking personal responsibility; change, initiative and proactive.

It is noted that, in general, the personality traits could be revealed with regard to different criteria. For example, based on results of a survey about the correlation between *participants' personalities* and *products' personalities*, it has been showed that personality data are not usually employed in product marketing [6, p. 239].

Objective and methodology of research

The objective of the present research is to develop and reveal important matters associated to a new aptitude testing of engineers mainly focused on soft-skills evaluation.

The research methodology has been designed and applied based on the following reference elements: defining fundamentals; structuring and unrolling a confident and large survey; adequate analysis and interpretation of the results, revealing representative categories of personality traits associated to engineers.

2. Hard facts and soft skills assessment

In this work, the aptitude testing is considered as an activity supporting a company in human resource recruitment and selection for a vacant position.

Thus, the main task of an entity performing the aptitude testing is to search, find and evaluate potential employees, as well to select the right candidate, i.e., the distinct person who fits best and remains affiliated with the company for a long time. One has to ensure that the candidate's fit, unerring being and long-term success are given. It is essential that he or she does not only perform well up to the signing of the contract, but especially afterward. The employee ought to be successful in the business and not leave due to professional or personal mismatch. Only when that is guaranteed following assignments of the respective company keep coming.

A large uncertainty in the proposal of a candidate for a vacant position is the ambiguity whether the candidate meets the requirements of the company.

The technical aspect being pretty easy to clarify, the aspect of soft skills is however rather difficult to assess. To maximize security, the competence and potential analysis are conducted along with the assessment of the personal impression of potential employees understood as the term aptitude testing.

In order to resolve the uncertainty whether the right candidate has been found for the vacant position, both hard facts and soft skills are to be assessed.

The technical requirements, also known as “hard facts”, are to be assessed. In addition to the typical professional tasks, these are the characteristic details for the vacancy and can be specified exactly. These include, for example, the required school leaving certificates and university degrees, the accepted fields of study, the level of performance, experience, specialized knowledge, etc. These are the requirements to pursue the profession in general. This so-called expertise can be captured using objective performance tests, work samples or references and thus the suitability can be checked from a knowledgeable perspective. The most famous achievement tests are intelligence tests, where the overall performance is to be evaluated. In addition, there are memory tests, language tests, learning tests, etc.

In parallel or consequently, the non-technical skills, so-called “soft skills”, e.g., ability to work independently, good time management, entrepreneurship, high degree of initiative or teamwork, etc. have to be assessed. These social skills, better known as soft skills, are characterized by a reduced observable acquisition.

3. A newly designed test as soft-skill check for engineers

A newly designed test, the “soft-skill check for engineers”, has been developed, as follows.

3.1. Fundamentals

The personality tests are based on observable *traits/* features and associated *dimensions*.

Preferably, an objective image of the personal nature of the candidate's properties should be created regardless of his subjective impression. For instance, when asked about the trait “care”, the questioning item would not be *Do you care?*, but it would draw a conclusion addressing the candidate's real action on the degree of his care with the question: *Do you follow a clean desk policy on a daily basis?* This, in addition, allows a quantifiable response that contains information that can be better compared.

Based on hierarchical dimensions, personality traits are identified. For example, in the management style analysis, the 3rd-order dimension “Key qualifications” that result from the underlying 2nd-order dimensions “Self-Organization” and “Executive Functions”. A 2nd-order dimension is in turn composed of the 1st-order dimensions, which are the observable traits. For instance, “Self-Organization” is made from the observable traits “Perseverence” and “Care”. The lowest level is represented by items that together characterize an observable trait. The item “Absolute carefulness suits me”, including the answer, and the item “I work really accurately, even if it takes longer”, including the answer, form the observable trait, i.e., the 1st-order dimension “Care” (Fig. 4).

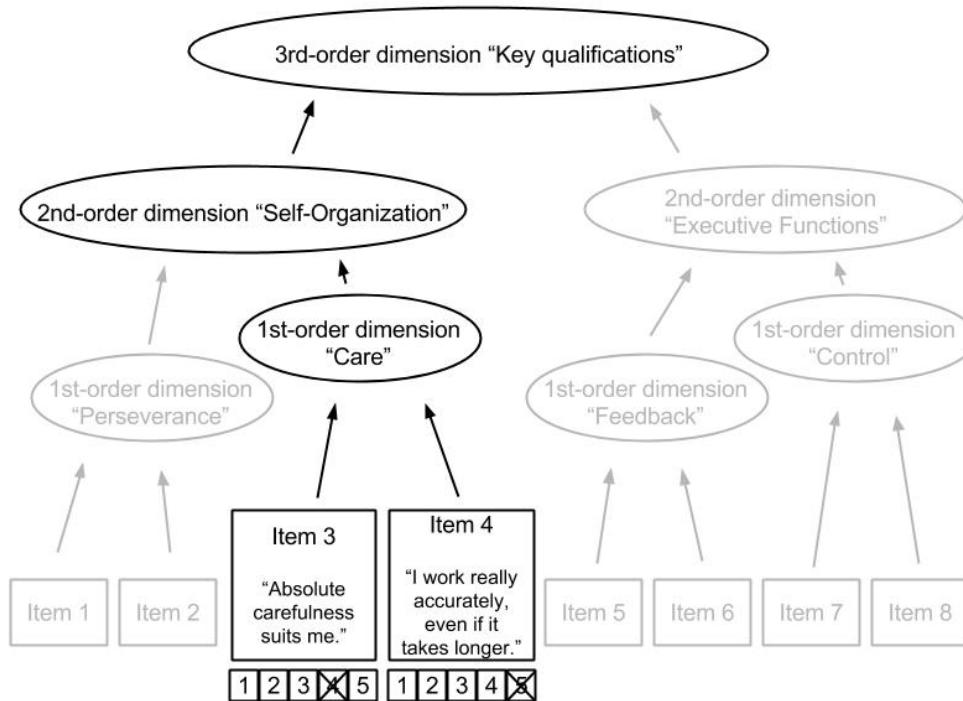


Fig. 4. Relationship between order of the dimensions, observable traits and items

The sample space of an item lies within the range referring to as a five-point Likert scale [5], i.e.

$$\begin{aligned}
 x_i \in \{1, 2, \dots, 5\}, 1 \Leftrightarrow 20\%, 1 \Leftrightarrow 40\%, \dots, 5 \Leftrightarrow 100\%, \\
 1 \text{ or } 10\%: \text{strongly disagree}, 2 \text{ or } 40\%: \text{disagree}, \\
 3 \text{ or } 60\%: \text{neutral}, 4 \text{ or } 80\%: \text{agree}, 5 \text{ or } 100\%: \text{strongly agree}
 \end{aligned} \quad (1)$$

It is to note that, for an observable *trait*, each associated item is evaluated by the mean value of the x_i marks, from possible 1, 2, ..., 5, given by participants, as exemplified in Fig. 4.

Within a certain series of effective tests, SET, let M be the considered number of *tests/ participants*, t - order number of a *test*, a_{ti} - number of *appearances* of a x_i associated to a test t , a_t - total number of *appearances* of all x_i and μ_t - the mean value of all x_i associated to a test t , as well μ - the mean value and σ - the standard deviation associated to all M tests, and, their relationships:

$$a_t = \sum_{i=1}^5 a_{ti}, \mu_t = \frac{1}{a_t} \sum_{i=1}^5 a_{ti} x_i \quad (2)$$

$$\mu = \frac{1}{M} \sum_{t=1}^M \mu_t, \sigma = \sqrt{\sum_{t=1}^M \frac{1}{M-1} (\mu_t - \mu)^2} \quad (3)$$

It is to be emphasized that the mean value reveals the character of the series, and the standard deviation - the scattering of the random variable values around its mean value; the smaller the standard deviation, the closer are the values to the mean.

It is assumed that almost all effective marks, $x_{\text{ief.}}$, are within $\mu \pm 4\sigma$ interval, and, taking into consideration rel. (1),

$$x_{\text{ief.}} \in \{1, 2, \dots, 5\} \in (\mu - 4\sigma; \mu + 4\sigma) \quad (4)$$

An example of a series of effective tests *SET* is presented in Table 1.

Table 1
A series of effective tests *SET*

Test order number	Questioning item order number			Mean values		Standard deviation	$\mu \pm 4\sigma$ interval
	b	d	f	μ_t	μ		
t	x _i mark			μ_t	μ	σ	$(\mu - 4\sigma; \mu + 4\sigma)$
h	3	4	5	4			
k	3	4	4	3,67			
l	4	5	4	4,33			
p	3	4	4	3,67			

Note. For the calculus of μ and σ , in rel. (3): t = 1, 2, 3, 4 correspond to t = h, k, l, p, respectively, and, consequently, M = 4.

Furthermore, the range of $\mu - 4\sigma$ to $\mu + 4\sigma$ is splitted in nine parts, so that the regions contain a number of results per cent. These nine areas, the so-called stanines, represent characteristic sections.

The areas 1, 2, 8 and 9 are neglected, because outlier are eliminated this way, and the data can be presented more perceptibly (Fig. 5). So, in total, 78% of all results, i.e., five stanines are considered. The width of the stanines shows the significance: are the stanine very tight, then the values are near to the mean and the result is of high significance, since there is small scattering; if the opposite is the case, then the stanines represent expansive areas and represent a low significance because of high scattering.

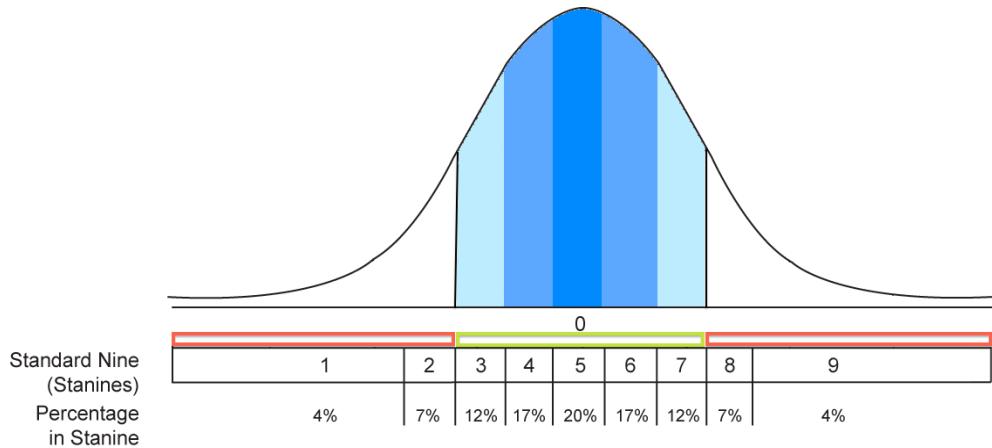


Fig. 5. Illustration of the used (green) and neglected (red) stanines

3.2. Effective defining data and results

The considered test, the “soft-skill check for engineers”, was carried out with 1530 participants.

Among all participants, a series of 8 *clusters* - gender, degree, age, etc. and 56 *traits* - care, optimism, professional interest, etc. have been defined.

A distinct *test* was associated to one participant/ person.

For different subsets of all tests, certain *standard profiles* have been defined. For the cluster “hierarchy”, e.g., the standard profiles were “expert”, “project management”, “head of department” and “managing director”.

All relevant values are taken into consideration. Thus, for instance, the cluster *gender = female*, out of all 1530 tests provided, only those 146 are taken into account that were answered by women.

At each test, the mean value of effective marks was calculated for each trait.

A validity can be derived against the background of the number of tests. In order to obtain reliable results a certain minimum amount of tests is required. It has been shown that the thresholds are at 15, 50, 100, 110. From 15 values on, a trend can be observed; from 50 values on, the trend is fixed; for values from 100 upwards, the point nearly does not move.

When creating the standard profiles, it was taken care that at least 50 values are available. It has been found that each standard profile satisfies this requirement. By analyzing additional data collected along with the test data, it is possible to determine *personality traits* that are typical for all clusters.

The soft skill check was developed in consultation with the VDI (Association of German Engineers) and the Geva Institute and published and advertised on their websites and in the print edition of VDI Newspaper [7]. The

online test was completed by all participants, 1530 engineers, and delivered an equally large number of evaluable test results. Firstly, the test provided the opportunity to learn about potential and opportunities for development of their own personality. Secondly, the test was voluntary. Often the result of self-assessment tests is questioned, since they are rumoured to hold the effect of social desirability and have self-image of the subject that is stated not to be reliable. In this case, however, these objections are no longer relevant: the test takes place voluntarily and is either self-financed or paid under an incentive of a successful employee by the employer. Thus, the test situation has not an immanent examination character, resulting in a reduction of the effect of social desirability and is aligned to give the tested person a realistic impression of his abilities and to identify possible development potential. This is generally to be seen as the primary intrinsic motivation for participation.

The *effective typical traits* and *effective standard profiles* are determined based on the mean values calculated for the considered traits and tests. For instance, the effective standard profile “Thought pattern” is the result of the traits as presented in Fig. 6.

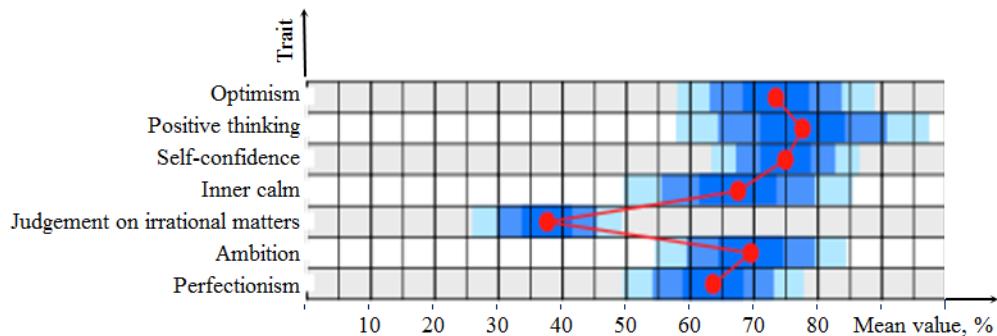


Fig. 6. Traits defining the standard profile “Thought pattern”

Once the standard profiles for different subsets of all 1530 tests have been build, further evaluations can be conducted. For the cluster “hierarchy”, e.g., 4 *standard profiles*/ subsets, i.e., “expert”, “project management”, “head of department” and “managing director” were defined and evaluated. This means that, by structuring the whole set of tests into subsets of different topics (i.e. clusters), the conclusions can be drawn by comparing the resulting standard profiles, as follows.

(1) Least differences of the mean values associated to traits, $\Delta\mu$ - given as percentage point as it is the difference of two percentages, when comparing standard profiles represent traits that are not influenced by the topic. These are the traits that are affected the least by the engineer's development from the lowest to the highest hierarchy level. Thus, they are almost not influenced at all by the career. For this reason, one can derive that the shown traits are - from the

perspective of development during his job history - the ones that are characteristic and seem to change only negligibly.

For this, as an example, the cluster "hierarchy" shall be represented by six traits (out of all 56) having the associated mean values with highest accordance, as presented in Fig. 7.

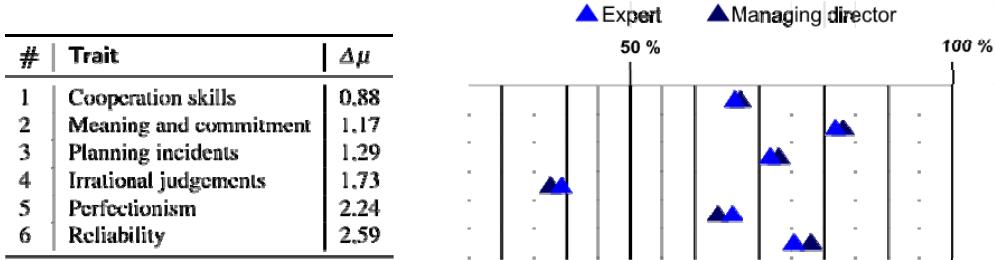


Fig. 7. Minimal distances of mean values of traits associated to career standard profiles expert and managing director in the cluster "hierarchy"

By processing to cluster "hierarchy" and other time-independent clusters, e.g. static differences of distinct standard profiles, the typical traits almost not influenced by career are revealed as presented in Table 2.

(2) By analyzing the mean values associated to traits that differ the most between the lowest career standard profile "expert" and the highest career standard profile "managing director", further results can be deducted. These are the traits that are effected the most by the engineer's development from the lowest to the highest hierarchy level.

For the most deviating traits, in the cluster "hierarchy", e.g., nine traits (out of all 56) having the associated mean values with highest differences are as presented in Fig. 8. Thus: the trait "Executive functions" is influenced most by the career; the considered traits hold the biggest development potentials because they change the most.

By processing the development areas/ potentials for engineers, evolved from cluster "hierarchy" and other time-independent clusters, e.g., static differences of distinct norm profiles, the typical traits that can be influenced by career, training and education are as presented in Table 3.

A closer look to the dimensions should be taken. The presented traits, of 2nd-order dimensions, derive from only three of 1st-order dimensions.

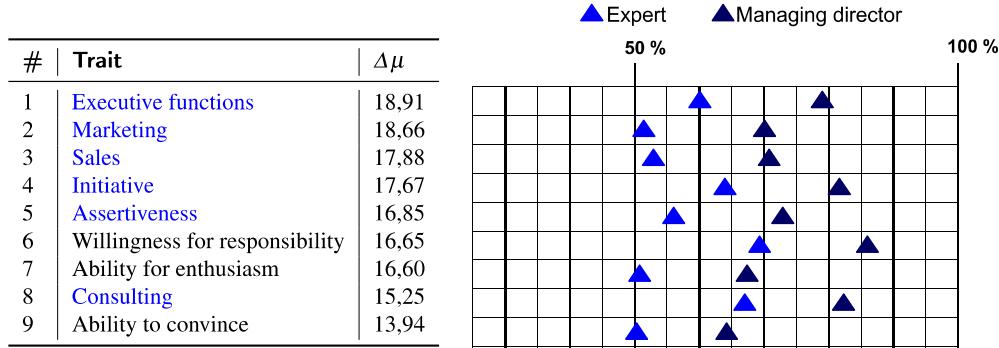


Fig. 8. Maximum distances of mean values of traits associated to career standard profiles expert and managing director in the cluster “hierarchy“

Table 2

Personality traits of engineers (1)

<u>Traits that are almost not influenced by the career</u>
• Cooperation skills
• Meaning and commitment
• Planning possible incidents
• Judgement on rational basis
• Reliability
• Perfectionism

Table 3

Personality traits of engineers (2)

Category	1-st order dimension	2-nd order dimension
<u>Traits that can be influenced by the career</u>	• Professional interests	<ul style="list-style-type: none"> • Executive functions • Marketing • Sales • Consulting
<u>Traits that can be influenced by training and education</u>	• Commitment	<ul style="list-style-type: none"> • Initiative • Willingness for responsibility
	• Communication	<ul style="list-style-type: none"> • Assertiveness • Ability for enthusiasm • Ability to convince

The professional interests are defined by features that can not be directly influenced, but are intrinsically formed and evolving. Interests arise in the engineer in the course of his career that are aroused by rising up the career ladder and continue to develop with significant differences features by comparing the standard profiles “expert“ and “managing director“ (Fig. 8).

The situation is different with the features of the other two 1st-order dimensions, commitment and communication. These represent features that can be changed through training and education. Thus, they may contribute to further advancement. These features should be highlighted, discussed and improved.

4. Conclusions

People of engineering profession have matching expressions of personality traits that are typical and characteristic for each investigated group/ cluster.

Defined personality traits emerge as the key criteria that are essential for the successful practice of the profession/ activity and responsible for the success.

Creating the difference between actual and target profile shows which personality traits must be enhanced by setting personnel development measures in motion to prepare and implement the next step in profession.

Based on the results of a robust *soft-skill check for engineers* test, the personality traits of engineers can be grouped in certain categories, i.e., traits which are: almost not influenced by career; influenced by career; influenced by training and education.

The personality traits of engineers which are almost not influenced by career are: cooperation skills, meaning and commitment, planning possible incidents, judgement on rational basis, reliability, perfectionism; the personality traits of engineers which are influenced by career are: of 1-st order dimension, i.e., associated to professional interests, and of 2-nd order dimension, i.e., associated to executive functions, marketing, sales, consulting; the personality traits of engineers which are influenced by training and education are: of 1-st order dimension, i.e., associated to commitment or to communication, and of 2-nd order dimension, i.e., associated to initiative, willingness for responsibility, or to assertiveness, ability for enthusiasm, ability to convince, respectively.

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