SUSTAINABLE STRATEGIES IN MECHATRONICAL EDUCATION AS VOCATIONAL TRAINING ENVIRONMENT

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Abstract

Education and training with specific procedures and techniques are crucial in continuously economic and social changes. The vocational educational training systems (VETS) together with industry are confronted with the need to develop theoretical sequences integrated with practical learning sequences, as well, all participants being determined to acquire key competences and update their skills as a continuous process throughout their lives. These objectives can be achieved only by sustainable long term effort raising skill levels with lifelong learning and knowledge triangle, education, research and innovation strategies. The VETS have to contribute efficiently and equitable to the modernization of education at all levels. Lifelong learning is imposed as a necessity in the new emergent knowledge based economy, supporting creativity as a contextual innovative process enabling full economical and social participation, teachers and trainers been challenged by a lot of problems. Technology education holds the potential for teaching all the people involved in the VETS as lifelong learning apprentices to get ability in problem solving, being considered as only logical system based on a new, synergistic education. The new profession, mechatronician, as a technology education job profile, has to be made more attractive, only the quality of teacher education being able to influence the performance of the apprentices.
Key words: *knowledge triangle, lifelong learning, mechatronics, synergistic signification, transdisciplinarity, vocational educational training systems.*

Introduction

The aim of the present paper is to apply the transdisciplinary approach to achieve knowledge in the context of the necessity that the trainers and the apprentices should to work altogether in a new manner and from a new perspective, in order to configure a *new synergistic vocational educational training model*. The way is to involve an active engagement of the apprentices rather than passive reception of information, emphasizing on teaching/learning processes rather than simple memorization of information; opportunities to apply new knowledge to real-life situations; the ability to represent concepts and knowledge. It is important to know how the educational environment assures the process to pass on the accumulated wisdom of society and to train disciples for technical occupations, through the three blended missions: pass on knowledge, train professional workers and advance the frontiers of human knowledge, in co-participation with community as public service (Pop, 2009b). To *raise skill levels, using lifelong learning strategies, in the context of the synergistic knowledge triangle: education, research and innovation,* presupposes to combine online and traditional methods to develop social aspects of learning through direct communication, debate, discussion and consensus building, considering that the computer simulations alone cannot replace all forms of applied training, the hands-on activities in laboratories and workshops remaining an indispensable constituent of an effective vocational educational training systems (Report, 2007; Pop, 2009b). The new transdisciplinary model proposed is only chance to develop a systemic thinking, to achieve abilities and skills for team work, where thinking and flexible action, designing and productive creativity as essential qualities for the researcher and for the disciple involved in a creative-innovative knowledge achieving process, along together with *new ways of evaluating teaching/learning training processes and outcomes.*

The purpose of education was, is and will be the transfer of the accumulated wisdom to future generations. This happened in the ancient universities, in the Middle Ages and over the centuries when other different subjects were added, one of the most important being the applied professional vocational training curricula and the philosophy of tertiary education.

The research tries to reconfigure the role of the vocational education training systems including tertiary education in the knowledge based society, with lifelong learning strategies, in a strong connection with industry in a synergistic contextual communication model, where it is very important WHAT are we doing, but the most important is HOW it is being done, in a very contextual legitimacy of WHY it is so important to do a thing or another one, knowing WHO with WHOM are communicating in a synergistically significant transdisciplinary way (Pop, 2008).

Transdisciplinarity and Vocational Educational Training System

The idea that the trainers and the apprentices have to work altogether in a new manner and from a new perspective was developed by J. Dewey (Dewey, 1897) and B. F. Skinner (Skinner, 1968). They introduced the shaping of complex behavior as a means of proper motivation in contrast to the traditional methods of *trial and error* in learning. Jean Piaget (Piaget, 1976) made the observation that the development of children`s intelligence have implications for the teaching situations, so the teacher should appreciate the limits and capabilities for each individual child and focus on gaining a greater understanding for the ways in which the students operate. Very closed to us M. Feldenkrais introduced the "awareness through movement" (ATM) and a Functional Integration (FI) lesson, each ATM lesson being a kind of semiophysical experiment in tinkering with how the apprentice (student) achieves and constructs experience mixing action, thought, attention and intention, the main object of the lessons being to introduce naturally the student in the process of learning how to learn, knowing that the greatest of all pleasures is the pleasure of learning (Feldenkrais, 1980).

In the knowledge based-society, the education and training are build on option for transdisciplinarity, representing a necessity in the new context of education and a guarantee for future success, at the same time with a new attitude, an active participation, flexibility and adequation to the context, transforming any problem into an opportunity. Transdisciplinarity, as doing and being approach of knowledge achievement, is based on an active process that enables the actors of the vocational educational training environment to use successfully the information, to question, integrate, reconfigure, adapt or reject it. The rigor in argumentation is a barrier for potential deviations, an open-mindedness approach in terms of accepting the unknown, the unanticipated and the unpredictable and tolerance in acknowledging the right to sustain ideas and truths contradictory to our own beliefs (Nicolescu, 1996; Berte, 2005). The framework of transdisciplinary approach on education presupposes the formulation and affirmation of original opinions, the rational choice of an option among several, the problem resolution/solving, the responsible debate of ideas. The process of learning beyond matter boundaries, beyond strictness of traditional academic rules can prove more efficiency from the point of view of the contemporary man. Thus, it is necessary to encourage and support changes in education, identifying and acknowledging critically and creatively the major tendencies that have determined modifications of the education purposes and have led to a reviewing of curriculum (Boden, 1994). The transition to education reforms is determined by the pass to worldwide globalisation, the emphasis on higher order learning skills and on cross curriculum capacities, on the integration of disciplines and on constant coordination with the community, on the use of modern technologies in a cooperative training process, to optimise performance assessment, to assure the amplification of the responsibilities and managerial capacities in vocational education training systems (universities, schools, others institutions).

In order to explain in an integrative way the process of knowledge achievement in a transdisciplinary context, was introduced the semiophysical model of functional-informational integrative process, as a systemic, modular perspective of the knowledge achieving process by communication, in functional structures, producing and signifying signs and valuing the educational products of knowledge processes in an ethic-semiotic context, with the key synergistic significant questions: *who, with whom, what, how* and *why* (Pop, 2008).

The third wave of knowledge integration, after the agrarian and industrial revolutions, due to the transition from an economy based on brute force to a knowledge and thinking based one, determines the moving of an increasingly large part of the population towards information manipulation activities (Toffler, 1983).

Based on information, mechatronics is not only the best suited technology for a highly advanced informational society, but also is the new educational paradigm, a reflexive way of communication (the creative logic of the included third) and a socio-interactive system of thought, living and action (Gitt, 2006; Pop, 2009a). Being flexible, unlimited, infinitely extensible, information can assure, in the context of the knowledge based society, the fulfillment of spiritual needs, at the same time with the material ones, intermediating the creation of products which incorporate an increasing amount of information, containing a high level of intelligence and complexity. Mechatronics have lead to the development of new educational principles through *the development of a systemic thinking, the development of skills for team work*, where *thinking and flexible action, designing and productive creativity* are essential qualities for the researcher and for the disciple involved in a creative-innovative knowledge achieving process. The transitional process from disciplinary approach to transdisciplinary in the knowledge based-society is a specific multiple integration process at the functional and structural levels, at the logic-creative signification and at the ethic-moral axiology of the whole knowledge spectrum, including the spiritual dimension (Reason, 1996; Cooks et al., 2002; Pop, 2009a). The transdisciplinary approach in the process of achieving knowledge is based on the equilibrium balance between the outside (with its extrinsic active knowledge aspect „learning to learn to know by doing") of the person and the inside (with its intrinsic reactive knowledge aspect "understanding to be by living with other people") (Pop & Maties, 2008).

It is important to choose to train with methods which help the disciples to distinguish what is real from what is quite illusory, with an intelligent access to the fabulous knowledge of our age, in the context of the emergence of continuously connected beings to build a new scientific spirit, to bridge the gaps between the different disciplines and between the meanings of these disciplines and the capabilities of the inside transdisciplinary potentialities as an indispensable complement to the disciplinary approach, to adapt the disciplinary context to the necessary and continuously changing of professional exigencies, in order to achieve new competences. Acting with a permanent flexibility always oriented towards the actualization of the insides and to open windows towards the knowledge field is a necessity in acquiring desired competences, adequate skills, working as a creative, competitive, adaptive, integrative person in the knowledge based-society (Pop, 2009b; Hildreth et al., 2000).

How Does Work the Vocational Educational Training System

Universities and vocational training schools, with their links to industry, are placed to an increasing pressure to expose students and apprentices to real working environments in education and training of multi-skilled technicians, in order to generate a new type of job profile as a synergistic significant mix of electrical, mechanical and IT knowledge, with the development and evaluation of a new kind of multi-perspective vocational educational training environment in mechatronics (Hanson, 1994; Jarvinen, 1998; Grimheden & Hanson, 2005). The mentioned principles of the mechatronical education can be applied successfully to all educational levels, creating the necessary environment to define the curricular areas with the possibility to switch from a unilateral thinking, based on a single discipline, to a flexible, global thinking, which assures an integrating approach to the educational process. The following directions have to be pursued institutionally: (1) the disciples (apprentices, students) must be considered as open systems, in an ongoing forming process, each training stage contributing to the educational profile; (2) the learning plan (curricula) has to be centered on quality rather than quantity, in order to stimulate creativity and flexibility in thinking; (3) the promoting of team work imposes the introduction of the networking concept in the elaboration of the learning plan, based on the existence of working modules, activated as depending on the requirements; (4) because education as achieving knowledge is an ongoing process, the implementing of a new transdisciplinary creative-innovative language, with a synergistic significance will take place at all ages in a new teaching/learning training environment (Maties et al., 2008; Pop, 2009b).

A sustainable educational vocational training system presupposes: *(1)raising of skill levels,* necessary to avoid the risks of economic and social exclusion, because the future labor markets of the knowledge-based economy will demand higher skill levels from a shrinking work force; (2) *lifelong learning strategies***,** which includes all levels of education, the qualification frameworks, with informal (hand-on) and non-formal (hands-off) teaching/learning methods, as well, in a transdisciplinary creative-innovative context, with sustainable approach for high qualitative, efficient and equitable educational training environment; (3) *the knowledge triangle, education, research and innovation,* plays a key role in boosting jobs and growth, accelerating reform, promoting excellence in higher education and university-business partnerships and ensuring that all sectors of education and training play a full role in promoting creativity and innovation (Waks, 1997; Report, 2007; Pop, 2009b). Education and training with their specific procedures and techniques are very important in the continuously economic and social changing context, in order to fulfill the demands for multi-skilled technicians and skilled workers. Vocational educational training systems (VETS) altogether with industry are confronted with the need to develop theoretical sequences integrated with practical training sequences. Flexibility and security needed to achieve more and better jobs depend on ensuring that all participants can acquire key competences and update their skills as a continuous process throughout all their lives. As guidelines for growth and jobs, these objectives can be achieved only by sustainable long term effort in the three areas mentioned above: *raising skill levels, lifelong learning strategies and the knowledge triangle* (Report, 2007).

The capacity of the vocational educational training systems (VETS) to contribute efficiently and equitable to the modernization of education is reflected in the development of new approaches and policies, by revision of teaching/learning content, of the methods and techniques used, adaptability of the teachers, extension of compulsory schooling as components of all the educational levels, quality assessments and increasing investments. The fore-coming strategies and the knowledge triangle are in the front of the battle for the continuous modernization of education at every level, with new forms of stakeholder involvements, in relation to curriculum development and the definition of learning outcomes (Siegwart, 2001).

The continuous lifelong learning process to equip people with the necessary key competences and to improve educational attainment is an essential part of the strategies for growth and jobs for a sustainable development in the knowledge based-society (Cooks et al., 2002). Greater efforts are still required to raise skill levels and to achieve flexibility and security across the labour market through participation in lifelong learning. In the context of a highest demand for high skills and fewer opportunities for the low skilled it is very important to introduce the new methods to achieve knowledge. Education and training for all, teachers and disciples as well, can contribute to overcoming socio-economic disadvantage, the ensuring equity of access, participation, treatment and outcomes remaining a priority. Teachers need better professional preparation and continuing development, a good reason to improve education and training outcomes, involving teachers and trainers in innovation and reform as a very important purpose of the knowledge based society, with universities as heart of the knowledge triangle, working together in partnership and focusing on teaching, research and knowledge transfer as vital processes. Research and innovation need a broad skills base in the population, so excellence, creativity and learning-to-learn skills must be developed in all systems and levels of education and training, contributing to facilitate innovation as major component of creativity in action, high-quality VETS at the workplace (Boden, 1994; Report, 2007; Barak & Doppelt, 2000). The greatest challenge for lifelong learning strategies, to transform the simple intentions into sustainable policies with short, middle and long term results, represents integrated guidelines for growth and jobs. In the vocational educational training systems, teachers and trainers are challenged by a growing heterogeneity of the classes, a demand for new competences and the need to give more attention to individual learning needs, to achieve basic skills by specific training methods for all the participants. In order to make the profession more attractive, only the quality of teacher education could influence the performance of the disciples, the measures imposed to achieve excellence at all levels of VETS, especially in higher education institutions, should focus on education, research and knowledge transfer (Report, 2007; Maties et al., 2008; Cooks et al., 2002).

As a key priority, the first measure which has to be done is to improve the quality and attractiveness of vocational education and training systems, increasing their relevance to the labour market. The second possible work to be done is a renewed emphasis on apprenticeship and work-based training. Finally, it is necessary to reduce obstacles between VETS and other educational systems to integrate naturally with all educational existing systems. An important source of know-how supported in order to continue the monitoring of the development and implementation of lifelong learning strategies are peer learning and experience exchange between policy-makers and stakeholders. The increased investment in early education is very necessary because it could produce the highest returns to efficiency and equity, as well, so the transition to the labour market would be made easier in order to avoid skills shortages (Siegwart, 2001, Pop, 2009). The tasks and problem solving methods in mechatronics require cognitive, operational knowledge and practical experience about building systems, diagnosis - and maintenance - techniques using tele-media systems. A significant challenge for these tasks, is working in a synergistic significant networking system, elaborating concepts concerning pedagogical, technical and organizational aspects in a new significant synergistic way, using the new methodology of the top-down and bottom-up transdisciplinary knowledge search window (Pop, 2009). The mechatronical training schools have to integrate naturally in the vocational educational training systems, working in so called learning/teaching transdisciplinary training fields, with synergistic problem-solving approach or tasks distributed over time of training with increasing requirements to the disciples trainers, as well, avoiding a disciplinary approach of the achieving knowledge (Pop, 2009).

To provide alternative sources of training technologies, interactive situations and simulation of the systems that cannot be used in reality for reasons of cost, size or safety are used the computers and software as tools. The use of the internet is considered as the greatest source of knowledge available in the asynchronous training system and as complementarily methodology (Furman & Hayward, 2000). Simulation tools have a lot of benefits for educational training process because the disciples are not strictly related with real world and at the same time is possible to explore a range of possible solutions easily and quickly, available in industry, with significantly less costs (Schäfer, 1996). Web-based virtual laboratories, remote laboratory experiences and access to digital libraries are examples of the new learning enhancing opportunities to increase connectivity, tertiary institutions with virtual libraries could join together to form virtual communities of learning, helping each other to apply and enrich available open education resources with significant challenges (Hanson, 1994; Waks, 1997; Quinsee & Hurst, 2005). So, it could be created a more active and interactive training environment, called *instructional integration* with a clear vision to develop and create the new adequate technologies and the most effective way to integrate them in the design programs and delivery (Waks, 1997; Barak & Doppelt, 2000). The combination of the online and regular classroom courses gives more opportunities for deeper human interaction, developing the social aspects of learning through direct communication, debate, discussion in a synergistic communicational context (Pop, 2008). The new types of distance education institutions and the new forms of e-learning and blended programs meet acceptable academic and professional standards, but a poor connectivity could become a serious constraint in the use of the informational control technology related opportunities, with their limitations (Schäfer, 1996; Quinsee & Hurst, 2005). It is very clear that

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real experience cannot be replaced by learning with simulations, being necessary to use them complementarily, virtual tools as design, modelling, simulation and real world representations as prototyping, building smart products (Bridwell et al., 2006). The computer simulation cannot replace all forms of applied training, hands-on activities in laboratories and workshops remain an indispensable constituent of effective learning in technology-oriented programs (Jacobs & Jones, 1995; Olsen, 2000).

Changes in the economic system led to a transformation of the labour relations as a phenomenon observed in all economies, the people involved (scientists, teachers, employers and publicists) discussing the importance of identifying promising areas for the development of education in a transdisciplinary way using specific synergistic methods and methodologies. Because professional boundaries are changed or just disappear, in the context of a temporary increasing number of workplaces, it is necessary an adaptation to these new conditions as quickly as it is possible. The changing nature of economical relations, the evolution of organizational forms and the use of the creative laboratory work leads to the need for structural changes in priorities and the content of the training: themes, methods, trainers, teachers, disciples (Waks, 1997; Report, 2007; Grimheden & Hanson, 2005). Flexibility and adaptability are the most important characteristics to determine tertiary education ability of the institutions to contribute effectively to the capacity building needs of developing knowledge achievement skills and to react swiftly by establishing new programs, reconfiguring the existing ones, to eliminate outdated courses, in the context of systematic efforts to develop and implement a vision through strategic planning, by identifying both favourable and harmful trends in their immediate environment and linking them to a rigorous assessment of their internal strengths and weaknesses, so the institutions could better define their mission, market niche and medium-term development objectives and formulate concrete plans to achieve these objectives (Salmi, 2005; Bridwell et al., 2006). An efficient educational technology at every school level allows to improve the efficiency of learning/teaching material by disciples and to give more attention for the individual and personal growth of them, using both ways of teaching, the passive way (reading, hearing words, looking at pictures, watching a movie, looking at on exhibit, watching a demonstration, seeing it done on location) and the active way (participation at the discussions, having a talk, doing a presentation, simulating the real experience, making real things). The very important goal of the education is to promote educators (instructors, facilitators, teachers, mentors, trainers) to incorporate engineering concepts into the training vocational environment and to investigate how experiences of the disciples at all levels have shaped their perceptions of the field of mechatronics to enhance the understanding of the relationship between spontaneous activity of the disciples and to achieve adequate concepts. In this way it is possible to determine the effects of participation in pre-engineering activities on elementary perceptions of the disciples in the field of intelligent systems and to understand the interest in studying science and engineering (Furman & Hayward, 2000). Therefore, teaching and learning in the synergistic communicational model are considered as activities carried out by professionals (educators and disciples as well), who change mentalities of the people providing them with new knowledge, skills, values, education being delivered, from pre-school through university, continuing after, according to recognized syllabi and institutional requirements, in a well-organized structural-functional system (Bridwell et al., 2006; Giurgiutiu et al., 2002; Doppelt & Schunn, 2008). In the disciplinary educational system there is an obvious lack of flexibility and low level of adaptation to the changing conditions of the environment, therefore it is very important to achieve new synergistic entrepreneurial skills, with flexibility and adaptability, so the educators (mentors, instructors, facilitators, teachers, trainers) and disciples (students, apprentices, pupils, adults) actively respond to the rapid change of economical conditions and increasingly combine practice and theory, to determine the direction of these changes and to offer a tool that will work for promoting competences, bridging both formal and informal learning. A theoretical framework for this didactics requires more insight into how individual and collective learning styles use specific teaching/learning methods, techniques and technologies, to outline paths to develop meanings and concepts from basic experiences, with natural and technical phenomena, being important to analyze the transitions between concrete and abstract models of production systems and to specify abstract solution for an automation problem by a concrete demonstration (Stiffler, 1996; Erbe & Bruns, 2003).

To be able to face effectively the challenges of economic development within a global marketplace, it is of a biggest importance to educate the new generations of engineering professionals in the new framework, VETS, as a continuum educational lifelong learning program, to develop and strengthen the integrative skills in analysis, synthesis, and contextual understanding of problems and also, to expose them to the latest technologies in different engineering fields and the implications for sustainability of their use. The problem-based learning (PBL) approach (Bruns, 2005; Lamancusa et al., 1997; Hanson, 1994), open-ended design problem solving by a multi-disciplinary team of disciples in a transdisciplinary context, simulation, modelling, prototyping are integrated altogether with the four dimensions of the sustainability: technology, economics, ecology and ethics (Reason, 1996; Pop, 2009; Bridwell et al., 2006), considering them as parts of a synergistic approach of knowledge (Pop & Maties, 2008). There is a three level system where the PBL method is working in different specific features, disciples as receivers (students, apprentices, pupils, adults), instructors as senders (teacher, facilitator, guide, mentor) and methods (experiential selection–know-what, interactive synergistic communication-know-how, functional contextual legitimacy-know-why, working together as is presented in the semiophysical contextual message model) (Pop, 2008; Hildreth et al., 2000). In PBL method the focus is on what disciples learn, more important being the way the knowledge could be applied (Bruns, 2005; Lamancusa et al., 1997; Hanson, 1994). The PBL project maintains the balance between theory as a top-down approach of the knowledge achievement process and practice as a bottom-up perspective, creating open-ended problems, taking time and creativity, the support for teaching assistants being essential (Pop & Maties, 2008; Barak, & Doppelt, 2000). In the assessment stage, the learning team (disciples) is evaluated by the teaching team (instructors), resulting a better coverage of specific problems, the results and experience of the research activity being carried out by the teachers and is incorporated in the educational and training programs for disciples (Pop, 2009b; Maties et al., 2008). As specific synergistic methods used preferentially in mechatronics, Problem Based Learning (PBL) and Team Teaching (TT) methods lead to more self-motivated and independent disciples, preparing them better to apply their achieved knowledge to real-world situations (Maties et al., 2008; Savary, 2006; Fink, 2002)).

Conclusions

Conventional education systems are not adequate to develop products for the contemporary society, being necessary a reformulation, only the transdisciplinarity knowledge achievement can explain the way the creativity works with a synergistic signification, to realize smart products, sustainable technologies and specific methods to give solution to the emerging theoretical and practical problems. Real experiences cannot be replaced by simulation, being necessary to use them complementarily. It is necessary a culture of expertise for the enterprise (common place learning) and the individuals in it (personal process of learning-teaching) as the most important challenge. The problem-based learning (PBL) approach, open-ended design problem solving by a transdisciplinary mix team of disciples and teachers, in a creative background should be integrated altogether with the technological, economical, ecological and ethic sustainability in a synergistic approach of knowledge achievement. Mechatronics evolves and works transdisciplinary through knowledge search window mechanism defining the bottom-up and top-down flexible limits in the process of achieving knowledge in the knowledge-based society. The suggested *new synergistic, vocational educational training model* involve active engagement of the disciples rather than passive reception of information, emphasizing on teaching/learning processes rather than simple memorization of information; opportunities to apply new knowledge to real-life situations; the ability to represent concepts and knowledge in multiple creative-innovative ways. The *new transdisciplinary model calls for new ways of evaluating teaching/learning training processes and outcomes.* Even the combining online and regular classroom courses are tremendous opportunities for human interaction and development of the social aspects of learning through direct communication, debate, discussion and consensus building, the conclusion is that computer simulations alone cannot replace all forms of applied training, the hands-on activities in laboratories and workshops remaining an indispensable constituent of an effective vocational educational training systems, in order to *raise skill levels, with available life-long learning strategies in the context of the synergistic knowledge triangle: education, research and innovation.*

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