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Original Article

THE CONCEPT OF INTEGRATED ENGINEERING AND BUSINESS (EB) EDUCATION SYSTEM

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ABSTRACT
In our approach to engineering and business education system an engineer is a man working as creator and user of technical products. We stress that the process of understanding and gaining knowledge of technical reality and creativity of engineers are the essential for EB concept . Next, we describe briefly three perspectives for building the system of innovative product origination as a basis for EB system: 1) designer's perspective; 2) business perspective. 3) consumer perspective.

Keywords: engineering educational system, heuristics, innovation, organization.

INTRODUCTION

Modern engineer must not only be a specialist in engineering (for example: an electrician, mechanic, architect, and so on), but very often he also needs to be a businessman. More and more often an engineer works as a logistics specialist, environment protection expert, a manager, an IT specialist. He works as a constructor, technologist, materials expert and simultaneously as a chief production manager. Very often he must participate in the process of creating the organization and as a work-safety specialist.

It is necessary to create the appropriate place at technical universities to combine multiple disciplines including business, management and ergonomics. We have to choose what knowledge and specific fields of study (perhaps all) students of engineering need to master. The humanities and social sciences must represent sub-disciplines that allow achieving high qualifications to design objects to the various fields of engineering. We propose a new approach – an engineer is a man who is simultaneously a creator and user of technical products. He need modern knowledge and XXI century skills from all disciplines concerning examining various characteristics for own work, for example: physical, psychical, social, health aspects. We name some important fields: physiology, psychology, praxeology, medicine, neurology, anthropometry, and some important sciences related to engineering, such as: management, business, economy, health and work safety management etc. Our modern engineer must be prepared to perform a creative work for innovative organizations within large and continuously and turbulent changing spheres of the needed knowledge and skills.

A process of understanding the process of gaining knowledge is the best model of a process of education at a technical university. This process includes the following four stages: understanding basic facts of reality; the process of understanding, followed by binding acts of understanding into particles of knowledge; enriching the current knowledge with understood elements of knowledge and enlarging the state of understanding; creating knowledge assets. Therefore, the profile of a student educated in the sphere of technical science should include the requirements connected with

knowledge of heuristics and methods of creative work, and other human and social sciences [6].

PLACE OF HEURISTICS IN THE PROCESS OF GAINING ENGINEERING KNOWLEDGE

Most often creation is defined as a process based on matching and analogies which bring new and useful products. In many authors' opinions creative process comes for four basic phases:

- preparation – preparatory actions for finding of idea,
- incubation – finders of brain action,
- illumination – actions of idea appearance,
- verification – actions of estimates and modification.

It is possible to identify all of them in the schemes of ergonomic structures of project designs in authors discussing the problem of useing complex knowledge about functioning technically-social system for technique. It is also possible to single out many trends in modern uses of heuristics:

Heuristics as a creative solution of a problem equal to logical, managerial as well as mathematical (e.g. solution of task, building of definition) particularly by experiment, often with the aid of methods of attempts and errors, appealing for analogy, generalization, called as 'applied creation', formulated by A. Góralski as: 'approach oriented on purpose, first of all, drying inspiration from requirements of practices of inventions and serve this purpose'.

Heuristics as a method of instructing, facilitating and inviting a student to discover knowledge in an active and independent manner. Socrates was a precursor of such understanding of heuristics (469–399 b.c.). He developed a method of dynamic dialogue consisting of critical and constructive element. He comprehended teaching not as devolution of knowledge, but as a process of investigating the truth.

One of unmistakable advantages of creative approach for solving project problems is that it does not only develop imagination of a planner but also promotes the inclusion of human factor criterion to a specific technical attitude of mind. It is necessary to remember that there is no algorithm which guarantees the fastest solution to problems. Without creative approach in solving problems the conditions of solving engineering problems will not emerge [6].

THE SYSTEM OF INNOVATIVE PRODUCT ORIGINATION AS A PRIMARY SOURCE OF THE INTEGRATED EB EDUCATION CONCEPT

The development of ideas for an innovative product needs to be subordinated to complex activities of teams of creative people to a systematic procedure (see: Figure 1). The need of recognition is a mental perception which initiates a product development project [9].

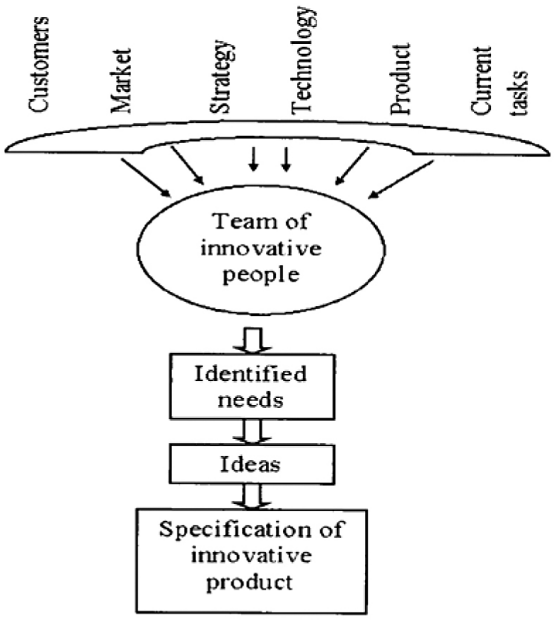

Fig. 1. The system of innovative product development [9]

Companies achieve competitive advantage through acts of innovation. They approach innovation in its broadest sense, including both new technologies and new ways of doing things [7].

We emphasize that innovative research in particular is a relatively young and unconsolidated field. At technical universities we need to prepare your students for the necessity of synthesizing the knowledge that exist in real world. Moreover, this knowledge must be useful for wider community and for various nations and cultures.

Tidd et al. describe four different kinds of innovation in engineering design processes:

- innovation to introduce or improve products,
- innovation to introduce or improve processes,
- innovation to define or re-define positioning of the firm or products,
- innovation to define or re-define the dominant paradigm of the firm [10].

VARIOUS PERSPECTIVES ON INNOVATIVE PRODUCT CHARACTERISTICS, AS BASIS FOR INTEGRATED EB EDUCATION CONCEPT

While the understanding of knowledge which engineers use in practice is rapidly growing, there is still much to be learned from exploring the contribution which related disciplines can offer. Since each discipline has its own way of developing its knowledge base, it is important for engineering science and practice to grasp the underlying manner in which they tackle their work. EB concept must bring together the material about many of these disciplines, which is normally scattered amongst a wide range of sources. It must be presented in a manner which is both accessible and relevant to engineering community for its practice and education. It will help engineers in practice and scientists to identify the ways in which the knowledge they acquire through study or experience can be used constructively to develop the service they offer to their clients.

The concept has the following assumptions:

- It is directly related to engineering practice and education at technical and corporate universities.
- Specialist contributors must explore complex ideas and present them succinctly and clearly
- We need a way in which the theory which is taught and the theory which is used in practice can be brought together to improve engineering practice and technical science.

Our concept will offer insight into some of the fundamental changes which need to occur, especially in Poland as EU member, for engineering attitudes and thinking. It will provide stimulating reading and discussion material for practice engineering, technical universities professors etc. It will be useful for teachers and instructors working in degree and post-registration courses, as well as for practitioners who wish to keep at the forefront of a profession which is undergoing continuing and dramatic change.

According to Hansen and Andreasen one can distinguish three different perspectives on the product idea which we use as a basis for our integrated EB education concept;

- The engineering designer perspective.
- The business perspective.
- The consumer perspective [3].

Following the basis of a very short literature review we describe a subjective selection of some important research works about innovative product characteristics.

The designer perspectives

Asimov writes: ”The first step in the study is to demonstrate whether the original need, which was presumed to be valid, does indeed have current existence, or strong evidence of latent existence”.

He writes: ”We assume that we have been given a primitive statement of needs. By primitive we mean that the statement represents opinion based mainly on causal observations, but unsupported by organized evidence. Such opinions are valuable as starting points when they come from people who have had the opportunity and have the ability to make observations and to temper them with considered judgment”. And: “Effective needs we will define as those which have an existence in the market place, by virtue of consumers’ willingness and ability to acquire the means for their satisfaction” [1].

According to Asimov the work needs to be strongly integratied with the ideas about their products and the market place, by virtue of consumers and clients.

Harrisberger writes: “A feasibility study is an iterative process – check and revise, then check again – until all possible alternative ideas for achieving the requirements of the design, are explored”. And: ”The ultimate goal is a product idea that has enough merit to be worth extensive design, development, and testing. However, it is also likely that a feasibility study will verify that the idea would not be practical in terms of cost or utility; that is, ‘Sure we can do it – but is it worth the effort?” [4].

Ulrich and Eppinger write: “Needs are largely independent of any particular product we might develop; they are not specific to the concept we eventually choose to pursue”. They write: “A product concept is an approximate description of the technology, working principles, and form of the product. It is a concise description of how the product will satisfy the consumer needs. A concept is usually expressed as a sketch or as a rough three-dimensional model and is often accompanied by a brief textual description” [11].

We stress, that Ulrich and Eppinger approach engineering concepts based on strong integration

between engineers' ideas and which must satisfy the consumer needs.

The business perspectives

In the USA Cooper described and recommended a state-gate model of the design process. The spirit of stage 1 is to 'spend a little money, gather some information, so that the project can be reevaluated at gate 2 in the light of better information'. Therefore, this first stage is a quick and inexpensive assessment of the technical merits of the project and its market prospects. Preliminary market, technical and financial assessments constitute stage 1.

Cooper writes that an idea occurs when technological possibilities are matched with market needs and expected market demand. Ideas may be generated by the marketplace – a recognition of unsatisfied customer needs, direct request from customers, or a competitive product. Such market-pull ideas represent the source for the majority of new product projects. But technology-push ideas – which are generated by researchers, science or technology, or result from serendipitous discoveries – also play an important role, particularly in radical innovations or breakthrough products [2],

We stress, that in the approach called 'Total design' market needs and demands are very strongly integrated with engineering activity and have priority before the concept of engineering design.

Leifer et. al. define a radical innovation project, which is the one with the potential to produce one or more of the following: an entirely new set of performance features; improvements in known performance features; of five times or greater; a significant (30 percent or greater) reduction in cost.

He writes that in some cases, radical innovation starts with a technical idea or a set of technical ideas. The idea may be born out of natural curiosity of a scientist or engineer, or be stimulated by a challenging problem. The technical idea can take a form of a discovery of novel technology, new insight into an old problem, or a new way of linking the existing technologies. In other cases, radical innovation has its roots in a market need, an industry 'Holy Grail' (a great and unsolved challenge in the company's industry), or the strategic vision of the firm's leadership. Each of these can catalyze the development of technical ideas with a potential to be breakthroughs. Because ideas can come from so many sources, noticing them is difficult. Many are missed for lack of an alert receiver.

In the following text Leifer et. al. clearly describe the concept of strong integration between engineering and business integration. By analogy, this idea is very important for education of engineers in XXI century – century of turbulent market economy.

For a radical idea to move forward, someone must recognise its business potential, in other words, make a connection between a novel technical solution and a compelling market need [5].

The consumer perspective

Creusen focuses on consumers' 'responses to product appearance'. In many purchase situations product appearance determines the consumers 'impression', and based on this impression, consumers reason about other product attributes, e.g. performance and quality. Creusen distinguishes six roles of product appearance: attention drawing, categorization, communication of practical, ergonomic, hedonic, and symbolic product information. The roles are not independent, and consumers evaluate product appearance in a holistic way into accounting a global product appearance, rather than the way the specific functions are designed. Tidd et. al. discuss buying behavior of consumers. Two types of theories describing consumer behavior are presented: utilitarian theories and behavioral approaches. Utilitarian theories assume that a consumer is rational and make purchase decision based on a comparison of the product utility with consumer's requirements. However, such a rational process is seldom seen in practice [10].

Henry Mintzberg was the first one who regards the most crucial part of managerial activity (Table 1) as that concerned with making decisions. He divided the managerial activity into three categories: interpersonal relationship, information processing and decision making.

For Henry Mintzberg the roles that he places in the managerial activity roles are based on different classes of decision, namely: entrepreneur, disturbance handler, resource allocator, negotiator.

As enterpreneurs, managers make decisions about changing what is happening in an organization. They may have to both initiate change and take an active part in deciding exactly what

Table 1. Managerial roles [9]

Interpersonal	Informational	Decisional
Figurehead	Monitor	Entrepreneur
Leader	Disseminator	Disturbance handler
Liaison	Spokesperson	Negotiator
–	–	Resource allocator

is to be done. In principle they are acting voluntarily. This is very different from their role as disturbance handler, where mangers have to make decisions which arise from events beyond their control and unpredicted. The ability to react to events as well as to plan activities is an important managerial skill in Mintzberg's eyes.

The resource allocation role of a manager is central to much of the organizational analysis. Clearly, a manager has to make decisions about the allocation of money, people, equipment, time and so on. Mintzberg points outs that in doing so a manager is actually scheduling time, programming work and authorizing actions. The negotiation role is put in the decisional category by Mintzberg because it is 'resource trading in real time'. A manager has to negotiate with others and, in the process, be able to make decisions about the commitment of organizational resources.

For Mintzberg these roles provide a more adequate description of what managers do than any of various schools of management thought. In these roles it is information that is crucial; the manager is determining the priority of information. Through the interpersonal roles a manger acquires information, and through the decisional roles it is put into use. The scope for each manager to choose a different blend of roles means that management is not reducible to a set of scientific statements and programs. Management is essentially an art and it is necessary for managers to try and learn continuously about their own situations. Self study is vital. According to Mintzberg 'the management school has been more effective at training technocrats to deal with structured problems than managers to deal with unstructured ones [8].

We emphasise that according to Mintzberg's text we have no suitable management theory for teaching our students, he need to try and learn on basis own experience.

Mintzberg presents a way of understanding the design of organizations and suggests that there are seven types. As shown in Table 2, the first five types are differentiated according to which the basic part of the organization forms the key to its operations. In the entrepreneurial organization it is the strategic apex which is key. In a manufacturer, for example, this would be the President of Chief Executive, the Board of directors, and their personal staff. In a machine organization, it is the 'technostructure' which is key, this includes those in planning, finance, operations research and work study and production scheduling. The key part in a professional organization is the 'operating core', those at the working base of the organization. While in a manufacturer this would be the buyers, machine operators, sales people and dispatchers, in a professional organization it might be doctors and nurses (in a hospital) or teaching staff (in a college). It is important for mangers to understand the configuration of their particu-

Table 2. Seven organizational types according to H. Mintzberg [8]

Seven Organizational Types			
Organizational configuration	Prime coordinating mechanism	Key part	Type of decentralization
Entrepreneurial	Direct supervision	Strategic apex	Vertical and horizontal centralization
Machine	Standardization of work processes	Technostructure	Limited horizontal decentralization
Professional	Standardization of skills	Operating core	Horizontal decentralization
Diversified	Standardization of outputs	Middle line	Limited vertical decentralization
Innovative	Mutual adjustment	Support staff	Selected decentralization
Missionary	Standardization of norms	Ideology	Decentralization
Political	None	None	Varies

lar organization in order to ensure that the various parts 'fit together' and are consistent in what they do. But, Mintzberg warns against forgetting that there will always be contradictions among the forces in organizations. Managers should use these contradictions creatively rather than ignoring or trying to suppress them [8].

CONCLUSIONS

1. An engineer is a man interpreted as a creator and user of technical products.
2. Without knowledge of heuristics and knowledge management the condition will not emerge for achievement of progress in engineering education systems.
3. Basis for integrated engineering and business (EB) education system is subordination the complex (engineers and business people) teams to a systematic procedures.

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