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Cross-Disciplinary Cooperation as the First Step in Engineering Education on the Road to the Convergence of the Technics, Sciences and Humanities

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In this article, consideration is given to some new ideas that are devoted to the world community's problem concerning the convergence of the technics, sciences and humanities. The 40-year period of the author's activities in the field of higher technical education, which has been made more active due to his close collaboration with the UNESCO International Centre for Engineering Education (UICEE) over the last decade, has concentrated on the problem of the implementation of interdisciplinary connections. The latter should be understood as the first real step and contribution of universities to the tendency of convergence. In doing so, the author incorporated the achievements of ethics, philosophy, psychology and synergetics. In the article, the author outlines briefly the basic pedagogical approaches being used in the author's pedagogical activities.

INTRODUCTION

The basic aim of training students for the engineering profession consists of facilitating their acquisition of a taste for, and skills in, raising and independently solving original high-level problems. In most instances, studies are currently based on solving well-known theoretical and practical tasks that contain no creative searches because the answers, as a rule, are always known. It is obvious that the modern specialist, who graduates from a technical university, is obliged to possess knowledge and acquire the skills required for solving creative tasks.

A great deal of engineering methods destined for creative work have already been widely elaborated on, among which are the heuristic and computer methods for searching design (synectics and control question methods for the analysis and synthesis of designs and technological decisions, etc) [1-4]. However, it should be noted that successful creative work supposes increased emotional creativity and a higher aspiration for success. Hence, moulding engineers who are notable for their creative understanding presupposes their definite aesthetic preparation for realising and sensing the interior functional beauty of the technical object.

Part of the subject matter of this article is devoted to a new approach to making students' thinking, when lecturing on engineering courses, more active by introducing discursive thinking, and the associative connections between the technical sciences and the humanities, and works of art. The method also promotes the development of students' spiritual demands.

The dialectical unity of theoretical thinking and emotional attitudes of the mind encourages the student's cognition in solving traditional problems in the sphere of conceptual, functional and logical processes, as well as structural or engineering design. The grounds above cited agree with Einstein's well-known opinion that real science and real music demand a homogeneous process in thinking processes.

Emotional thinking presupposes turning over in one's mind images of works of art and, eventually, predestines insight into the optimum decision for problems in the technical search process. Fostering students' focus on the sphere of thoughts promotes the application of various associative approaches. The most productive are the so-called *reasonable* associations that make possible connections with many types of the humanities and works of art, particularly literature, music, painting, philosophy, ethics, etc. It is

easy to see that cross-disciplinary cooperation is a true term when using Hegel's dialectical method of philosophy in the delivery of lectures in engineering courses.

The new approach to making students' thinking more active, as expounded in the author's published papers, results from 40 years of his lecturing activities in the Electrotechnical Department at Donetsk National Technical University (DNTU) in Donetsk, Ukraine. The use of concrete examples when applying the *reasonable* associative approach improved students' understanding when lecturing on the engineering courses *Electromagnetic Transients in Electrical Systems*, *Electromechanical Transients in Electrical Systems* and *Fundamentals of Scientific Research* based in the courses *Theoretical Fundamentals of Electrical Engineering* and *Electrical Machines*.

The motive to publish the author's ideas was stimulated from the numerous favourable reviews of his colleagues at the university level, as well as at international conferences on technical education and electrical machines.

In this article, no consideration is given to the version of convergence put forward by Teilhard de Chardin and based on the unification of the scientific methods in the sphere of the humanities, technical sciences and religious approach when carrying out investigations associated with the key problems of future society [5].

THE PROBLEM OF THE CONVERGENCE OF THE TECHNICS, SCIENCES AND HUMANITIES

At the present time, the strong trend towards the convergence of the technics, sciences and humanities has not been declared. However, the aspiration to search for the common conformity to the natural laws of objects in the world and the way to progress further the area of technics and technology is the actuality point for convergence.

To some extent, the striving for convergence in the past was considered as a manifestation of the collective unconsciousness for the lack of strong convincing proof of the effect being expected [6].

Nowadays, the prospects for the acceleration of the rate of cognition of the conformity to natural laws by comprehending the more general laws of the universe, through passing to the generalised and the more profound laws in the field of science and technics, are largely substantiated by historical examples. The breaks at the joints between separate disciplines and the creation of new fruitful synthetic lines of investigations, eg physical chemistry, have become common knowledge. The intellectual and cultural levels in the sciences, education and technics are, to a certain degree, currently favourable to the integration process in the broad sense, including the values pertaining to the humanities.

As for engineering education, the similarity between technical objects and the humanities, as well as the diverse kinds of art, being systematised in the context of separate aspects reflect the common character of the latter ones. This has been realised in the following manner:

- The use of a philosophical approach;
- An approach based on artificial ideas in the structure of wordy and logical thinking in the form of generalisation in the field of the functional characteristics of the technical object and painting. The latter approach paved the way for the achievement of the synergetic effect.

Most likely, the line of attacking the problem of convergence between the sciences, technics and humanities will be advanced over extended stages. In that event, the first period will be reduced to the establishment of the overall conformity to natural laws in the development of technical objects in various technical and technological fields. Specifically, by the early 1990s, the following generalisations connected with the structure and development of technics were established:

- The law of homologous rows;
- The law of widening the multitude of functional necessities;
- The law of technical object symmetry [7].

The above-mentioned laws are based on definite hypotheses.

The second period will be completed upon generalising the appropriateness of the separate kinds of technics. The third period should be associated with searching for the generalisation between the heterogeneous fields of the sciences, technics and humanities.

The outlined considerations allow for the affirmation that the convergence can help in responding to the challenge of the 21st Century.

PREREQUISITES TO THE CONVERGENCE OF THE TECHNICS, SCIENCES AND HUMANITIES

The diversity of means currently creates prerequisites

for a transition to generalised conformity to the natural laws that exist between the technics, sciences and humanities. This may be exhibited conditionally in the form of a block diagram that reflects a human's inner world (ethics, psychology and philosophy) and the progress of society.

The interconnections presented in Figure 1 provide a method to retrace the interrelations between the technical disciplines and spiritual values. It should be noted that synergetics has been set aside from *Globalisation of achievements of science and engineering* in Figure 1, as it is an interdisciplinary science.

The impact of ethics on the convergence is mediated in light of the fact that ethics is connected with the element *Cultural and educational advance of the terrestrial globe population*. The latter is among the prerequisites reflecting the progress of society (see the lower part of Figure 1).

The pedagogical methods that directly or indirectly promote the successful teaching process and implementation of the cross-disciplinary connections between the technical and humanitarian courses are considered below.

THREE METHODS OF CROSS-DISCIPLINARY COOPERATION

Activating Students' Thinking

The distinction between modern heuristic methods of activating the creative work developed by Osborn, Gordon, Zwicky, etc, with the approach being considered consists of a level of excitation of the cerebral cortex neuron system and the intensity of neurodynamics [1-3]. Being continuously re-formed, the neural network of a cerebral cortex, when entering irritants of a high level, permits the use of stored knowledge more completely; however, at the same time, it results in overcoming logical thinking by generating diverse reactions, including the optimum solution that corresponds to the moment of insight of the researcher [8-12].

For a lecturer, the considered method of activating the thinking process of the audience should not lead to a deviation in logical thinking. Therefore, introducing humanistic values in the contents of a lecture should be coordinated with the volume of the short-term

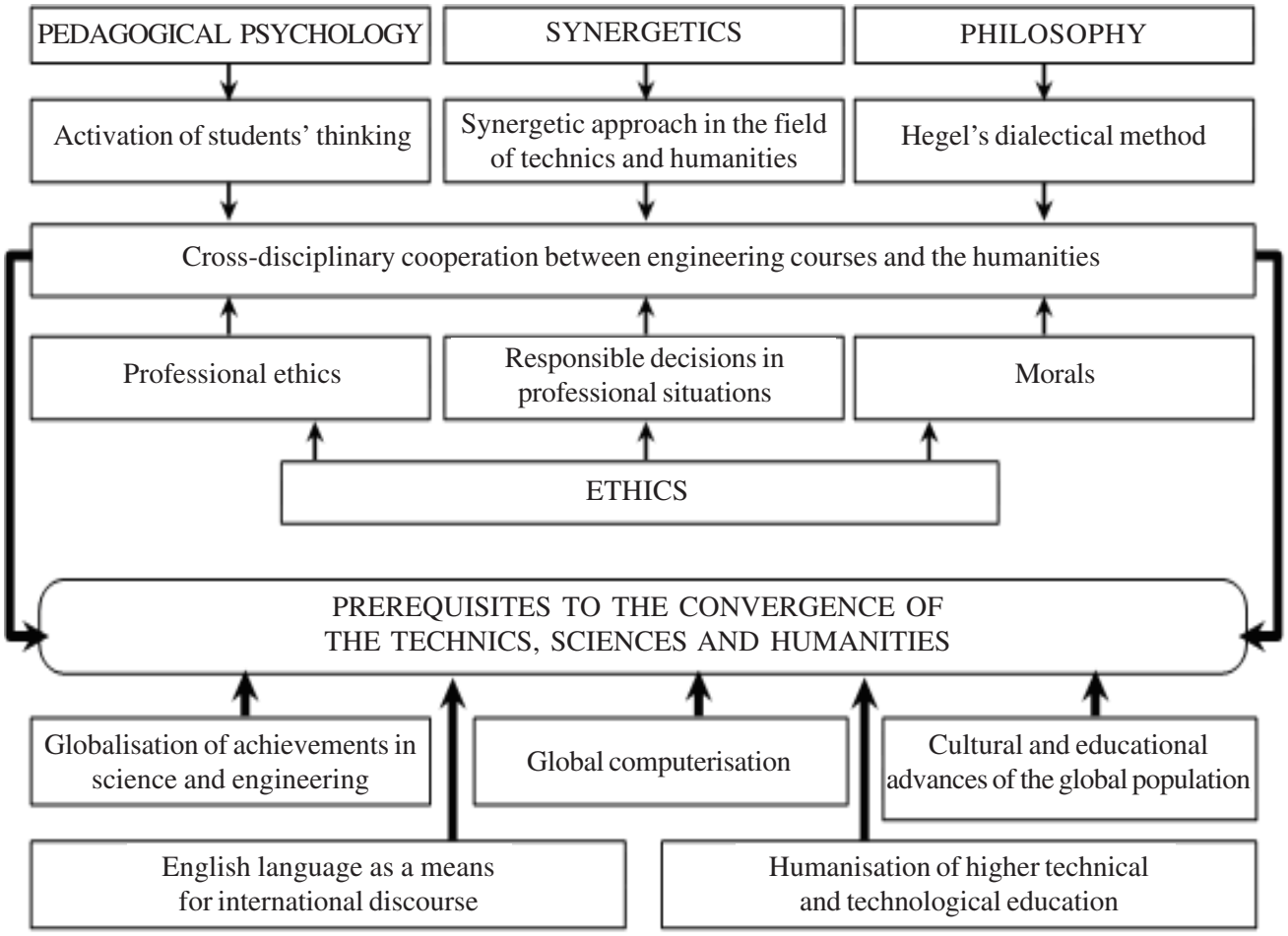

Figure 1: A simplified diagram reflecting the interrelations between the essential components at the initial stage of the convergence process.

memory limited to the quantity of information with the number determined by Miller. Less essential change in the neural structures of the cerebral cortex occurring in this case permits one to keep post-arbitrary attention on the engineering problem being considered and to obtain a positive effect in perceiving the subject of study.

In order to make the best use of the method, it is advisable to take, as starting points, the key concepts and subjects from the area of ethics, arts, philology, mythology, aesthetics and industrial design, as proposed in ref. [13]. The integration of the humanities and arts into engineering education, when lecturing engineering courses, directly provides auspicious conditions to stimulate students for active thinking.

Hegel's Dialectical Method

Effective activities of professional engineers should be fostered at the university level. University graduates of the generation to come ought to become proficient in the most effective methodology for analysing any technological phenomena and processes. Such methodology that distinguishes a high degree of conclusive evidence from deductions and synthesis (by concluding from the general to the particular) is typical for the humanities.

The mentioned logical approach is similar to software application when using the same mathematical methods to solve the diverse processes being described by similar equations – irrespective of their nature. In this instance, the dialectical method can be evaluated as a tool to highlight the interrelations between the causes and effects when studying the phenomena and processes. Knowledge of the latter allows one to substantiate, with great assurance, the logical order of their progress for the effective design and development of advanced technologies and their control devices.

Cross-disciplinary cooperation between electrical engineering courses and the humanities may be attributed to the most important problems in a list of topics on the social, philosophical and cultural aspects of engineering education. It is worthwhile noting that the mentioned problem has not been adequately studied yet.

Nowadays, as a matter of convention, all the sciences are subdivided into the natural and humanstic types. It has been affirmed that the main objective in scientific thinking is to see the general in the particular, and the eternal material and spiritual values in current events.

Establishing conformity to the natural laws of the complicated processes and phenomena can be grounded not only on the mathematical description, but the logical deduction of the dialectical method of philosophy developed by Hegel as well [14]. The dialectical categories most generally employed are as follows:

- Cause and effect;
- Possibility and reality;
- Transition from quantitative changes to qualitative ones;
- The struggle of opposites;
- Chance and necessity;
- Unity of opposites, etc.

The discipline of *transient processes in electrical power systems* is destined for students who specialise in electrical power systems. The methodology adopted when delivering a lecture in this engineering course has to follow the basic pattern of the Hegelian logical subjective development in thought from a thesis through an antithesis to a synthesis.

A dialectical process known as the *Hegelian triad* includes three recurrent stages, namely:

- Gaining an immediate grasp of the object (thesis);
- Opposing the primary idea with contradictory evidence (antithesis);
- Considering the multiplicity of the evidence and arriving at a resolution (synthesis) [15][16].

In so doing, the first stage can be defined as an external manifestation of the process (phenomenon) expressed in terms of the operating variables.

The second stage can be treated as the unity of the manifold opposite forces stipulating the current condition of an electrical system as a whole or its separate elements. At this stage, the processes should be distinguished by the following characteristic features:

- Their origin or the kinds of disturbing actions;
- Assumptions made when deriving and solving equations that describe the process;
- The rate of changes in the system.

Mathematical descriptions of the process (phenomenon) are considered closely through their physical interpretation. The tendencies in changing the system-operating variables produced by the action of the above mentioned forces are analysed from the viewpoint of the dialectical category of *Cause and Effect*.

The third stage is associated with discussing the results of discovering the dialectical development of

the process. The final analysis should reflect the following elements:

- An appraisal of the feasibility of the operating condition immediately following the transient process and transition (in the operating variables) from quantitative changes to qualitative changes;
- The estimation of the possibility of a qualitative leap in the state of the system being analysed (establishing a fact of negation the previous system state as a result of the *struggle of opposites*);
- An estimation of the stable transition from one operating condition to another and the stability of the resultant steady-state condition.

The application of the new teaching approach in engineering education results in the following:

- Enables students to obtain further insight into the physical aspect of the problem;
- Provides the possibility of mastering the most effective approach for analysing the complex phenomena through the use of an example taken from a specific branch of industry;
- Induces spiritual interests to the humanities, which is a central problem in moulding the technical elite.

It should be pointed out that the traditional approach in delivering the lecture on electromechanical transient processes is based on using the simplest practical (engineering) criteria. In this case, the second stage of the dialectical method, which exhibits the most promise for getting to the root of a problem being considered, is largely omitted.

Synergetic Approach in the Field of the Technics and Humanities

An attempt to discover the latent associative connections of the hierarchical character between technical objects and works of fine art and their self-organisational processes was made, for the first time, in ref. [17]. In doing so, considerable attention was focused on a practical implementation of the reasonable associations between technical objects and works of fine art.

CONCLUSIONS

The author sometimes feels at international conferences that he is a certain *Don Quixote*. Actually, it is quite possible to attract considerable interest to the original innovations, especially as the latter are correctly substantiated in terms of ethics, psychology and philosophy. However, the force of traditions and inertia put obstacles in the way of changing classical lecture examples.

It is worthwhile taking into account the personal lecturer's qualities (the latter can be an advanced scientist) and the necessity to go beyond the scope of a secondary school programme in the sphere of the humanities. Of great importance is showing interest in students' problems [18-20].

Nevertheless, the author is convinced of his position, and believes in the pedagogical progress and the lecturer generation to come.

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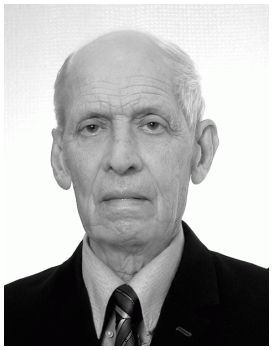
BIOGRAPHY



Georgy G. Rogozin was born in Taganrog, the former Soviet Union, in 1927. He is a professor at the Electrical Systems Chair of the Electrotechnical Department at Donetsk National Technical University (DNTU) in Donetsk, Ukraine. He graduated from Kharcov Polytechnical Institute in electric power engineering in 1951. His employment experience includes steam power plant as the head of the electrical workshop (1954-1965). He defended his CandSc degree (equivalent to a PhD) in electrical machinery at the Electric Machinery Research Institute VNIIElectromash in St Petersburg, Russia, in 1964.

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Prof. Rogozin is a leading Ukrainian authority in the field of determining the electromagnetic parameters and technical diagnostics of AC machines. He has participated in international conferences held in the UK, Italy, Germany, Poland, Finland, Greece, Belgium, Turkey and Russia. He has published one monograph and about 250 scientific papers in journals and conference proceedings. The complete list of the author's publications dedicated to engineering education includes about 20 papers published in Russian. In addition to this, he is the author of 35 inventions. He was elected a full member of the International Academy of Electrotechnical Science (Moscow) in 1999.

Prof. Rogozin was awarded the *UICEE Silver Badge of Honour* for distinguished contributions in engineering education at the *2nd Global Congress on Engineering Education*, held in Wismar, Germany, in 2000.