Description of Teaching Processes Using Six-dimensional Space Framework

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Abstract - **This paper describes an innovative 6D-space concept and appropriate reference entity that are intended for description of motion architecture of any distributed conceptual system, a model or a real device. The aim of this paper is to show that the 6D-perceptivity is generally understandable and can be used in education to effectively clarify informational interactions between teachers and students, and to structure and define communication between them and for description of different physical devices used in the field of automation and mechatronics.**

Implementation of the innovative 6D-thinking method can help teachers and students to organize their knowledge, improves factor of merit of teaching and learning and speeds up adaptation to rapid changes that exist in industrial environment.

Basic views of realization of a dynamic distributed entity together with the 6D-reference entity are explained and illustrated. The framework is implemented in learning system descriptions that vocational students use during theoretical training and practical work in the field of electrical engineering and industrial automation technology. A sample laboratory stand is described.

I. INTRODUCTION

Today's Estonian labor market is very flexible and we cannot predict with a high degree of accuracy the structure of the human resources that is needed in economy. New trends in the meaning of a professional career emerging - predictability of results, continuity and confidence in the future, are gradually replaced by more mobile forms of employment. Professional boundaries are changed or disappear altogether, and an increasing number of workplaces are temporary [1].

Below are some situations that the higher education system is interacting at present. The changing nature of economic relations, the evolution of forms of organization and the use of labor leads to the need for structural changes in priorities and the content of training students.

The current educational system lacks flexibility and its adaptation to the changing conditions of the labor market. There is a strong need to build entrepreneurial skills - the ability and willingness to support themselves and others through the creation of new workplaces [2].

However, students respond to changing economic conditions actively and increasingly combining work and school. Students require higher education but at the same time they are agreeing to unattractive working conditions. This has become a significant convergence model of student study activities in European countries [3].

According to the Vocational Education Standard [4] requirements the professional qualifications system [5] clearly defines following:

1. Requirements for professional skills arise from the professional standards approved by professional councils.
2. The content of studies is determined by the requirements for professional skills set forth by the professional standards. In the absence of a professional standard, the content of study shall be coordinated with the relevant professional associations.

The curriculum in the Vocational Education Standard is defined as follows:

1. The national curriculum is a document which determines the purposes and functions of vocational training, the requirements for starting and graduating from the studies, the modules of curricula and the volumes thereof together with short descriptions, the possibilities of and conditions for electing modules and possibilities of specialization.
2. The national curriculum shall be reviewed and if necessary, a new version shall be approved if the professional standard which constitutes the basis for the national curriculum is repealed, a new professional standard is established, or the name of the professional standard or the requirements for professional skills provided in the standard are amended.

This approach to education has a clear focus on the constant interaction with the labor market. All changes in the standards of the professional qualifications system are the reason for the adjustment of the national and the school curriculum that provides flexibility for vocational education.

The main aim of Estonian education is to prepare human for innovation and to develop creative abilities of the individual. To achieve this goal it is necessary to apply new innovative educational technologies in vocational schools and universities.

Today there are social orders for such professionals who are able to profitable innovate all spheres of activities. New teaching technologies in the educational system are aimed to fulfill following tasks:

- Development of cognitive activity of students,
- Improving communication skills of students,
- Teaching of profitable innovators,
- Effectively describe the organization and the realization architecture of different systems, etc.

II. SHIFT IN THE IDEOLOGY

The modern approach of learning involves mastering separate knowledge and skills in the complex. In this regard, competences of students are developed on the basis of fundamental principles, universality and practical orientation.

Important characteristics of professional competence for the expert in the field of automation and mechatronics are:

1. Creativity – cognitive (cognitive) activity of students;- analysis of technical information research, formulate and solve fundamentally new problems in the field of automation;
2. Innovation and efficiency – successful implementation of the results of creation through professional activity's in own personal life and in an enterprise;
3. Mobility – a willingness to upgrade existing experience and knowledge to adapt to changing economical conditions;
4. Perspective – a willingness to continue their education, self-improvement, professional and personal growth.

To implement these objectives it is most appropriate to use a mixed mode of education – blended learning. In modern terms blended learning is based on the use of effective "mix" of traditional and distance learning technologies and innovative pedagogical methods of teaching [5]. In the blended learning distance learning technologies are actively supporting full-time basic education. In the information age the production workers involved in making products regularly participate in further trainings. This means that people need different educational means (resources, equipments) and their delivery systems, as well as a general platform for communication and collaboration [4].

The concepts in educational content are structured. It's helpful to design and use structure and algorithm representations as educational materials. For example, general structure chart of an automated manufacturing systems (Fig. 1) can be used [8]. The innovative developers are using information, energy and physical manufacturing technology together with modern development methods in order to produce an automated manufacturing system. People, automatic control systems and driven energetic (partially mechanical) equipment are integrated during the system development. New manufacturing equipment enables us to produce more complicated products in shorter time. The technology used in manufacturing products is becoming more and more complex.

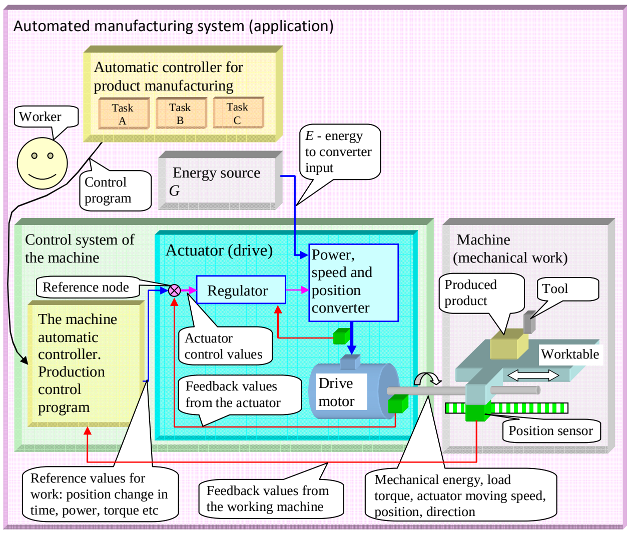

Fig. 1. Structure of an automated manufacturing system [8].

III. The Basic Idea Behind a Six-Dimensional Coordinate System

The learning content of technical subjects (e.g. automation) is often difficult to understand. In this case it is appropriate to structure the learning using six-dimensional coordinate system (6D). The coordinate system is imaginary (still real) object that helps to describe not only geographic properties of an entity but also integrates inseparably description of realization (interaction) of the entities in a system.

As we know the logical, information, energy and physical mobility values cannot be described sufficiently (in detail) and identified (in space and time) by a single point. For example, the speed of a large scaled material object is sufficiently defined if it's measured minimally from two consecutive 3d geometric positions.

Different actions and activities of more complex concept, such as task, process, application, game, project, life, dream etc. are realized in close conjunction. There exists some kind of transformation between all these motional concepts.

The learning process is a knowledge development that cannot be expressed through three-dimensional geographic coordinates. The development of knowledge and creativity can be expressed through two different types of space. The two type of spaces are geographic and realization. The geographic space is subspace (distillate) of the realization space. Motion is realized through the spatial connections that exist between subjects and objects or reformulated, sources and resources.

Simplified symbolic explanation does not care about the observer but the explanation doesn't have any characteristics (quantities, effects) if there is no observer [6]. In today's geographical space-time the idea of action is identified as sufficiently monosemantic but the name definition (identification) is polymorphic. A verb for example can show specific movement, plus his ability influence other (nearby, side by side) ideas, information and movements. The complex geographical organization idea is best explained by the general term – topology. Geographical axis system and 3D idea are visually interpreted in Fig. 2 [2].

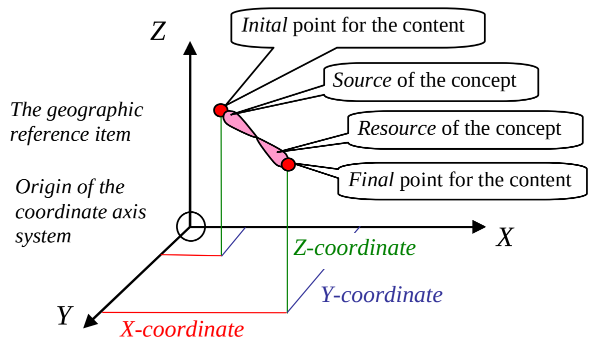

Fig. 2. Geographical axis group and logistical content of concept [2].

Real (and reference) objects with similar geographic topology may have completely different architecture of actions (functions). For example, an IBM-compatible and an Apple computer may have even a similar look and physical organization but their realization architectures (the operating systems and programs) differ markedly. The geographic reference entity can be used also for the description of natural items, models as well as concepts created in the mind of a neighboring subject.

The complex idea of the movement structure (realization structure) is visualized in Fig. 3.

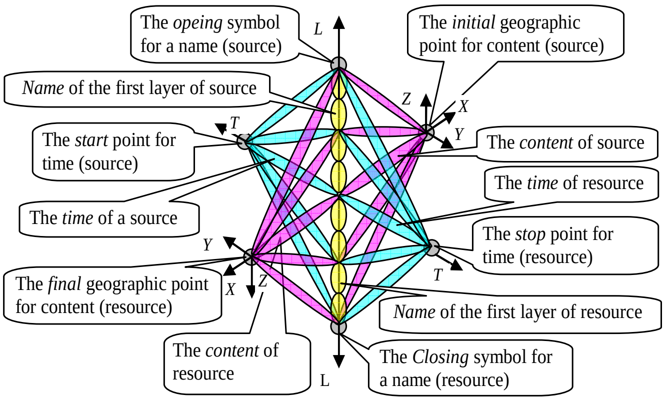

Fig. 3. Concept of the complex action is represented in 6D space [2].

The string-like path of the content of an action is basically visualised as geographic but as we look at the sample concept visualized in Fig. 3, it also depends on the type of the action. To be more precise, the path for content is logistic.

Graphic models are commonly restricted to space-partitioning regression functions.. These functions are often called piecewise regression functions because they approximate the desired function (motion) by partitioning the space and matching a simple local model to each region [3, p.188].

As a step towards improved space framework the name merit was given to the new dimension and the new axis that concerns the architecture of motion. The merit dimension helps us to better understand the freedom of matter and merital (the logic) connections between different actions of motion.

Merit is a rather common term in our everyday thinking but unfortunately its importance and connection to the time and motion (content) dimensions is not profoundly comprehended in our mental systems, neither is it precisely used in technical manuals. The meaning of the word merit is close to that of a substance, one's portion, nature, achievement, virtue and also quality of being.

In simple terms, the fifth dimension should be used to model the complexity of the motion of a concept. Human brain is capable of sensing the merits of a subject and an object (are not cognizable using more simple sense organs).

Content value of an action of motion of a geometrical concept is defined by using the content axis and temporal value of the action is defined by using the time axis. Merital value of actions of motion of the concept is defined by the help of merit axis.

The independent merit, (motion) content and time axes together form a new complex reference item LTV visualized (geometrized) in Fig. 4. The realization axis group (system) can be used for complex measurements of the motion of the subject and object parts of a concept. Because the realization is distributed, we obtain the corresponding content, time and merital values for every (different) action of the concept.

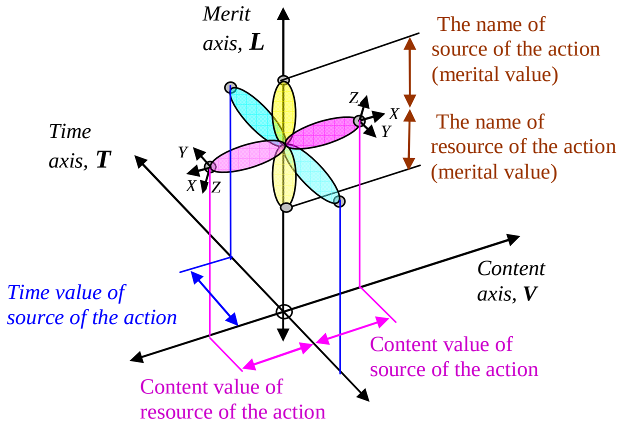

Fig. 4. The realization axis group [2].

The detailed organization and architecture of the axis system is represented in Fig. 5. The named vertical arrows represent organization and architecture of the merit axis L. Axes V and T are not detailed. The lines of motion of the etalon and a sample application concept (identified with geometric points P1xyz and P2 xyz) are visually represented in the central area of Fig. 5.

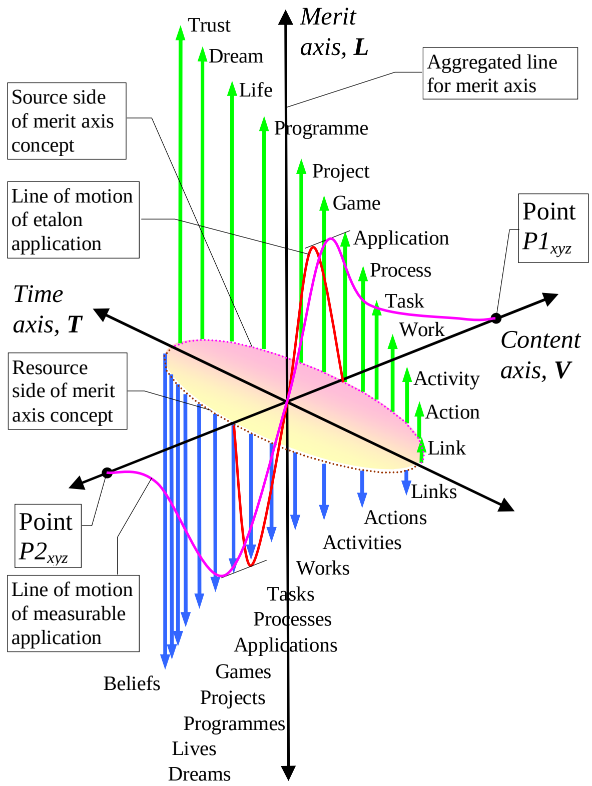

Fig. 5. Organization and architecture of the merit axis concept [2].

The source and resource parts of the merit axis item can be represented in a more compact form (Fig. 6). Every scalar (name) in the visual array has lower and higher neighbours. Signs "+" in Fig. 6 represent channels between the logic layers for the transformation of matter.

The organization and architecture of the merit axis can be used by a system designer for function classifier design. An intelligent system can use the classifier e.g. to create the data schemas of an application function.

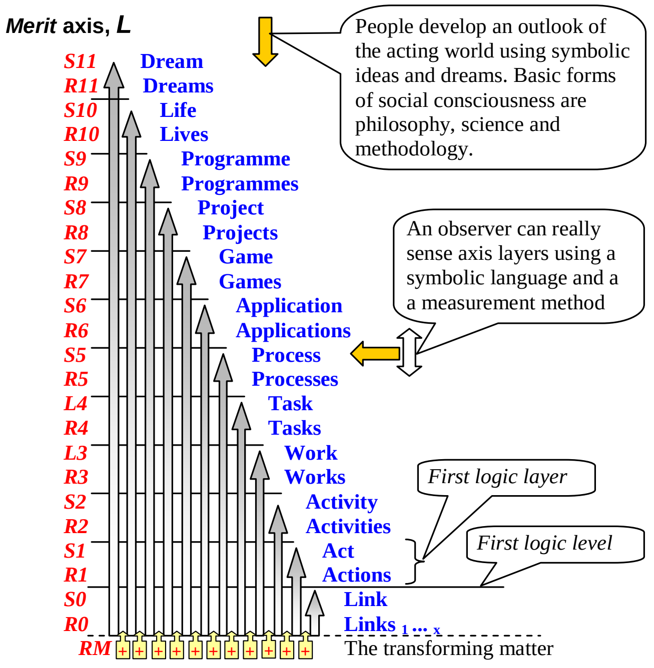

Fig. 6. Organization and architecture of the merit axis. A source (S-level) and corresponding resource (R-level) together with the matter form of the logic layer [2].

The realization axis entity provides a method for the measurement of clustered solutions. Clusters are represented by their associated etalons (names, located in a nameroom). Each of the functional cluster or subgroup should be as homogeneous as possible. A generic merital type is, e.g., a simple, an array or a structured. The exact definition of the clustering problem differs slightly from field to field.

Stationary-action means that there is a balance between the corresponding source and the resource of a given concept. For example, for a future smart electricity network it can be declared as the cluster of information-energetic-massive actions. A smart electricity cluster has the supply side (generators and line links) and the demand side (loads and line links). Between the electricity suppliers and consumers (at the connection places) smart electricity metering devices that measure content values of different actions, e.g., current, tension (voltage), power, energy, emergency events will be installed. The defined actions belong to their merit levels.

A graphically defined concept, model or device can be more precisely described by the symbolic (merital) action name value, the action content value (commonly numeric) and the time value.

The proposed merit axis can be integrated into an axis system that is used for modeling of a future smart electricity grid or complex automated production equipment. Such an integrated development, design or simulation environment helps not only navigate in concepts (including subjects and objects) under discussion but also helps to understand the structure of the dynamics of the system. It is useful to implement the proposed architecture for simplicity of learning, economic and safety of performance reasons [2].

IV. Symbolic Description of Realization

The framework proposed by the on an analysis that focuses on the use of words and terms by humans in different real-life situations and in written texts of different documents and software tools. The findings result from the study conducted during several years [2].

People use a symbolic language to sense an existing realism in five dimensions. One reason why people at all use a symbolic language is the need to explain why object motion comes into being in so many different forms (different actions, properties), and why a property value appears at the moment and place.

A meaningful technical text (as subject) that describes an object realization also clarifies the levels (hierarchy) of the merit axis. Many people (also students) unconsciously use the merit dimension in complex everyday situations. But they are not clearly informed about this five-dimensional space model and as a result, use the same terms in a system in a different order.

In fact, in this paper we discuss a six-dimensional framework because major attention is paid to the content value of the motion of (real) matter. The content value is not separable from the description of a system. Every action value (property value) is measured using the corresponding named etalon.

The five-dimensional basic framework for a concept (declared with two geometric points) is visually represented and explained in Fig. 7 Layers of motion are represented by different color 3-D boxes.

Every measured physical, energetic or logic value belongs to a defined merit layer (and box). Remember that stacked boxes in Fig. 7 are visualizing a concept realization not its geometry [2].

The geographic points can be associated with parts of a hierarchical organization constituting an acting system, for example, an element, a component, and a module. An element is a so-called black box. It consists of at least two points (each including some matter), two internal links and a portion of acting matter between them. The matter has a role to transform foreign motions that belong outside the system (Fig. 7).

The *merit* axis can be used to describe concepts keeping in mind the following:

- Merit axis can be differentiated (actions are expressed by many different symbolic layers).
- The base point of the 5D axes system is hidden in deep matter.
- The structure and the most basic actions of matter are unknown to today's physicists.
- Human brain can sense the declared merit dimension and is capable of creating mental systems that include also a dream level.
- Lifecycle is the name for a logically high level concept, model or physical body.
- Massive logistic connection should be defined below the first logic level of the merit dimension.
- Mental systems can be realized (as models or natural objects).
- Today's standards define function blocks that potentially can include meritally high-level sources and resources.

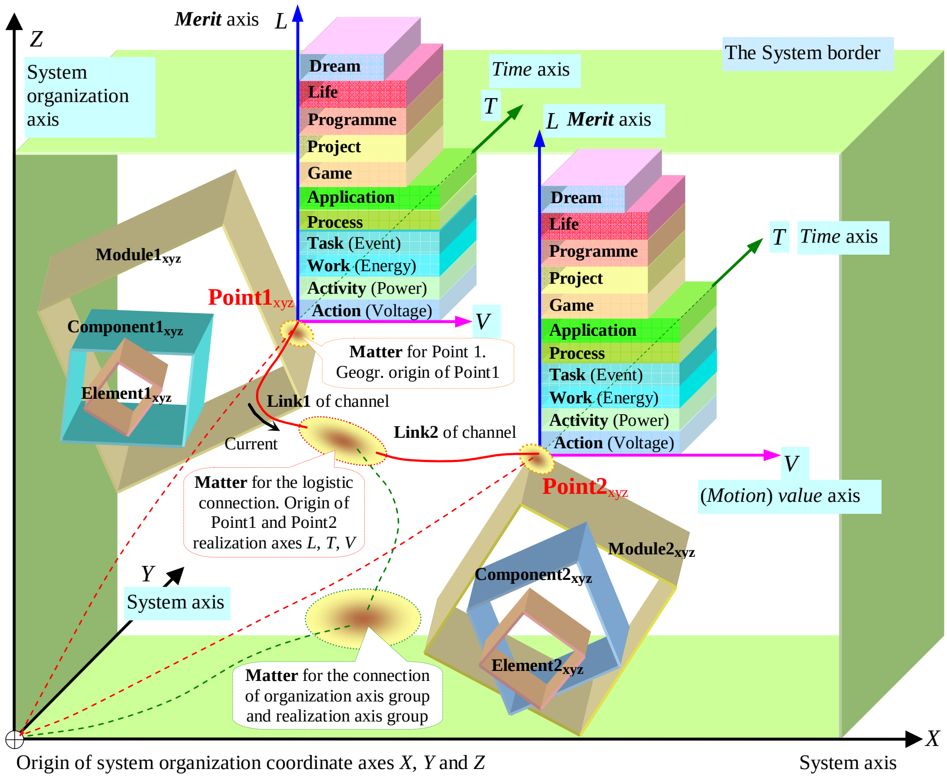

Fig. 7. Visualization of a five-dimensional space framework [2].

- During implementation of an application its function blocks can be managed by management function blocks.

V. Description of the Learning and Teaching

How can be explained the concept of education? It consists of two concepts: learning and teaching. Teaching is an implicit, explicit and dynamic as well as social, personal and situational process of life. Teacher can influence implicitly, explicitly and dynamically on the learners cognitive, affective and conative learning processes and learning outcomes choosing right information, methods and supporting materials [11]. The following figure illustrates this definition (Fig. 8)

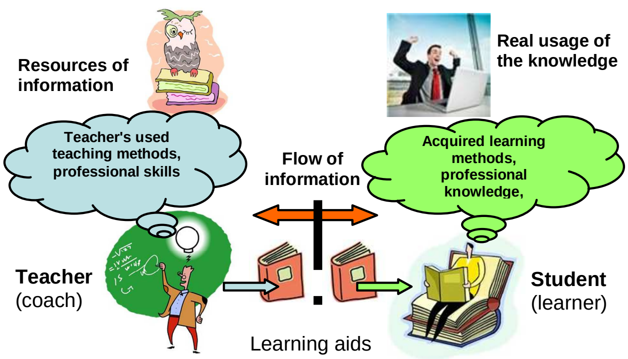

Fig. 8. Visual representation of connected teaching and learning concept.

When someone looks at the learning as an interactive motion consisting of information exchange between student and teacher through dialog and comprehensive visual interface. For example, Moodle users interface. During this dialog student and teacher are connected (see system 1 in Fig. 9) through different levels of merit. Then system 2 in Fig. 9 is user interface.

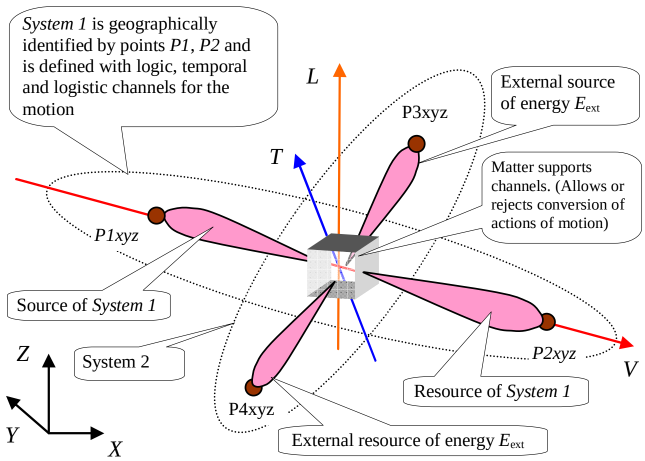

Fig. 9. Dialog student (P1 system 1) and teacher (P2 system 2) consisting also teaching and learning aids.

Let's look how definitions (competences) create a dialogue that is taking place between the student and teacher. The dialogue can be spoken or written form, sometimes even non-verbal interaction between two or more persons or participants.

Dialogues have been studied from the perspective of the teacher. Dialogues main characteristics are the teacher's ability to think, reflection, the concept of personal and professional identity. Then the observation focuses on pedagogical skills, action repertory, teaching methods, the knowledge hided in a learning content, and also teaching organization. (Fig. 10) [11].

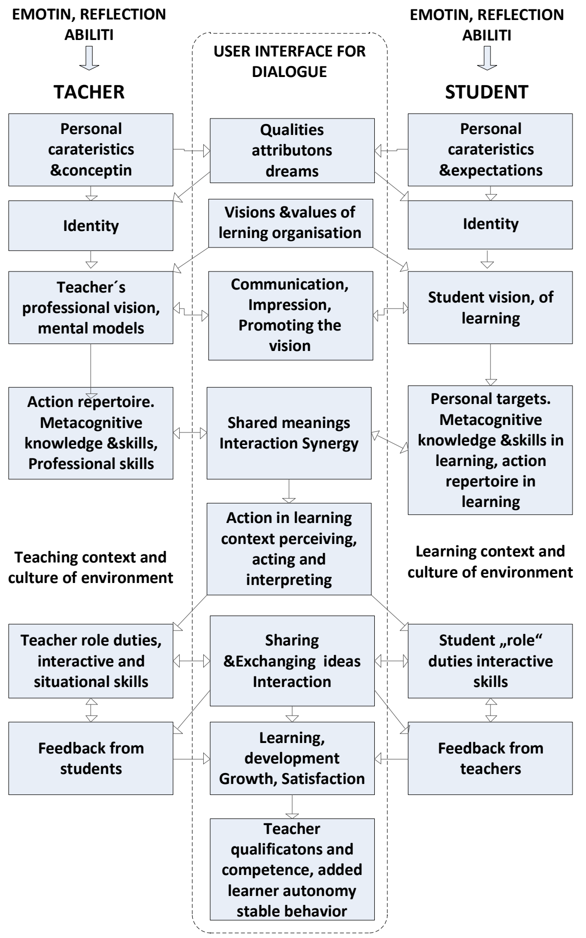

Fig. 10. Dynamic dialogue in teaching and learning.

VI. STRUCTURE OF THE LEARNING PROCESS USING THE STANDARD IEC 61499 FUNCTION BLOCK

Distributed system functions can be organized into a large function block. Detailed function block diagrams are prepared using standard methodology [9]. Overview of IEC61499-based architecture is presented in Fig. 11. In the current market situation only few software tools, e.g., ISAGraf that supports the IEC61499 function block model are available [12]. Function blocks of a distributed network can be grouped and allocated in different merit layers according to general control architecture.

Fig. 12 (see next page) shows a simplified model of today's learning process in teaching control engineering where the standard IEC 61499 function blocks have been used. Every visual block in Fig. 12 is replaceable with a network of detailed function blocks. A full set of functions of a mental system, a model and a technological device is organized and allocated to the corresponding merit levels and connected. The sources of function blocks are connected with corresponding resources.

The figure is basically an L–V diagram; not all of the logic, logistic and temporal connections is rendered. The logic functions devised or invented and used first by a human (operator or engineer) can be later distributed to microprocessor-based control systems or real technological equipment. For example, a real technological equipment is the multifunctional production automation stand MFS, which is presented in Fig. 13 and 14. As seen on Fig. 12 the merital system describes learner, the MFS stand and teacher. Together this parts form a learning system.

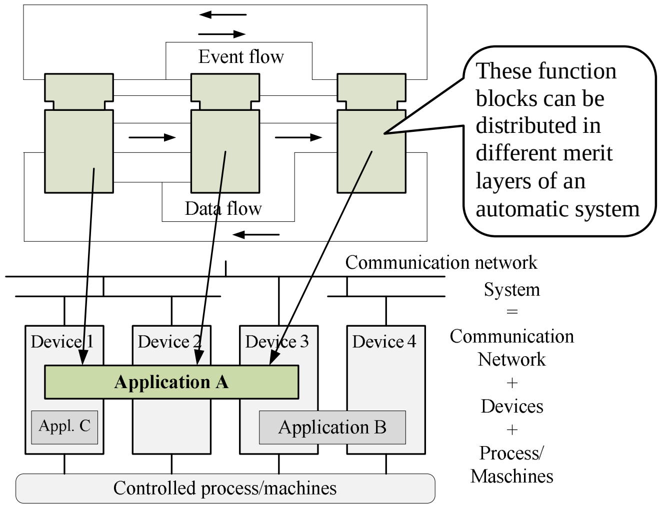

Fig. 11. Overview of the standard 61499 function block model and architecture.

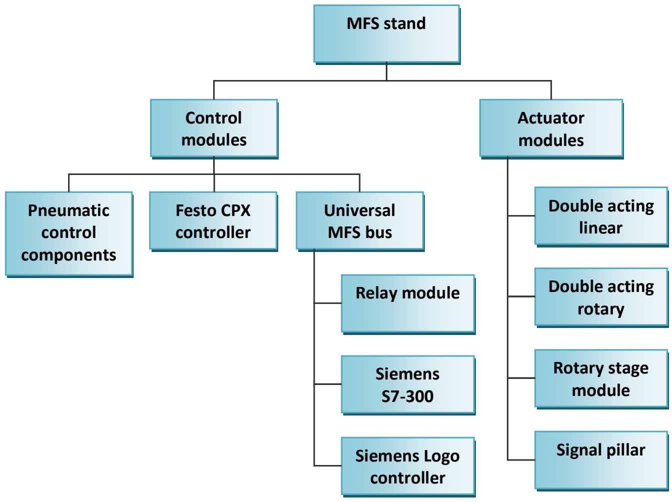

Fig. 13. Structure chart of MFS.

The MFS stand consists of two parts: the control module and the actuator module. The control module itself is divided to different integrated control units: relay unit and Simatic S7-300 controller unit. The actuator module consists of a pneumatically controllable input module, a placing module and an electrically controllable rotary stage module. Work piece feeding, repositioning and placing it to the rotary stage module take place in this module. It is possible to carry out practical work at various execution levels.

Control module enables the learner to get to know: control units, how to install the units (getting to know the software and hardware settings in the programmable controller using development software); finding faults; programming (learning how to use the software and programming instructions, solving simple programming tasks, and also how to debug the programs).

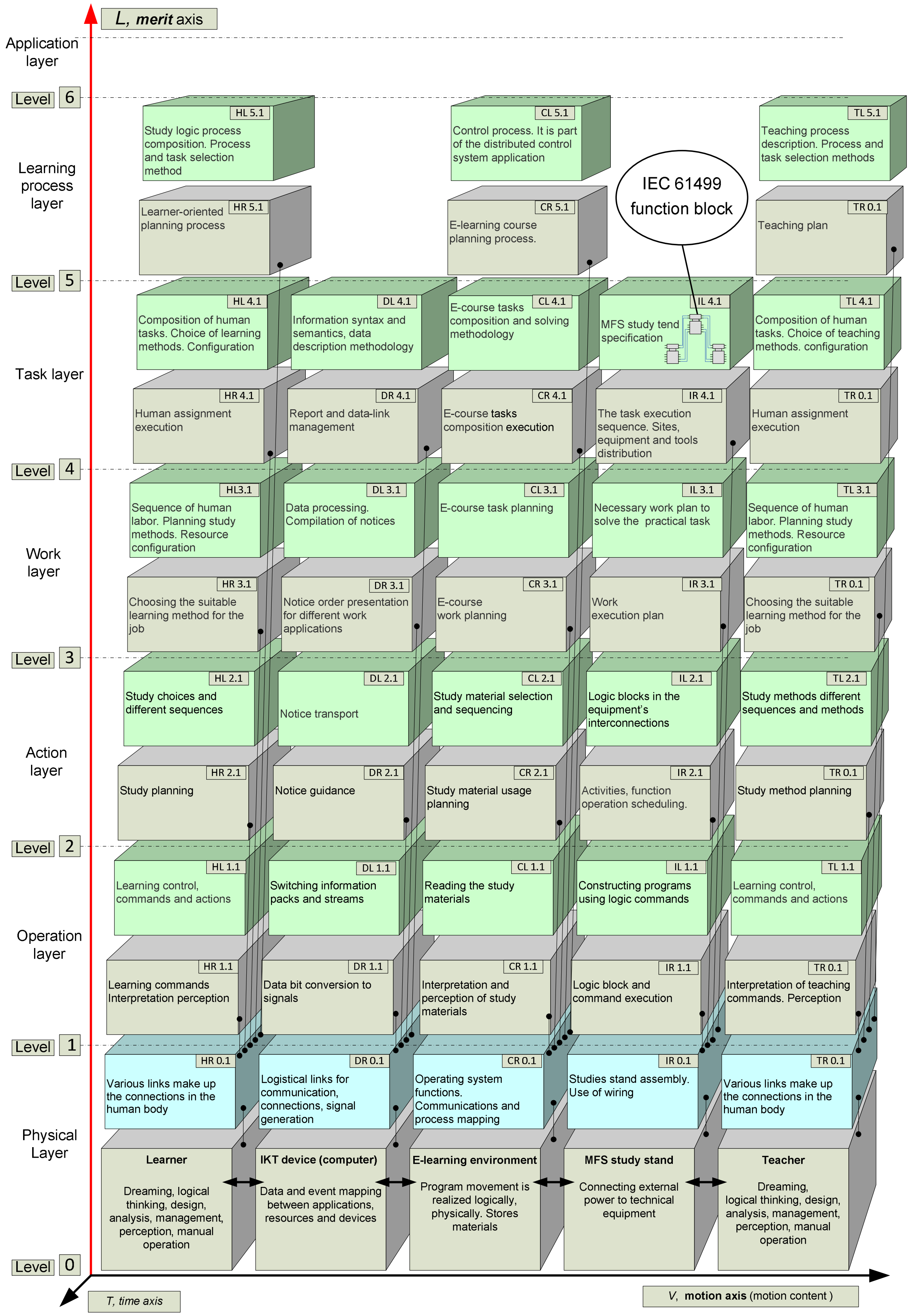

Fig. 12. A simplified model of process control engineering education.

The following is learned about the text and graphical operator panels: usage of text- and operator panels in automation; installation of panels (finding the building and installation errors); software development (getting to know the software; object oriented programming; displaying variables, trends and moving pictures; solving simple tasks; testing).

Fig. 14. The multifunctional stand MFS.

Actuator module (Fig. 15) enables learner to get to know the pneumatic control components and the actuators, the production automation systems and the installation of the automation system components.

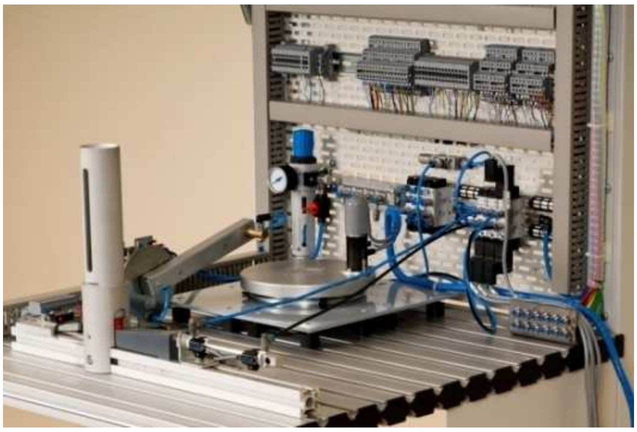

Fig. 15. Actuator module.

The control- and the actuator module together provide an excellent opportunity to get to know the automation systems: installation and troubleshooting; programming and tuning of flexible manufacturing modules; experimenting with a flexible manufacturing system.

Installation of automation system components includes the following: installation of electrical, magnetic, optical, inductive and capacitive sensors; connecting sensors with measuring transducers or computers measuring interfaces; processing the measurement data with computers; software needed for processing of measurement data.

VII. Conclusions

An innovative 6D-space concept and appropriate reference entity are used in education technology to effectively clarify informational interactions and the structure of communication between teachers and students. It is useful for description of different physical devices that exist in the field of automation and mechatronics.

The innovative 6D-thinking method helps teachers and students to organize their knowledge, improves factor of merit of teaching and learning and speeds up adaptation to rapid changes that exist in industrial environment.

Basic views of realization of a dynamic distributed entity together with the 6D-reference entity are explained and illustrated.

The framework is implemented in learning system descriptions that vocational students use during theoretical training and practical work in the field of electrical engineering and industrial automation technology.

The learning process function blocks can be grouped and laid-down into the different merit layers according to the proposed 6D space architectural model.

The present work describes the integrated teaching-learning scheme, where are presented students, computer, e-learning environment, MFS study stand and teacher learning process application.

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