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FOS electronic database as training in RTV (Develop Creative Imagination)

Abstract

The present work offers a variant of an electronic database on generalized (elementary) functions intended for describing the operation of various Engineering systems as part of the approach of FOS (Function Oriented Search), which is proposed for use as a training device for developing creativity according to the course of RTV (Development of Creative Imagination or DCI). This software could be used for testing the candidates being hired by the specialized departments of the enterprises, in which the projects of innovative design are being independently developed. This software also has a non-electronic simplified version, which the students could use in the course of coaching sessions after 18 exercises, which were done by them using electronic software. The next stage of using this software in practice of TRIZ training will imply the organization of research work relating to precise measurements of IQ level enhancement after the training received and practical application of FOS methodology.

 Key words: "function of engineering systems", RTV (DCI), "Function Oriented Search", "Development of creativity", "Tests on creativity measurement".

1. Main issues considered in the present work:

 As the practice of last 10 days demonstrated – classical heritage and experience accumulated while teaching courses of DCI in Russian TRIZ universities, appeared to be inapplicable in teaching TRIZ at the Korean market. This experience was concentrated in the Provisions concerning certification on DCI in MATRIZ (1) .

On the one hand, reject of using DCI courses reduced the quality of TRIZ education at the Korean market, while on the other hand it placed the task of

creating the analog of these kinds of mental training irrespective of the national peculiarities of market, at which TRIZ training takes place.

Neither did the attempts to develop creative thinking based on the tests of Gilford (2) or Torrance (3) satisfy the requirements of TRIZ training tasks due to several considerations.

1. The above-listed tests on creativity measurement suffer from the same disadvantage, as the classic heritage of DCI – they use tasks, which have no sense from the standpoint of practice of implementing innovation projects. These are, for example, the tasks, which concern defining the level of divergent thinking parameters: "How many applications could one suggest for the object "brick"? How many words starting with the letter "O" can you name?" and exercises like this. At the same time inventive thinking includes not only divergent and convergent thinking, but also logical thinking.

2. Tests of this kind don't include the personal motivation of the person being tested. It means that the measurement of creativity level is incorrect. Concentrated criticism of these approaches is offered in the work by Bogoyavlenskaya (4)

Function Oriented Search (FOS) was chosen as one of the prototypes for developing creative thinking, since it is a highly efficient tool, which causes serious difficulties for the students, who study it, because of constant transitions from application level to abstract level and then back to application level, in order to search for an efficient prototype in solving inventive problems.

1.1. The Origins of FOS (Historical Aspect)

The history of FOS as an inventing tool could date back to 1973, starting with the pioneer work of Tamerlan Kengerly, the unfortunately forgotten professor of Azerbaijan School of Scientific and Engineering Creativity (TRIZ University, to use modern Russian language) in Baku. "Transfer of engineering solution in inventive creative activity " .(5) The author set forth the idea of targeted search for

FS (Functional Solutions) for search of analogies and then imposed over this idea the model of variability of kinds of energy in engineering evolution developed by Boris Zlotin (MATHEM) and the model of increase of dimensionality of obtained results in ES functioning of Vladimir Petrov ("point – line – plane" or 0-1-2-3) and obtained quite a workable tool for using the basic idea of the method of analogy with a functional criterion.

The term FOS appeared in the work of S.Litvin dated 2004 and called «New TRIZ-based Tool – Function-Oriented Search». (6) The author proposed a 12-step algorithm, which included the elements from the approach of T.Kengerly, the idea of addressing the leading field of engineering and communication with a network of experts in science in order to refine the possibility of using the ideas, set forth in the course of application of the said methodology.

In order to use FOS or IFOS (inverse, back FOS) several specifying algorithms were developed later.

Function Oriented Information Search. A.Ya.Khimiuk . (7)

Two variants of function generalization are used in this work: according to object-free action, for example, "to heat" or according to objectified action, for example, "to heat liquid" (this classification was proposed by B.M.Akselrod for function-oriented search in patent literature).

CONCEPT OF AUTOMATED SYSTEM FOR FUNCTION-ORIENTED SEARCH (8)

S.A.Kolchanov, Russia, M.S.Rubin, Russia, E.L.Sockolov, Russia

This work contains an attempt to prepare the algorithm of S.Litvin for creation of a software product. Besides, the work also emphasizes the fact of dependence of the level of success in using this methodology upon the level of preparedness of the user.

3. Problems, which are solved in research work:

Everything, which was said above, signified an important trend in using FOS as a tool in terms of training the users. How would it be possible to accelerate the installing of habits of recognizing identical functions in different industries with a

beginning user and thereby to make the practical application of the basic ideas from this approach more efficient?

Very helpful in answering this question was the work by Yu.Fedosov dated 2009 and entitled "Statistics of Elementary Functions " (9)

In this research Yury Fedosov demonstrated that *"Performing 2132 functions implies only 40 names of functions;*

- More than half of them implies only four names of functions: move, heat/cold, brake/accelerate and hold (support);

- In 90% of cases only 16 names of functions are used."

In 2009 Yu.I. Fedosov confirmed the hypothesis, which the authors already had: it was the hypothesis concerning the basic <u>finite</u> number of elementary functions and the ability of creating a reference book on elementary functions, in the same way as they create reference books on synonyms, antonyms and homonyms in Russian, English and other languages of the planet.

It fact it can be supposed that the number of elementary functions, which describe operations performed on objects with very high categories of abstraction, for example, substance, energy and information is finite in the same way as the number of notes in music and the number of letters in the alphabet of any language is finite.

This work was an impetus for forming the classification system of generalized functions, which was reported at the TRIZ conference of 2010 in Seoul.

Yu.Danilovsky, S.Litvin, et al. «Yu. Danilovsky, S.Litvin et al."Method of analogy in TRIZ" Seoul, 2010 (10) .

The fundamental hypothesis of this work in its part, which concerned FOS was based on the supposition concerning the finite character of the number of generalized functions.

According to the definition from the Glossary (11) compiled by S.Litvin, A.Lioubomirsky and I.Sigalovskaya

Generalized Function: Function, for which a particular object and the action associated with it are reformulated and worded using universal terms. For example, a particular function "remove water" could be reformulated in generalized form as "move liquid". Generalized functions are used in performing Function-Oriented Search.

In order to construct a full and non-contradictory axiomatic system of generalized functions the combination of two approaches was used – dichotomic subdivision of notions (12) and logics of twin negation from Hegel's dialectic (13).

Dichotomic subdivision is a traditional way of creating classification systems in mathematics, which is reduced to subdividing objects using the negative particle "NON". For example, the separation of society according to sexual character in an ordinary way will yield the following classification: society could be subdivided into men and women. Thus, we will obtain an obviously incomplete classification system. The application of logic of dichotomic subdivision will yield a different result: society consists of "men" and "NON-men", the category of NON-men implying both women and those who cannot exactly be related to the category of "man".

The logics of using the law of twin negation (third law of Hegel*) was well studied by one of the authors in his work Yu.Danilovsky "Use of Models of Spiral Evolution in Forecasting Projects" ([14])

1. *The law of the unity and conflict of opposites;*
2. *The law of the passage of quantitative changes into qualitative changes;*
3. **** The law of the negation of the negation***

G. Altshuler in his conversations with disciples several times called TRIZ <u>applied and practical</u> sphere of Hegel's dialectic application, since the first law of Hegel (unity and conflict of opposites) is a model of Engineering and Physical Contradictions, while the second law of Hegel concerning passage of quantitative changes into qualitative changes forms the basis for the model of irregularity and

non-linearity of evolution of engineering system parameters and is called S curve model, while the third law of Hegel or "the law of the negation of negation" could be found by you in any historical sequence like: mono - bi - poly - – complex - new "mono-system" - new "bi-system" - new "poly-system", finding the repetitions of characteristics of previous systems in the properties of future systems, as it is shown in Figure 1.

Figure 1 "Examples of manifestation of the model for spiral evolution of engineering as a phenomenon of repetition of important properties of previous systems.

This drawing offers two examples of repetition of important properties of systems as part of a model of spiral evolution of engineering. The left-hand picture illustrates the repetition of a number of operating members – two wheels of a motor-cycle, while in the right-hand picture we see the repetition of the type of motion: "translation – rotational and again translation", however it is encountered in electronic clock.

Such kinds of historical chains correspond to the model of evolution of engineering according to the formula of "twin negation" according to the following chain:

System A → System "non-A" → System "non (non-A)",

In which the third element is like the first one, however, does not coincide with it. This formula is depicted in Figure 2.

Figure 2. Logical Scheme of the Law of Twin Negation

1 law - contradiction
2 law – transformation of quantity into quality
3 law- twin negation

Mind "not" – "negation"- object with opposite features
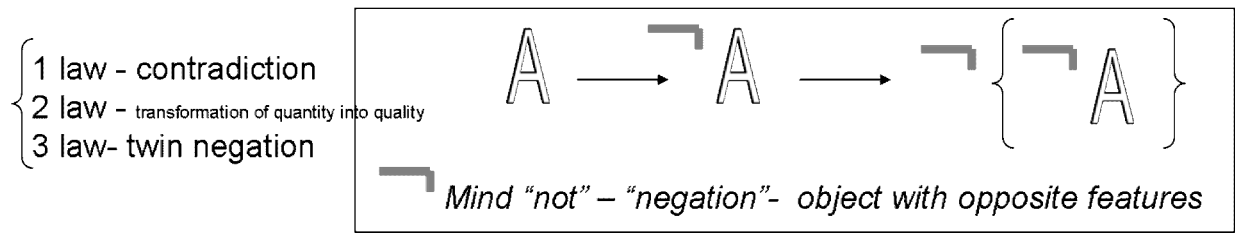
We can also act in the same way, while analyzing all types of operations with resources – substance, Field and Information.

Generalized function according to its definition, which is given above, performs certain operations with substance-and-field resources of engineering evolution. The simplest thing that we could do with the object <u>without changing its nature</u> is: Push (***move***) the object → first negation A = NOT move = it means ***hold*** → second negation NOT (NOT hold, but move) = curve – ***change the trajectory of movement*** of the object A.

As a result of the above-quoted reasoning we obtained the first triad of main operations – move – hold (fix) – change the trajectory of motion (reflect, diffract, deflect).

Let us analyze the second triad, the goal of which is to describe reversible and irreversible transformations, which we could perform upon the objects Substance, Field and Information.

We could "add" new substance, when we draw in pencil, or we could "add a field", when we boil water in a kettle using an oven or we could "add information", when we enrich some database with new facts.

To change the state of the object A = ***to add*** something from three selected categories (Substance, Field or Information) → the first negation A = (NOT to add) = extract, ***remove*** → the second negation A = NON (remove, but change the condition of the object) = split, perform some "***transformation***", now let us unpack the meanings according to MATHEM – split – heat – electrify – magnetize. Thus, using two approaches – mathematical logics and the logics of philosophical law of "double negation of Hegel" we obtained the second important triad of

transformations: add – extract – transform. Both triads constitute complete algebra of transformations.

2 important triads
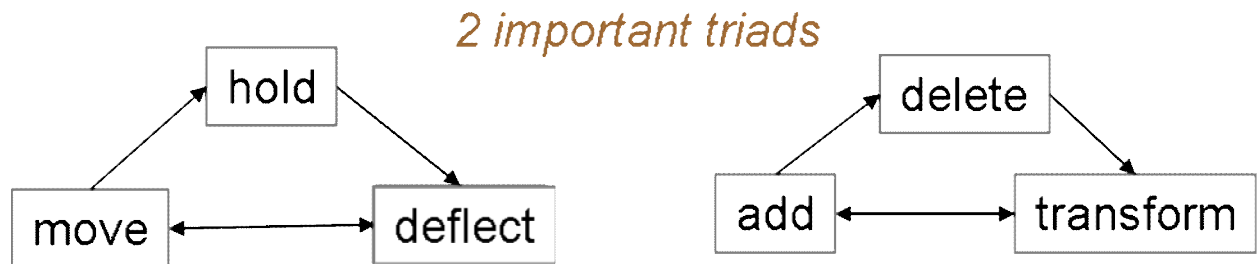
So, we can conside only 6 main actions (verbs) with 3 objects of functions : substances, fields, and inormation. In the future can be created another classification sustems for root function, but right now we can create system for to do training in FOS.

4. Novelty of the work:

In order to accelerate the process for installation of habits for recognizing identical functions in different fields of engineering a specialized electronic reference book on generalized functions was created.

The reference book is organized as a matrix of 18 cells, in each of which there is a hyperlink to the corresponding collection of examples of generalized functions, which is to be found in Internet. Three vertical columns (columns of the matrix 6 by 3=18)   follow the classification of three main objects, upon which the operations are performed: substance, field and information.   These objects were selected by the author. Six horizontally placed lines of classification of typical operations (main verbs and their synonyms) in generalized form, which were singled out both based on application of the content of the double negation law from Hegel's dialectic and based on empirical experience of the author.

The database, which is thus created, could be used for development of creativity, enhancement of habits of inventive thinking, namely – the ability to see similar generalized functions in different engineering objects. The meaning of the training consists in the proposal for the trainee to find several examples of his or her own after having previously studied the content of 20-30 examples in each of the cells of database intended for training the practical use of FOS.

The proposed system of training sessions, which is presented as the simplest computer program could at the same time be a test for measuring creativity through measuring two parameters – time for doing exercises and the level of proximity of examples found by the person being tested to examples from the reference book. The greater the distance between examples from the reference book is, and the less time is given for performing the exercise, the higher the level of creativity of the tested person will be.

The system for creative thinking development based on recognition of generalized functions includes both important elements needed for the process of creating inventions: divergent (ability to generate ideas associated with the application of a piece of cardboard, for example) and convergent thinking (ability to follow proposed algorithms of behavior and thinking). In contrast to metal techniques and courses of DCI, in which the user performed metal operations on invented objects and situations – transition to objective level is proposed, which provides for inclusion of personal motivation of the user, because the success in fulfilling the tasks will determine the success of the trainee and of the person being tested during his (her) participation in forthcoming actual projects based on the themes proposed by trainee himself.

5. **Instrumentality of Proposed Development:**

Consists in the fact that the device for creative thinking development is embodied both as a computer program and as hard copies of reference books.

Function -Oriented Search (FOS) training for the development of creative thinking skills through the 18 exercises. *Product for Smartphone.*

TYPICAL VERBS FOR FUNCTION	SUBSTANCE	FIELD	INFORMATION
Move, pull, push, revolve, propel, stir, jump, shove, jostle, poke, jab, insert, put, bump, hustle	Typical examples	Typical examples	Typical examples

Add, pour, infuse, inject, blast, append, supplement, throw in, tag, top up, tack, eke, stick, weld, sew	Typical examples	Typical examples	Typical examples
Extract , dig, delete, cut, remove, eliminate, purge, expel, exclude, filter, move away, prune, amputate, elicit, retrieve, recover, derive, draw, unearth	Typical examples	Typical examples	Typical examples
Hold , fix, retain, maintain, withhold, hold down, deter, deduct, restrain, detain, stop, confine	Typical examples	Typical examples	Typical examples
Deflect, reflect, change direction of movement, reflect, mirror, agitation of some substances or fields, focus, repel, repulse, beat back, parry,	Typical examples	Typical examples	Typical examples
Transform* (change of matter), convert, shatter, disintegrate, crush down, heat, warm, hot, calorify, cold, froze, **Transform – change the parameters of aggregate states of substance according to classification of B.Zlotin, MATHEM**	Typical examples	Typical examples	Typical examples

Notes:

1

The authors don't claim that the proposed classification is the only possible one and that it is perfectly correct. This is only an experiment and the first experience of the author in creating the architecture of the software program, which would

develop the habits of any person in terms of thinking according to the method of analogy.

2

«Disadvantage or a logical phenomenon?»

The practical use of this kind of exercises demonstrated that the selected type of classification of elementary functions meets with a "phenomenon of multi-variant interpretation".

For example, engineering system "household knife" could be defined through the verb "to cut" , i.e., "to change the parameter of the object integrity" , which could be related to cell 1.1.   "move", i.e. increase the distance between the parts of the object being handled, which were once an integrated whole, however, engineering system "knife" could be defined through the cell 1.6. "transform", where there are synonyms "splitting".

The engineering system "graphite pencil" could be defined through the cell 1.2. "add substance" (parameter "change graphite concentration on 1 cm^2 of paper surface"), but it could aloso be defined through the cell 3.2. "add information".

The engineering system "toothbrush" could be defined through the cell 1.3. "remove substance" meaning the dental plaque and bacteria and through the cell 2.2. "add field" (mechanic and chemical).

For example, engineering system "cigarette" can be defined either through the cell 1.2. "add substance" (parameter: increase the concentration of nicotine in blood), however, it could also be defined through cell 2.2. "add field", since one of the mechanisms of cigarette acting upon human organism is the increase of pressure in blood vessels of the human brain (parameter: "intracranial pressure"). In each of the selected cells you will be able to find an interesting analogy, which corresponds to the context of your project.

From the standpoint of FOS application efficiency there are no defects here. In practice defining of a function depends upon the context of the whole project, upon the procedure of "aim taking", i.e., upon different variants of formulating the function. Besides, in the same way as in mathematics, the equation can have several real roots, i.e. "correct answers", the definition of functions can imply several answers, which are absolutely correct.

Besides, it has to be noted that the goal, which has been set is to install stable habits of inventive thinking in the brain of the trainee. It is important for us that the trainees should have subconscious ability to see similar functions in different objects.

For this purpose it is also possible to use non-electronic teaching aids, as it is shown in photographs below. These devices: a cube or a folder version with six very important functions could be used after a set of training sessions with an electronic database and necessary 18 exercises employing these teaching aids.

Figure 3.

Hard copies of Coaching Equipment for Using FOS Method.

- Move, pull, push, revolve, propel, tir, jump, shove, jostle, poke, jab, insert, put, bump, hustle

1. MOVE

GEN3 PARTNERS
KOREA
www.gen3.co.kr/
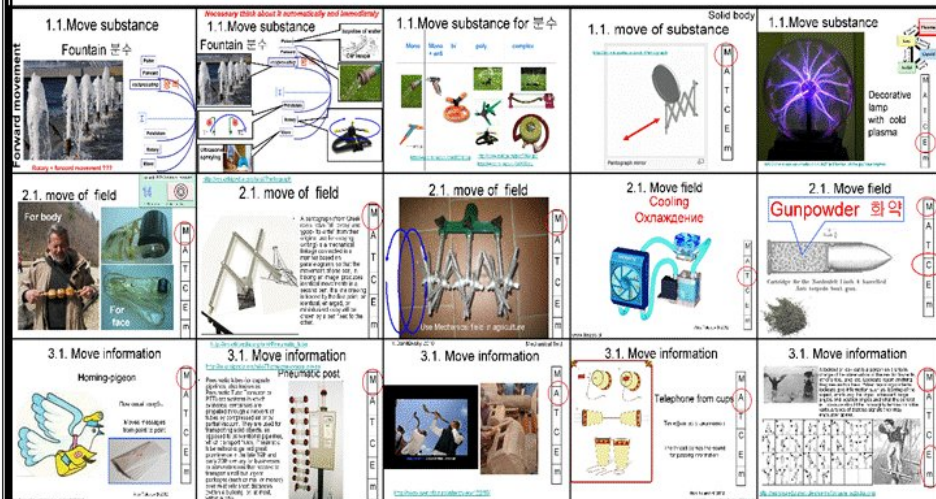
- Add, pour, infuse, inject, blast, append, supplement, throw in, tag, top up, tack, eke, stick, weld, sew

2. ADD

GEN3 PARTNERS
KOREA
www.gen3.co.kr/
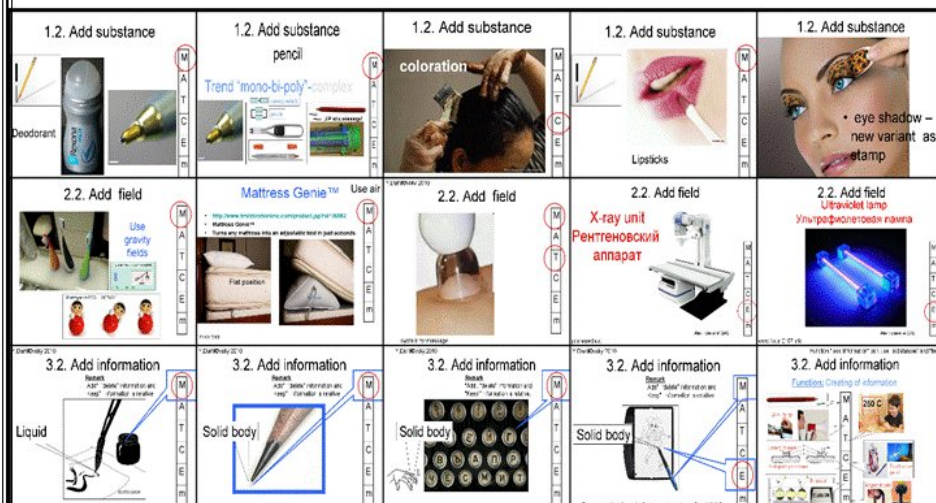
- Remove, extract , dig, delete, cut, eliminate, purge, expel, exclude, filter, move away, prune, amputate, elicit, retrieve, recover, derive, draw, unearth
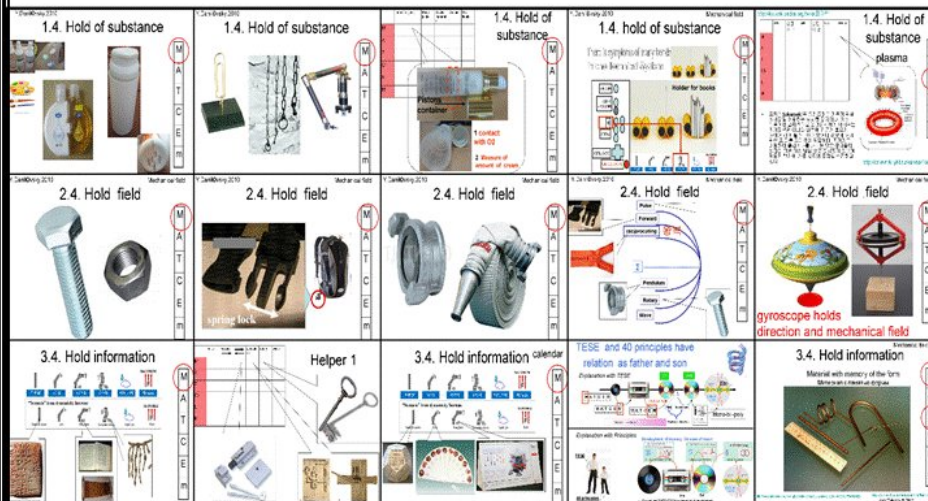
3. REMOVE

GEN3 PARTNERS KOREA
www.gen3.co.kr/
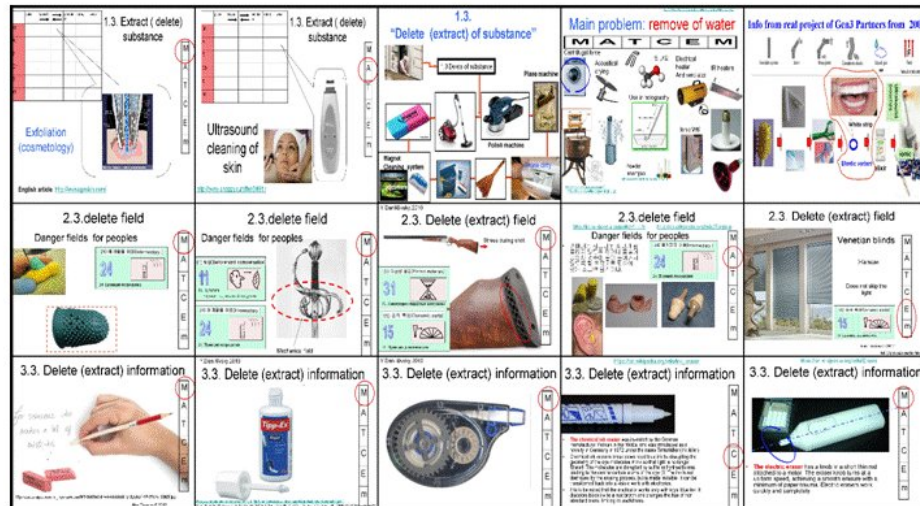
- Hold, fix, retain, maintain, withhold, hold down, deter, deduct, restrain, detain, stop, confine

4. HOLD

GEN3 PARTNERS KOREA
www.gen3.co.kr/

- Deflect, Reflect, change direction of movement, mirror, agitation of some substances or fields, focus, repel, repulse, beat back, parry,

5. DEFLECT

- Transform* (change of matter), convert, shatter, disintegrate, crush down, heat, warm, hot, calorific, cold, froze,

6. TRANSFORM

The dodecahedron on the left is also a teaching aid intended for coaching sessions with students. It describes interconnections between trends and 40 techniques for resolving contradictions: EC (engineering contradiction) and PC (physical contradiction) and helps to generate additional ideas in forecasting and ordinary projects. The structure of this kind of equipment will be described in greater detail in another article by the authors of the present work.

Advantages of proposed system of exercises in the field of DCI:

1. The publication of this reference work offering open access to it implements the simplest Ideal Final Result (IFR): there is no trainer in RTV (DCI), however the function of the trainer is performed. The student trains HIMSELF (HERSELF) on a training device, which is called "recognizing similar functions in various objects of engineering". Or according to the third wording of IFR: the ambience of the trainee contains a certain X-element, which, without taking the time of the trainee for visiting classes and without making the trainee pay for training during 5 – 10 days can HIMSELF obtain the necessary habits of inventive thinking at any time, which is convenient for him (her).

2. The trainee spends time on studies according to the flexible time-table – when he(her) has free time: on the way to work in the morning, on Saturdays and Sundays.

3. The student spends very modest means only on buying the software product loading it into his mobile phone (or buying a book made of paper) and on certification for MATRIZ, thereby enriching our development budget.

4. This type of training sessions is appropriate for any market and any language.

5. This training went through two-year testing in 2010 -12 at three markets corresponding to the languages used in the table – English,

Russian, Korean and Thai and was easily mastered by all users irrespective of their TRIZ qualification.

6. This type of trainings enables during a short period of time (6-10 months) to identify and to form a base of future strong solvers, which further on would be able to become a reserve of specialists for development of our company.

7. This type of trainings could be a means for comparing the candidates for hiring by our company and by approximately 50 TRIZ consulting companies, which exist in the world today. Similar tests were introduced in the methodologies of <u>G.Gilford</u>, E.Torrance (*Torrance Tests of Creative Thinking* — *TTCT*) on divergent thinking, however our work requires convergent and logical thinking, which are not to be found in the existing tests.

Conclusions:

1. As the experience of last two years showed, the use of proposed reference book on elementary functions is quite possible at any market as an auxiliary material in TRIZ training: fundamentals of function analysis, function oriented search and at the same time as an object-oriented set of exercises on DCI, which is proved by well-known thesis: *"Language of functions is Esperanto of innovation consulting". (aphorism of S.Litvin)*

2. The authors hold to the opinion that the Presidium of MATRIZ could some time later reopen the certification on DCI as a separate discipline or use a different approach, for example, in the form of creating "centers for measuring the quality of training", where it could be possible to get the services on development of DCI and concurrently conduct the procedure of measuring the creativity level or recommending the regional organizations to open postgraduate courses for preparing TRIZ specialists for defending 4-level theses under the guidance of experienced 5-level specialists.

Conclusion:

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