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Mechatronic Platforms for Transdisciplinarity Learning

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doi: 10.22545/2012/00026

This Chapter presents details related on the possibilities to use educational potential of mechatronic platforms for transdisciplinarity learning. Mechatronics, the result of integration of mechanics - electronics and information is a reach environment for active learning and understanding the basis of integration process, complexity and the role of the information flow between transdisciplinary objects (levels of reality) and transdisciplinary subject (levels of perception). The mechatronic identity based on the concept of complexity is trans-thematic one. The basis of integronics as a science of the integration processes are outlined too.

1 Introduction

The term mechatronics, patented by the Japanese at the beginning of the eighth decade of the last century, was used to describe the integration of three major areas of engineering: mechanical engineering – electrical engineering, electronics – control science, computer science [1, 2, 3]. The twentieth century was marked by three major revolutions: the quantum revolution, information revolution and mechatronic revolution [4].

Started in the ninth decade of the last century, mechatronic revolution has marked the transition from information-based society to knowledge-based society [5]. Integration is the paradigm of mechatronics[1, 2, 3] and knowledge is the result of structuring and integrating information. As integronics is the science of integration processes and hyperintegrated systems [3, 6], it deals with integration levels, integration degrees, hyperintegrated systems and the benefits of integration process.

Integration is not a useless process. On the contrary, integration gives new possibilities to control the systems. Integration gives the possibility to associate complementary elements, the possibility to connect, to form cycles and networks. But integration also gives the possibility to obtain a surplus of elements, a structural redundancy. In the case of hyperintegrated systems, where everything is linked to everything, the structural redundancy results in a fantastic combinatory redundancy. Integration therefore gives to systems larger possibilities to maintain their identity despite the second principle of thermodynamics.

In the knowledge-based society, education and training efforts for the development of complex and integrative thinking are essential in order to stimulate creativity as a basis for increasing productivity in the knowledge production. At this stage, mechatronics is the educational environment for the development of complex and integrative thinking, too.

In vision of Stephen Hawking, English theoretical physicist, the twentieth century will belong to complexity [7, 8, 24]. The complexity is closely related to the idea of non - separability, which *seems to be* *a fundamental principle of all that is profound in the world'* [7, 8, 24]. Consequently, research and education of the future must be shaped by the force lines of complexity and non-separability.

In other words, *intrusion the complex and transdisciplinary thinking the structures, programs and areas of influence of the University, will enable the progress towards its mission forgotten today – the study of universality.* Emphasis is provided by Prof. Basarab Nicolescu, founding president of the International Center for Transdisciplinary Research and Studies, Paris [9, 10]. In [7, 11] it is shown that, in mechatronics, complexity is a thematic concept, as defined by Holton, which gives the depth of mechatronics identity, which is a trans-thematic one.

Mechatronic platforms are complex technical systems which integrates in their structure elements of mechanical engineering (mechanisms, mechanical transmissions, etc.), electrical - electronic engineering elements (actuators, sensors, microcontrollers, filters, amplifiers, etc.) and control science – computer science elements.

Mechatronic platforms can be: stationary, mobile, portable and virtual [12]. Stationary platforms include: equipment's for education and research that are fixed in laboratories. Mobile platforms are made of mechatronic modules in a reconfigurable structure.

They are used for demonstrations outside the universities (in schools, companies, etc.). Portable platforms are made of mechatronic modules of low-cost and low-weight; they make possible experiments everywhere and every time. Virtual platforms include virtual laboratories, virtual libraries and knowledge bases.

The educational potential of mechatronic platforms has been presented in [13, 14, 15], but when it comes to use their transdisciplinary potential, the literature lacks in providing edifying solutions.

The transdisciplinary methodology elaborated by Basarab Nicolescu facilitates our exit from a world in which thought is fragmented by the scalpel of the indisputable dichotomy of binary logic, crushed under the load of excessive specialization, a "disciplinary big-bang" [9, 10, 16]. As finalities of pluridisciplinarity (the study of an object that is specific to one discipline by more disciplines, simultaneously) and of interdisciplinarity (the usage of the methods that are specific to one discipline in the territory of other disciplines) remains on the disciplinary investigation, they are unable to answer the human beings unitary need of knowledge.

Therefore, Basarab Nicolescu introduced a complementary transdisciplinarity concept defined as: what is at once, between the disciplines, across the different disciplines, and beyond all disciplines."; the finality of the transdisciplinary measure is the understanding of the world through the unity of knowledge [9, 10, 16].

In this context, mechatronic platforms are the basic infrastructure for learning transdisciplinarity, in order to stimulate creativity and growth of labor productivity in the mechatronic knowledge production. It is important to note that, disciplinarity, pluridisciplinarity, interdisciplinarity and transdisciplinarity are complementary approaches.

Mechatronic knowledge is a technological one, or knowledge about how to manufacture intelligent products, systems and services [5]. Taking into account the trans-thematic identity of mechatronics, mechatronic knowledge is a transdisciplinary knowledge.

The identity of a subject to be taught can be: disciplinary (mathematics, physics, chemistry etc.), thematic (system theory-based on the concept of system) and trans-thematic (based on the complexity concept) [16, 17, 18, 23].

Learning transdisciplinarity is a major need in the knowledge based society. Integral education ensures the achievement of this objective. The concept is introduced in [12, 19, 20, 21, 22] and brings into attention educational and technological approaches where the subject participate in the educational process with his whole being (mind, emotions and psyche).

Thus, modern and interactive educational technologies will be based on hexagonal model for mechatronic integral education, elaborated in doctoral Thesis [16].

The proposed model is the key to strengthening the pillars of education in twenty-one century, presented in the Delors report [7, 11, 16]: learning to know, learning to do, learning to live with others, learning to be.

2 The Concept of Mechatronics

2.1 The Flow to Mechatronic Integration

The evolution and development of the human society is closely related to evolution in technology. This connection is easily understandable if we take into account the fact that starting from the Stone Age technology we are now in the information technology age.

The transitions between stages in human society development were caused by revolutions, often caused by great discoveries in technology (the invention of steam machine at the end of the XVIIIth century is one relevant example).

The twentieth century was marked by three important revolutions: the quantum revolution, the information technology revolution and mechatronic revolution. The basis of quantum physics defined by M. Plank at the beginning of the 1930s was the starting point for the information technology revolution. The information technology revolution has marked the shift from the industrialized society to the advanced information society.

The word mechatronics is generally taken as having being coined in the early 1970s by Tetsuro Mori of the Yaskawa Electric Co. in Japan [1, 2, 3, 4]. It is important to note that the word transdisciplinarity was used for the first time by Jean Piaget in 1970 with the occasion of the International Conference "Interdisciplinarity-Teaching and Research Problems in Universities", held by Nissa University and organized by Organization for Economic Cooperation and Development and French Ministry of Education. Also, at that time (1970), Francois Jacob launched the book: "La logique du vivant" (The logique of living). In the book, the author used the word "integron" as integration messenger. Interestingly, from 1972 to 1982, mechatronics was a registered trademark of the Yaskawa Electric Co [1, 3].

The term was used to define the technological fusion: mechanics – electronics – informatics. Its meaning has been continually enriched as a natural consequence of the technological development and, step by step, mechatronics has become a philosophy, the science of intelligent machines and the educational environment for integration thinking development in the knowledge based society. The flow to mechatronic integration is suggestively highlighted in Figure 7.1.

Traditionally, mechanical technology dealt mainly with the problems of energy and material. The progress of semiconductors, especially integrated circuits, made it possible the integration of machines and electronics in one body. However, at this stage, the system could not have intelligence yet. Next revolution began with the appearance of microcomputers. Small and cheap microprocessors have been integrated into machines, and permitted machines to think and take decisions. Then, mechanical technology has changed to mechatronics by merging information-processing functions.

2.2 The Elements of the Mechatronic Technology

At this stage in education, developing the integrating design skills is just as important as developing the reading and writing abilities. Through transdisciplinary integrated perspective, the mechatronic offers the needed mechanisms for innovation in knowledge-based society.

Long before the word mechatronics came into general use it was recognized in industry that in order to facilitate innovation and increased efficiency in manufacturing and product design, it was vital for engineers and technicians from the disciplines of mechanics and electronics to work in synergy as teams rather than independently. Competing in a globalized market requires the adaptation of modern technology to yield flexible, multifunctional products that are better, cheaper, and more intelligent than those currently on the shelf.

Mechatronics represents an integrative vision in technological field, as shown graphically in Figure 7.2. The importance of mechatronics is evidenced by the myriad of smart products that we take for granted in our daily lives, from the cruise control feature in our cars to advanced flight control systems and from washing machines to multifunctional precision machines.

The technological advances in digital engineering, simulation and modeling, electromechanical motion devices, power electronics, computers and informatics, MEMS, microprocessors, and DSPs have brought new challenges to industry and academia.

Based on Figure 7.3, we can analyze comparatively the three components of mechatronic technology. Comparison accentuates the origin of resources, reserves, demand and what means life in terms of these three elements. Analysis motivates the worldwide interest to promote this technology. Obviously,

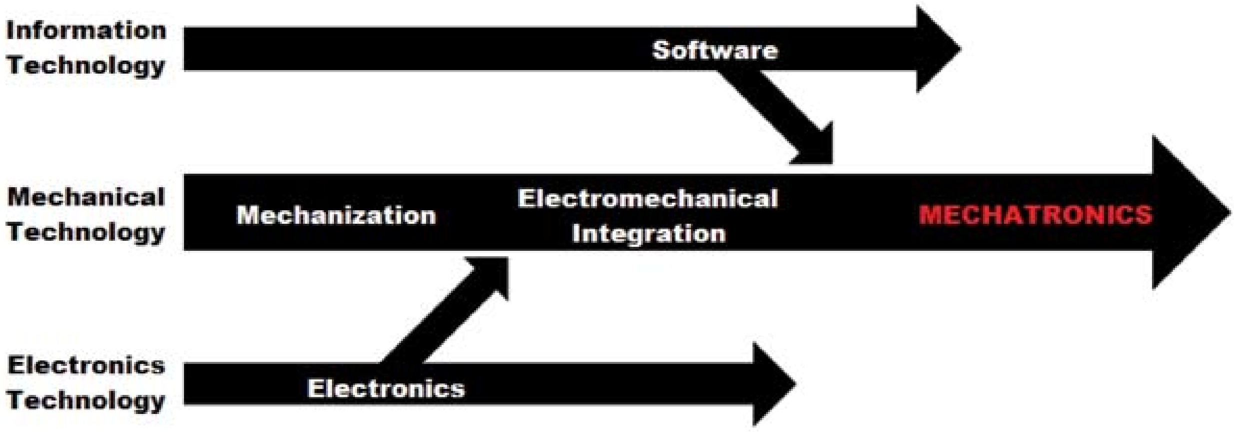

Figure 1: Technological flow towards mechatronic Integration.

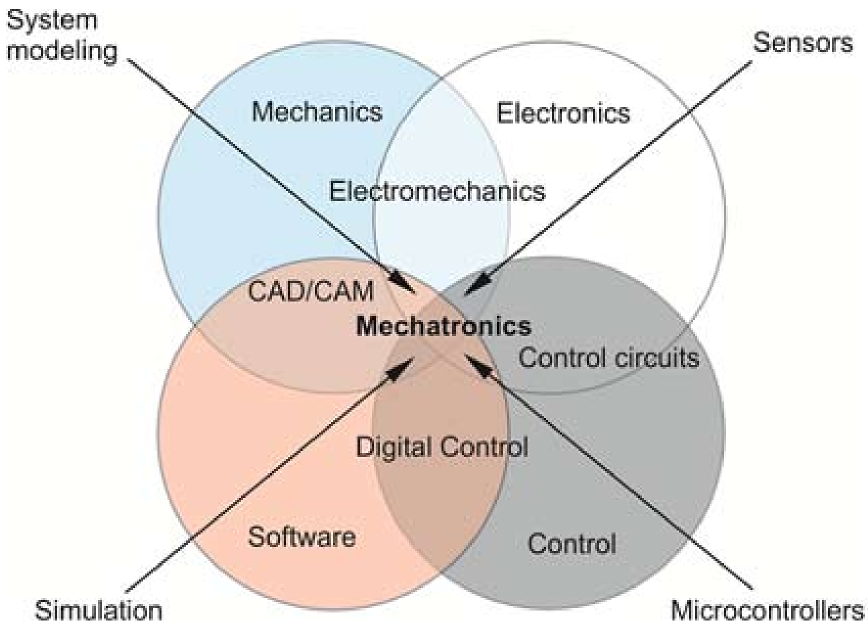

Figure 2: The elements of the mechatronic technology.

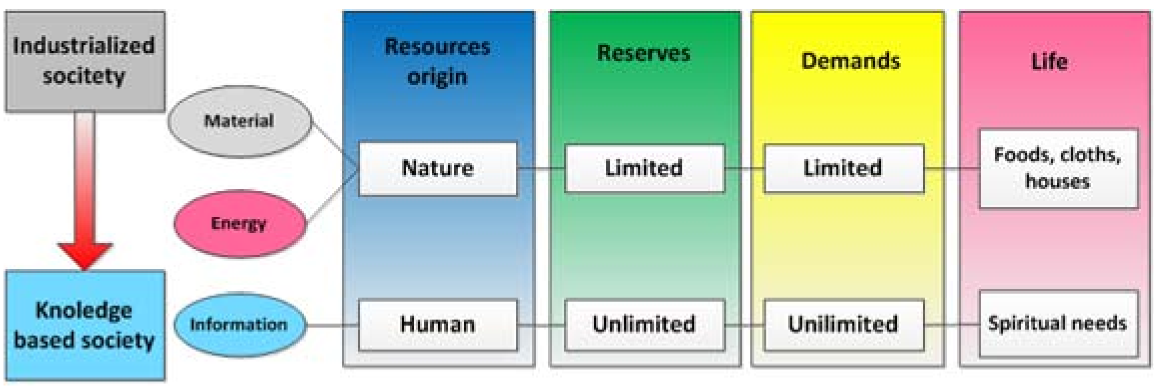

Figure 3: Material-energy-information relationship in mechatronic technology.

making products that includes more information (intelligence), their functional performance increase.

On the other hand, in this way the material and energy resources are preserved. But, less material and less energy means less processing, so less pollution. In this context it follows another facet of mechatronic technology: it is a no dissipative and less polluting technology.

The information is the most important element of the mechatronic technology, by comparing against material and energy. Why? Because: [2].

- satisfaction of the mind of human beings is caused by information;
- only information can increase added value of all things.

The value of information is evaluated by it's freshness and not by it's quantity, because the human mind always requires new stimuli. In other words, the value of material and energy depends of integration, but that of information depends of differentiation.

Mechatronic technology launched the challenge related on "sensitivity information". The commercial value of the passenger car for example does not depend on its basic function only.

It rather depends on its appeal to human senses for example, style, color, and so on. Any machine sends information to stimulate the five senses of human beings.

In particular, products that are originally designed to output sensitivity information such as musical instruments, toys, dolls, and so on have become increasingly important in the knowledge based society.

2.3 Mechatronics and Complexity

Through a mechanism of stimulating transdisciplinary ideas and techniques, mechatronics provides ideal conditions to raise the synergy, thereby providing a catalytic effect for the new solutions to technically complex situations.

An important characteristic of mechatronic devices and systems is their built-in intelligence that results through a combination of precision in mechanical and electrical engineering, and real-time programming integrated into the design process.

Mechatronics makes possible the combination of actuators, sensors, control systems, and computers in the design process.

The mechatronic approaches are very knowledge intensive (Figure 7.4). They combine kinematics and dynamics, material technology, control engineering, information technology, micro technology, etc.

Mechatronic systems, being the product of an integrated design approach, are superior to any products that could emerge from traditional sequential engineering approach [16, 17].

The mechatronic approach is thus essential for the development of the manufacturing systems of the future. Evolution in the technological development means: micromechatronics, nanomechatronics and biomechatronics.

Furthermore, mechatronic solutions are applicable in many others sectors that are of significant importance to the welfare of the citizens, such as healthcare and transport.

The power of mechatronics approach can only be fully deployed if vast amounts of knowledge and expertise are correctly combined and canalized. Integration is therefore the key issue in the mechatronic discipline. Integration means, among others, the establishment of research teams beyond the borders of specific projects, existing institute or companies, with a profound transdisciplinary character.. Integration also means establishing the mechanisms that enable the joint management of these research teams. Integration of research resources is therefore a major undertaking.

2.4 Mechatronics Philosophy in Engineering Practice and Education

Mechatronics technology development surprised the universities, which were forced to adapt their educational programs on the fly for the new demands. As a result of this laborious work emerged the mechatronics principles in education. These principles aim to develop systemic thinking and skills for team-work.

In mechatronics education affective learning is very important. Because of the important role of information in all fields of activity, it is necessary to redefine the objectives in educational process.

In this context, it is important to develop skills like: informing , mental, social and action training. Networking is the key in mechatronic education.

Mechatronics technology and mechatronics principles in education have led to the definition of mechatronics philosophy. For engineering practice this philosophy marked the transition from traditional engineering (sequential) to simultaneous or concurent

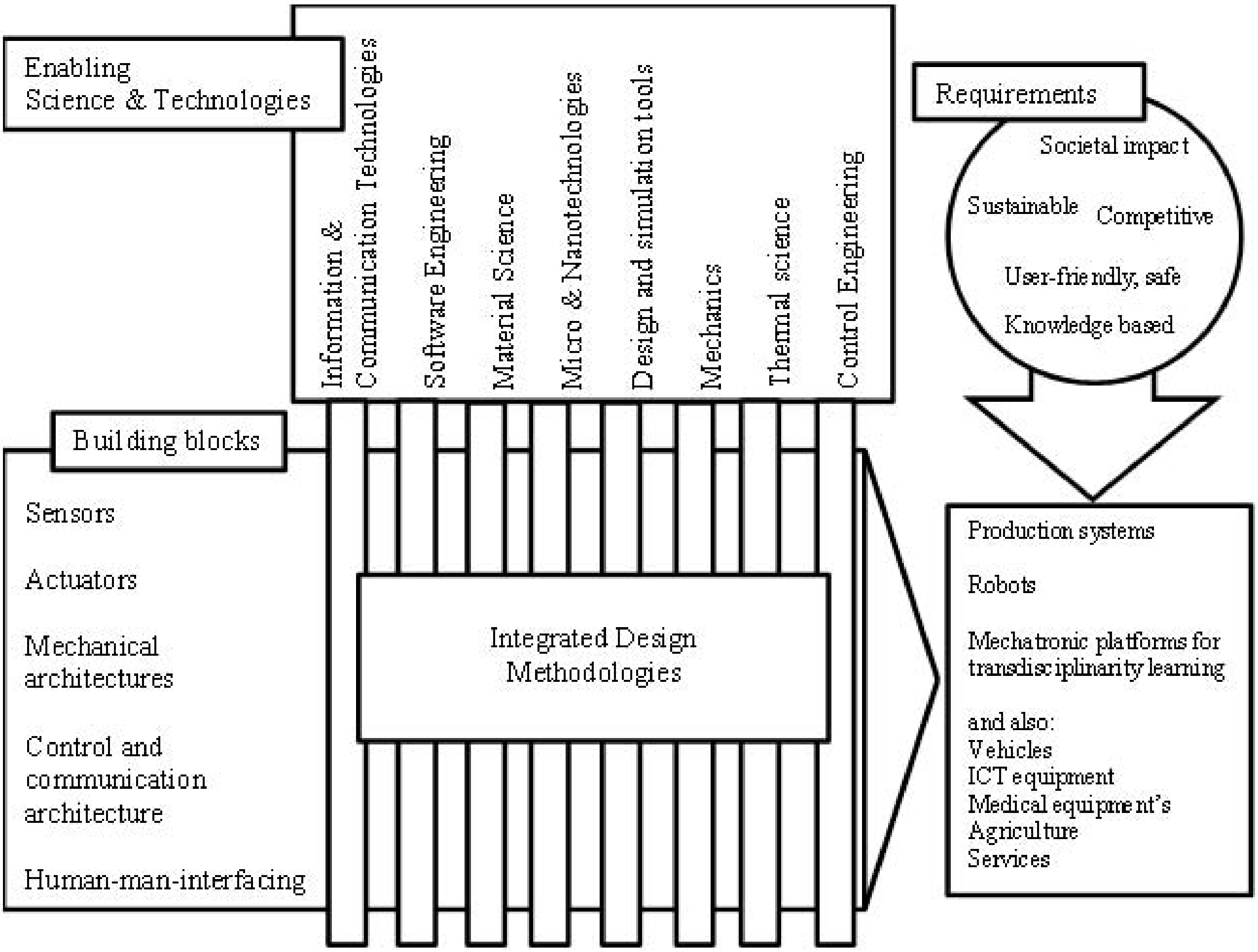

Figure 4: The complexity concept as basis for trans-thematic identity of mechatronics.

engineering (parallel).

In Figure 7.5a is presented the traditional approach and in Figure 7.5b the mechatronic approach. In traditional approach, controller is “attached” to system when in mechatronic design is ”integrated”. In mechatronics design the system is seen as a whole. Informational chain has a more compact structure and interconnection through data buses increases the speed of information processing.

Mechatronics education provides flexibility in action and thinking, defining features of market economy specialist. Mechatronics creative valences were confirmed both in education, research and production. The economic results of developed countries are an irrefutable proof.

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 teams is designed 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 teamwork. This is confirmed also by the works presented at international scientific events in different areas.

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.

Team-work skills are a major goal of mechatronics education. Multidisciplinary teams have proven their effective in sensitizing members on the need of

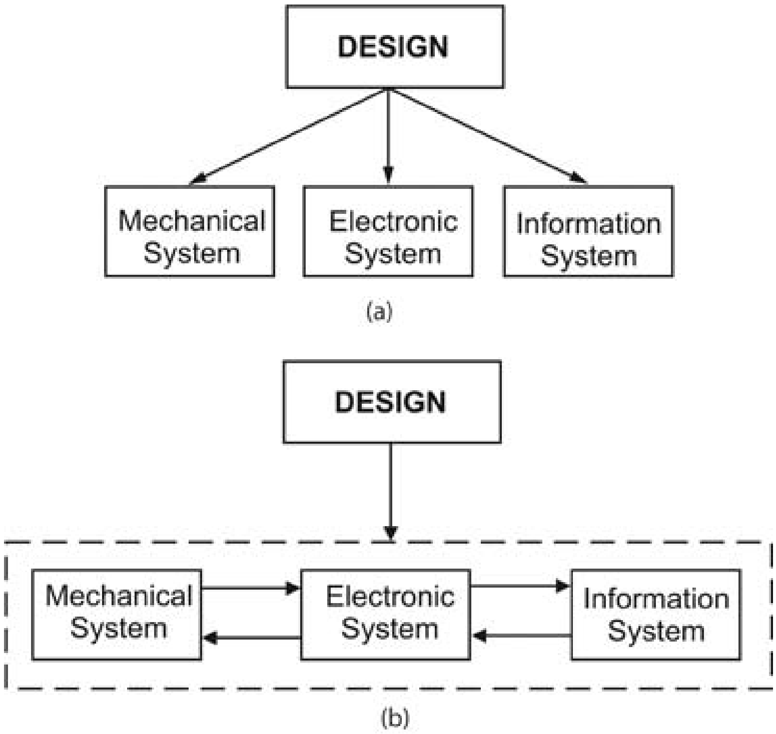

Figure 5: Traditional design vs mechatronic design.

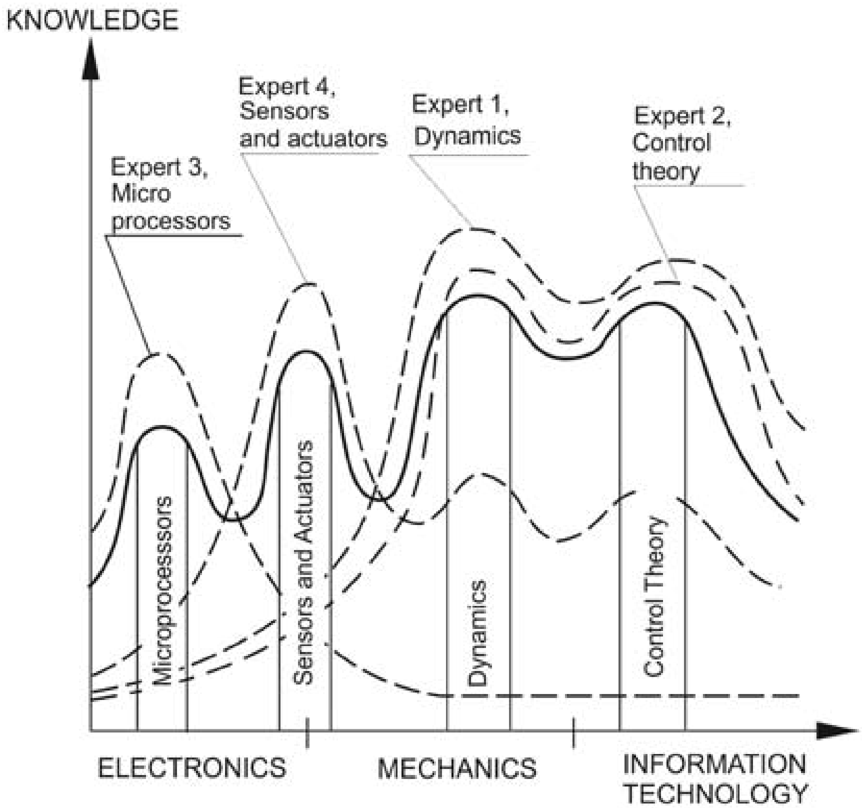

Figure 6: Relationship between individual training and average level of knowledge of the team.

optimal solutions for general problems.

Figure 7.6 shows the relationship between individual training and average level of knowledge of the team [2]. It's about a team that aims to design a precision robot. The average level of training, depending on their responsibilities in the team is shown in Table 7.1. The assessment is based on a given scoring between 1-5. This approach is important in school education. By defining the curricular areas, the framework to move from a narrow approach imposed by a single discipline to a global approach was imposed. In schools, the general objectives cannot be achieved without the contribution of all curricular areas, so the professorial staff must constitute a team and act as such.

3 Integronics

Integronics is the science of integrated processes and hyperintegrated systems, as the human body is. It takes account of the indissoluble unity of the world in which we live and the need for unique perspectives on the world. The concept is illustrated in Figure 7.7. [12]. Unit: science, literature and art, technology, takes place in the framework of mathematics, cybernetics and philosophy. Basis of integronics is not only the world around it but also the gnoseologic drive unit, of the subject knowledge of this world. Because there is no physical, chemical and even of scientific or artistic knowledge, human knowledge is unitary.

Integration is a natural process in nature, which created forms and structures that promote development in this way. Based on superization principle, the whole, the system, has emergent properties due to the synergistic effect. In the knowledge-based society, efforts to promote the concept of integration in education, research and technology is a major need. Knowledge itself is the result of structuring and integrating information. ICT facilitates these efforts.

Integration is a principle of functioning of the human psyche, and it is integrated in the nervous system. In the literature are brought into attention approaches regarding philosophy of integration and logics of integration. Also, the messengers of integration are defined. In nature, the integration can be: genetic, through coercion, depending on your choice, random etc. Integrating systems can be: material-energetic dominant or functional-informational dominant.

In socio-economic plan, we need to consider different levels of integration: institutional integration, inter-institutional integration and integration at national level. Integrating the knowledge and the resources is the basis to stimulate initiative and creativity in education and research activities.

It is well known that an individual personality does not depend of the richness of his knowledge as his organizational and integration capability.

Vectorization of innovation by encouraging transdisciplinary approaches, integration of knowledge's and resources in education, research and technology is the basis for labor productivity growth in the production of knowledge. Mechatronics has opened unsuspected horizons in all areas, thanks to it's synergistic effect.

Studying the inextricable links between different objects and phenomena, integronics is trying to overcome the extremely narrow limits of particular sciences, but cannot replace them. Particular sciences have been developed as a result of the limited possibilities of man to comprehend the realities of the world around us. Need for progress removed the borders between sciences and the evolution towards interdisciplinarity and after all to transdisciplinarity. In this manner have appeared chemistry-physics, biophysics, biochemistry, etc.

Accentuating the limits of fragmented approaches and the need for a global vision, integronics try to avoid such situations, emphasizing more strongly that we need to consider not only the subsystem on which to act, but also his links with other subsystems and finally the suprasystem of which it's a part. Integronics inscribe herself in the context of modern thinking which after all is a global, probabilistic, modeling, operational, pluridisciplinary and prospective one.

Integronics conception is one of the great gains of mankind due to the information revolution. It's very basic principle: the principle of order and systemic organization which is contrary to the second principle of thermodynamics, could be made due consideration of information. In the formulation of the second principle of thermodynamics information is not taken into account.

Extremely useful, this process of emergence of interdisciplinary sciences has not been sufficient to solve complex problems of this unitary world. It is natural, because, being more than the sum of its

Table 1: The average level of team training.

Position/Score	Dynamics	Control Theory	Electronics	Sensors and Actuators	Programming	Management	Economy	Design
Project manager	3-4	3-4	2-3	2-3	2-3	5	4	4
Control Theory Expert	4	5	1-2	2-3	2-3	2-3	1-2	3-4
Dynamics Expert	5	4	1-2	2-3	2-3	2-3	1-2	3-4
Sensors/Actuators Expert	2-3	2-3	3	5	2-3	2-3	1-2	3-4
Programming Expert	2-3	2-3	3-4	2-3	4-5	1-2	1-2	3-4
Electronics Expert	1-2	3-4	4-5	2	2-3	1-2	1-2	3-4

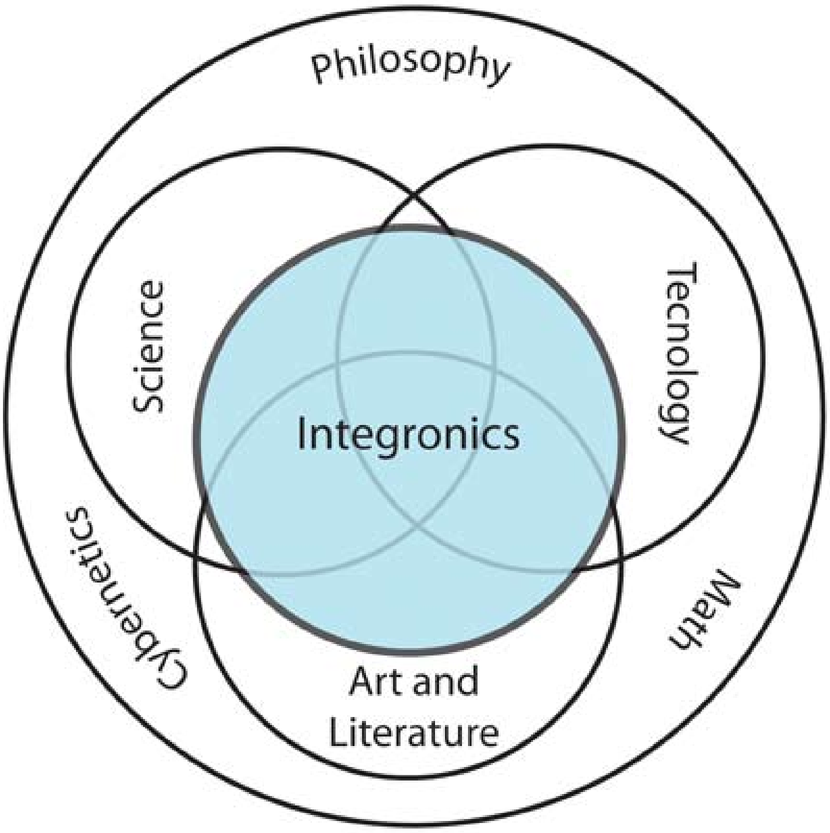

Figure 7: Concept of integronics.

parts, the unity of the body for example cannot be restored by simply unifying neuroscience with the endocrinology or of psychology with immunology and the world alone cannot be retrieved by a simple unification of astronomy with physics, with chemistry and biology.

Because information is the key element in mechatronics, the impact of technology goes beyond areas of economics, being essential in the social, cultural environments etc.

This explains the great interest in the world to launch initiatives and develop special programs for this area. These approaches reinforce the belief that in the knowledge-based society, cultural relevance depends on technical, technological performances.

4 Conclusions

The development of the knowledge based society and the mechatronics as a technology to support such a society is a historical necessity. Since the word mechatronics was patented by Yaskawa Electric Cp.in Japan, the content of the word improved continuously as a result of the technology development. Step by step mechatronics became: philosophy, science of intelligent machines and educational environment for transdisciplinarity learning in the knowledge based society. The mechatronic paradigm is integration and its identity is a trans-thematic one. So, based on the hexagonal model for mechatronic integral education, the mechatronic platform are very efficient tools for transdisciplinarity learning, in order to stimulate initiative and creativity process..

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