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# Mechatronics Environment for Smart Education and Organizational Learning

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## Introduction

The evolution of the society development is closed related on the technology development. It is relevant if the limits are mentioned: the stone technology-mechatronic technology. The shift in the society development from one stage to another was caused by revolutions. As it is known, in the literature are mentioned: material revolution, energy revolution, quantum revolution, information revolution and mechatronic revolution (Berian, 2010) (Kajitani, 1992) (Maties, 2016) (Pop, 2011). Mechatronic revolution marked the ninth decade (1980-1990) of the 20st century and defined the shift from the information society to the knowledge based society (Hunt, 1988) (Maties, 2016) (Peters & Van Brussel, 1989).

In the last two decade a new concept was launched, regarding the smart society development (Giffinger *et al.*, 2007), (Smart Romania: The Country of the Learning Communities, 2019). At the EU level the main pillars of the smart society are defined: smart government, smart economy, smart environment, smart mobility, smart living and smart people. The smart society is a society of learning, of knowledge, of creativity and innovation. The society learns through their citizens that are integrated into organizations (family, schools, universities, companies etc. So, in that context smart education and organizational learning are major needs.

Based on the world experience in the field of mechatronic technology and education and national experience of more than a quarter of century, in the paper are outlined solutions for smart education and organizational learning problems, based on valorization the innovative potential of mechatronics.

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## Mechatronic Concept

The word mechatronics was patented by Yaskawa Electric Concern in Japan at the beginning of the eighth decade (1970 of 20th century and was used to describe the technological fusion of three major engineering fields: mechanical- electrical, electronics-automation and computer science (Kajitani, 1992) (Maties, 2016) (Peters & Van Brussel, 1989). All high-tech products are mechatronic ones. Practically, mechatronics is present in all the fields of activity, including agriculture and construction. The evolution in technological development has led to the emergence of mechatronics. Microelectronics and information technology development stimulated that evolution. The stages of the technology development to mechatronics integration are shown in the Figure 1.

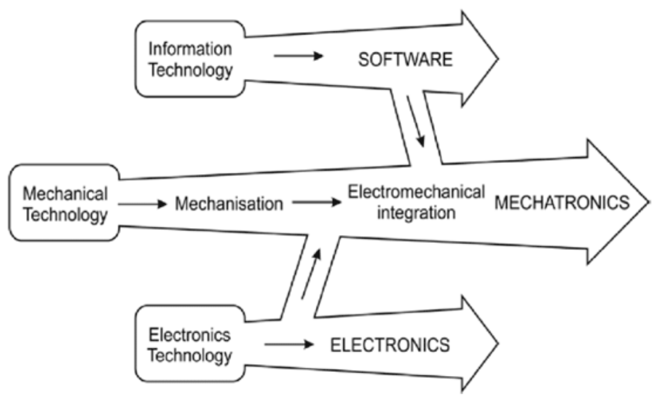


*Figure 1. Technology evolution to mechatronic integration*

The concept of mechatronics is highlighted in Figure 2 (Maties, 2016). In the traditional technology the basics are the material and the energy, in mechatronics these two elements are added a third tune-giving component, the information.

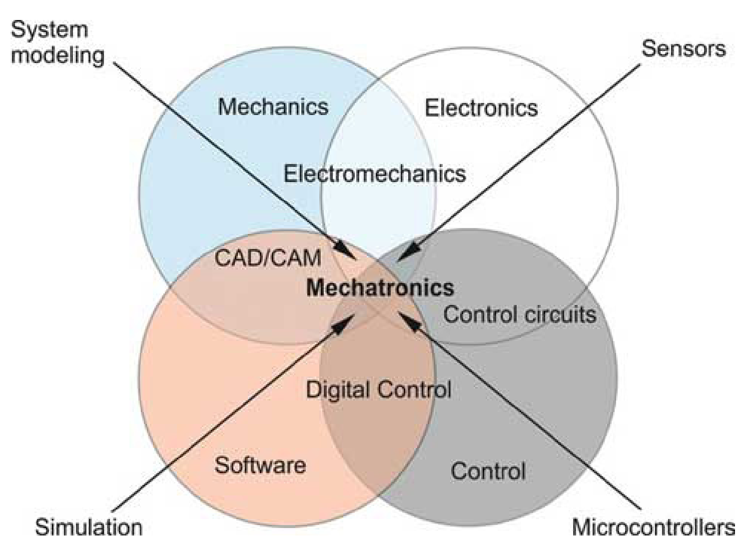


*Figure 2. The mechatronic concept*

In the traditional technology the basics are the material and the energy, in mechatronics these two elements are added a third tune-giving component, the information. This position of information in relation with material and energy is supported by the following arguments (Kajitani, 1992) (Maties, 2016) (Peters & Van Brussel, 1989): satisfaction of the mind of human beings is caused by information; only information can increase added value of all things.

The relationship: material, energy and information is shown in the Figure 3. The integration of information links in to the technical systems structure provides them with flexibility and reconfigurability (Berian, 2010) (Kajitani, 1992) (Maties, 2016) (Peters & Van Brussel, 1989)

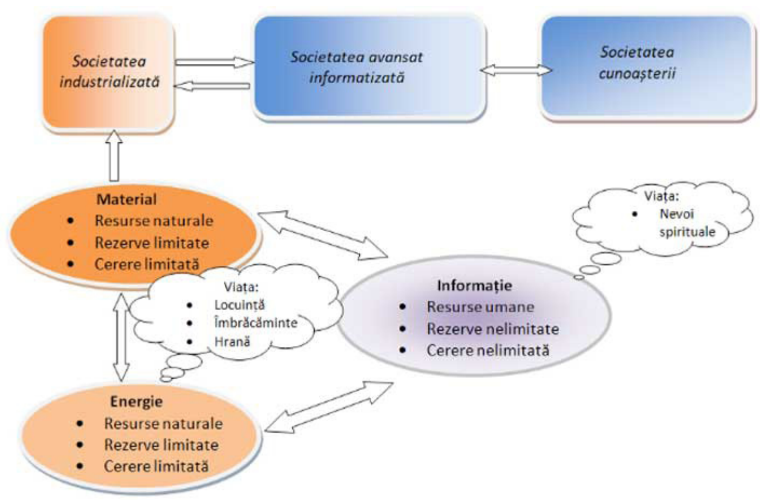


*Figure 3. The relationship: material,energy and information*

The presence of information links in the structure of technical systems requires small quantities of material and energy; this implies an increase in the operating flexibility and efficiency. In this context, quantitative and qualitative information assessment is a major issue in education, research and technology. The signal is the means of physical manifestation of information. The signals are generated by sensors (artificial sensing organs) integrated into the structure of smart machines and systems.

The sensors materialize the perception function in the structure of an intelligent system. Microcontrollers materialize the brain functions and the actuators (the execution elements) are the artificial muscles. New concepts, both in education, research and technological development, such as: information carriers, information links, information kinematic chains and information field (Berian, 2010) (Kajitani, 1992) (Maties, 2016) (Peters & Van Brussel, 1989), have evolved in this context. The basic functions of an intelligent machine are shown in the Figure 4.

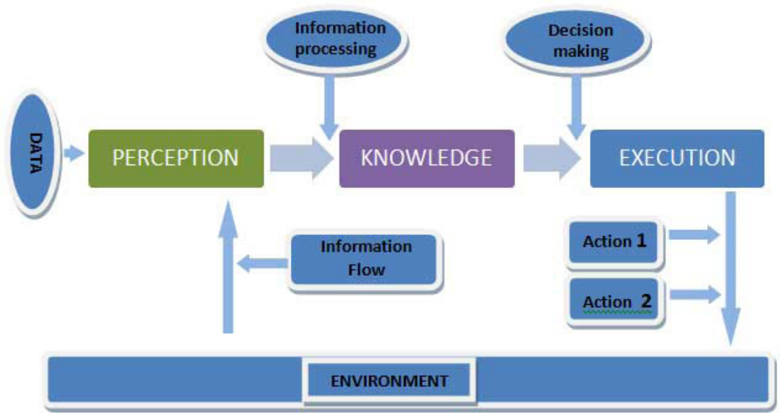


*Figure 4. Architecture of an intelligent machine*

## Mechatronic Education

The mechatronic principles in education focus on the systemic thinking developing, integrating and forming skills for team work. In the knowledge society, approaches to the development of systemic, integrative thinking are as important as writing and reading. The knowledge production results from the structuring and integration of information. Of course, the wealth of knowledge and the horizon of knowledge influence an individual's personality, but the ability to structure and integrate this information is predominant in defining the personality of the individual.

The defining features of the market economy specialist are flexibility in action and thinking; these skills are formed through mechatronic education. In this context, mechatronics education meets the requirements of smart education, providing the necessary skills for pupils, students, adults, etc. for intelligent integration, smart organizations, smart community, etc. Organizations and communities become intelligent and therefore competitive, by learning. Competence is the bridge between man and organizations (institution) and beyond, between organizations and the community.

Successful self-programming of individuals, organizations and communities results in a qualitative participation on each level, with a positive impact on integrated elements (Kajitani, 1992) (Maties, 2016) (Vermesan & Friesss, 2014) (Yamazaky, Suzuki & Hoshi, 1985). In the intelligent education environments the basic infrastructure by mechatronic platforms is provided. As complex technical systems, these platforms integrate into their structure elements of mechanical engineering (mechanisms, mechanical transmissions, etc.), electrical engineering elements (actuators, sensors, microcontrollers, filters, amplifiers, etc.) and control and informatics elements (control algorithms, dedicated software, human-machine interfaces etc. The specific structure of the mechatronic platforms facilitates the understanding of the integration- complexification process in the, nature and technology, as well as the role of information and information links in that process. The trans-thematic identity of mechatronics, based on the complexity concept is argued in the works (Berian, 2010) (Berian & Maties, 2011) (Maties, 2016) (Pop, 2011). In this regard, we can say that the mechatronic platforms are the basic infrastructure for transdisciplinarity learning, with the aim of stimulating creativity and increasing labor productivity in the knowledge production. Mechatronic knowledge means technological knowledge, focusing on methods and tools of producing intelligent systems, services and products (Kajitani, 1992) (Maties, 2016) (Peters & Van Brussel, 1989) (Pop, 2011) (Vermesan & Friesss, 2014) (Yamazaky, Suzuki & Hoshi, 1985).

## Mechatronics in engineering education and practice

For engineering practice, mechatronics marked the shift from traditional, sequential engineering to simultaneous, concurrent engineering. Therefore, the concepts of integrated design and design for control were developed. The details on the integrated design methodology are presented in the works (Maties, 2016) (Peters & Van Brussel, 1989) (Vermesan & Friesss, 2014) (Yamazaky, Suzuki & Hoshi, 1985). Thus, it is necessary from the conceptual design phase to consider the problems regarding the integration- interfacing processes, the information links as well as the integration of the control functions into the product structure. In this way, the conventional functions made by the mechanical components are transferred to the electronic control and software components. This increases the constructive and functional performance of products and systems.

In Figure 5a is presented the traditional approach and in Figure 2b the mechatronic approach. In traditional approach, controller is “attached” to system but in mechatronic design it is integrated. In mechatronics design the system is seen as a whole. Informational kinematic chain has a more compact structure. Interconnection through data buses increases the speed of information processing.

Mechatronics specialization does not mean ignoring super-specialization. High performance is not possible without the contribution of super-specialists. Their presence in research fields and design teams is estabblised according to the nature of the addressed problems. This relationship is similar to general/super-specialist that exists in medicine (practitioner doctor, specialist doctor).

Mechatronics training is practiced on all levels of education, proving beneficial in simplifying the problems of professional reconversion. Undoubtedly, attending performance in research and design activities is inconceivable without a team-work.

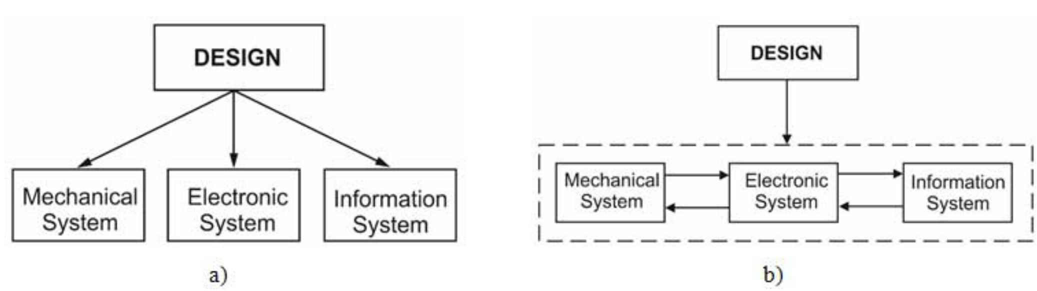


*Figure 5. Traditional design vs mechatronic design*

It is easy to understand that a surgical robot for instance, cannot be realized without a comprehensive team that includes doctors, physicists, biologists, mechanical engineers, electrical engineers, computer scientists etc. The integrated approach promoted by mechatronics is essential for the development and manufacturing of cyber-physical systems (CPS) (Gunes, Peter *et al.*, 2014) as well as for harnessing the Internet communication potential through internet of things (IoT) approaches (Vlasin, 2018). Mechatronics (the backbone), Cyber Physical Systems (CPS) and Internet of Things (IoT) the triangle of the 21st century technologies are the foundation of the 4.0 industry.

## The Organizational learning concept

The concept of learning organization was launched by Prof. P. Senge from MIT in 1990. In 1991 at MIT was founded The Center for organizational learning. The center developed, and in 1997 became Society of the Learning Organization (Senge, 2006, 2016).

Senge defines the Learning Organization as an organization where people continually expand their capacity to create results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together.

It is easy to understand that, as the world becomes more interconnected and business becomes more complex and dynamic, work must become more ”learning full”. It is no longer sufficient to have one person learning for organization. The organizations that will truly excel in the future will be the organizations that discover how to tap people's commitment and capacity to learn at all levels in an organization (Senge, 2006, 2016). As business organization, schools are learning organizations too. Senge defines the discipline of the learning organization: Personal Mastery, Mental Model, Shared Vision, Team Learning and System Thinking (Figure 6).

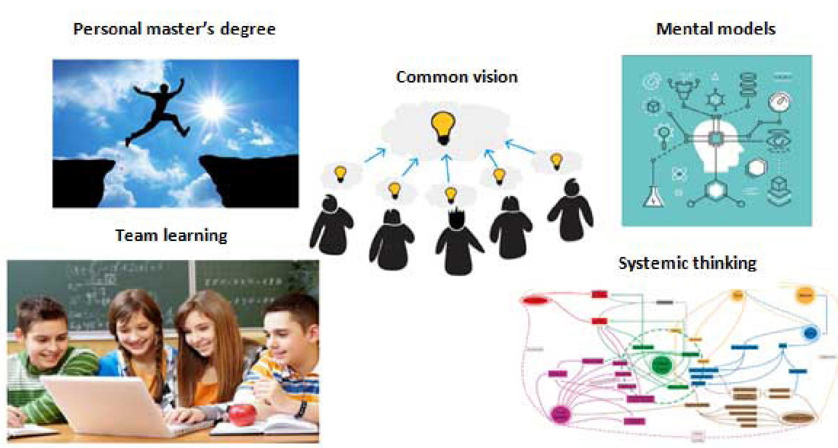


*Figure 6. The Senge's five discipline (Senge, 2006)*

The discipline consists on a body of theory and technique that must be studied and mastered to be put into practice. A discipline is a development of path for acquiring certain skills or competencies.

*Personal Mastery* is a discipline consist of continually clarifying and deepening our personal vision, of focusing our energies, of developing patience, and of seeing reality obiectively. As such, it is an essential corner stone of the learning organization-the learning organization's spiritual foundation. An organization's commitment and capacity for learning can be no greater than that of its members.

*Mental Models* are deeply ingrained assumptions, generalizations or even pictures that influence how we understand the world and how we take action. Mental models of what can or cannot be done in different management settings are no less deeply entrenched.

*Share Vision* is a practice of shared vision involving the skills of unearthing shared "pictures of the future that foster genuine commitment and enroll rather than compliance.

*Team Learning*. That discipline starts with dialog, the capacity of a members of a team to suspend assumptions and enter into genuine "thinking together". Team learning is vital because teams, not individuals, are the fundamental learning unit in modern organization.

*Systems thinking* are a way holistic. It is a framework that emphasize on understanding of internal relations of phenomena, not on identifying them one by one. Senge see systems thinking at the heart of his" learning organization" models, where all of organization members develop an understanding of the whole rather than just fraction of parts of organization in terms of structures, processes, thinking and behavior. It is important the five disciplines develop as an ensemble. This is challenging because it is much harder to integrate new tools than simply apply them separately, but the payoffs are immense (Senge, 2012).

Analyzing the requirement of the five discipline of the learning organization it is easy to understand that mechatronics is true environment for smart education and organizational learning. The mechatronic platforms are the basic infrastructure for such environments. The specific approaches are appropriate for all the levels of education, since kindergarten to adult education (Maties, 2016) (Vermesan & Friesss, 2014) (Smart Romania: The Country of the Learning Communities, 2019).

## Romanian National Mechatronic Platform

Mechatronic philosophy developed in Romania since 1991 by founding the branch of mechatronics in engineering in the main technological universities from: Brasov, Bucharest, Cluj-Napoca, Craiova, Galati, Iasi and Timisoara (Maties, 2016). As a result of cooperation at the academic level in education and research activities too, along of a quarter of century (1991-present) the National Mechatronic Platform was developed (Maties, 2016). The Platform is conceived as a:

> National mechanism of a network structure which aims to activate material and human resources on a local, regional and national level, and also to ensure the systemic approach, in a holistic way of dealing with complex problems regarding smart education and organizational learning (p.146).

At that stage (the pilot stage) the platform integrates seven Regional Centers of Mechatronics developed on the structure of the Mechatronic Departments of the technological universities from Brasov, Bucharest, Cluj-Napoca, Craiova, Galati, Iasi and Timisoara. The regional Center founded in the Technical University of Cluj-Napoca is the coordinating one. Within the regional Centers will be further developed Virtual Mechatronic Competence Centers. These will include: virtual laboratories and libraries, databases, sources of knowledge and other facilities regarding access to knowledge in the field of mechatronic for students, researchers, professors or any other interested users.

After the pilot phase is validated the Platform will be able to extend integrating other universities, organizations, institute or companies. In this way the Platform will become a veritable national company producing knowledge in the field of mechatronics, and the universities will become real Knowledge Factories. For practice and experiments at all the levels in education and training activities the mobile lab of mechatronics and portable one were developed (Maties, 2016) (Smart Romania: The Country of the Learning Communities, 2019).

In the last years, 11 universities in the country developed mechatronic departments. Also, The National Institute for Research and Development on Mechatronics and Measurement Technique is integrated in the structure of the National Mechatronic Platform (Maties, 2016). Now, The National Mechatronic Platform is the scientific and technical foundation of The National Platform for Smart Education and Organizational Learning. Based on this scientific and technical support was launched the Project: Smart Romania: The Country of The Learning Communities (Smart Romania: The Country of the Learning Communities, 2019).

## Conclusions

Mechatronics, the 21st century technology, the integration philosophy and science of intelligent machine, is the foundation for the development of smart competence-based educational technologies in line with the knowledge-based society.

Mechatronics platforms are the basic infrastructures for smart education and organizational learning. Mechatronics education aims at developing systemic thinking, integrating and shaping skills for team work, skills indispensable to the worker in the knowledge production. The flexibility in action and thinking, the result of mechatronic education, are essential to stimulate initiative and creativity. Flexibility and reconfigurability define the features of the mechatronic technical systems resulting from the integration of information links into their structure. In other words, the mechatronic technology, through the integrated approach of the components: material-energy-information makes it possible to materialize the concept of quantum realism. This context draws attention, both in education and research, on the issues of quantitative and qualitative evaluation of information integrated into the structure of intelligent products and systems.

The scientific foundation based on mechatronics and organizational learning concept are major needs for smart education development. Smart people is one of the main pillars of the Smart Society.

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