URN (Paper): urn:nbn:de:gbv:ilm1-2011iwk-059:0

56[TH] INTERNATIONAL SCIENTIFIC COLLOQUIUM
Ilmenau University of Technology, 12 – 16 September 2011
URN: urn:nbn:gbv:ilm1-2011iwk:5

MODELLING OF CREATIVITY AND COLLOBORATION METHODOLOGY FOR DEVELOPMENT THE MANU FUTURE PRODUCTS AND PROCESSES.

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ABSTRACT

In the face of current globalization, modernization and development, invention, innovation and creativity are fundamental factors for manufacturing industry's future. Technological engineers, developers, and designers must meet the market's need for continual innovation and build appropriate Manu future culture. Creativity seems essential to organizations for both imagining and bringing about a productive and practical world. Understanding the larger picture of how the products of their work will be used gives engineers the perspective to think creatively. Engineers must be innovators. And this innovation is dynamic and evolving, and at times profoundly practical, as when engineers move from thought to action, from vision to decision making. It is a source of joy in itself, and when applied to challenges new and old, it can lead to outcomes of great social worth. It asks researchers to see the whole and ponder connections and intensive collaborations, between people, between engineering disciplines, between manufacturing sectors, and between places.

***Index Terms* -** Manu future, creativity, collaboration, modelling.

1. INTRODUCTION

The contemporary manufacturing environment, complex consumer requirements, market uncertainty and vigorous competition lead scientists, designers and engineers to a high level of technology and innovation, the development of high quality production at an ever increasing pace. Most of us think of innovation as something that happens suddenly and unexpectedly. But it can also come about through the slow incubation of a really good idea which may be based on: increased interactions with industrial designers, scientists, and users; a special set of rules and requirements for a project; competitors' solutions; an engineer's experience and knowledge-base or even on his desire to improve his own novel ideas based on his skills. Finding creative or innovative solutions to the development of Manu future products and processes is often a collaborative achievement [1]. Creativity and collaboration add a new dimension to classical manufacturing transforming it into the Manu future. Creativity and collaboration also increase understanding of what is going on, and generate ideas that someone will pay good money for. Discussion in design is almost always tied to concrete artifacts: designers use sketches, photographs, physical and virtual prototypes as examples, or other artifacts to structure conversation and collaboration [2, 3]. Those abilities enable designers to respond more widely or even positively unpredictably to consumers with various types of product demands. One of the most important traits that support Manu future products is good leadership, which allows people the opportunity to put forward ideas and collaborate.

Today, product complexity is increasing due to the integration of different technical domains and the various techniques during the product development phase. Such products and their design process require innovative solutions, timely implemented; solutions which one person can hardly meet or even imagine. These factors involve a wide spectrum of creative designers, planners and producers in new product design; each of them with their own philosophy of creativity depending on their knowledge and expertise which, in turn, comes from their experience. Coordinated action of all development team members is required in order to generate an innovative solution to a problem, making maximal use of the collective creative power of all team members. The novel and creative activities of those members of the project must be built on good collaboration between them seeking to overcome weaknesses or other disadvantages of the system or its design process, and in such a way enhancing its performance, efficiency, reliability, and quality. The objectives of this paper are to review Manu future practices and related issues, which improve manufacturer's productivity, profitability and competitiveness, and creativity. The paper will also look at collaboration methodology based on the creation technological knowledge for developing Manu future products and processes. The created methodology generates solutions for enhancing creativity and enabling creative thinking amongst participants.

2. RELATIVE RESEARCH

2.1 Manu future

Manu future products and processes rely heavily on underdeveloped methodologies and knowledge bases, generating immature technologies. Developers must to try to routinely provide radical, disruptive innovative Manu future products, and to strengthen innovative design processes. The need to assess and manage the risks resulting from the incorporation of immature technologies in technological systems is an essential part of the innovation process [4]. The design of a product determines the flexibility of that product for future evolutions, which may arise from a variety of change modes such as new market needs technological or environmental change. The energy, material, and information exchanged between components of a product along with the spatial relationships and movement between those components all influence the ability of that product's design to be evolved to meet the new requirements of a future generation [5]. In order to avoid competition based purely on production cost, European industry needs increasingly to concentrate its capabilities on high-added-value innovative products and Manu future technologies offering a broadened service range that fulfils worldwide customer requirements – not only in terms of product satisfaction, but also in meeting environmental and social expectations. Increasing the knowledge content of manufacturing will lead to more economical use of materials and energy. The manufacturers are intensely focused on areas like energy, emission, waste and production. Manu future addresses a number of manufacturing matters that do not harm the environment during any part of the manufacturing process. Creative engineers develop products, processes and their related manufacturing matters to overcome existing processes those can endanger the environment. Scientists in collaboration with manufacturers are seeking methodical and practical solutions that can be implemented to optimize product design, development and enhance customer service. Design and development optimization is essentially seen as improvement of those engineering processes [6]. Manufacturers, consumers, government and community must take flexible collaboration, creative thinking and support at manufacturing practices to improve production and design quality. An important key of positive Manu future perspectives are new generations of novice engineers. These engineers must become more and more creative in their activities to stay competitive in Manu future environment. They have to modify their design reasoning instead of simply applying their competences in the engineering sciences. Later technologies for artificial intelligence techniques as knowledge base and expert systems with fuzzy logic, neural network and other computational means have to be integrated in Manu future technical systems enabling work and unmanned manufacturing environments.

2.2 Creativity enhancing

There are many cases as problem occurs when individual researches or even experienced engineers, who possess a good amount of individual knowledge, face a problem they are not able to solve by themselves and that could be effectively solved by some of their peers. Competitive innovation is affected by knowledge exchanges as it depends on a culture of technical sharing and openness to others. It takes people working together across different domains to realize it [7]. The development of new products requires the generation of novel and useful ideas. A number of collaborative problem solving methodologies finding a creative solution process in systems engineering have been reported. The Agile method called eXtreme Programming (XP) is analyzed and evaluated from the perspective of creativity, in particular the creative performance and structure required at the teamwork level [8]. Nowadays products and processes consist of such different technical domains as mechanical, electronic and electrical engineering, use of new energy resources and the wide application of information technologies. In a such way engineers have to collaborate with other knowledge creators becoming more capable of: generating varied and original ideas; using other participant's knowledge; generating and acquiring relevant knowledge; combining problem setting and problem solving in a nonlinear process [9]. The teaching aims precisely to help students learn to design in a creative, collective, and controllable way, and to face unknown design situations. Change of attitude in teachers and students is one of the most influential factors when seeking advantages to prepare engineers for such innovative design issues, and in creative abilities too. In order to achieve the intended effects a process model of creative problem solving named *Double Helix* has been produced [10]. The Double Helix is based on two key issues, *what* has to be done and *how* this can be done, which engineers have to address on a daily basis, seeking to be both competitive and innovative. This approach is able to meet requirements of creativity supporting tools in various collaborative periods. Such tools could be frameworks [12], methodologies, models [11], creativity techniques or computer supported tools. The heterogeneous characteristics of creative collaboration and its dimensions, and the barriers to be overcome are outlined by Thomas Herrmann [13]. The empirical methodology of conducting and analyzing interviews with a group of people is generated. Influences on the potential of creative collaboration such as *creativity in every day*, *workshops or a series of workshops*, *seeding*, *and collaborative writing* are proposed. Mary Rose Cook [14] proposes a few collaborative approaches to support public-sector behaviour change programs such as improving thinking behaviours. Spaces that can facilitate conversations, collaboration, and creativity have to be created . Virtual reality (VR) technologies also play an important role in Manu future product and process development. Participants can conveniently gather in a shared virtual environment, which contains the virtual product and is presented to everyone using VR technology. A virtual design review system is introduced [15]. The system provides the means of discussing and changing the design by collaboration between all participants. Kokotovich and Barker [16] consider pedagogical strategies and techniques in design for attaining sustained innovation collaboratively in order to assist in the New Product Design process and enhance opportunities for creating truly innovative products. Creative (or collaborative) problem solving in several fields has been supported by supplementing domain specific techniques with functionalities of a Group Support System (GSS) [17]. It is demonstrated how GSSs can also be used to support collaborative problem solving. Using the Design Science research methodology, a method was designed to support collaborative problem solving during enterprise architecture creation. Florence R. Sullivan [18] examined the interactions of a small group of students solving a robotics problem. He analyzed their interactions and how a small group develops a creative solution to a technology problem.

3. DEVELOPMENT OF CREATIVITY INCREASING METHODOLOGY

3.1 Creativity enhancing social and domain aspects

Due to increasing international competition, the industrial sector and its development has a significant impact on social and economic situation in industrial countries. In order to survive in the market, manufacturers must immediately respond to market needs by improving the quality of products, reducing prices and increasing labor efficiency. Advanced production must be based on modern achievements in industrial technology, electronics, industrial equipment and information processing. One of the most important but often under-estimated elements of the production process is the human element. Product design has always been considered to be a creative process. It is based on creative methods of solving problems. It is a conscious decision-making process during which information (an idea) is transformed into results regardless of whether it is a material or nonmaterial product. This can only be achieved by creative engineers able to generate and find alternative solutions and responsive to problems encountered.

When stimulating creativity by engineers, social and domain aspects and interaction of the two gain increasingly more importance (Fig. 1). The ability to learn is an important skill for developing creativity. It helps finding or even creating new knowledge which can contribute to the development of skills. Directing oneself to further learning must become a daily task. The major part of knowledge used by producers for implementing innovations, are taken from outside sources. In order to solve a problem in a creative way, an engineer may be required to learn new things outside his specialty area. This in turn can create possibilities for better visualization of the present situation and clear identification of the problems related to construction of products and processes. Technological information and sources are constantly changing. Training and workshops make up a large part of post-vocational education, and may result in acquiring new information and knowledge. Skillful learning may improve the ability to recognize the value of new information coming from the outside, to understand and apply it. All this is very important to creative engineering activity. Engineers demonstrating an advanced thinking and ability to develop are able to implement innovations and integrate more creativity into the process of designing a product. Knowledge and ability to apply it play a very important role: a human is not only able to create but also to find compromises matching the situation. New thinking formula and their applications enhancing engineer's creativity may develop through observing and analyzing the work of others. Cooperation among companies as well as information exchange between universities and companies may help in creating new knowledge, and significantly influence the creativity of students and employees. Having been provided full-rate practices by the companies, students can solidify their knowledge by applying it in practice. Therefore, it is very important that company managers assess the activity of students, encourage them, and provide them with a suitable working environment. One of the major obstacles to becoming more creative is chaotic management. Some people can only be creative through communication; however, others need total isolation to generate ideas. In this respect, a relevant working organization, and creation of attractive and suitable working conditions become very important factors. In this way, employees are not only encouraged to work more creatively, but also to assess and educate responsibly the students employed by the company. An attempt to improve the quality of life also stimulates creativity. Suitable working conditions, and a highly-paid job helps to motivate mechanical engineers, a specialty which has became quite complicated, advanced and flexible in the 21st century. Even genius ideas are worthless if not communicated well. It is aimed that engineers present their ideas and plans to other engineers, management, bankers, production staff, and customers.

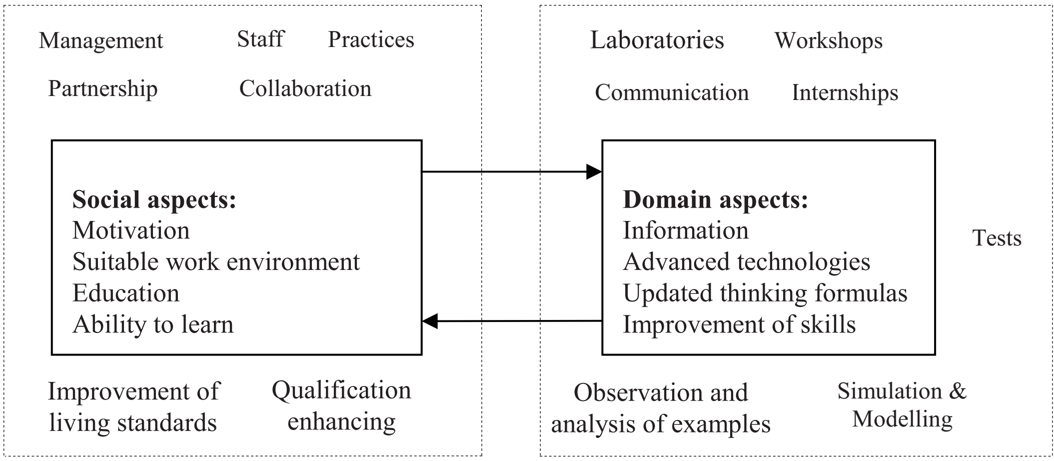

Fig.1 Creativity-enhancing aspects and their interface

Engineering activity may be very creative irrespective of the branch. A suitable strategy could help moving forward and become more creative. To solve a problem new knowledge about other areas is needed which help to develop creativity. When creating innovative technical systems (ITS), mechanical engineers are improving through solving complex problems. ITS can be multifunctional or complex combined technical system requiring considerable research and development. An important aspect of enhancing creativity is following and using new advanced technologies. Virtual reality (VR) technologies, imitation and simulation systems provides for new increased possibilities resulting from the interaction of human and a computer. In this way engineers can more easily create more than one variant or alternative of a product or a system when looking for the best solution. A successful education of an engineer starts far during the studies. The first workplace gives experience of working in teams made up of engineers from different disciplines working in projects, production, testing and sales.

3.2 Enhancing creativity through integrated product and production process

The process of creating innovative products requires good understanding of constantly changing needs and requirements of consumers. Generation of new ideas, creation of an innovative product, its construction, and creation of an innovative production process and production are the most crucial stages of the integrated production process made of phases such as formulation of the concept according to the market data, materialization of the concept through engineering solutions, and eventually a complete perfection of the construction, designing of the technology, production and assembly of the product (Fig. 2). It is a very sensitive and expensive stage of work since the constructor must design a product in such a way so as the product and its elements are manufactured easier, economically, and meeting the requirements raised for efficiency, accuracy and quality. Considering the characteristics of the modern manufacturing environment, an integrated production model ensuring simultaneous and continuous work in the action chain consumer-constructor-manufacturer-seller should be sought. Such models are aimed to facilitate real time planning, production and assessment of client feedback, i.e. realization of such model would help assessing the requirements raised more flexible and implementing new more creative constructional changes, and reducing time and costs for creating and manufacturing products. Modular design allows developing products and technological processes using separate models (e.g. complex system of renewable sources, etc. [made up of the following models: sun energy accumulation system; wind energy accumulation system; geothermic energy accumulation system; systems transforming energy into electricity or heat energy.]) for shorter time of product development, easier remake, possibility to use models repeatedly, more effective implementation, improvement, and development of innovations, discovering new possibilities, new configuration, and other stages of design cycle, production, and product lifetime. Application of modular design allows creative assessment of consumer requirements and expectations, and creative application of such knowledge when designing a product.

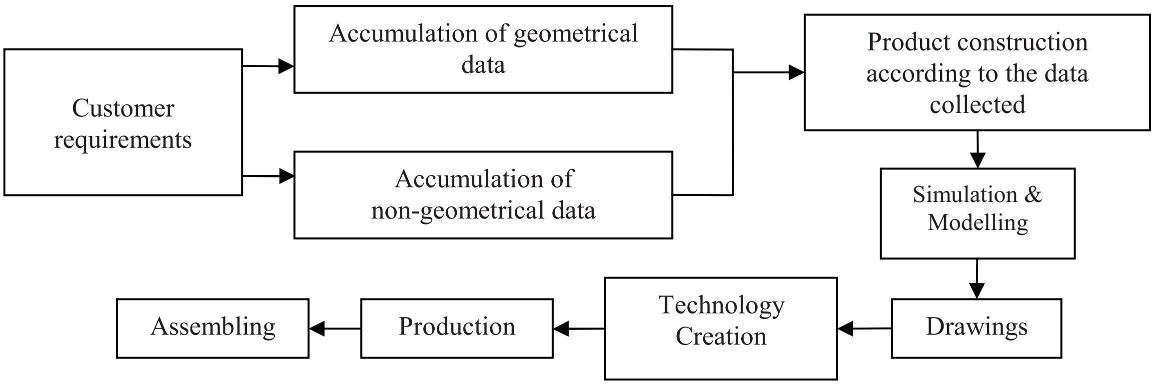

Fig.2 Stages of an integrated production process

3.3 Analysis of the impact of construction elements on production costs

When sending order enquiries, clients request a specific price and delivery time as quick as possible. In order to specify the price, the time for production is calculated on the basis of weight of the material to be used for manufacturing the product. In this way, however, it is difficult to define accurately the cost intensity of the product at the early stage of production. Cost intensity covers the equipment required for production, equipment loading, timing of all the equipment, stock of samples, etc. Having estimated product cost intensity, and provided detailed information to all the subdivisions taking part in the production process, it is possible to plan more accurately equipment loading and production time, especially in the case of CNC machines having the most expensive working time. Production cost is the main factor influencing the price of the product and its elements as well as the time for filling the order. Every product has many characteristics distinguishing it from other products. Such characteristics may include different construction elements, quality and quantity as well as functional parameters, material, surface roughness, manufacturing conditions, etc. Classification of products or their elements is aimed at facilitating and accelerating the process of preparing manufacturing technology. For easier and more convenient work, all the typical construction elements may be classified into two classes: cylindrical (1.1- 1.5) and non-cylindrical (2.1- 2.5) [20]. The major impact on manufacturing time T_i (1) is made by the volume of the material removed v (2).

$$\lg T_i = m_i \lg v_i + C_{i,} \tag{1}$$

where *m* and *C* are experimental constants. Removed amount of volume of the material calculable by:

$$v = V_b - V_p \tag{2}$$

where V_b is volume of the blank, mm^3, V_p is volume of the part, mm^3

Coefficients m and C depend on the real unit time of the operation. The values are calculated with reference to the diagrams using the following formulas:

$$m = \frac{\ln(T_1/T_2)}{\ln(v_1/v_2)} \tag{3}$$

$$C = \ln\frac{T_2}{v_2^m} \tag{4}$$

where T_1, T_2 are any values of unit time, h; and v_1, v_2 the respective volumes of the material removed, mm^3.

It is assumed that other factors influencing time - material (M), accuracy kvalitet (TI), surface roughness (R), and the number of elements (N up to 5) – are fixed. Such calculation of processing time accelerates automated calculation of technical operation time, and allows refusing large data bases. After the classification of construction elements into the above-mentioned classes and calculations according to the dependencies presented, the following diagrams were drawn: (Fig. 3).

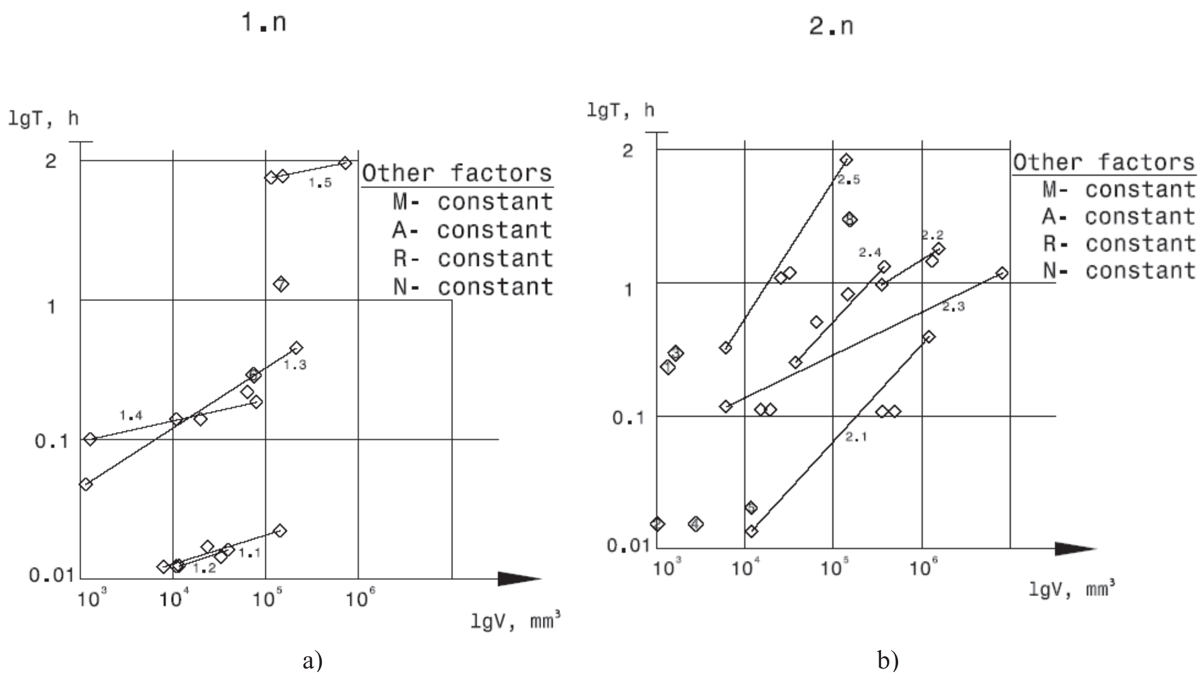

Fig.3 Nonograms of the subclasses of construction elements a) cylindrical; b) non-cylindrical

The calculations were made using 3D models. These elements are dominated by construction elements of the two mentioned classes – cylindrical and non-cylindrical. A virtual model of the element allows easy determination of the parameters influencing calculations, such as material of the element. Also, it is easy to calculate the required parameters which in this case are volumes of the blank and its elements (Fig. 4).

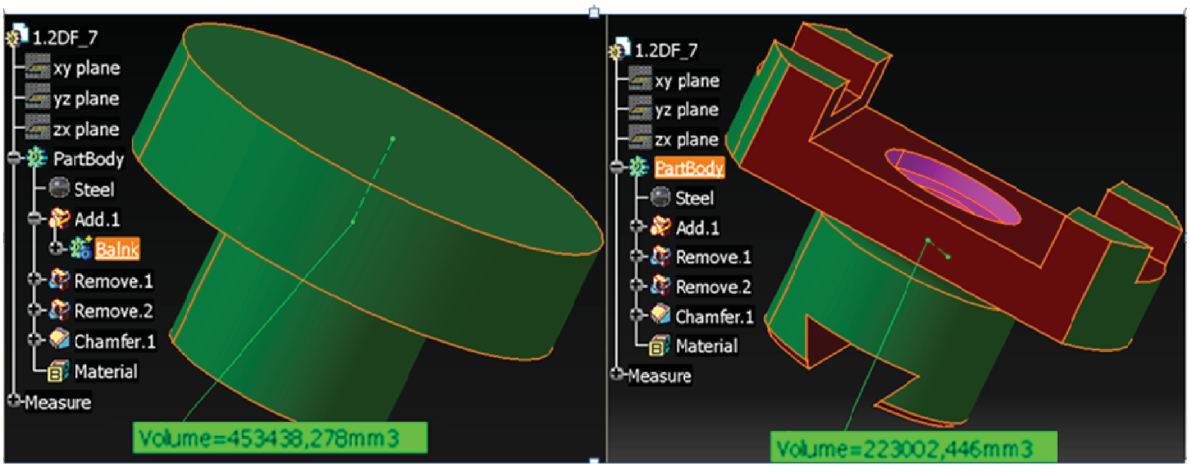

Fig.4 Calculation of the volumes of the blank and part in a virtual environment

RESULTS. DISCUSION AND CONCLUSIONS

With the aim to stimulate innovations and integrate more creativity into the process of product design, the methodology offered to increase the creativity of engineers with respect to social and domain aspects could increase the creativity of the specialists, and the value of the products they create. The systemized social and domain aspects of engineer's creativity have shown that creativity increase is significantly influenced by the interface of the two above-mentioned aspects. The interface of social and domain aspects offered helps defining creativity enhancing factors in the process of designing products and processes. The paper shows that creativity enhancement is significantly influenced by new knowledge and work methods used in the early stage of designing a new product.

Briefly it is concluded:

1. Developed interface between social and domain aspects has direct influence to creativity enhance, which can generate new knowledge, facts and methods in new product and process development.
2. At the same time new domain knowledge, facts and methods have reversible impact to social aspects of society or organization improving creativity environment.
3. Developed nomograms for machining time dependence on removed material volume during manufacturing process can help evaluate the new product cost and more accurately predict susceptibility of the product at the early design stage.
4. The primary test of developed nomograms has showed that errors have stay within 12- 16%

4. FURTHER RESEARCH

The elements analyzed will be classified into groups of construction elements applying the method of grouping technology when different construction elements are applied to the same processes and operations.

5. ACKNOWLEDGEMENT

This paper was partially supported by ES lifelong learning program project No 2010-1-TR1-LEO05-16777 "Transfer of Innovation, Multilateral projects, Leonardo da Vinci".

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