ENERGETICS. EECTRICAL ENGINEERING. MINING D43

Visually structured methods and tools for industry automation

EDUARD BRINDFELDT

TALLINN UNIVERSITY OF TECHNOLOGY
Faculty of Power Engineering

Department of Electrical Engineering

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Supervisor: Dots. Elmo Pettai
Department of Electrical Engineering, TUT

Opponents: Prof. Roma Rinkevičiene
Vilnius Gediminas Technical University, Lithuania

Prof. Krista Loogma,
Tallinn University, Estonia

Doctor of Science Jüri Joller,
OÜ Energiatehnika, Estonia

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Declaration:

Hereby I declare that this doctoral thesis, my original investigation and achievement, submitted for the doctoral degree at Tallinn University of Technology has not been submitted for any academic degree.

Eduard Brindfeldt …………………..

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ENERGEETIKA. ELEKTROTEHNIKA. MÄENDUS D43

Visuaalselt struktureeritud meetodid ja vahendid tootmise automatiseerimiseks

EDUARD BRINDFELDT

CONTENTS

Introduction

In a modern economy, well educated people are needed for highly diversified occupations. Description of occupation/job description will identify, in more general sense, the main functions and, more specifically, the work that is to be performed in a typical job in a company. Educational institutions of educational system will teach people, allowing them to acquire the needed qualification in thousands of specialties. Vocational system is a part of the qualification system, linking educational system to labour market, thus contributing to lifelong learning of the population, development of work-related competences, evaluation and acknowledgment and also comparison. Only 8 levels of qualification, dozens of vocations or hundreds of professions will be determined during the development of a qualification framework for the vocational system. The qualification framework will, first of all, support individuals in charge of the development of curricula of educational system educational institutions; second, development of abilities of students and improvement of their work-related proficiency (or competence) and third, will help the entrepreneurs to raise awareness of the requirements, linked to existing or prospective jobs, to educational institutions and students.

Research-based specialty related studies dominate in universities although it is known that specialty can't be applied in any occupation; personality will be applied, instead, and apart specialty-related preparation, individuals must have occupational and professional training. Which teaching methods and materials should be used to teach and to study technical specialties for the students of technical specialities to obtain the best education possible, i.e. for the university graduate to be able to apply its knowledge and skills in full?

To achieve success in engineering career, students must define their nature, wishes and objectives or dreams. Students will plan their career paths, taking to a success, in stages that are linked to each other and can be sometimes implemented simultaneously. After the completion of specialty-related studies in an education institution it often becomes obvious that the occupational training of the young specialists is often insufficient and there is little – or no – occupational training. Occupational (practical) training won't just appear by itself; instead, it must be acquired in course of practical training. This becomes highly important when we consider working with modern, highly automated production equipment. Communication and management of others is also learnt while honing once practical specialty-related knowledge and improving professional qualifications.

As we look around, we will see that cognition processes of people have become, in today's post-modernist society, either partly or fully technological. As technical and technological equipment keeps developing, we will come up with more and more accurate specification, however, we're unable to identify their role in social culture [1].

The most critical problems of university/college education Estonia, highlighted as the result of a number of surveys, and are of key importance for technical university education purposes, are listed below [2]:

1. **Insufficient links between academic knowledge and expectations of a society** – research and educational institutions are usually strongly focused on academic education, however, is this the only expectation of the society?
2. **Limited use of experiences of entrepreneurs for the development of curricula**, in the learning process and insufficient requirements for practical work during acquisition of academic education.
3. **The role of the university as promoter and supporter of entrepreneurship and the substance of an entrepreneuring university is underdeveloped** and therefore, the organisations institutions of higher education and business development (for example: Enterprise Estonia, EE) are poorly co-ordinated and with limited efficiency. http://www.arengufond.ee/)
4. **Teaching methodologies lack attractiveness and don't support the growth of initiative** and linking academic knowledge to business opportunities.
5. **Low entrepreneuring skill and knowledge level of students of specialties other than economy**.

As the level of complexity and scope of information, used in modern production and, above all, knowledge-intensive production, continues to increase, students will need better co-ordination between miscellaneous stakeholders, involved in education process – entrepreneurs operating in labour market, employees of companies, the state and educators – for efficient and fast development of systematic knowledge, skills, competences and attitude.

General frameworks for describing the substance and implementation of the structure of systems, that should be developed further, visualised more clearly and then used more extensively for the communication and processing of information between the stakeholders, could be one of the possible formal supports for improved co-ordination results. Information framework, characterised by commonly acknowledged structure, will allow the development and implementation of more accurate semantic models in teaching process of schools, for the assessment of qualification of employees and automation of production and manufacturing of products in companies. This will improve and speed up the adaptation of education to the requirements of modern production. Semantic frameworks and models developed on the bases thereof are about to become common joint assets of all the aforementioned subjects and will, when viewed in general, ensure the sustainability of economy.

I.1 Goal and Main Tasks of the Research

The goal of the doctoral thesis is to develop the methods for structuring and selecting presentation of information, used to provide and obtain education, related to automation of production; the methods discussed will be those used by students of technical specialties to obtain the educational information and practical experiences that are inevitable to acquire the knowledge, skills, proficiency and attitude, matching the levels of professional qualification, required at different jobs.

The main purpose of the doctoral thesis is the development of a new visual information model, teaching method and practical tools for extending the scope of knowledge, skills and independent work or research specialists, students and in-service trainees of technical specialities, involved in the qualification system, and for the intelligent implementation of such tools for the automation of production.

The following tasks must be fulfilled to achieve the established goals:

1. Analysis and classification of requirements, established to level of education and substance of knowledge of students and employees of companies (Chapter 1.2 page 46);

2. Investigation and classification of success of students, engineers and other employees (satisfaction, feasibility of a career taking to success) and requirements to jobs/positions, created in companies (knowledge and skills, required for the fulfilment of job-related tasks) (Chapter 1.3 page 61);

3. Investigation of newest teaching methods (technologies) and their development trends to develop a modern (state of art) methodology for conveying knowledge to students of technical specialities and acquisition of such knowledge by the students (Chapter 2 page 68);

4. Pooling of terms and definitions, related to the specialty, explaining their meaning and linking the definitions to requirements, established for different levels of specialty and vocational qualification (Chapter 3 page 80);

5. Analysis and classification of the algorithms for planning and controlling teaching/learning process and further development of the process in accordance with the must suitable (optimum) learning path of a student, professional requirements and specific needs of a job in a company (Chapter 6 page 154);

6. Collection, analysis and further development of the contents and implementation of specialty-related ontologies. Integration and visual description of ontologies for teaching subjects, related to automation of production (Chapter 4 page 97);

7. Elaboration and development of teaching materials (tutorials/software), needed for teaching methods and teaching/learning work (Chapter 5 page 109);

8. Development of a curricula for employees of small and medium size enterprises, needing in-service training in the spheres of mechatronics and automation of production (Chapter 7 page 174);

9. Organisation and implementation of practical training courses for studying the efficiency of teaching methods and analysis of the results (Chapter 4 page 97);

10. Development of recommendations for the implementation of new infrastructure and teaching and learning methods (Chapter 7 page 174).

I.1.1 Object and Subject of Investigation

Methods used for giving research-based professional education to students of technical specialties, training students of vocational educational establishments and in-service training of companies represent the object of study and development. Behaviourist, cognitive, constructivist, humanist, social and companied teaching methods will be used for the development of new methodologies and to identify the most suitable and effective ones. Different study groups will be formed to obtain objective information. The system of benchmarks, including practical tasks and tests, will be used. (Chapter 4, page 97)

The subject or the entity conducting the study is, above all, the author of the thesis. A sample of students of technical specialties, students of vocational educational institutions, lecturers, employees of enterprises and employers are also a subject for the purposes of using practical training tools and collection of empirical data. The following questions will be answered in course of questioning and interviews:

1. What is the opinion of students of technical specialties, lecturers and employers of the teaching methods investigated?
2. What is the importance they attach to practical training work and what should be the proportion of practical and theoretical studies?
3. Does the scope of academic knowledge, skills, responsibilities and, viewed in aggregate, also their applied training meet the expectations of employers; what are the main deficiencies in training programme?
4. What is the professional, vocational and occupational preparation of the other team members involved to describe the future vision of employers and implement the present mission, above all, the graduates of institutions of higher education?

The figure below (Figure 0.1) describes the changing links between the object and subject of investigation during the study process. A student (the subject) will link (get to know) learning objects by means of a structured field of information, having the interest and obtaining knowledge and also some practical skills.

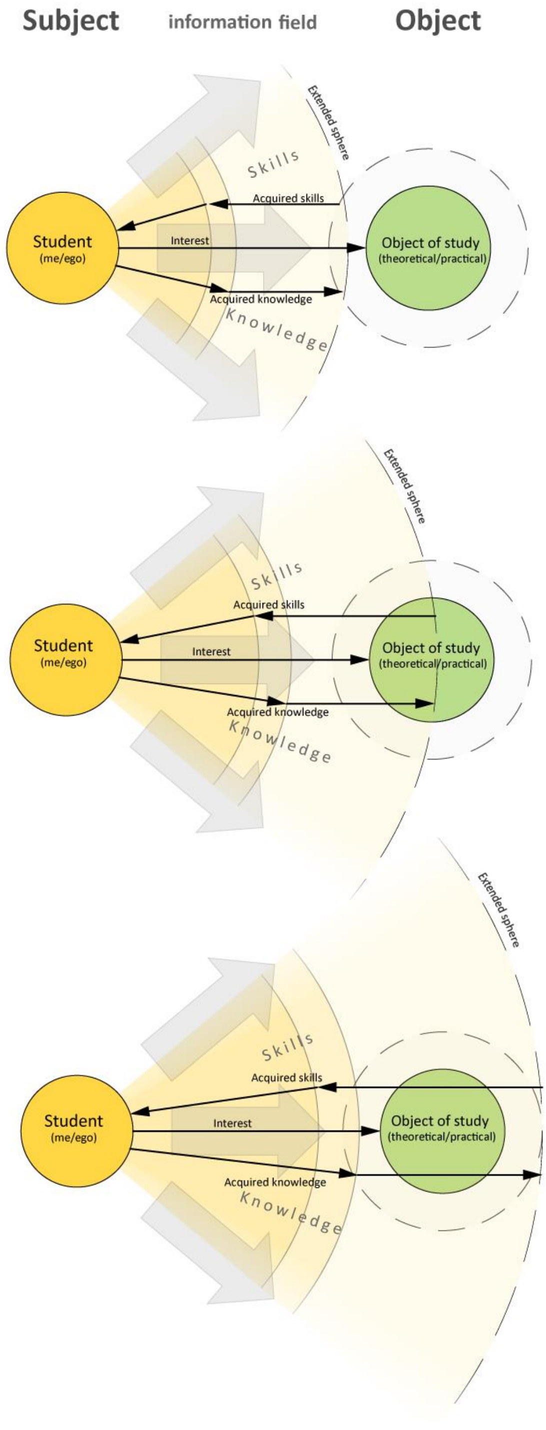

Figure 0.1 Changing scope of mutual links between object and subject during the learning process

I.1.2 Research Methods and Tools Used

For the purposes of this doctoral thesis, a collection of information available from educational literature and used for teaching work, technical tools used to convey skills in the field of automation, career plans of students and requirements of enterprises to the quality of technical education is used as the object of analysis.

Different methods for data structuring and processing will be employed to analyse information available from education related research and teaching literature. Questionnaires and interviews will be applied as practical research methods that will be used to collect information on subjects and objects and information flows between them, then to be used to determine the efficiency of information use. It will be assessed, how big is the time resource of people used or saved in case of regular information structure and losses, compared to more visually structured descriptive ontology of information and its structure and thus, also familiar for the stakeholders involved.

Data communication interfaces are used to ensure mutual information exchange between subjects operating in the sphere of education and qualification (including students). The structure and substance of the information, flowing between the parties involved, can be described in more and more understandable way and visualised more efficiently, as this is made possible by graphic tools of modern computers. The fact that sometimes a single picture can say more than a thousand words is well known. Visualisation of information, using graphic tools, allows to communicate its meaning (structure and substance) more efficiently than a simple text.

Social groups, operating in the field of education and labour market, using visually more structure description methods, will also gain certain advantages in communication and competition. It will be assumed that the use and development of more visual methods will mean, for both the sphere of education (including students) and enterprises, smaller loss of meaning during information communication process. Information interfaces between subjects operating in common information field of education and qualification and labour market are shown on Figure 0.2.

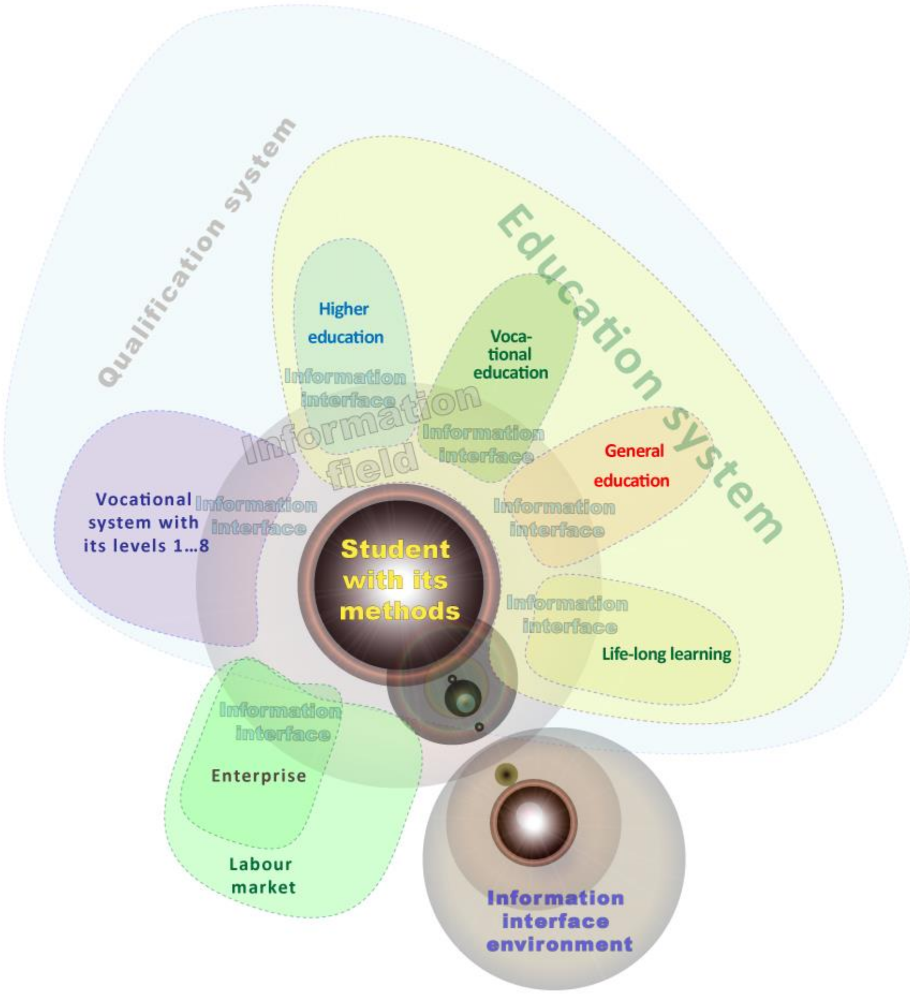

Figure 0.2 Interfaces are used to ensure information flow (data exchange) between student subjects operating in the field of education and qualification and labour market.

I.2 Novelty of the Doctoral Thesis

I.2.1 Scientific Novelty

The outcomes of scientific research and development work are summarised as the following items:

1. **A new visual model and method have been developed for presentation of information with a complex structure, using a six dimensional (6D) spatial model ontology, for information exchange between subjects and objects, operating in the fields of education, qualification and labour market.**
2. **New, seven stage visual method has been created for the provision and acquisition of research-based knowledge** to and by students of technical specialities, ensuring acquisition of subject-related (required) new information, new skills (practical experience), wisdom (experience-based theoretical generalisation), qualification of knowledge and skills (evaluation of knowledge and skills) obtained, followed by extended operation in sphere of purposeful implementation.
3. **A new visual methods is developed for navigation in a structure of complex specialty-related information, used to teach and learn various subjects to and by students of technical specialties, and a new model for geometrical description of content of information flows, using 6D spatial model.** Semantic bases for the visualisation of complex semantic information flows or a visual framework will be based on a six dimension spatial model, which, according to critical spatial theories, is used to merge (combine) objectively defined material space or "spatial practices" and subjectively defined mental, cognitive space or "spatial representation"; and a third, hyperspace or the combination or extension of the first two into additional dimensions, which will allow movement of semantic tools (information or data with meaning) between points of material and mental four dimension space. Real, mental and hyper-real exist, in parallel, within the space of representations.

   New visual navigation method and model will allow to create, communicate and submit information in a more intelligent and understandable way and can be therefore used in numerous fields, including:

   - in organisations, providing research based education, for providing new knowledge, more efficient transfer of knowledge from a researcher to lecturers, students or employees of enterprises;
   - acquisition of knowledge and skills, needed for planning and implementation of specialty-related career of the youth;
   - for the establishment of requirements, needed in professional organisations to prove competence;
   - for the development and specification of descriptions of occupations and specialty-related jobs, created by entrepreneurs;

- for product development efforts of enterprises, automation of production, preparation and marketing of products.

4. **New classifier if knowledge and skills has been developed, used to provide a new classification of knowledge and skills** (Chapter 2page 68), considering the research results about the success (satisfaction, career feasibility) of students, engineers and other employees and requirements established to jobs, created enterprises (knowledge and skills, required to do the job) and requirements, established to the level of education and substance of knowledge of students and employees of companies.

5. **Visual learning materials are available for providing students with a specialty-related qualification in the sphere of automation and teaching methods for lecturers for the transfer of the appropriate knowledge.**

I.2.2 Practical Novelty and Value of the Work

1. **Virtual e-leaning environment** for the students for learning and for lecturers for teaching. Curriculum, covering the subjects listed below, will help to implement the new substance in e-learning environment:
   1.1. Actuators in industrial automation (electrical drives, pneumatic drives) (http://www.tthk.ee/MEH/Taiturid_1.html ;
   1.2. PLC programming (http://www.tthk.ee/PLC/) and e-training course "Programmable Logic Controllers" in moodle environment (https://moodle.e-ope.ee/course/view.php?id=5264) ;
   1.3. Pneumatic automation (http://www.tthk.ee/PNEUM/) and e-training course in moodle environment (https://moodle.e-ope.ee/course/view.php?id=5266);
   1.4. Sensors in industrial automation (http://www.tthk.ee/MEH/Andurid_1.html);
   1.5. Industrial information networks (http://www.tthk.ee/INF/) and e-training course in moodle environment (https://moodle.e-ope.ee/course/view.php?id=6296);
   1.6. The use of ICT in industrial automation (http://www.tthk.ee/IKT/);
   1.7. Computer-Aided Design (CAD) (http://www.tthk.ee/RAALP/) and e-training course in moodle environment (https://moodle.e-ope.ee/course/view.php?id=5924);
   1.8. Mechatronic equipment (http://www.tthk.ee/MEH/) and e-training course in moodle environment (https://moodle.e-ope.ee/course/view.php?id=3962 .
2. **Practical training stand** for learning and teaching actuators, PLC programming and information networks. Universal practical training work station, its different parameters, deficiencies and compatibility for practical training will be investigated.
3. **Practical in-service training courses for** employees of small and large scale enterprises. New curricula was developed, considering the research

results, obtained by implementation of theoretical part of the work, and 7E model. Course materials for in-service training of employees. Testing courses and related study of students was conducted on the bases of curriculum.

I.4 Terminology – Terms and Definitions

Occupation – designated position within a hierarchy of task division, a set of tasks to be fulfilled by an individual during service or at work; wage swill be paid for the fulfilment of a job. For example: lathe operator, head of department, literature teacher at school. Occupation means, above all, the right to adopt *decisions* and the right to take *responsibility*, which will ensure automatically, as a consequence. A person, having an occupation, will constantly take decisions and fulfil tasks, related to process management. Structure and substance of tasks is often described in a job description [3]. Occupation can be also formally described, using data schemes and task fulfilment (work) algorithms. If a task is automated, it will be performed by a controller.

Accreditation – a process, involving an accreditation authority assessing entity's compliance with certain requirements. The purpose of accreditation is to determine the compliance of a quality of a certain part of education system (for example, an institution) with established requirements and grant the part concerned with activity rights. Certification authorities, incl. educational institutions and curricula (curricula groups) and accreditation authorities can be the objects of accreditation.

Accreditation authority – a legal entity, conducting accreditation, entitled to operate as an accreditation authority under law, for example, Higher Education Quality Agency (until today, KHN) [4].

Discipline – certain defined order; acting in accordance with rules; research discipline, subject [4].

Specialty – field of research, technology etc., which is narrower and more specifically defined Specialty represents a sphere of knowledge and skills, which is used to classify subjects, experts, research specialists and lecturers. Specialty can be obtained in school. In additional, job-related training will also include professional and occupational preparation and in-service training [3]. One must ensure readiness for operating as a professional in a certain field, needing to know what, when, how and where needs to be done, having the skills needed to use one's knowledge to manufacture products, considered as high-quality in society or culture, to organise the environment or to provide services. Today, it is recommended to become a documented professional in 2-3 specialties [3].

Level of education – quality class or level (competence standard), adopted to establish (implement) standard qualification framework with hierarchical structure to determine the competency of a student, which is linked to competence level measuring results of students and recognised with a document (degree, diploma or certificate), issued to the student. Level of competence demonstrates the level of competence (quality), achieved by the student.

Education system – a system of knowledge, skills, competences, values and behavioural norms of people, which contributes to consistent development, successful coping and self-actualisation as a personality and member of society. Also a system of knowledge, skills and competences, values and behavioural norms, determined by degree programmes, which is recognised by the society and checked against acquisition. Education can also mean acquisition of knowledge etc. in a certain specific sphere, but also acquisition of useful experiences in general, i.e. rather the general process of socialisation and adaptation with culture, guided by the society, in general.

Education – education is described as a set of knowledge, skills and competences, acquired or to be acquired via education system (e.g. situations where we discuss someone's education etc.). Education in most common meaning is acquired at educational institution. Such a definition of education means, above all, education as an individual resources. As the society is interested in highly educated population, education is also a social resources and providing learning opportunities for the population is one of the main functions of the public sector (Estonian Educational Forum).

Attitude – the tendency of people to gauge the nature of objects (for example; individuals, events, phenomena) in a certain supportive or non-supportive way. Such an evaluation is usually expressed as cognitive, emotional (affective) or behavioural (conative) response [4].

Inter-disciplinary – inter-research or inter-speciality, concerning a number of research fields or specialities; in pedagogy – inter-subjects. Interdisciplinary workshop, conference. Interdisciplinary curricula [5].

Profession –official result of evaluation of a person's competences, which is awarded once an institution or organisation decides that the person has the competence, needed in the profession, at the level, specified in relevant professional standard. For example: teacher's profession. Profession represents either officially acknowledgeable or acknowledged specialty-related competence (competence profile, required of a specialty). Profession means an official evaluation result that is obtained when a body, awarding the profession, will decide that the person has the competence profile, required of a specialty, at level concerned, as determined by a professional standard.

Professional preparation – a person will acquire ethical principles and philosophy, characteristic of a profession. Professional association or a certain committee will award a profession to the person concerned. A person, having mastered one specialty in school, may work in several professions. Willingness to adopt a behaviour that complies with ethical values, established in a society and culture, must be available. For that purpose, one has to adopt the methodology, applicable in professional activities, and embdace the norms and values, myths and taboos, that the given culture and society expects us to know and observe (doctor, teacher etc) [3].

Professional sphere – a field of competence that involves a number of comparable vocations.

Vocation – a sphere of competence that involves a number of comparable specialties. Area of activity, assuming similar competences.

Professional profile – description of a profession as a set of competences, whereas the proportion (importance) of each competence is identified. Description of a professional profile (professional standard) includes general human, professional, vocational and occupational competences [4].

Professional level – general description of a professional profile, which is given an agreed level number or name (for example, junior, senior, chief). Professional level can be described as universal, professional, vocational or specialty based [4].

Professional framework – a comparative framework for allocating professions and partial professions to different professional levels. Depending on whether the professional levels are described as universal, professional, vocational or specialty based, we are speaking of a single (universal) or several (professional sphere, vocational or specialty-related) professional framework [4].

Professional system – a set of activities, aimed at evaluation and recognition of work-related competences of people. Parts of professional system include development of professional standards, organisation of awarding a profession and maintenance of professional register.

Estonian Qualifications Authority – the foundation Estonian Qualifications Authority is an entity, established by labour market stakeholders to create a co-operation environment and to ensure competitiveness, transparency and equal opportunities in labour market. The Estonian Qualifications Authority will organise development of professional standards and co-ordinates the organisation of professional examinations. The main activities of the Estonian Qualifications Authority include the development of a professional system as an interface between education and world of employment and ensuring the implementation of the interface.

Area of professional activity – area of activity that involves a number of comparable vocations.

Professional level – indicates the scope of competence, required of an individual, against agreed scale quality scale); professional levels are comparable to levels of education, also demonstrates the scope of knowledge, skills, independence and responsibility, required of a profession [6].

Experiences – knowledge or skills, obtained by means of a practical experience.

Syllabus (study programme, subject card, subject passport – description of a subject that is used to specify formal parameters of a subject, methods for achieving learning outcomess and evaluation methods, substance, teaching methods, teaching materials and tutorial literature etc. In most cases, a certain standard is observed to prepare syllabuses for institutions of higher education.

European Credit Transfer and Accumulation System, *abbreviation ECTS* – student centred and result focused system, describing the scope of learning, used to express the scope of work, done by an average student to achieve the learning outcomes, specified by curricula/syllabus. The scope of learning is recorded, using credit points whereas one credit point (ECTS) of the European Credit Transfer and Accumulation System; one credit point is equivalent to 26 hours of work that a student has spent on studies. One academic year equals to 1,560 hours and 60 credit points (ECTS).

Formal education – learning that takes place within organised and structured context (at school, in a training centre, at workplace) and can be clearly classified (for the purposes of objectives, time or learning support) as learning. Formal education involves, for the purposes of a student, intention. Formal education is usually completed by awarding of a certificate [7].

Assessment – *also assessment, grading, marking* – assessment of the learning outcomess, achieved by a student, including self-assessment, which represents a part of learning process, involving the use of fixed assessment criteria to give fair and impartial assessment of the level of knowledge and skills, acquired by a student, in accordance with the learning outcomess, described in curriculum. The purpose of assessment is to support learning and provide students with reliable information on the efficiency of learning performed.

Assessment criteria – descriptions of which learning outcomes aspects will be assessed, based on planned learning outcomess yet more detailed, explaining how and to what extent a student will be required to demonstrate compliance with these criteria. Assessment criteria are divided into assessment and threshold criteria [7].

Assessment method – a method for measuring compliance with assessment criteria. Assessment method refers to a measure adopted to assess the achievement of learning outcomess written or verbal examination, project paper, presentation etc.). Most typical assessment methods are a test, essay, written or verbal examination, laboratory work, verbal presentation and research paper. Learning outcomess to be assessed will be considered for the purposes of choosing the assessment method.

Education standard – legal acts that will lay down the requirements, established for the competence of an individual, learning process or quality system.

Informal education – learning that stems from everyday activities at work, family or during free time. This is not organised or structured (with respect to objectives, time or learning support). For the purposes of student, informal education does not involve intention. It is not usually completed by obtaining a certificate [7].

Qualification – competence, acknowledged as the official assessment result. Competence to be officially acknowledged or acknowledged, involving certain rights and commitments (Scope of independence and responsibility). Qualification will be proved with a degree, diploma or some other certificate, issued by a competent organisation, which proves successful completion of a recognised curriculum [4].

Partial qualification – a part of qualification that is described and assessed as an independent unit. Examples of partial qualification are competences described and assessed independently, partial skills (for example, foreign language skills), subject course, graduation paper etc. [4].

Qualification profile – description of qualification as a set of partial qualifications, indicating the proportion (importance) of each partial qualification [4].

Qualification level – general description of a qualification profile or competence profile, which is given an agreed level number or name). Qualification can be described as universal or specialty based [4].

Qualification framework – a comparative framework for allocating qualifications and partial qualifications to different qualification levels. Depending on whether the qualification levels are described as universal, or specialty based, we are speaking of a single (universal) or several (professional sphere, vocational or specialty-related) qualification framework [6].

Qualification scheme – a scheme that will determine qualification requirements and the methods and procedure for conformity assessment [4].

Qualification system – a part of infrastructure for ensuring the quality of education, which includes the development of competence standards, methods for the assessment of competence and development of tools and conformity assessment (certification) of competences of people.

Quality system – organisational structure, procedures and resources, implemented within an education system to ensure the compliance of a person’s competence requirements (education standards).

Competence – proven ability to use one’s knowledge, skills and personal social and/or methodological abilities in work-related or learning situation and specialty related and personal development. “Responsibility” and “independence” are the terms, used to describe competence.

Competence profile – description of competence as a set of competences, indicating the proportion (importance) of each competence. It would be expedient to distinguish two aspects for the purposes of describing competency and competences [4]:

- **Expected competency,** which has a normative nature, i.e. certain (by default or documented) agreements exist in the society with regard to the competence;
- **Real competency** will characterise every specific person and his/her ability to operate in the given sphere.

Competence standard – description of expected competency, prepared as a standard. Standard represents an agreement between stakeholders of a relevant sphere, i.e. subjects of the sphere. In some cases the stakeholder may represent the society in general, for example, in case of a national curriculum of basic schools and gymnasiums. Stakeholders of a described sphere of competence, i.e. subjects of the field are always involved in the development of a professional standard as a special version of a competence standard [4].

Specialty-related competence – activity, ensuring (having ensured) success in a certain field of activity with descriptive monitored and measurable criteria. Competences are divided as follows: main competences (key competences) and domain-related (subject, professional, specialty related and vocational) competences [4].

Non-formal education – learning that is carried out as planned activities that are not clearly defined as learning (for the purposes of learning objectives, learning time or learning support), yet contain important learning elements. Non-formal education includes intention on behalf of a student. Usually the process is not completed with a certificate [7].

Module – an unit for providing semantic structure, based on learning outcomess of a curriculum, which is used to bring the subject together under a goal or only includes one subject [7]. The scope of a module, expressed in credit points, will be determined by educational institution, considering the purpose of providing the pre-requisites for supporting the mobility of students and consider previous learning results and specialty-related work experiences when determining the scope of the module.

Skills – professionalism, prowess, experience in a certain field. Skills may also represent an ability or craftsmanship for something or in a certain field. Skills for focusing attention, drawing conclusions ... etc.

Placement, work placement, internship – purposeful activities that are carried out to obtain certain learning outcomes that are obtained at practical implementation of acquired knowledge and skills in working environment, using the format, specified by educational institution and guided by a supervisor.

Study programme – aggregate name, haven to different activities, linked to curriculum administration, that involve development of curriculum, organisation of studies, financial development, required support services etc. The purpose of programme-based organisation of studies is to ensure efficient implementation of the curriculum and quality of studies. By general rule, academic employee (programme manager, curriculum manager) will be appointed to be in charge of the study programme.

Competence – integrated set of knowledge, skills and attitude, which can be evidenced and assessed, once acquired and/or achieved by a person. Learning outcomes are used to describe competences, acquired by a person in course of studies.

Certification process – activities employed by a certification authority (c-authority) to ensure that a person meets the defined competence requirements, including application, assessment, adoption of certification decision, supervision and repeated certification, use of certificates and logo/symbol [4].

Certification scheme – will determine the terms and conditions for giving a profession and methods and procedure for conformity assessment. Certification represents proceedings that area aimed at matching the competence of an entity against the requirements (competence standard) [4].

Certification system - certification process for implementation purposes, incl. a set of procedures and resources for maintaining certification, applied under a given certification scheme, which will result in awarding and maintenance of a certificate, ensuring competence [4].

Certification authority – an entity, performing conformity assessment procedures for assessing the competence of people, having been granted the right to act as a certification authority by law. Certification authority is an authority, in charge of a certification scheme, that has the key function of organising examination, by adopting purposeful competence criteria and assessment conditions. Certification authority must run a quality system that meets the standard requirements [4].

Standardisation – a process that serves the purpose of determining requirements to a person's competence, learning process or quality system [4].

Knowledge – (representations, also thinking units) represents information that is presented mentally and structured or organised in a certain way. Knowledge needs to be organised; better organisation of knowledge allows easier memorisation and more efficient use of knowledge. Available knowledge is used to describe new phenomena. The forms of knowledge are know-how, attitude, values, but also algorithms, procedures, forms of behaviour, skills.

Knowledge must not be identified as factual knowledge – these only form one part of knowledge in general.

Science – represents organised knowledge that is obtained by employing scientific methods. Science is, above all, characterised by methods that is used to acquire reliable knowledge about the world around us. Scientific knowledge is reliable if checked consistency. All scientific ideas can be checked against each other and scientists don't see them as final truths. Science may also represent a specific set of knowledge or something that scientists do; this is an activity, carried out by a scientific community.

Subject – identification of a certain group of subjects, phenomena that are discussed, studied or presented.

Know-how – know-how includes experiences, values, information placed into context, expert opinions that form a framework to be used for he collection of new experiences and new information. Company's know-how is also included in production-related documents (patens, technologies, recipes etc.) but also organisational routines, processes, practice and developed standards.

Data – detailed, objective facts describing events. Data either characterises or describes the events; they do not include assessment or interpretation. Efficient data management is one of the key criteria of success while large volumes of date are necessarily not. All organisations need data and most spheres of our lives rely on data. Data is important for an organisation as they are used to create information.

Information – can be defined as a message that is present as a communication, acquiring the form or a document or visual form. Like ever message, information has also a sender and recipient. The task of information is to influence the opinions or behaviour of recipient. Differently from data, information has a meaning, purpose and importance. Data will become information once their creator will attribute them a meaning.

Labour market – labour market represents a process of purchase and sales transaction that are mutually interdependent. Labour requirement will involve occupied and vacant jobs and the labour supply – labour employed and unemployed. Labour requirements shows how many – and which – employees do enterprises need. Labour supply shows the number of people, willing to be employed under the suggested terms and conditions.

Outcome-based education – attaching curriculum a purpose, relying upon student-centred approach, and organisation of learning activities in such a way that main attention is given to empirically measurable learning outcomes that a student is supposed to achieve as the consequence of a learning process. Traditional, input-based education is opposed to outcome-based education, focusing, above all, on communicating knowledge and skills or the input to the students.

Conformity assessment – comparing the real competence of an individual with the expected competence. Professional standard is used to describe the expected competence. Conformity assessment will be carried out by an authorised conformity assessment authority. Conformity assessment authority is an entity that carries out conformity assessment procedures and has been given the right to act as a conformity assessment authority by law [4].

Certificate of conformity – a document that indicates that an entity's competence, learning process or quality system is in conformance with a specific standard or some other normative document.

Scope of independence/responsibility – shows to what extent a person can work independently and what is the scope of responsibility that s/he takes for his/her work.

Responsibility – demonstrates an individual's ability and readiness to decide upon the influence and importance of his/her behaviour [8]. Responsibility as one of the main components of human ethics is considered to be one of the criteria of maturity, which shows to what extent an individual acknowledges him/herself and surrounding environment [9]

Learning outcomes – I Knowledge, skills and attitude or all three in various combinations (competences), acquired as the consequence of learning, that allow the verification and assessment of existence and/or level of achievement. Learning outcomes are described at the minimum level, required for passing a curriculum, module or subject. Assessment is used to differentiate the achievement of learning outcomes at a level above the minimum [7]. II Knowledge, skills and attitudes, acquired as the consequence of learning, that are described at the minimum level, required for passing a curriculum, module or subject. Assessment is used to differentiate the achievement of learning outcomes at a level above the minimum. Learning outcomes, achieved upon graduation from higher education level studies, and their links to qualification framework are described in Appendix 1 to this regulation, «Learning outcomes by levels of higher education and their links to the qualification framework». When the curriculum provides for specialisation in one or several specialties, the learning outcomes will describe the learning outcomes that are to be achieved in the main specialty or specialties, learnt within the scope, equivalent to main specialty [10].

Subject (also subject course) – integrated unit for teaching, learning and learning outcomes of certain sphere of knowledge. Special forms of a subject include internship, graduation paper and graduation examination. Planned learning outcomes serve as the bases for the development of a subject. Subjects are formalised as syllabus.

Learning skills – skills needed to acquire (supplement, improve) knowledge, link (organise knowledge), structure and use knowledge and form and acknowledge relations between different items of knowledge and, if appropriate, also restructure the bits of knowledge. Meta level skills are also distinguished – the skills to observer and be aware of what and how is learnt, also the skills to create and maintain learning motivation [11].

Learning – certain type of change in different forms of knowledge (further: knowledge) and the methods employed to organise knowledge. This will involve adding new knowledge, adjusting existing knowledge, creation of new and reorganisation of existing relationships. In other words, learning also includes storing the outcomes of thinking in one's brain. Changes that are short-lived and/or will result in loss of knowledge and simultaneous simplification of relations between definitions aare not construed as learning. The definition of learning will depend on theoretic approach (i.e. behaviourism or cognitivism) [12].

Curriculum – a plan for semantic, time-related and organisational shaping of learning process that will determine the objectives of studies to be provided, including the expected learning outcomes, nominal length and scope of studies, terms and conditions for commencing the studies, lists and scopes of subjects, short description and possible terms and conditions for making choices, specialisation opportunities and conditions for completing studies. Curriculum, apart the curriculum for doctor degree studies, provides for specialisation in one specialty (main specialty) or several specialties (main and subsidiary specialty). Curriculum is drawn up as an official document. It is recommended to prepare a programme for the implementation of a curriculum [10].

Teaching competence – pedagogical skills of a professor/lecturer – a set of knowledge, skills, attitudes and personal characteristics that is needed for successful teaching and supporting learning process, that is expressed in work-related activities. Teaching competence will include planning the learning process, conduct of studies, assessment and giving feedback, mentoring and reviewing and teaching methodological activities [10].

Joint curriculum – a special form of curriculum that is used for organising studies in two or more educational institutions that allow acquiring higher education that have jointly developed and approved the joint curriculum [10].

Face-to-face learning – a form of learning where teacher and students share a room (classroom, auditorium, laboratory etc.), also face-to-face education [13].

Credit point – calculatory unit to calculate scope of studies. In Estonia, European system of credit points is used, which means that one ECTS is equivalent to 26 hours and the scope of one academic year is 60 credit points.

E-learning course – a subject or module which is implemented, either in full or in part, in e-learning environment (supported by ICT) [13].

E-learning – learning process, supported by ICT, which takes place in both a classroom and outside classroom or official lecture. ICT tools, Internet, digital learning materials, e-learning environments etc. are used for the conduct of e-learning, with the purpose of enhancing the quality and efficiency of learning by providing better access to information and services, more flexible teaching/learning methods, more efficient co-operation between learners and new teaching methods [13].

E-learning environment – electronic environment for managing learning materials (e.g. teaching materials and tutorials, exercises, tests) and teaching/learning processes (e.g. mentoring, feedback, homework, group work, assessment) [13].

Blended learning – a learning process that combines e-learning and face-to-face learning [13].

Web Based Training – learning process that is computer based and performed by means of Internet. Web Based Training is categorised into synchronous learning (teacher participates) and asynchronous learning (independent learning at freely chosen speed) (Distance Learning Glossary, 1999).

Proficiencies – skills acquired by learning and practicing, becoming to a certain extent automatic, for doing something efficiently and rationally. Proficiency stands for partial automation of certain activity, emerging as the consequence of practicing; people are no longer required to commit all their attention to the operation that they are performing. Attention, becoming available as the result of proficiency, can be used for some other purpose, for example, to enhance quality.

I.5 Abbreviations

ECTS –	European Credit Transfer and Accumulation System credit point
EQF for LLL –	The European Qualifications Framework for Lifelong Learning
EQF for EHEA –	European Qualifications Framework for European Higher Education Area
ISCED –	International Standard Classification of Education ISCED that was adopted at the 20th session of UNESCO (Paris, 1978)
HES –	Higher Education Standard
ENDC –	The Estonian National Defence College
MK –	Estonian Entrepreneurship University of Applied Sciences Mainor
UT –	University of Tartu
TU –	Tallinn University
TUT –	Tallinn University of Technology
VÕTA –	Consideration with earlier studies and professional record
UA –	The University Act
CSCW –	Computer-supported cooperative work
CSCL –	Computer-supported collaborative learning
ICT –	Information communication technology
EKR –	Estonian Qualification Framework

Chapter 1 Methodology for Preparing Students of Technical Specialties for Independent Work

1.1 Traditional Study Methods

When speaking about learning and teaching, we must first observe old historical models in today's context. Opposition between learning and teaching has always been there and we can trace it down to modern teaching materials and methods. Learning is an active process where we can speak about teaching activities, carried out by lecturers. Studying takes place under certain conditions that have been specifically designed to improve learning results. In this chapter I'm going to focus on five different historical opinions about learning environment, that rely on behaviourism, cognitivism, constructivism, and two further developments of humanism (Figure 1.1) to find suitable methods for communicating knowledge to students of technical specialties and the learning methods they apply.

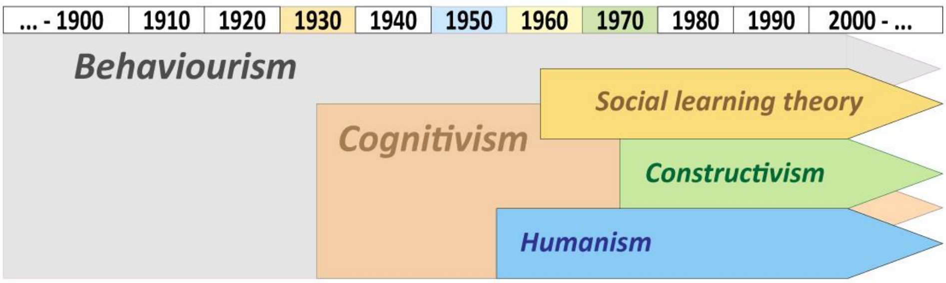

Figure 1.1 Durance of different learning and teaching theories

1.1.1 Behaviourism

According to behaviourists, the main source of learning is the inherent ability of humans and other higher organisms to avoid, based on experience, events that will result in unpleasantness or suffering. This sub-conscious motive shapes different behavioural patterns and automatic response to signals from environment in people. According to behaviourists, human behaviour in general can be explained by correct response to signals coming from environment. Behaviourists see the role of thinking as of secondary importance for learning purposes [14].

Behaviourism considers, in essence, only measurable and observable data and rules out inductive thinking, emotions and consideration of mental experiences and activities and is not interested in relationships with cognitive processes of consciousness. According to behaviourism theory by J. B Watson and B. F. Skinner, only physical behaviour is a suitable object for scientific research. Consciousness practically doesn't exist – for a behaviourist, this is a "black box" [15]. Consciousness is understood as a "black box" that obtains certain inputs (“stimuli”) and responds in a certain way. Learning – as opposed to learner – is the centre for behaviourist thinking. Theoretical and didactic problem focuses on studying the relevant stimuli and enforcing proper behaviour by employing adequate feedback. Physical punishment will be also used to obtain feedback. Such a method is comparable to technical systems in automated control theory and studying models used in the sphere of artificial intellect.

Anti Kidron has emphasised that learning technology, involving four main questions, is one of the most well-known key words of behaviourism [16]:

1. How to induce desired changes in human behaviour during teaching?
2. How to predict learning behaviour?
3. How to establish objectives that are as explicit and accurate as possible for learning?
4. How can be controlling of learning objectives used to guide the learning process?

Thorndike specifies in “The law of exercises” that values of inputs and outcomes, operating in a learning process, will strengthen, depending on the frequency for performing such processes (repetition). According to behaviourist teaching terminology, this will mean that enforcement of values will depend on the frequency of repetition. Thorndike also alleges, in his work “Law of effects”, that responses that were prepared immediately before a positive emotions will be stored better than responses that were prepared immediately before negative emotion.

Graphic chart depicts learning in accordance to behaviourist model (Figure 1.2):

- Sin (t) - marks input signal
- f(t) - external feedback
- Sout (t) - marks output
- z (t) - events that are not directly controllable, so-called disturbances

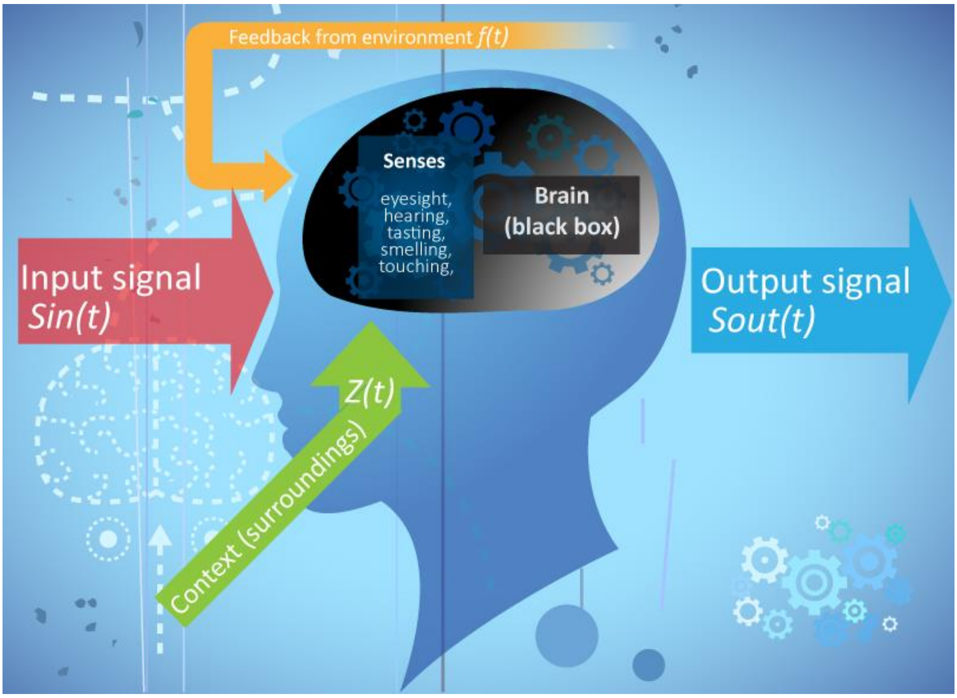

Figure 1.2 Behaviourist learning model

Skinner [17] tells us that the learning process must be divided into a large number of small strength and the achievement – condition at the end of each step – must be reinforced. "Skinner also announced that when small steps are employed for learning, the number of errors in learning process will decrease". Although this will raise a question whether avoiding mistakes during learning is sensible. Those not brave enough to make mistakes will never learn anything.

Skinner wrote in his article, "Teaching machines" [18], that mechanic equipment that are intended to reproduce teaching materials at a pace, found suitable by students, will reinforce recording of required knowledge. He invited to programmed teaching (using either the machine teaching employed or workbooks). Such a programme-teaching represents "interactive training" of a certain type.

The teaching machine, described by Skinner, works as follows:

> *One of the most important parameters of the equipment: correct answer will be displayed immediately. User interface for manipulation will maintain the information, allowing the student to use it at suitable time, every day, including checking and deleting earlier results.*
>
> *The equipment will reproduce well-planned materials; it's most efficient for the answer of a today's problem to be dependent on the result obtained while solving the previous problem. Complicated moments, supposed to create a new problem in the head of the student, are included in the process.*

The changes, planned in accordance with Skinner's theory, will release teachers from everyday routine, allowing them to fulfil more functions for improving learning didactic efforts. Mechanised studies should be integrated by all schools as supplementary training.

Behaviourist methods are suitable for adoption in the following situations:

- simple theoretic learning (for example: learning vocabulary and terminology, teaching mathematical formulae in course of a learning process)
- simple practical learning for developing psycho-motoric skills (for example: welding and metal work).

As we observe Skinner's teaching machine theory within the framework of behaviourist approach, we can establish the following requirements:

1. The contents of teaching material must be divided into small parts (learning units). Strictly structured navigation through these parts.
2. Students must be told what should be the final outcome of learning. Being aware of the goal, students can establish expectations and rate whether they achieved the expected results or not.
3. Students must be tested. Testing allows to determine whether student has achieved the final learning outcome or not.
4. Teaching materials must be ranked in an order – or sequence – that facilitates learning.
5. Students must be given feedback to allow them to see how they are doing and introduce adjusting activities, if appropriate.

There are some additional measures that can be used to enhance or at least maintain the motivation of students:

- Content multimedia, interaction and humour in learning materials to make the process fun.
- Adding libraries in the background so that students won't limit themselves to the materials presented and to be studied, but can also investigate materials that are not within immediate context or in conflict with behaviourist theory as other theories would misguide user's attention from the path of immediate learning [19].

Skinner tells that he only observes his teaching machine as a tool that should be used as and extension of teacher's hand and thought. Therefore, it should be treated as one possible way for improving learning motivation by linking behaviourist learning with a method based on learning theory, guided by a teacher (see Cognitive and Constructive Learning Methods). Such an approach is often described as "blended learning".

1.1.2 Cognitive Learning Theories

Cognition includes all conscious processes that cover issues like senses, emotions and memories.

Representatives of cognitive psychology see internal activity of an individual, expressed as an interest in surrounding world, as a source of learning. Theoretical part of most of the cognitive learning theorise are based on the general cognition process model by J. Piaget, where learning is interpreted as integration of new knowledge with existing experiences [14].

Such a model of human cognition and information processing largely imitates the work of a computer. This is a fact that has been acknowledged and accepted by most representatives of cognitive psychology [20]. According to this model, a certain sequence or chain of defined operations is involved to process the information, received by our senses. Attention mechanism, sensory register, short-term memory and long-term memory are essential tools in the chain for processing information [21].

Cognitivism emphasises internal processes that take place in one's consciousness, involving a human brain attempting to make a scientific distinction and employ relationships between every function described (Figure 1.3).

The meaning of symbols used on Figure 1.3 is the following:

- Sin (t) - marks input signal
- f(t) - external feedback
- Sout (t) - marks output
- z (t) - events that are not directly controllable, so-called disturbances

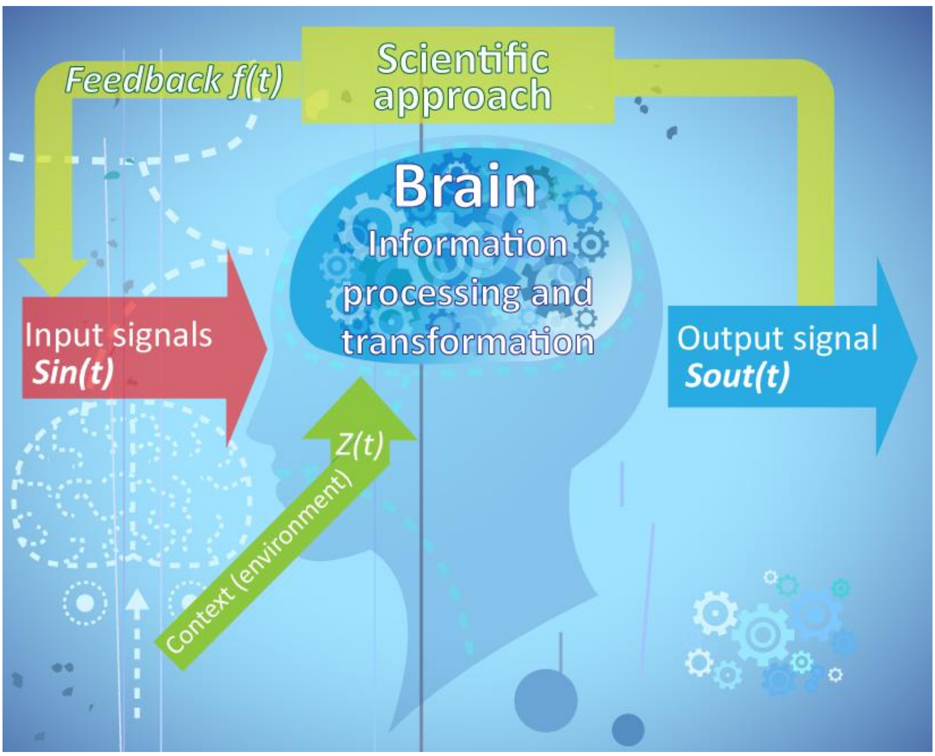

Figure 1.3 Learner's cognitive learning model

This approach also refers to brain's own capacity for information processing and transformation. Individual differences are less important than in the case of the behaviourism model.

Solving cognitive (sensory) problems represents the main way for learning, employing the correct methods and procedures that will give us to one or several right solutions. It is quite possible that there are more than just one way to take us to an optimum result.

Cognitive theories emphasise the need to assist learners in applying their knowledge and creating relationships in brain.

Requirements to assisting materials/instructions:

Good instructions must consider the current mental abilities of a student. Teachers should organise the learning process in such a way that the students can link new information with their current knowledge.

The most important tasks of a teacher are the following:

- understanding that people will apply different learning experiences in different learning situations and this may affect the learning outcomes;
- identification of the must efficient tool (method, methodology) for organising and structuring new information and employing the students' previously acquired knowledge, skills and experiences;
- organisation of practical internship and obtaining feedback that would ensure active new information that is efficiently assimilated and matches the student's cognitive structure.

The e-learning process requires us to put emphasise on active participation that would result in achieving the learner's self control and meta-cognitive training. Meta-cognitivism here means thinking part of thinking process, employing meta-data [22]; "meta-cognition" refers to a student, understanding his or her personal cognitive processes (i.e. "looking from aside"). According to this method, e-learning system should support the fulfilment of the following tasks that contribute to more efficient learning [22]:

- *planning* – students should be allowed to plan their learning process themselves (for example, how to obtain information by suggesting a calendar to be used in e-environment or some other simple planning tool like lists of learning tasks and benchmarks);
- *systematic supervision* – to determine the success of learning (for example: exercises or self-evaluation tests that offer statistic reporting on students during the learning/study period);
- *structured information* – focus should be given to structuring (hierarchic analysis, explanations and illustrations), organisation and sequencing of information to facilitate the processing process;

- learning environment should enable and facilitate the students to *create relationships* between the learnt material and surrounding environment.

According to the cognitivist theory, computer can be used to ‘design’ computer-based learning environment into an ‘anchor’ between a student and the teacher. This is described as ‘anchored instruction’ [23]. E-learning environments should support teacher’s didactic role but some have been designed to allow the teacher to fulfil the role of an instructor only, i.e. “teacher focused” learning software is created.

In the future, only a computer-based learning environment, comparable to a person, replacing the current role of teachers, is seen [24]. Should this happen, teachers should be probably re-trained to become technical learning software scriptwriters.

Understanding of this process is supported by 6D metamodel that assists teachers and learners with their personal cognition processes by enhancing the pace and quality of learning.

1.1.3 Constructivism

Constructivists say that learners interpret information and the surrounding world in accordance to their own mental reality. Definitions suggested by different authors:

1. Students will learn by observation, processing and interpretation and then they will personalise the information by transforming the results obtained into personal knowledge [25];
2. Constructivism is a learning philosophy that will suggest students a methods that can be employed to create one’s own understanding of new ideas [26].

According to Piaget, constructivism is a theory that is based on scientific results. This is different from the traditional understanding, stating that knowledge exist, regardless of the individual, that intellect is tabula rasa, a white sheet that can be used to paint a picture Figure 1.4.

- Sin (t) - marks input signal
- f(t) - external feedback
- Sout (t) - marks output
- z (t) - events that are not directly controllable, so-called disturbances

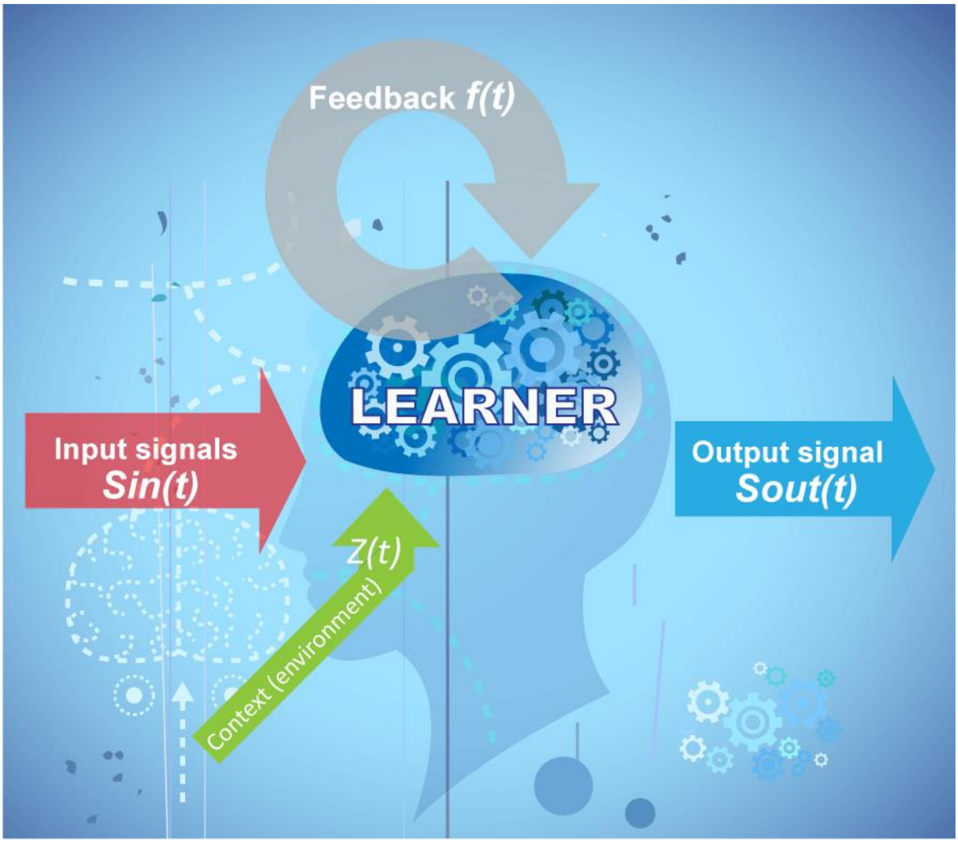

Figure 1.4 Constructivist learning method

According to Piaget's theory, individuals inherent interest in surrounding world is the mobilising force of human cognitive activities. As we grow older, cognitive maturity increases and children will acquire the ability to widen their perspectives and can adopt decisions that rely upon much larger set of experiences. Therefore, learning process moves from simpler to more complicated [27].

Thanks to a person's ability to remember activities, inspired by interest, and their results, the brain of a person will start store experiences that he described as "schemes" (scheme = reflection of experience in one's mind). During the development process, we don't only form new schemes but differentiate or integrate the existing schemes [27].

Human's development is a constant interactive process between an individual and the environment, involving individuals learning to predict and control environmental events. Assimilation or identification and accommodation or adaptation are two mutual operation mechanisms. Assimilation is triggered by reception of information for existing schemes and accommodation – upon situations where the new information no longer "fits" into the old scheme and the scheme will thus require updating. Therefore, human mind involves endless construction of knowledge and thinking schemes. As the base of experiences of every person is unique, the resulting thinking schemes are also unique [27].

The following principles should be observed for preparation and teaching of a subject [28]:

- thinking/mental structures evolve gradually, through development stages, and their development speed depends on both he subject and specificities of the student;
- by general rule, students solve their problems and discuss their potential development at a lower level;
- the absence of opportunities for disclosing one's real abilities will result in slowed intellectual development;
- students need the experience of mental activities both on lower level and edging on their abilities.

Cognitivist and constructivist approach to learning and tools needed for e-learning is comparable to production (above all, automation of production). Knowledge is, by nature, a product that is supposed to move down the production line, from the beginning to the end. This means a process for collating and automating knowledge, where knowledge is collected, organised and built up, following by processing and packaging. The process will end by delivery of the product to an individual. Students can be compared to workers and knowledge – to details that rely on data as a raw material.

Learning process, involving (or integrating) everyday learning from mistakes, learning by linking learnt subjects or learning by experimenting with human relations is covered by term "incidental learning" [29].

According to Holzinger [30], incidental learning is more efficient than intentional learning as students will rather focus on the objective or learning that the learning process itself, as they are not aware of the fact that they are learning at the moment. This explains very good learning abilities of toddlers.

Another strategy, that allows to add efficiency to learning, involves enhancing motivation (incidental or intentional learning), which relates to the excitement [31] and determining "motivating" as a function of excitement and students linking the results achieved to their behaviour. Holzinger uses a prototype system, VRfriends, within the system [32].

Here we could use a virtual avatar, VRfriends, to occasionally ask questions that a student will be required to answer. The user must find the correct answer. If the answer is correct, VRfriends will remain happy and becomes sad in case of a wrong answer. The aim here is to develop responsibility for their VRfriends, attempting to keep them happy (like similar) equipment called "Tamagotchi" that were once extensively used as toys at the end of the 1990ies.

Constructivists mention, among tools, computer-based environments that they call “microworlds” [33]. Microworld, like the name says, is a small environment that the student can enter to participate in the environment of ideas, obtain knowledge until becoming a part of the world. Individual ability to discover things becomes very important here as in microworlds, students usually acquires knowledge gradually (step by step) [34].

Constructivists also say that “experience makes the best teacher”, which reflects their conviction that we learn, in our lives, by trial-error methods and this is not negative, but very efficient instead as a student will have a chance to encounter other aspects and elements of the environment. Students will easily make mistakes in environments like that, but a mistake will result in a strong individual commitment to solve the problem.

Simulation is used as a tool in microworlds as it would be difficult or even dangerous to recreate the situation, including a training element, in reality (e.g. production process control programmes). Here we should keep on mind that an environment too realistic may be bad instead of being good as students will tend to admire the “out of body” experience far too much as microworlds will take them into an environment that they would otherwise not encounter [34].

1.1.4 Humanism

According to humanists, learning is an outcome of activities of a learner and must only rely upon internal activity of an individual. It is important to learn to learn. Individual must be open to experiences and changes, communicate and act with other people and as a consequence, new knowledge is born [35].

According to humanists, knowledge is personal, experience-based and developing in course of communication. New knowledge will be tested, analysed, assessed and will continue developing in further course of action. Learning is a process, involving people creating knowledge as his/her experiences change. Assessment to learning comes from the learner himself/herself. Evaluation of learning process, given to learning process, is of little or no importance.

In institution of higher education, workshops for first-year students, sophomores and third-year bachelor degree students could serve as an example. This would involve natural mutual learning and development. This would assume, of course, that didactic tools of specific nature, suitable for both independent and joint learning, are available. The task of a lecturer is to observe the processes and provide instructions and guidance, as necessary.

The pedagogy of Steiner or Waldorf, applied by numerous schools, could be used here as an example. This education theory is based on recognising an individual within a global and universal context, considering the effect of experience and environment during different stages and context of human’s life and learning to consider with the rhythm of humans and nature, making the most of opportunities to support development.

The contribution of humanist approach at the end of the previous century [35]:

- Emphasising human potential – equal treatment, creating atmosphere of equality – all the students will be treated with equal respect, with dignity, as everyone has the ability to grow and develop.
- Taking diversified influences, sensory world into consideration – practicing holistic approach in study and educational processes, often improving and applying cognitivist and behaviourist practices.
- Emphasising the importance of individual lifelong learning – considering with the needs of an individual, learner within the context of different stages of his life/her span.

The theory of humanist learning observes the future as a learning process within a high-tech environment, where very rapid social and economic changes take place in the society. IT (information technology) has become available to anyone wanting it, 3D technology is available, standardised learning and teaching design is dominant; active virtual participation and learning communities or me-machine personal relations, social learning. The future of humanitarian education could be the following [35]:

- fusion with standard education methods (virtual, face-to-face, standardised blended learning);
- absolute reliance on consciousness and disappearance (abolishment) of religious trends;
- using holistic approach to education as a part of internship;
- supporting the development of different pedagogic systems:
    - as closed fundamentalist systems;
    - their integrated forms and
    - emergence of new trends.
- transition from modernist to post-modernist – dissolving in diversity, fragmentation;
- supports conception of world that is based on living systems (biocentrism – *an attitude, based on respecting the nature*), which can be treated as a base science even today.

From the point of view of ecological approach to systems (Green Psychology), human mind is not unique. We can see that consciousness and levels of consciousness exist both above and below of the level of consciousness of humans as a specie.

Development and spread of deep humanism (fundamental shared/common values, transnational literacy or competence) as a phenomenon, ensuring sustainable co-existence of societies that are growing more and more apart [36].

1.1.5 Social Learning

Social learning theory emerged from behaviourist positions back in the 1960ies and the leaders of this trend studied the effect of social-cultural environment on individual's learning and behaviour [37].

Two research schools have investigated the development of web-based environments, suitable for shared working or learning, and learning processes that can be employed in such environment [37]:

1. the trend, focusing on investigation of CSCW or Computer-supported cooperative work that emerged in the middle of 1980ies as co-operative learning, serving the main goal of designing suitable learning environment for co-operative work, using computers [38];
2. the trend, focusing on collaborative or CSCL – Computer-supported collaborative learning trend, that focuses on establishment of theoretical and methodological foundation for collaborative learning, using computers [39].

Collaborative learning assumes consistent, co-ordinated and distributed co-operative work of individuals to achieve certain objectives, whereas the roles and tasks may be re-distributed during the activity concerned. During co-operative work, tasks can be distributed both by subjects, like this is done during co-operative work, or the roles fulfilled by people, responsible for the tasks, which is more characteristic of collaborative learning practice [40].

Collaborative learning also differs from co-operative work with respect to forming the knowledge and skills. In the case of collaborative learning, students need to define what their companions are thinking about and what their plans are. This will result in forming of a social (group) knowledge of each other's knowledge at a certain moment of time. None of the group members has a complete understanding of knowledge and skills, however, the group can successfully operate. Such a complex of group knowledge and skills has been also called community practice [37].

The development of individual and inter-subjective knowledge and skills through co-operative work can be explained by two principles of socio-cultural learning that were defined by L. Võgotski already back in the 1930ies:

- I principle – individual will acquire new knowledge, above all, through co-operative work that s/he can understand and perform, relying on companions, who already have the required knowledge and competence (e.g. teacher, parents). Knowledge and competence of ain individual will therefore evolve as the consequence of understanding and acceptance of shared knowledge and practices of the group.
- II principle – by nature, learning is rather a social than individual phenomenon, involving the engineering of knowledge and emergence of skills by means of interaction with other individuals, using tools,

characteristic of the group or by implementing objects to reach a common goal.

Individual learning is, above all, a process, involving an individual acquiring more and more cultural practices or methods of a certain type, moving, towards the process, from the status of a peripheral member of some practical community towards the nucleus of the community or full control/mastering of the practices and knowledge/know-how. The other level includes improvement, development and constant changing of learning process and community practices [27].

Knowledge and know-how emerge, in practical communities, not only from fragments of knowledge, available to every individual, and contain parts of knowledge and skills of other individuals, but, above all, from relations – mutual relationships between individuals during the performance of a certain activity (for example, their role division and rules that are observed); tools that they use; environmental conditions that provide for the performance of the activities [41]. Bereiter (2002) describes, as one more important type of knowledge/know-how, the output produced by learning communities – intellectual capital, which can be separated from community practices and used, separately, by other individuals and communities [41].

1.1.6 Contemporary Teaching and Learning Methods and Their Importance for Learning Process of Students – Blended Learning

The definition of blended learning is of American origin – „blended learning" first used to mean training, offered by private sector training companies, employing, in combination, both traditional training methods and training, involving technological tools and means [42]. Theoretical approach to pedagogy has not reached a consensus, regarding the substance and meaning of blended learning, and it is not possible to provide a common and uniform interpretation of the sphere of blended learning. The term – blended learning – usually means teaching, combining face-to-face learning and teaching/learning process that employs technological tools. However, there are many different approaches to practical blending issues. In most cases, authors focus on the question of skilful blending of two different communication tools. The proper approach requires weighing the opportunities, advantages, priorities for both face-to-face learning and technological tools available in every single case. Blended learning is not a new phenomenon in higher education. Only the understanding of the number of components to be combined and blended can be described as new. Every single institution has to decide, relying on selection criteria determined earlier, upon the ratio of face-to-face and e-learning to be adopted, attempting to achieve a result that is, didactically, most justified. Regardless of the combinations, it is always most important to focus on the expected learning outcomes. Learning outcomes play a central role for assessing the sustainability of learner, culture, available teaching materials, (technological) infrastructure and teaching work.

It is not possible to squeeze the interpretation of blended learning directly into any learning theory network. We're rather discussing a methods within the framework of different pedagogic approach. Different materials that discuss the issues of blended learning use different theories [43].

Gunther [42] raises four important didactic issues for the purposes of practical blended learning:

1. What sort of knowledge does a learner needed and what type of pedagogic tools are needed to achieve the desired result?
2. How should be the learner's "space" organised?
3. How to create the necessary learning milieu?
4. Which tools does the teacher/lecturer need to support the choices, described above?

According to Gynther [42], the definition of blended learning should be directly linked to specific didactic methodology. Gynther [42] suggests that the use of the term of blended learning should not be limited solely to the idea of blending face-to-face and e-learning. The combination should include the dimensions of substance of learning and pedagogic methods and semantic understanding of which tools should be used in case of the specific teaching/learning methods and substance of learning concerned. It is important to prefer technological solutions that support the chosen didactic methods. According to the approach, adopted by Gynther [42], the term "blended learning" refers to both pedagogic approach, teaching/study methods, use of media, technology and their mutual relations, considering, of course, what is being learnt.

Wiepke [44] has depicted holistic approach to blended learning visually (Figure 1.5) indicating the components of blended learning, which are linked to constructivism, cognitivism, behaviourism, asynchronous and synchronous teaching and communication and media not linked to web and web-based media.

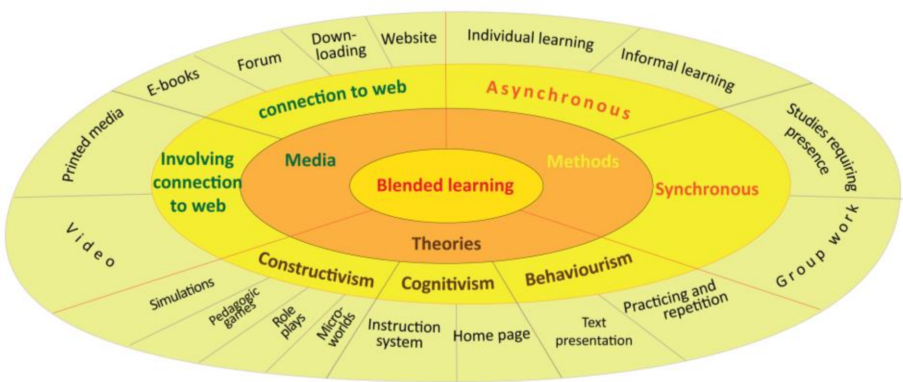

Figure 1.5 Holistic approach to blended learning [44]

Torrão [43] suggests that the following aspects should be considered before a blended learning course is launched:

1. What are the advantages of face-to-face learning?
2. What are the known dangers that accompany virtual learning?
3. Which parts of training should be preferably planned as face-to-face learning and which components can be web-based?
4. What to consider for choosing different (technological) tools and so-called mediated teaching methods?

It’s highly important to be aware of the possible threats and first consider the learning process in detail. Each tool and teaching methods has its advantages and disadvantages, every chosen method can both support and restrict the student’s and lecturer’s opportunities for acquiring the material [43].

Gynther [42] recommends to consider the following details for planning blended learning:

1. Does the chosen medium allow the student to observe communication from the lecturer?
2. Does the chosen medium allow the lecturer to observe communication from the student?
3. Does the chosen medium allow the student to observe the learning process of other students?
4. Does the chosen medium allow the student to obtain consistent overview of his/her own learning process (activities, outcomes etc.)?
5. Do the chosen communication tools and environment ensure the student with an opportunity for obtaining information and communication?
6. Do the chosen communication tools and environment ensure the lecturer with an opportunity to organise communication between the lecturer and the student? Between students and for group work purposes?
7. Do the chosen communication tools and environment contribute to creation of general positive learning milieu?

The use of blended learning will offer lecturers many different opportunities for communicating information to students. This will ensure students’ enhanced readiness to acquire the information. In addition, blended learning will offer new didactic opportunities and in training groups, consisting of students with uneven level of knowledge and skills, there will be more alternatives for learning the material [43].

Several institutions of higher education that participated in the „B-Learn“ project have stressed that the learning outcomes of students improved after the employment of blended learning [43]. For example, using blended learning for a course conducted by University of Helsinki, Data Analysis II (30% web-based, 30% face-to-face and in average, 30% independent learning), used to improve the learning outcomes of second and third year students of social sciences [45].

Organic chemistry course can be suggested as an other example – examination results of biology bachelor degree sophomores of Tallinn University improved [46]. The students' feedback to both blended courses was positive [20].

Blended course, Physics of Dynamic Systems, by University of Porto was compared by Villate [131] to another course, organised earlier, using face-to-face learning, Classic Mechanics; the results showed that apart improved learning outcomes, the number of students skipping the course also diminished from 34% to 14%. In addition, Villate [131] noticed that the proportion of those successfully passing the course increased from 43% to 94% and the proportion of those participating actively yet failing at graduation examination dropped from 47% to 13%. Moodle learning environment forums, chat room, tools and tasks, questionnaires and dictionary were used at the blended learning course [20].

Chen Michigan from Flint University and Jones from University of Illinois [48] investigated the opinion of master degree students of North-American universities on both the traditional and blended learning accounting course. One of the groups passed a course, that was fully based on face-to-face approach (38 students) and the other group (58 students) – as blended learning course. The results showed that those participating in blended learning course assessed the growth of their analytical, inter-personal and computer literacy skills to a higher level than the students of the other group. In addition, the participants of blended learning course gave higher rating to the lecturer, understanding of the subject, usefulness of the course and they also enjoyed the course more than the participants of face-to-face course. 90% of the participants of the blended learning course wanted to use the same learning methods also for their consecutive accounting course [48] [20].

Pereira, Pleguezuelos, Meri, Molina-Ros, Molina-Tomas and Masdeu [131] conducted a study at Pompeu Fabra University, Spain, to explain how does the use of blended learning to teach human anatomy will affect the results and satisfaction of students. 134 biology students of Pompeu Fabra University took part in the study. Blended learning was carried out in one group (69 students) while traditional group consisted of 65 students. Although similar tools were used to test both groups, statistically, the grades received by blended learning group were much better (6.3 versus 5.0; $P < 0.0001$). In addition, the share of those passing the examination at the first attempt was also higher (87.9% versus 71.4%; $P = 0.02$) while the percentage of those attending the examination yet failing was lower (4.3% versus 13.8%; $P = 0.05$) than in those participating in blended learning course. Both groups came similar feedback to the human anatomy course [131]; [20].

Face-to-face learning has become one among many different learning and teaching alternatives. Paradigmatically, blended learning is not an independent method but instead, one of the possible means for transferring education among different pedagogic models [43].

1.1.7 Summary

In the case of behaviourist approach, the main task of teacher is to provide students with stimuli and then confirmation to their responses. Students will respond, passively, to external influences. In today's education system, behaviourist approach is still quite common.

According to the cognitivist methodology, teachers should mostly assist in learning and developing independent learning skills in students.

According to the social learning theory, teachers will create, by their authority and personal example, new behavioural models which the students will copy/imitate and thus acquire. Main purpose of teaching is to support socialisation process.

Humanists see supporting students' self-actualisation as the main purpose of teaching and education. Learning, based on self-regulation, plays a highly important role in teaching students and adults. Teacher remains in the background and will be equal to any other person, standing by the learner.

Teaching is, according to constructivism, an activity that is expressed in a dialogue with students, attaching meaning to their surroundings. Teacher remains at the same level with all the other sources of learning. Knowing different learning approaches and theories will give us fulcrum for acknowledging our own understanding of learning. To understand learning, a student must obtain a visual overview of learning process, learning and teaching, while also understanding how s/he will acquire new knowledge and skills, how attitudes and values evolve and how we experience emotions.

Blended learning is understood as a combination of face-to-face learning and teaching involving technological tools. We must observe blended learning, for teaching technically complex and complicate disciplines, as a special symbiosis of methodologies. Here, apart face-to-face and information communication tools we need to employ technical tools that are meant for developing practical skills.

There are still several different approaches to practical blending and combining. In every single case, one must weight all the opportunities, advantages, priorities accompanying the use of both face-to-face, practical and technological tools. Blended learning is not a new phenomenon in higher education. Only the understanding of the number of components to be combined and blended can be described as new.

To see the complete picture we need to employ individual's ability to acquire graphic information at a faster pace to obtain a quicker and easier overview of the processes that take place in reality. For that purpose, we must give the subjects (students and lecturers) a visual overview of the learning process, learning and teaching. Students and lecturers will create dynamic models of real objects within their mental space for the fulfilment of visualisation tasks (as a part of learning).

Five main fields need to be analysed in the sphere of blended learning:

1. Students and their self-regulation;
2. Pedagogic skills and methods of lecturers (instructors);
3. ICT (information communication) technology and the opportunities it provides for visualisation of mental models and real objects;
4. E-learning courses and study objects and their structure and feasibility;
5. Main technical tools for practical studies and their feasibility for the purposes of real-life work procedure and operations.

Every single institution of education has to decide, relying on selection criteria determined earlier, upon the ratio of face-to-face and e-learning to be adopted, attempting to achieve a result that is, didactically, most justified. Regardless of the combinations, it is always most important to focus on the expected learning outcomes. Learning outcomes play a central role for assessing the sustainability of learner, culture, available teaching materials, (technological) infrastructure and teaching work.

Blended learning will allow to learn the knowledge, provided by a subject or discipline, at most suitable time. It's very important that quite often, students can find practical use for their knowledge, using technical tools. Such a practical process will allow students to obtain experienced information, using the knowledge that is already available. Therefore, students who have acquired real experiences, feel smarter.

1.2 Education Topology and Schemes

1.2.1 International Classification of Education

The International Standard Classification of Education (ISCED) was devised by UNESCO in the beginning of the 1970 ies as a suitable tool (or classification) for collecting statistical information about education, preparation and submission of reports in both different countries and at international level. The classification was approved by an international education conference (Geneva, 1975) and later also UNESCO's General Conference that adopted a document called "Revised Recommendations for International Harmonisation of Education Statistics" [7] on its 20th session (Paris, 1978).

The classification that is known as ISCED 1997 (hereinafter the Classification) was approved at the 29th session of UNESCO's General Conference in November, 1997. The classification was prepared by a work-group, established by UNESCO's Director General for that specific purpose, as an outcome of extensive global consultations. The classification includes two dimensions, using levels of education and fields of training as variables.

The ISCED-97 levels, names of stages and the meaning of appropriate codes is explained as follows. The first digit in level code is determined by stage code. Two symbols or additional dimensions or a combination of a letter and a number will be added to the latter. The character will express the type or final target of continuing education. The other or numeric dimension will indicate the bias or orientation of curriculum. The second additional dimension at level 2-3 divides curricula into three classes: 1 - general education, 2 – education preceding vocational or technical education, 3 – vocational or technical education. The second additional dimension, used at level 5, will characterise the national degree and qualification system [49].

Table 1.1 ISCED (International Standard of Classification of Education) is a uniform classification of international education [49].

Name of level	Level code	Type or final target of continuing education
Primary education	0	Absent
First level education Primary education	1	Absent
Lower secondary education Second stage of basic education	2	2A: curricula devised for progressing directly to stage 3 for further progress (i.e. admittance to stages 3A or 3B), whereas such a progress is one stage of education, that will finally take to tertiary education 2B: curricula devised for progressing directly to stage 3C 2C: curricula devised for entering labour market after the completion of second stage of basic education (sometimes also called terminal curricula)
Upper secondary education	3	3A: curricula devised for progressing directly to stage 5A 3B: curricula devised for progressing directly to stage 5B 3C: curricula that are not devised for progressing directly to stages 5A and 5B
Post-secondary, non-tertiary education	4	4B curricula that won’t allow to continue from stage 5 (are devised, above all, for entering the labour market) 4A: curricula that prepare for entering stage 5

First stage of tertiary education (will not provide the qualification, needed for high-level research work)	5	5A: curricula that are based on theory and prepare for research or provide the opportunity for working in an occupation that requires high level of skills 5B: curricula with practical, technical or vocational character
Second stage of tertiary education (will provide the qualification, needed for high-level research work)	6	Absent

The final targets of a student, studying in accordance with a curriculum, are marked with three letters:

A – will take to next, higher level; represents a shortcut for reaching ISCED 6.
B – will take to next, higher level; however, does not represent a shortcut for reaching ISCED 6.

C – will not take to a next stage.

The original version of the classification represented a two-dimension approach to curricula, level of education and field of training being the independent axes. The mentioned visually crossing axes or reference scales are also maintained in updated classification description.

According to the classification, curricula are also described as two-dimensional – by stages and fields of training, whereas both variables are independent of each other. Therefore, every curricula can be allocated, in essence, to one and only one cell of two-dimensional cross table of education. Of course, all the possible pairs of types of education (simultaneous presence) are neither possible nor needed [49].

1.2.2 Structure of Education in the Republic of Estonia and Classification of Levels of Education in the Republic of Estonia

Over the last two decades, the rules and identifiers used for linking curricula to certain levels of education have been specified in the Republic of Estonia during the implementation of original version of classification and the division of fields of training has been developed to a further level. This resulted in a valid structure of education in Estonia, which is depicted in the figure below (Figure 1.6).

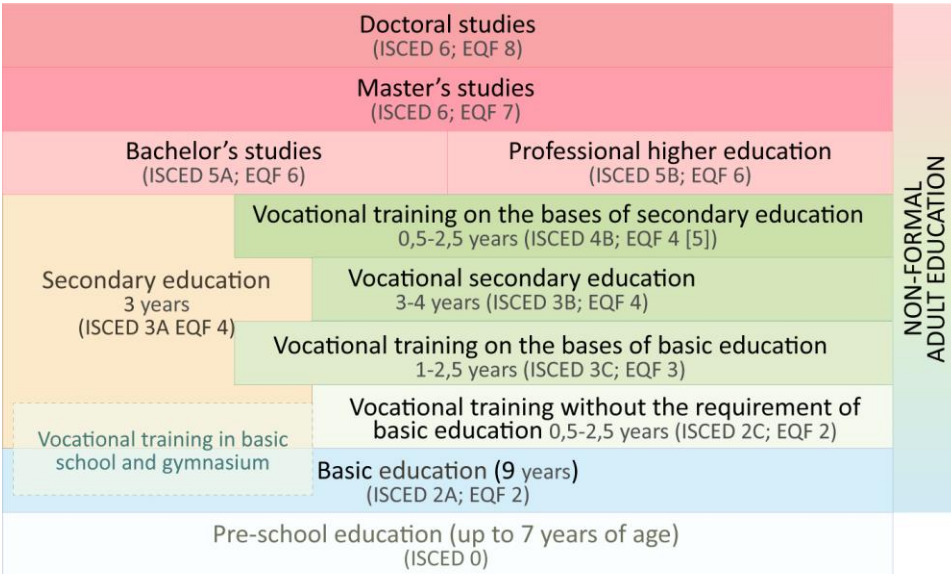

Figure 1.6 Links between levels of education in Estonia and the European qualification framework [50].

The European Qualification Framework (EQF) is a comparative framework for different qualifications (general education, vocational education, higher education and professional qualification (in-service training and re-training)) which will link the qualification systems of the EU countries to each other (see further in Chapter 1.3.1).

In the sphere of higher education, the European common lifelong learning space idea is implemented within the framework of the so-called Bologna process and in the sphere of vocational education – within the framework of Copenhagen process. Implementation of the principles of earlier studies and working experience (VÕTA) and the systems for accumulation of European credit points – ECTS and ECVET – represent essential parts of these processes. The European Higher Education Area (EHEA) qualification framework (QF-EHEA) was also developed within the framework of the Bologna process. The recommendation of the European Parliament and Council for the implementation of EQF (2008) also includes the principles for ensuring the reliability and quality of qualifications [51].

The following development plans and strategies are available in the sphere of adult education in the Republic of Estonia:

Development plan of the Ministry of Education and Research (for a four year period, with rolling interval), "Tark ja tegus rahvas" (Smart and Entrepreneuring People);

- Development plan of the Ministry of Education and Research (for a four year period, with rolling interval), “Tark ja tegus rahvas” (Smart and Entrepreneuring People);
- Development Plan for the Estonian Vocational Education and Training System 2009 – 2013;
- Higher Education Strategy of the Republic of Estonia 2006 - 2015;
- Strategy for internationalisation of higher education in Estonia 2006 - 2015;
- Adult Education Development Strategy 2009 - 2013.

Educational *acquis* includes the Education Act and legislation that regulates the running of different types of educational institutions (pre-school child care institutions, basic school and gymnasium, vocational educational institution, institution of professional higher education, university, hobby school, private school). Only the Adult Education Act mostly focuses on learners, and not educational institution. Such a structure of educational *acquis* does not facilitate the development of a lifelong learning system [52].

Estonia has a well-established network of educational institutions (according to the information, available from EHIS for 2009/2010 academic year, there were 638 pre-school child care institutions, 253 basic schools, 240 gymnasiums, 51 vocational educational institutions, 22 institutions of professional higher education, 9 universities, 417 hobby schools that are run by either state, local government or a private person). There are more than 1,000 in-service training establishments for adults.

Main standards of education, based on learning outcomes, have been developed:

- Vocational education standard and 53 national vocational education curricula;
- Standard of higher education;
- Professional standards (so-called 2nd generation professional standards).

Systems for ensuring learning quality, relying upon different principles, are used in higher education (built in accordance with the principles, agreed within the framework of the Bologna process) and vocational education (internal evaluation, taking constantly base in educational institutions, periodic external evaluation, case-based state supervision). Quality assurance within the vocational system is ensured by compliance with ISO 17924 standard (General requirements to certification authorities of persons). Regrettably, the system for ensuring learning quality in adult education system is practically missing [52].

The main problems, encountered in the education system of the Republic of Estonia, are the following:

- Large parts of the education system (for example, vocational education system, higher education system, adult education system) and its support structures (standards, qualification system, quality assurance, support structures that offer social support and protection) are not linked at required level and not operating in full.
- Early selection, taking place in formal education system and, above all, excessive differentiation of secondary education and its extremely uneven quality will considerably restrict the academic – and later employment-related – movement of students.

Background information of the Estonian Education Strategy 2012–2020 [52] shows that the following problems have not been solved at required level within the last 10 years:

- even before acquiring professional education, a large number of students have terminated their studies (according to the targets, the respective number should be less than 9%);
- progressing to higher education level from vocational secondary education level;
- professional orientation is very insular for different types of formal education; attempts are made to focus only to the labour market requirements and there is no systematic approach;
- implementation of education standards, relying upon learning outcomes, is often not linked to the assessment, based on learning outcomes;
- involvement of stakeholders into standard development process is not systematic and often there is no complete analysis available on the effects of the standard;
- non-uniform level of quality assurance between educational institutions. Most of the educational institutions have not developed a quality culture to be considered with;
- the results of the adult in-service and retraining audit, conducted by the National Audit Office [53] show that the organisation of adult in-service and retraining efforts are not systematic, well-elaborated and won't support the acquisition or supplementation of one's qualification.

1.2.3 Estonian Qualification Framework

The establishment of the Estonian qualification framework (Estonian QF) started back in 2005, when the Minister of Education and Research established a wide-based work group that was given the task of analysing the first draft of European Lifelong Learning Qualification Framework (EQF) and the options for referencing the Estonian five level vocational qualification framework to the EQF and make proposals for the development of Estonian qualification framework. The work group made a proposal for the establishment of eight level comprehensive national qualification framework. The proposal was supported by representative organisations of employers and employees, Estonian Chamber of

Trade and Commerce, the Ministry of Social Affairs and the Minister of Economic Affairs and Communications [50].

The comprehensive eight level qualification framework was established in Estonia in 2008 with a new Professions Act [50]. The qualification framework consists of four sub-frameworks that include the following level descriptions:

- formal education qualifications
- vocational education qualifications
- higher education qualifications
- occupational qualifications or professions

The descriptions of levels of qualification framework determine the general requirements to education system, learning outcomes by levels of education and professional levels of professional system that are grouped as follows:

- knowledge (distinction is made between theoretical and factual knowledge) - information;
- skills (distinction is made between cognitive: use of logic, intuitive and creative thinking, and practical skills: manual skills and the use of methods, materials, tools and devices) – use of information;
- scope of responsibility and independent activities – trust.

While, for the purpose of intelligently defined competence, knowledge, skills, experiences, proficiency and attitude are involved, the general EQF requirements do not include proficiency and attitude. This is a deficiency. At the same time, a group called "Scope of Responsibility and Independent Action", that includes terms and definitions that can be associated to definitions of attitude.

Relations between Estonian QF with the EQF took place from December 2008 through August 2011. The establishment and implementation of the Estonian QF based on responsibility and quality assurance principles that have been laid down by the European Parliament and Council for the implementation of EQF.

Table 1.2 Outcomes of referencing formal education qualifications to EQF levels presents the outcomes of referencing Estonian formal education qualifications [50].

Table 1.2 Outcomes of referencing formal education qualifications to EQF levels

Formal education qualifications	**Name of formal education graduation document**	**EQF levels**	**Professional titles** *Examples*
	Leaving certificate on passing of coping curriculum	1	
Basic education	Leaving certificate of simplified curriculum	2	
Basic education	Basic school leaving certificate	2	
Vocational training without basic education requirement	Vocational qualification certificate without basic education requirement	3	Electrician, indoor installations, level 3
Vocational training based on basic education	Vocational qualification certificate based on basic education	3	Electrician, outdoor installations, level 4
Secondary education	Gymnasium leaving certificate	4	Electrician, indoor installations, level 4
Vocational secondary education	Vocational secondary education certificate	4	Electrician, outdoor installations, level 4
Vocational training based on secondary education	Vocational qualification certificate based on secondary education	5	Electrician, outdoor installations, level 5
Bachelor's studies	Bachelor degree	6	Engineer
Professional higher education	Professional higher education diploma		
Master's studies	Master's degree	7	Statutory engineer
Doctor's studies	Doctor's degree	8	Authorised engineer

Estonian occupational qualifications or occupations are referenced to all the eight EQF levels. Their total number is 620 (see the qualifications register [54]). Occupational qualifications can be also obtained by means of formal education, adult education and in-service training.

1.2.4 Higher Education Curriculum Development

For bringing the competences of university graduates and employees of companies into compliance with labour market requirements, the professional system will establish typical (standard) set of competences, required for working in different professions (different roles) and appropriate professional standards will be developed for each and every one of them. Professional standards are the tools for assessing competence and this is described as awarding a profession. Professional standards allow institutions of education to improve their training, in-service and retraining systems.

Labour market, learner and the qualification system, which consists of education and professional system, should be fitted into a uniform, well-structured and mechanised information field (Figure 1.7). Unfortunately, the Republic of Estonia lacks a uniform structured model of qualification system and labour market information and an information system that would help to co-ordinate the functioning of economy. Quite often, both labour market participants and learners are left out of information field development process and this will result in difficulties for interpreting information flow structure and implementation.

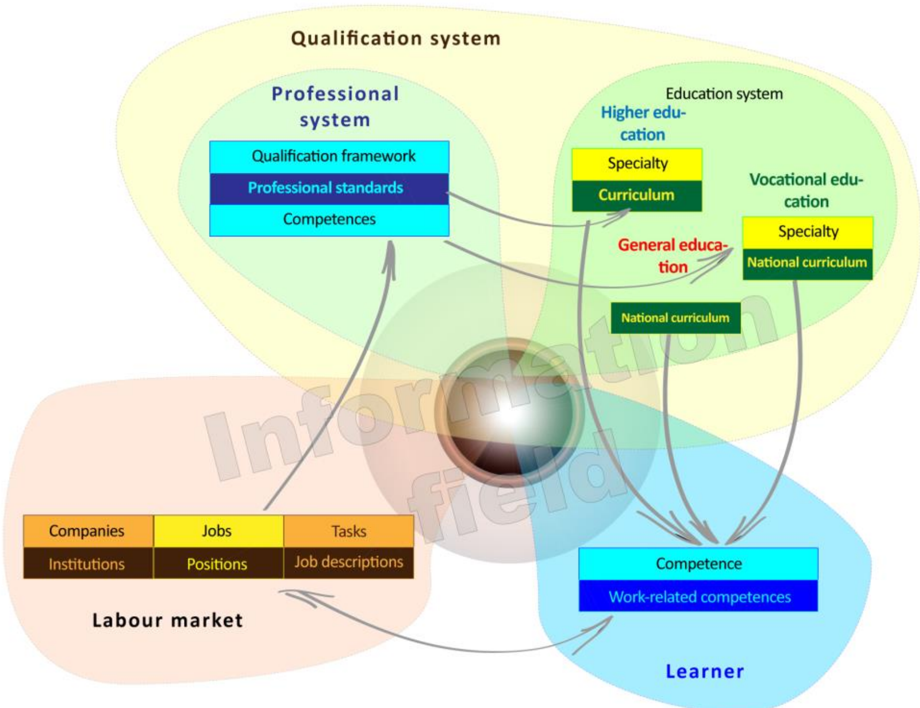

Figure 1.7 Professional and education system information fields form the qualification system information field, which is referenced, by means of interfaces, to labour market and learners' information fields. The arrows show information flow movement between different parts of the common information field.

Important shared part of professional and education system is represented by education standard, using curricula as their output.(Figure 1.8) depicts the information flow, currently implemented in the Republic of Estonia, which depicts the professional system referencing labour market to the education system [6].

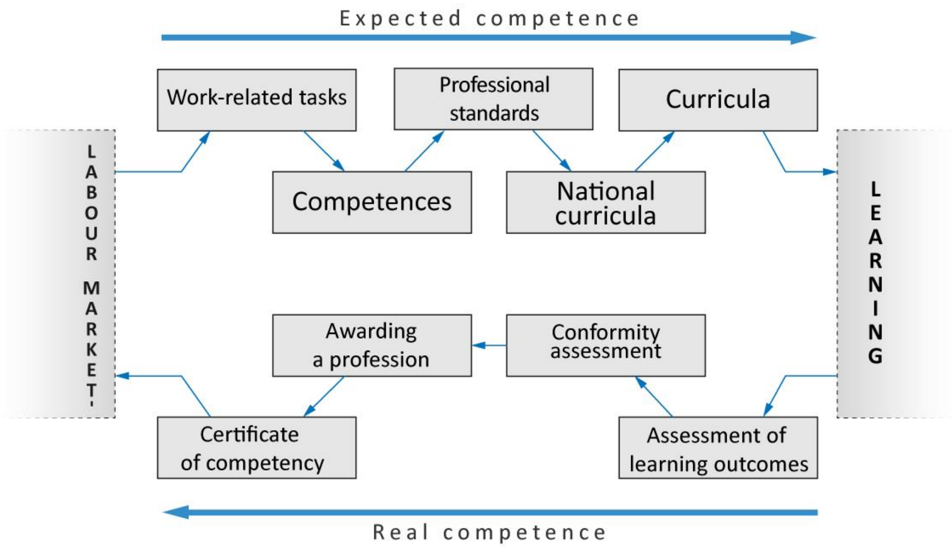

Figure 1.8 Circle of competence of professional system

Tallinn University of Technology (TUT) is a part of higher education system of the Republic of Estonia. TUT is one of the most rapidly developing universities within European context. The Bologna process is one of the factors that has the strongest influence of higher education in Estonia and therefore, also for the development of curricula of the Department of Power Engineering. One of the main goals of the Bologna process is to reach a system of easily understandable and comparable professional degrees in Europe that would support the mobility of students and free movement of labour. Most naturally, comparable length of study cycles is one of the indicators, ensuring comparability and this resulted in so-called 3+2 reform in Estonia. Using learning outcomes to describe curricula allows, in essence, to take earlier studies and working experience into consideration as a part of higher education (VÕTA), thus supporting lifelong learning [55].

Apart comparability and comprehensibility of higher education qualification, the output-based curricula development will also serve to support other goals of the Bologna process, including strengthening of trans-European co-operation for quality assurance purposes, development of lifelong learning as a natural part of European higher education space, strengthening the social dimension of higher education and enhancing the attractiveness of European higher education space in the world in general [55].

Figure 1.9 depicts topological links between professional and education systems that form the qualification system and labour market stakeholders, students and government institutions. The links and references are characterised by movement of complex information flows; parties of the communication process should know and understand the structure and formation of the information flows. Only living persons (incl. employees and students) will communicate information flows to higher levels of the structure of information. According to the ontology to be adopted, dream and trust are the highest levels of information [56]. Curricula of institutions of education are not alive; restricted structure of information won't allow the creation of data flows at the aforementioned levels.

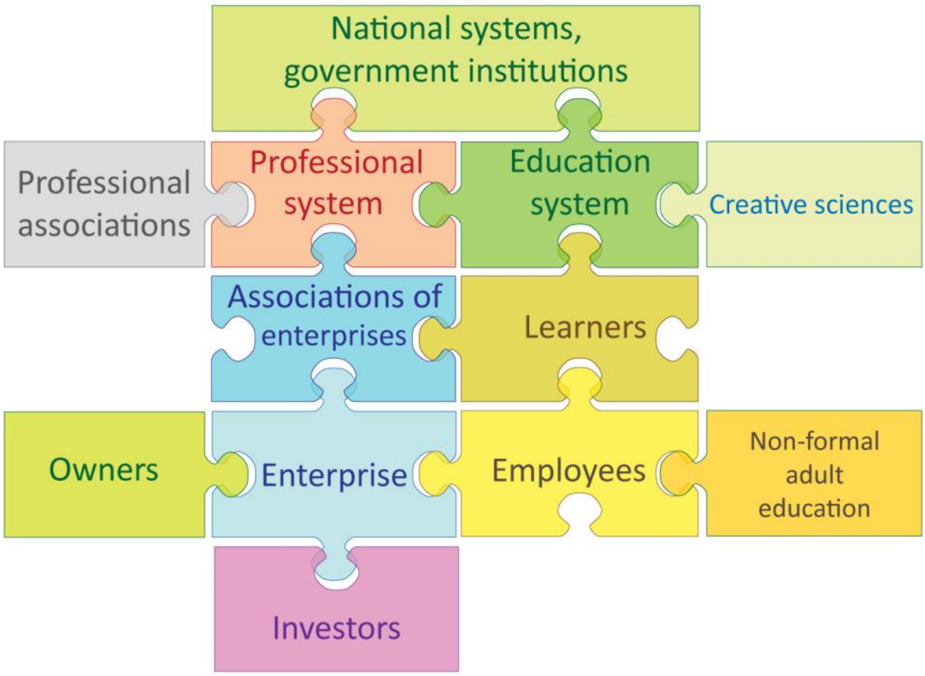

Figure 1.9 Reference links between professional and education system

Curricula reforms that take place in Estonia and Europe focus mainly on learning outcomes. Until now, input-based approach has been applied in several countries. Governments are applying, more and more, for better matching of professional education of learners with labour market requirements of the institutions of education.

Interests of learners and achievement of personal life objectives is supported, within the framework of opportunities available, by study programmes offered by education system, professional system and associations that offer non-formal adult education; the programmes are defined as curricula.

Three main focuses must be observed for the authorities involved for the purposes of curriculum development [55]:

- In the case of input-based learning, focus is given to substance of learning or the theories, authors, research achievements etc. that are taught.
- Output-based learning gives the central role to learning objectives and assessment, therefore, output-based curriculum serves as instructions for both the learners and teachers.
- Process-based learning that focuses on the learning process. Here the goal is to create a learning environment that would support the achievement of very different goals by very different learners. Process-based learning honours teaching skills; students are not selected upon admittance to institutions of higher education and good learning experience is a pre-requisite for good learning outcome.

As a learner's learning outcomes are most important for his/her coping and therefore, also the quality of education, curriculum is, above all, expressed by means of learning outcomes although input and process, the lack of which would make the achievement of learning outcomes highly complicated, if not impossible, is also considered important [55].

Threats in curriculum development process:

- Focus is only given to learning outcomes and their assessment, forgetting about the importance for updating the inputs and processes (lecturer, learners, methods, time, teaching materials etc.). Not everything can be reliably assessed in education and apart the learning outcomes described and assessed, studying in an institution of higher education will also give knowledge and skills and the skill for their implementation, which can't be measured yet are highly important in later life. This is why it is important to consider, for the purposes of curriculum development, that apart the outcomes described, students will learn much more.
- Values of new curricula. Apart the lack of material resources, the lecturers' skills to use teaching and assessment methods and their resources (time, number of lecturers etc.) may be limited.
- The main problem of Estonian (and not just Estonian) institutions of higher education is the fact that outcome-based approach is strange for Estonian German-originating learning and teaching culture and requires changing of paradigms, which is a very long process.
- The tighter are the links between higher education and labour marker, and this is matched against pragmatic criteria, the bigger will be the threat of adopting a too restricted approach to materials learnt. Employers often assume that what is learnt in institutions of higher education, is too wide-based and most of the information acquired

will never used in real working life. The education, given by academic institutions of higher education, is also too academic and sufficient attention is not given to applicability.

As for the definition of 'academic higher education', the word „academic" stands, above all, for something related to research institutions or institution of higher education, but also compliance with traditions. "Applied" means purely practical importance and something that can be applied in practice. Antonyms are applied and theoretic, not applied and academic. Therefore higher education can be academic and must be applied [55].

1.2.5 Curriculum of the Specialty of Electric Drives and Power Electronics

Bachelor's studies (AAAB02) and Master's studies (AAAM02) in the specialty of „Electrical drives and Power Electronics" are offered by the TUT Faculty of Power Engineering. European Credit Point (ECP) is used [36].

The curricula were accredited by an international commission in 2006. Standard period of study in the specialty of electric drives and power electronics is, respectively, 180 ECP and 120 ECP for bachelor's and master's studies.

Graduates acquiring bachelor's degree will have obtained interdisciplinary knowledge about the following subjects: production, assembly, sales and provision of quality services to clients. Accordingly, the contents of bachelor degree curriculum assume knowledge of the following disciplines: mathematics, physics, computer sciences, electrical engineering, engineering industry, electro technology, technology of materials, electrical drives, electronics ja power electronics.

Graduates of master's studies curriculum must have the knowledge for designing and tuning electrical engineering systems. Therefore they will be given additional knowledge about automatics and programmable logic controllers, computer studies, electrical drives, power electronics, production technology, marketing, maintenance and servicing.

Curriculum can be depicted as a two-dimension system where the subjects, related to the chosen science, are referenced to transferrable knowledge flows.

Blue arrows depict subjects that are directly related, i.e. the subject shown in the beginning of the arrow needs to be taken before the subject, shown at the end of the arrow, can be taken.

Specialties are divided into general training (G), initial training (B), basic training (C), and special education (S) [36].

Bachelor's studies curriculum is depicted on Figure 1.10 and master's degree curriculum on Figure 1.11.

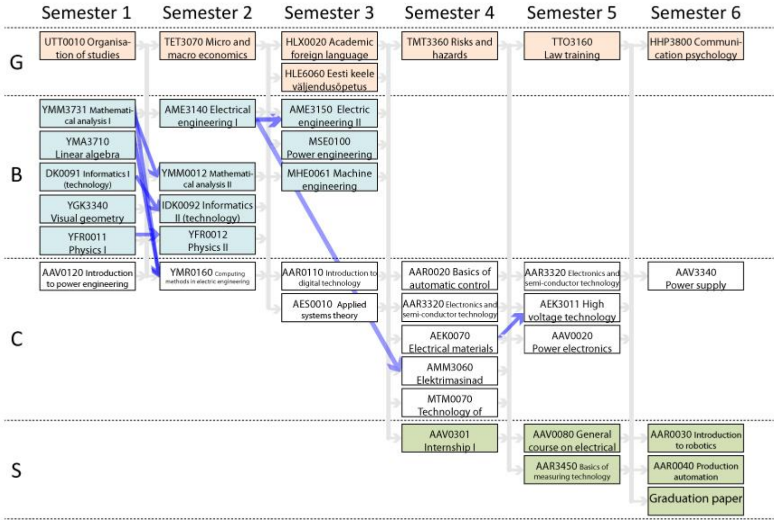

Figure 1.10 Bachelor's studies curriculum AAAB02 flow chart [57]

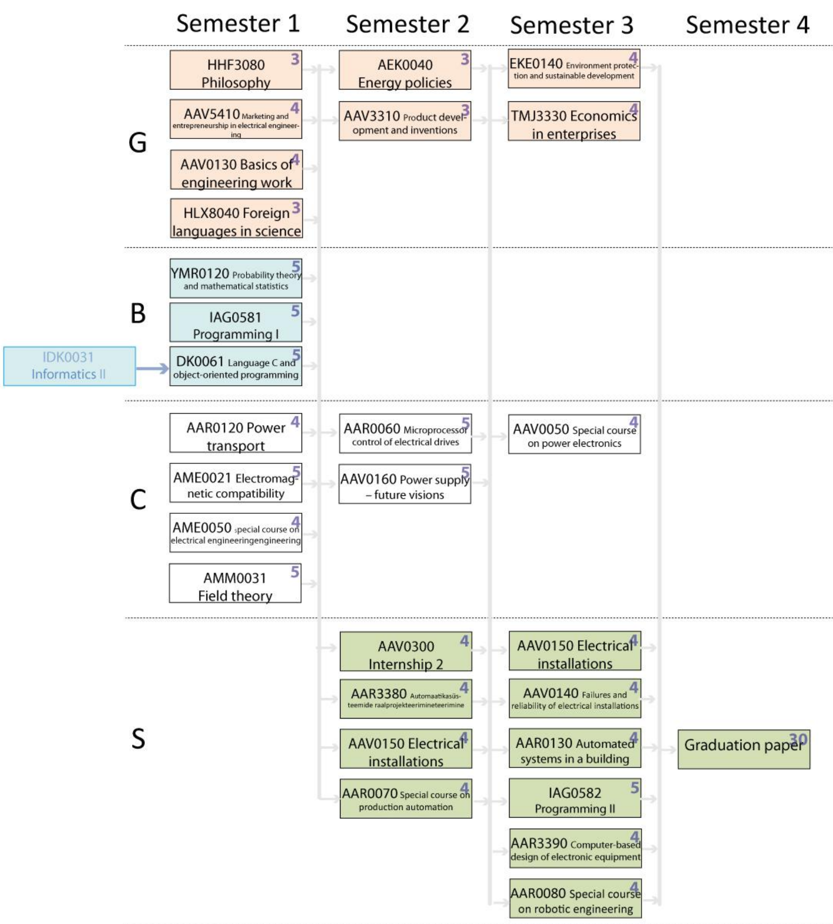

Figure 1.11 Master's studies curriculum AAAM02 flow chart [57]

Curriculum development and studies of the Faculty of Power Engineering is based in internationally acknowledged research and development work. The curricula, incl. supplemented and in-service training curricula, are all outcome-based, developed by involving all the key partners and in accordance with the expectations and needs of the interest groups (students, employers, the society) concerned. The main direction of curriculum development is student focused, interdisciplinary training. In-service training curricula offer the graduates of all the specialties opportunities for in-service training.

The faculty has a curriculum committee, heads of curricula and advisers who are all involved in curricula development. Curriculum development is based on analysis of feedback from stakeholders (students, employers, alumni) and forecasts for the future, thus allowing the students to obtain an education, ensuring their competitiveness at international level [58].

All the master's study curricula include economics and entrepreneurship module to ensuring the conformity of graduates with labour market, economic development and competitiveness requirements [58].

Study information system (ÕIS) represents the official environment for information exchange on organisation of studies, used, among other things, to collect, process and maintain information on studies.

1.2.6 Summary

After reviewing the level descriptions of the qualification framework and determining the general requirements on learning outcomes for different level of education in the education system and professional levels of the professional systems, it was concluded that the situation is most complicated with EstQF levels 3, 4 and 5 EQF, as the same curriculum – and the same learning outcomes – apply for vocational training based on basic education, vocational secondary education and vocational training based on secondary education.

Employers complain that there is a deficiency of level 5 specialists, which represents the former technical school graduate level (secondary specialised education), who should be the middle-level managers. To a certain extent, this is compensated by professional higher education, but not in full.

The main problems of curricula development involve giving too much focus to learning outcomes and assessment only, forgetting about the inputs and process in general.

In education, not everything – like knowledge and skills, acquired at institution of higher education and obtained in course of practical work and the skills for their implementation – can be measured yet are highly important for the purposes of later life. Therefore, for the purposes of curriculum development it is always important to consider that students will also acquire other, different skills during the learning process, for example, they develop their social skills.

The tighter are the relations between higher education and labour market, the bigger will be the danger of adopting an approach too narrow to the subject studied. Employers often assume that what is learnt in institutions of higher education, is too wide-based and most of the information acquired will never use in real working life. The education, given by academic institutions of higher education, is also too academic and sufficient attention is not given to applicability.

Study information systems are extensive databases that provide the opportunities for the collection, statistical processing and maintenance of data, yet fail to offer the tools for modelling curricula.

Analysis of curricula revealed some elements of randomness in prerequisites. Creation and consistent availability of a visual data model will contribute to more accurate curricula development and limits the opportunities for the incurrence of errors.

It is recommended to use the current databases (study information system ÕIS) and add them some applicability by providing additional services to students, for example, the chance to model and visualise personal curricula by giving them multiple dimensions.

The available e-learning materials could be added to curriculum database (as references) under the module/subject concerned.

The proportion of internship in enterprises, offered by curricula, is limited (AAAB02 Practical internship – 2ECP and AAAM02 Practical internship – 4ECP). Considering the needs and requirements of employers, the proportion of internship should be increased at least twice. The curricula have been developed, based on traditions and considering the assumed requirements of employers, failing to comply with modern professional level requirements, as these do not reflect in assessment of knowledge. It is necessary for bachelor's and master's study graduates to acquire the knowledge, skills and responsibility and independent operating skills to a level that would allow them to apply acquired competences, efficiently, in real life.

1.3. Qualification of Engineer and Awarding the Qualification in Estonia

In globalising economy, enterprises must do everything possible to remain in business in tough competition. Only the enterprises with employees with qualification high enough and contributing to the productivity of the enterprise will survive – only the best will remain in business. The system of occupational qualifications may influence the efficiency of enterprise's work by the quality performance of competent employees – they work quickly and have the ability to develop. The information they develop as the consequence of their work is also of high quality and this will ensure smooth cooperation between people in an enterprise. Saving of expenses can be highlighted as one of the major benefits as employer will no longer have to start by identification of skills and repeated training when employing someone, holding a certificate of competency.

For trainers, professional standards represent a valuable (systemised) material for the development of curricula that meet labour market requirements. Thanks to the well-established system of professional standards the knowledge and skills, required by labour market, will be developed and learnt first.

1.3.1 Qualification Framework for Engineer's Qualification

The new professional standard for electricity engineers is competence-based and will be expected to be completed in 2013. Table 1.2 and Table 1.3 describe requirements, established for the knowledge and skills in the old and the new professional standard of electricity engineer, statutory electricity engineer and authorised electricity engineer. This will allow to compare whether the knowledge and skills, acquired in institution of higher education, will match the knowledge and skills, required under occupational qualification framework.

Table 1.3 Five-level occupational qualification framework (description of levels of occupational qualification of an engineer, based on the Professions Act of 2001) [54].

Level	Name of occupational qualification	Competences
Level 4	electricity engineer IV	Employee will fulfil official duties that require analysing and decision-making, has the required professional knowledge and skills; organises distribution of resources and work done by others and takes the responsibility for the outcomes
Level 5	statutory electricity engineer V authorised electricity engineer V	Employee will fulfil official duties that require improvement of knowledge, solving problems, implementation of scientific theories and definitions, analysis, systematisation and development of available knowledge and functions that assume teaching in changing situations, has extensive professional knowledge and skills, organises distribution of resources and work done by others and takes the responsibility for the outcomes

Table 1.4 (Levels of occupation of an engineer in accordance to eight-level occupational qualification framework [51].

Level	**Name of occupation al quali-fication**	**Knowledge**	**Skills**	**Scope of responsibility and independent work**
Level 6	electricity engineer, level 6	Extensive knowledge in the sphere of work or teaching, incl. critical understanding of theories and principles	Developed skills that demonstrate master or innovator abilities for solving specific, complicated and unpredictable the sphere of work or teaching	Manages and controls complicated technical or professional activities or projects, takes responsibility for decisions adopted in unpredictable work-related or learning situations
Level 7	statutory electricity engineer, level 7	Highly specialised and advanced knowledge, partly ranking to the highest level in work-related or learning sphere, which serve as the bases for original thinking, critical awareness of work or study-related and inter-speciality problems	Specialised problem solving skills that are needed for research and/or innovation, creating new knowledge and procedures and for linking knowledge on different spheres	Controls and modifies work or study related situations that are complicated, unpredictable and required new strategic approaches, takes responsibility for contributing to professional knowledge and activities and/or controls strategic actions of teams
Level 8	authorised electricity engineer, level 8	Knowledge that ranks highest in work or study related and interdisciplinary spheres	Highly advanced and specialised skills and techniques, including synthesis and assessment, that are needed to solve critical issues in research and/or innovation activities and for supplementing or re-defining existing knowledge and professional skills	Has the authority and demonstrates innovative abilities, independence, research-related and professional master ship and consistent dedication to developing new ideas or processes in work or study-related situations, incl. research work

Awarding of a professional qualification is a process that involves issue of examination materials by the provider of professional qualification who will establish a professional qualification committee that will appoint, where appropriate, evaluation committee that will assess the compliance of skills and knowledge of the individual, applying for a profession, against the requirements, laid down on professional standard. In case of a positive result, a certificate of competency will be issued. Certificate of competency is a document that evidences the conformity of the holder of the certificate with the requirements, established in professional standard.

Occupational qualification of an engineer can be applied for, in the Republic of Estonia, by a person who has met the requirements, established to occupational qualification of an engineer, wants to obtain a certificate of competency and has submitted an appropriate application.

The highest body is Occupational Qualification Council of Engineers that will give the body, awarding occupational qualification, the right to award occupational qualifications and conducts supervision over the process for awarding professional qualification.

By general rule, the Body Awarding Occupational Qualification (BAOO) represents professional association (societies, unions) of engineers that have been given the right to award occupational qualifications by the Occupational Qualification Council of Engineers. The right to award occupational qualifications is given to BAOOs with respect to certain qualification levels that are referenced by approved professional standards [59].

The body that awards the occupational qualifications to electricity engineers is the Estonian Society for Electrical Power Engineering that is a legal entity under private law and a voluntary professional association that joins electricity engineers of power stations, networks, systems and supply and legal entities that pursue activities directly involved with electrical power engineering and have common interests in shaping research, technological, education and economic policies that facilitate the development of the Republic of Estonia and implementing such policies in the sphere of electrical power engineering [59].

For the adoption of semantic decisions, regarding the awarding of occupational qualifications, the BAOO shall establish an occupational committee, involving stakeholders interested in occupational qualifications of engineers – acknowledged experts, employers, trainers etc. A representative of the Qualification Authority or Occupational Qualification Council of Engineers will also belong to the committee. The committee may establish examination committees to carry out specific occupational examinations.

The Estonian Qualifications Authority plays a supporting and advising role, being a co-operation partner of the BAOO and a member of professional qualification committees. BAOOs, formed on the bases of associations of engineers, will be responsible for the conformity of professional standards, developed for the professions concerned, while certificates of competency are issued by the Estonian Qualifications Authority [59].

1.3.2 Qualification Framework of Electricity Engineers

Electricity engineers of the sphere of electrical power engineering are either technical and/or technological specialists with higher education that operate as medium or top level managers or specialists in the sphere of engineering, involved in production, transmission and distribution electricity energy, having passed the training, required for the occupational qualification and have practical work experience [59].

Electricity engineers of the sphere of electrical power engineering understand the links between engineering activities and social, economic, environmental and ethical problems, tasks and their solutions and maintain their professional competence by participating in specialty-related in-service training on constant bases [59].

The assumed personal characteristics are ethical behaviour, scientific and technical ability to think, creative attitude towards their work, independence, responsibility and decisiveness, economic thinking, ability to work in a team, the skills needed to manage people and resources, focus on the outcome.

One of the possible pre-requisites must be met to apply for the occupational qualification of an electricity engineer:

- Higher education in technical speciality, acquired over 4-year period, and at least 1 year of practical experience of working as an engineer;
- Higher education in technical speciality, acquired over 3-year period. 3 years of practical experience of working as an engineer and in-service training.

The profession of an electricity engineer in the sphere of electrical power engineering is awarded without a term.

The occupational qualification of a statutory electricity engineer in the field of electrical power engineering is based on substantial knowledge of theoretical basics. Statutory electricity engineer must know technique and technology and have the ability of solving technical problems creatively [59].

The profession of a statutory electricity engineer is awarded without a term.

Authorised electricity engineer in the field of electrical power engineering is, in Estonia, a statutory, higher level electricity engineer with special authorities for a special field; his or her qualifications are based on the ability to design new equipment and systems and/or scientific models and methods for solving specialty-related problems. S/he must have the skills for managing projects and groups of people [59].

The profession qualification of an authorised electricity engineer will be valid for 5 years.

The following paragraphs list the requirements that are applicable to all the occupational qualifications of electricity engineers of the sphere of electrical power engineering. [59]:

- General skills and knowledge (basics of economic activities; legislation related to profession; labour safety and protection; management and organisation of work; project management; communication, presentation and written and verbal skills of presentation; basics of mathematics and natural sciences; basics of information and communication technology; basic of quality and environment management; computer literacy; language skills and compliance with professional ethics and engineering ethics;
- Basic skills and knowledge (theoretical basics of power electricity engineering; electrical machines; electrical supplies; electrical measurements; high voltage equipment; transition/transformation processes in electrical systems; basics for electricity generation; basics of power transfer and distribution; energy systems and the principles for their control; economics of energy systems; basic safety of electrical equipment; basics for operating electricity installations);
- Special skills and knowledge (generation of electricity; transmission and distribution of electricity; organisation of power management);
- Personal characteristics and abilities (logical thinking; spatial imagination; accuracy (reliability, responsibility, self-discipline); adaptation, stress tolerance; self-assertion; independence; responsibility; ability to predict situations; sense of danger; environmentally sustainable and sparing approach; willing to co-operate; ability to learn).

1.3.3 Summary

The requirements, established for an electricity engineer, are mostly of descriptive nature. The occupation of electricity engineer is determined in Estonia by relatively narrow means. The diploma of electricity engineer will be awarded in the sphere of generation, transmission and distribution of electricity energy.

In Estonia, there are no descriptions of requirements, established to knowledge, skills and credibility of engineers in other spheres, related to electricity. For example, major part of electricity is used for automation purposes. We should consider identification of requirements, established for the competence of electricity engineers, working in the spheres that involve the use of electricity as this would allow extending the profession of electricity engineer also to the filed of production automation.

For solving the problems, related to awarding of occupational qualification in the sphere of automation, we need to describe the profiles for competence, using an eight-level qualification framework and modern information modelling tools, and investigate how does the knowledge, skills and high quality (credibility) of students of technical specialties emerge in the teaching process.

Chapter 2 Knowledge and Skills as a Part of Students' Learning Process

2.1 Creation of Knowledge and Skill During the Learning Process

Professional development of students takes place during a consistent study programme.

Study programmes are classified as follows:

- programme for the acquisition of knowledge;
- programme for the acquisition of skills;
- programme for extending responsibilities and the scope of independent operation;
- winning credibility or Leader Programme. Leader Programme will take engineer to level 8, identified in the qualification framework for competences of an engineer.

In course of the programme, the student will acquire desired qualification or acknowledge competences that will allow him/her to act in accordance with changing requirements to skills. Professional development of students can be identified by measuring the quality and quantity of work performed. Work-related contextual factors will offer a characteristic framework, needed for understanding and measuring the developments that take place during learning. The work will be done, according to the completion ontology, used for the purposes of the doctor thesis, within the framework of a task.

Hierarchic implementation model, helping to explain relations between individual development and results of work, is given below. Dynamic components of professional development of a student are depicted on Figure 2.1

Values and indicators, measured for the purposes of the model of professional development students, are summarised in the table below [60]:

1. Specialty-related tasks. The substance of a specialty-related task is defined by standard works that are to be performed in a specific job. Contextual task. Contextual task, which included the performance of specialty-related task, is supported and maintained by the educational institution with its pedagogic, social and psychological environment. Contextual task is also called the learning process. This model has two levels. For example: tasks given by a worker at craftsman's level will be performed by worker, therefore, the vocation of a worker is more restricted (defined; craftsman is given in worker's context).
2. Performance of a task is influenced (configured) mostly by cognitive abilities and talents with performance motivation, specialty-specific skills and knowledge and meta-competences, which will simplify constructive response to changes. General abilities with personal

characteristics (incl. values and objects of interests) and performance motivation will shape contextual performance.

3. Specialty-specific skills and knowledge, meta-cognitive skills and general professional abilities are the outcome of both explicit and implicit learning. Explicit learning refers to growth and development that takes place within the framework of an official education programme and as its result, while implicit learning is related to natural learning opportunities that emerge in everyday life.
4. Explicit and implicit learning are related to personality and talent. Cognitive abilities and talents and personal characteristics, values and objects of interest, that provide the grounds for individual abilities and learning motivation, are the main shapers of specialty-related qualifications and competences.
5. Intelligence is an individual's ability to distinguish, within the context observed, smaller components and more performance levels. Intelligence can be taught, however, not all students have the same academic talent. We must also not forget that emotional intelligence (characteristic, property) will usually have a much more powerful influence on a person's life than academic intelligence would.
6. Results can be divided into outcomes (that relate to specific objectives and are objectively measurable as they tend to be rather direct and can be documented and described)

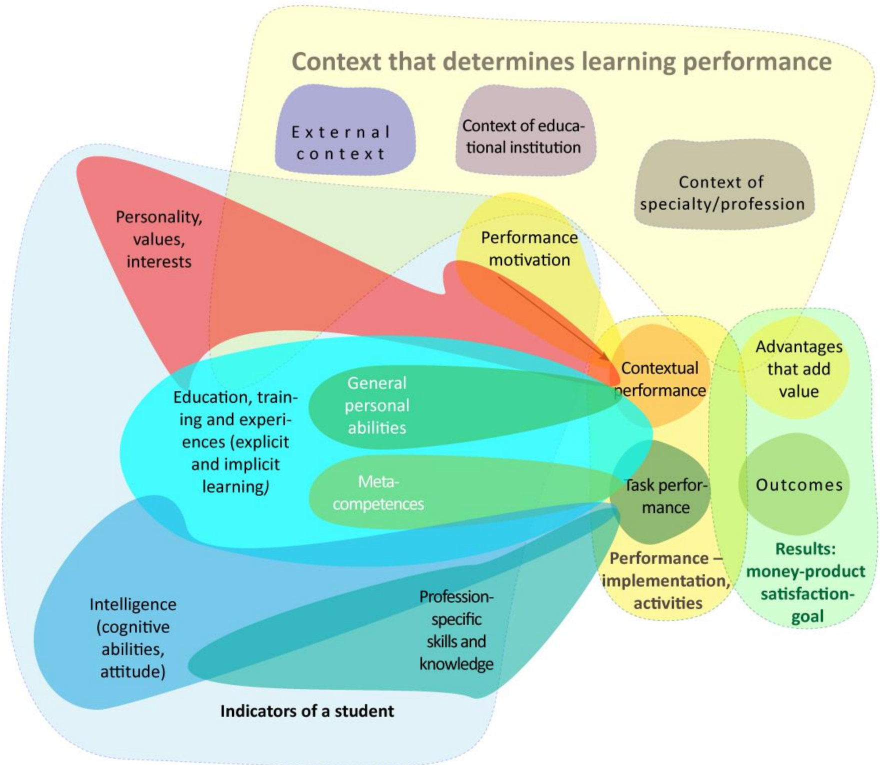

Figure 2.1 Factors that determine learning performance [61]

and advantages that add value, being less tangible and having elements that are more indirect and long-term by nature and therefore, also more difficult to measure. Student's own performance of a specialty-related task has respectively direct and indirect effect on outcomes and advantages, while contextual performance will take to advantages that value and only indirectly – to the outcomes.

7. Performance motivation is shaped by different higher learning context factors, like supervisor's support and encouragement, nature of the goals of curriculum, inspiring values, nature of assessment system and certain characteristics like self-esteem, entreprisingness and focus on service. Shapers of performance motivation stimulate, guide and maintain learning performance.
8. Learning outcomes are not determined only by the given task and contextual performance, but also the learning context and its mechanisms. Learning context is not limited to immediate learning environment (syllabuses, physical learning conditions, team work, laboratory and practical stands, used technology, evaluation methods etc.); this will also include the context of educational institution and even more wide and general context that remains outside the educational institution. Organisational context includes, among other things, factors like the structure and culture of educational institution as an organisation, operating strategies, student's vision and mission. External context is characterised by several macro-level changes, "mega trends", i.e. technological changes and innovations, changes in economic and political environment (e.g. enhancing competition in the global market), the opportunity to create one's own assets and changes in social environment. These factors all apply strong pressure for changes on internal organisational environment [61].

Nijhof, W. J., & Streumer [62] state that overviews of different skills and classification of skills are still useful and needed as the demand for abstract and cross-sphere qualifications and competences seems to be growing. In the society, individuals need professional abilities (thinking ability, communication skills and ability to shape one's opinion), problem solving skills (ability to analyse problematic situations, understand human behaviour and interpersonal conflicts and interpret issues related to communication and information flows) and transferrable skills (ability to cope with changes in life, stress management skills and the ability to adopt decisions).

Specialty-related literature gives some suggestions (also requirements??) on supporting and promoting key qualifications, required of labour market [62]. These can be summarised as follows:

1. Management/development of general skills must be related to specialty context. While general skills are the same for every profession, some specific properties and their importance may vary in case of different professions and tasks. For example, problem solving skills, nature of

communication and teamwork vary, according to the requirements of the profession, while the requirements of a profession vary in accordance with goals, tasks that form the process, organisation of work etc. Therefore, general skills (for example, project management skills, which assume, on their turn, project management software applications) are defined within a context and should be taught in a way that is, contextually, as authentic as possible.

2. Learning environments of employees must reflect automatic working environment. Acquisition of general skills is most efficient in well-organised learning environment that resembles working environment. Traditional apprenticeship methods and cognitive apprenticeship methods are a good example, indicating how skills and knowledge are applied within an authentic learning environment [63].
3. Teachers' training and development of collective must use and promote the development of authentic learning environment. According to the widely spread socio-constructivist learning theory, high-quality mentoring/learning process includes the following elements: constructiveness (learner will create new knowledge that rely upon earlier acquired knowledge); intention (learner has acknowledged intent to acquire specific information); activeness (learning is the outcome of learner's own activity), context (learning is linked to tasks/phenomena emerging from semantic real world), reflection (learner assesses learning outcomes and reflects the learning processes and decisions that are needed for the learning process), co-operation (learners work together and create new knowledge in co-operation with others) and transfer (learner can transfer the learnt material into new situations and apply the acquired skills and knowledge to acquire new knowledge). There are several opportunities for paying more attention to the needs of learner, for example, changing the teacher's role from director to learning facilitator, use of functional project groups and information technology and different forms for learning by experiencing. Authentic learning environment will offer fertile grounds for development [60].
4. Close and working partnership needs to be developed between education and working life. According to a study, conducted in Europe, learning by working meets its biggest obstacles as the consequence of poor co-operation between education institutions and enterprises in the process of developing training programmes and establishment of partner relationships. Dynamic and diversified partnership between education and working life will create new opportunities to cope with future challenges. Information models that parties understand and can link to their objectives are of assistance for devising the partnership.
5. Description of skills should have social relevance. It is important to approach the skills and requirements to skills from a socio-cultural aspect, considering the following factors: how do the economic market forces, emphasising efficiency, and material values determine skills to requirements; how people really create workers and how do collectives shape tasks and learning. Skills must be assessed and measured from

different angles and by different methods. Ethnographic studies provide information of new type, yet can't completely replace analysis of tasks. Cognitive psychology offers also new opportunities for assessing skills [60].

6. Transition of skills to new contexts is never spontaneous. Brown [63] shows that transfer of acquired skills and knowledge is specific to the extent that it will need guidance. Transfer will also depend on how the skills and knowledge was obtained and how knowledge is used in different situations; therefore, both general skills and fragments of skills, acquired within specific context, may be transferrable. Two pre-requisites must be met for the transfer. It is necessary to bring together context-specific knowledge and general skills and look actively for means for enhancing the transfer in learning situation; visual models developed by next chapters (Chapter 5 page 109; Chapter 6 page 154) are suitable for that purpose. If the goal of a training programme is to help the students to improve their knowledge transfer skill, the meaning of skill transfer ability should be paid attention to in learning situation. It is recommended to introduce the learners study methods that are used for learning (for example, 7E and 5E model, Chapter 6 page 154). For example, students may be helped to find opportunities for applying skills, knowledge and experiences themselves, suggesting them a chance to attempt to transfer their skills into practice [64]. Transfer is always related to individual motivation and commitment. Students may be guided to growing their intellectual capital (patents, inventions).
7. Reflection of what is already learnt and is to be learnt in future may link work and learning. Reflective processes are also linked to the development of deep thinking processes (professionalism). Therefore, learners should be encouraged to express their ideas in discussions with lecturers and other students. Mentors/supervisor and students may offer their views about specialty-related problems and also explain which schematic constructions they have developed to understand different interpretations and links between these interpretations (for example 6D model, Chapter 6, page 154).
8. The primary task of higher education should be developing self-regulation abilities in students. Learning to learn is a basic skill that is needed for taking initiative and adapting to constant changes. Such changes include the development of working processes, structural flexibility and technological innovations. Adapting to changes requires faith in one's ability to adjust one's understanding and behaviour during life. The main challenge of technical higher education is to develop learning ability (capability, wish and intent) among those who will be pushed to the background as society and working life develop. In learning situations, it will be the task of instructor/advisor to place learning strategies into a context: learners must be shown, which strategies are available in a given situation, why and when they will become useful [64].

2.2 Implementation of Knowledge and Skills

In the following I'm going to analyse, which knowledge and skills is considered useful and essential in Estonia in youth with higher education for coping in labour market, both for entering to labour market, remaining there and leaving the market (for example, in the case of retirement). Apart an overview of different knowledge and skills I'm also going to discuss who should see to the creation and development of such knowledge and skills. All these issues will be analysed from the perspective of three different parties (university graduates, employers and institutions of higher education), comparing and referencing different views [65].

Earlier studies of the same topic show various knowledge and skills that are linked to young people with higher education, entering the labour market. Pavlin (2009) lists, based on interviews, the following expectations of institutions of higher education and employers of five countries (Lithuania, Hungary, Poland, Slovenia and Turkey):

1. general and area-specific knowledge;
2. skills related to learning (independent learning, self-improvement, lifelong learning etc.);
3. individual skills (team work, time planning);
4. communication skills (incl. foreign language skills);
5. handling information and communication technologies (ICT);
6. other skills (incl. working experience, loyalty, tolerance, ethical values etc.).

Another international project, involving 12 European countries [65], attempted to define the main clusters of knowledge and skills, given by people by higher education (known under the name of Dublin descriptors):

1. general knowledge, acquired through formal education;
2. skills for the implementation of professional knowledge;
3. skills for the interpretation and reflection of knowledge;
4. communication and learning skills.

As the previous studies show, a number of quite universal, specialty-related knowledge, social skills and skills related to learning emerge. At the same time, several researches also demonstrate a number of rather specific or unique knowledge, skills, proficiencies and attitudes that are often justified with different objectives and methodologies, used for studies [65]. Organisation of education and labour market institutions is often seen as one of important explanatory factor in working links between education and labour market [66], which could, in turn, shape the expectations that employers have with respect to competences of young people with higher education, entering the labour market. Therefore, highly structured knowledge and skills may dominate higher education and labour market and these knowledge and skills are also expected of people, entering the labour market. From the other hand, training may take place only upon commencing employment, and the field graduated of specific knowledge and skills won’t be then as much dominating upon entry to the labour market. At the same time, young people with more wide-based knowledge, having graduated from a specialty more “general”, have more alternatives and therefore, also a bigger number of potential jobs to choose from [67].

As we study these research projects, they convey an impression that in most cases, university graduates are observed as paid labour and university graduate as a possible entrepreneur is left aside.

Apart more general institutional context, knowledge and skills, but also expectations regarding them may be different by disciplines [68]. The role and balance of general and specific knowledge is often highlighted as an aspect, distinguishing the spheres. This is also done to link specific sills to technical fields.

Therefore, for the purposes of labour market context, differences between specialties mean that young people with more general skills must often compete with young people with more specific knowledge and skills, while the presence of more specific knowledge and skills will give a certain advantage for entering the labour market, as according to employers, those people don’t need any more training and are ready to start working immediately [69]. This also means that the prospects of graduates of different specialities may be very much different in labour market. From one hand, this is due to general difference between knowledge and skills: while in case of some disciplines the focus is given to more general knowledge, the other focus on more specific stuff and knowledge and skills, acquired-reinforced in course of practice. From the other side, the understanding and expectations of both the graduates themselves and the employers are different with respect to certain specialties, which will set some limits, again, to both expectations and opportunities.

Individual’s coping in a modern world depends on his/her activity as a learner, willingness to see him/herself in learning situations as a subject, active and responsible “me” [70]. Responsibility shows individuals ability and willingness to decide upon the importance and effect of his or her behaviour [8]. Responsibility as one of the main components of human ethics is seen as one of the criteria of adulthood, which expresses to what extent an individual acknowledges him/herself and the surrounding environment [9].

The scope of independence/responsibility shows to what extent an university graduate can work independently, how much responsibility s/he can take for the outcomes of his/her work.

A study, conducted by Tallinn University in 2012 [71] shows that both the institutions of higher education and young enterers of labour market, the master’s degree is seen as labour market maturity indicator, while, according to their experiences, for employers, knowledge and skills rather than the degree are considered important and both institutions of higher education and the young people themselves are considered responsible for the creation of such knowledge and skills.

The same "personal responsibility" applies for the development of numerous social skills. Social skills – like teamwork, compatibility with collective, initiative, responsibility and the skills of independent work are competences that employers often appreciate, but are difficult to apply within the framework of curriculum and train separately. These are all skills you won't find from curricula of institutions of higher education, but the absence of which would make coping in labour market rather difficult. This will enhance the "personal responsibility" of students in developing the competences, required by labour market, even more [71]. Students must also think about solving a dilemma, whether to focus on learning during their studies or also find some time for working.

Institutions of higher education will rather see movement towards integrating larger proportion of internship into learning to match the professional experience demand context while this would mean decreasing the share of general knowledge and skills [71]. According to earlier studies, internship will help to develop social skills that prepare young people for taking on obligations of an adult and entering the working world [72]: such an experience will develop communication skills, teach to behave in accordance to specific labour situation and organise one's work [73], while being responsible and consistent and meeting the deadlines [72].

Apart the information provided above, the understanding and expectations that people have with respect to higher education and related skills and knowledge, may differ by different stakeholders [65].More specifically, the understanding and expectations of employers to young people with higher education, entering the labour market, may not coincide with the expectations of institutions of higher education, which will result in an ambivalent situation for young highly educated individuals, entering the labour market and therefore, their perception of knowledge and skills, required by labour market, given by institution of higher education, may not be equally acknowledged by employers.

For the purpose of considering the diversity of perception and expectations to knowledge-skills-credibility and the factors that shape them, the current analysis attempts to set out the positions of different stakeholders (young people with higher education, institutions of higher education, employers). For that purpose, I have analysed interviews with employers, representatives of institutions of higher education and young graduates of institutions of higher education, who have experienced unemployment, referenced the visions of all three groups. Adding the interviews of young people, who have experienced unemployment, to the sample will given an opportunity to include the aspect of compliance of "expectations and reality", explaining the conformity or non-conformity of understanding and practice, governing the institutions of higher education and labour market, in the best possible way. The latter is also important to understand the strategies and course of action, chosen by different stakeholders, in general. Should the visions of different stakeholders coincide, young people entering the labour market will find coping with transition from school to work easier while different understanding may result in a number of conflicts and challenges that will mostly make the young new participants of labour market suffer [71].

2.3 Teaching and Learning as a Dialogue

How could we explain the definition of education more explicitly? For the purposes of education system, teaching/education is described as a (bilateral) communication between teacher (mentor) and student, resulting in increased knowledge and experiences of the student, better independence and responsibility. As education is acquired, students are given educating information by means of communication and collected feedback for mentor to evidence the achievement of established learning goals and introducing adjustments, where appropriate. At least two different angles are needed to define the definition of education. Teacher can influence, indirectly, directly/explicitly and dynamically, the cognitive, influenced and conative learning processes and learning outcomes of students by choosing the right information, teaching methods and support materials [74]. The definitions is illustrated in Figure 2.3.

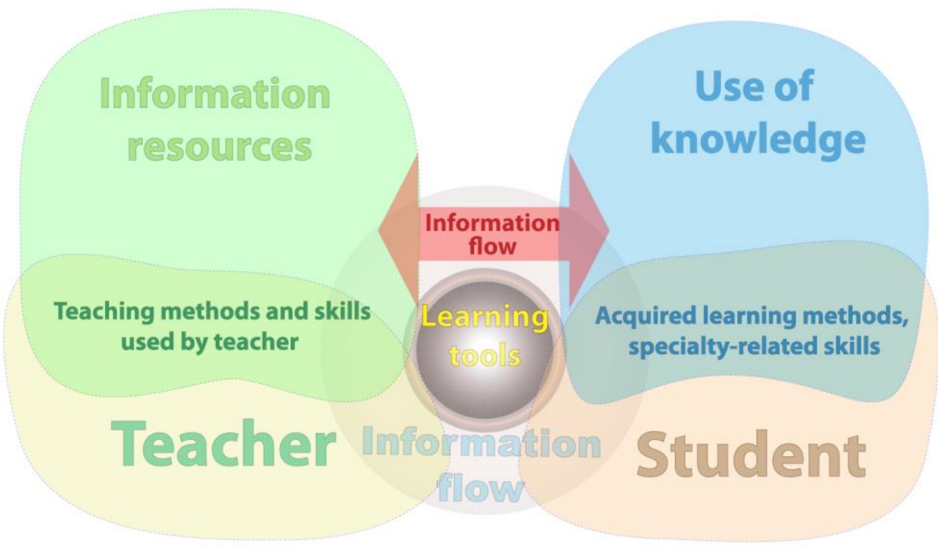

Figure 2.2 Visual depiction of related concepts of teaching and learning

The dialogue between student and teacher may be in both verbal and written form. Dialogue involves communication of information. Sometimes there may be non-verbal communication between two or more people or participants.

Dialogues have been studied from teacher's point of view. The main characteristics of dialogues are teacher's ability to think, reflect, personal and professional identity concept. Teacher will focus on pedagogic skills, repertoire of activities, teaching methods, knowledge that are hidden into learning content, and also to organisation of the teaching process (*Figure 2.3*) [75].

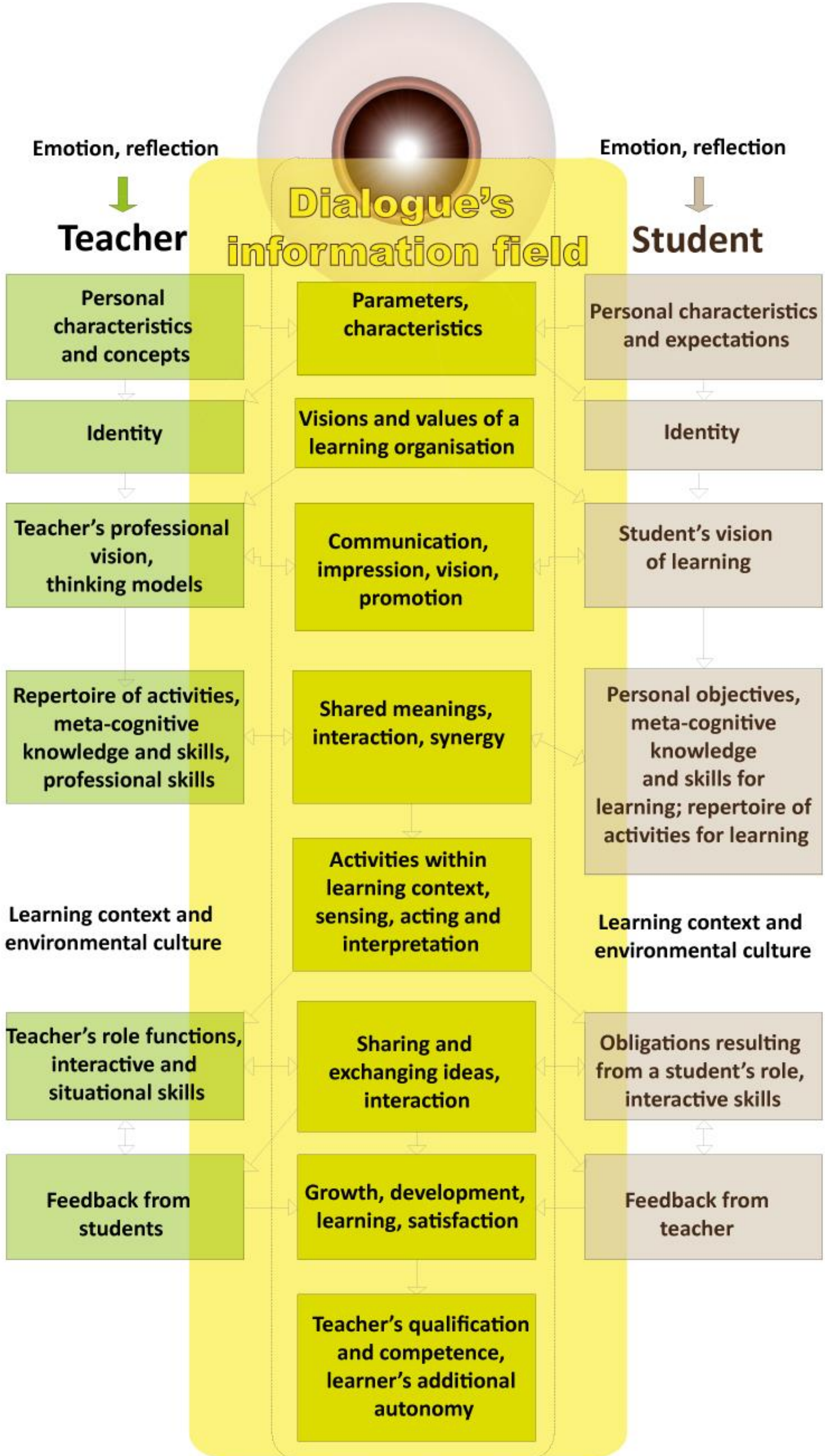

Figure 2.3 Dynamic dialogue in teaching and learning [76]

Thinking stands for “action or activity of someone who thinks, by formulating in his or her mind the method for justification, assessment, belief or mental engagement” [74]. Thinking, at teaching level, refers to critical thinking skills. Critical skills that a teacher / lecturer should have:

- perception of knowledge as consumable that can be sold and transferred;
- perception of knowledge that can be different or based on different understanding; it is important to make a distinction between different positions;
- processing, writing of knowledge will create new knowledge; this is also one of the reason why the importance of written papers as a part of learning process is emphasised;
- understanding of empathy, the desire to understand and help other people.

Thinking may be expressed either verbally or in writing. To be a good thinker, we most move from verbal methods of communication to written. This results in the need to create links that explain the ideas of a thinker, visually. It is necessary to create illustrations and diagrams to shape thinking into a logical model.

In our everyday activities, in thinking, we use mental models that represent internal pictures of our world and the way it works. They restrict us by safe thinking and acting methods. Therefore, the discipline for the management of mental models is highly important as we consider the education of a lecturer. Mental models may be simple and highly complicated theories. It is important to understand that these are all active and represent the way how people act and influence what the see and look at.

2.4 Summary

Fresh teachers often describe their profession by using parameters that include academic knowledge and professional competence (doing certain things well), positive and proper attitude towards students and good communication skills. As their experiences increase, teachers will start to shift their focus from single components (actions of a teacher) to more general aims, goals, mental values and principles. The following is needed for highlighting mental/spiritual values and principles:

- dynamic and also visual tools for representing different perception of learning and teaching;
- for a lecturer, also methods for giving education that are capable of adapting to rapidly changing and new requirements, develop the thinking of student, enhance mental7spiritual values and increase emotional stability;
- when giving a lecture, lecturers should treat the learning process, happening in the classroom as a complete entity. Apart good knowledge

of facts a professor will also need the ability of sensing the subject taught as a summation;

- creation of adequate and explaining models that will take the lecturer from regular routine and task context to details and back, where appropriate.

Chapter 3 Acquiring Specialty-related Competence in Learning Process of Students

3.1 Different Interpretations of Competence; Measuring Competence

People with an education that matches higher professional level usually work in occupations that assume the ability to think, responsibility and management skills. Today’s managers are often trainers of people who are their subordinates, information providers and distributors of resources. More and more often, they share responsibilities or delegate some of it to others. Professional employees are expected to have the desire and ability to take responsibility and manage the team. Employees are responsible for consistent improvement of their skills and they’re expected to apply their knowhow flexibly and be able to co-operate, as this will result in new combinations of know-how, i.e. collective competence [60].

Pugh ja Hickson [77] refer to the opinion of McKinsey, stating that at the beginning of this millennia, 80% of the work done would rather demand brain capacity than manual skills while only 50 years ago the situation was just the opposite. Although mental work involves, without any doubt, certain technical know-how and occupational skills, it will also demand more and more abilities, skills and predisposition for acting as a leader from employees.

In all the spheres of education, above all, in professional education, more and more attention is given to general key competences or the development of trans-disciplinary qualifications.

3.1.1 Competence and Qualification

There’s lots and lots of literature about competence and qualification, however, the implementation of suggested approaches has not been consistent and there is no consensus with respect to the accurate, specific meaning. Competence and competency are synonyms.

Ellström [78], for example, gives the following definition of competence: competence is individual’s (or collective’s) potential ability to cope, successfully (according to certain formal or informal criteria, that are determine) with certain situations or perform certain task or work. This ability is determined by:

1. cognitive motoric skills (e.g. manual skills);
2. cognitive factors (knowledge of different type and intellectual skills);
3. affective factors (e.g. attitude, values, motivation);
4. personal characteristics (e.g. self-confidence);
5. social skills (e.g. communication and co-operation skills).

Therefore, such a definition is task or employer-focused and will not assume leader level knowledge or skills of a person. Employees are only required to abide by work discipline and workplace rules. Why the task needs to be fulfilled, is up to the employer; professional competence is [79], according to the definition, a working relation between individual's ability and certain task or situation, which involves:

- combining of knowledge and intellectual skills (e.g. inductive, logical), plus non-cognitive factors (e.g. motivation and self-confidence);
- proven abilities, which are a function of the five factors, listed above;
- rather potential than real ability, i.e. an ability that is, in reality, only used when certain conditions are met (e.g. task representing a challenge or work situating that is sufficiently independent).

Ellström [79] defines qualification as a competence that is needed for a certain duty and/or that is, either implicitly or explicitly, defined by individual characteristics. He approaches professional competence from three different angles and gives it five different specific meanings with these three angles (*Figure 3.1*).

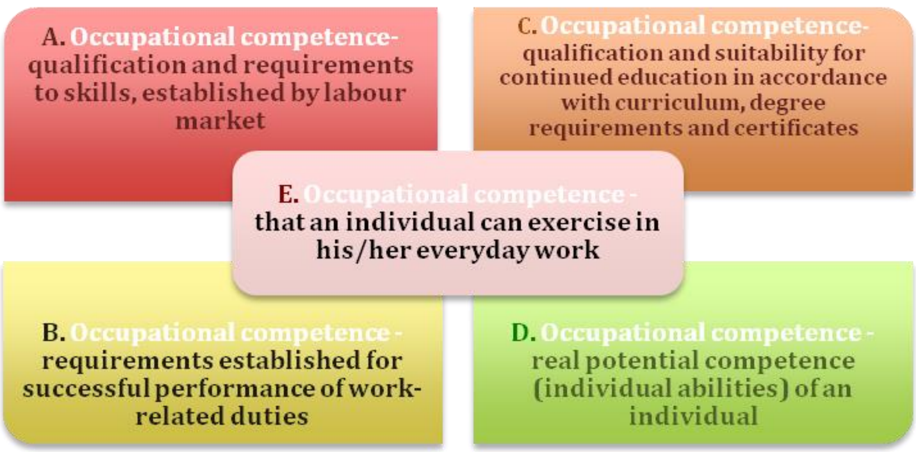

Figure 3.1 Different meaning of occupational competence [79]

Atwell [80] finds that the use of the term of competence with the meaning, defined by Ellström, will cause confusion, as the consequence of different meaning of the nature of aforementioned competence, in Great Britain, competence is seen as an ability to fulfil certain duties/tasks in accordance with certain criteria, defined by an organisation.

In Germany, however, competence is seen as individual characteristics that are linked to both knowledge and skills and involve professional identity. This is illustrated by four types of competence, distinguished by Bunk [81]:

- occupational competence: individual will cope well in a specific work-related sphere and won't need supervision;

- methodological competence: individual will respond systematically to problems that may emerge during performance, will independently find solutions and is capable of implementing the experiences obtained in new situations;
- social competence: people communicate and co-operate with others, show empathy and skills required for teamwork;
- participation competence: people share their work and working environment, are capable of organising things and adopting decisions, being responsible for their activities and development.

According to Hövels [82], competence is a definition of Anglo-American background and relates to competence and performance theories that date back to learning and knowledge psychology. The concept of qualification comes from economics and it can be assumed that this involves the combination of acquired skills and knowledge with professional practice.

Streumer and Björkquist [83] conclude that key qualifications or closely related concepts, like general qualifications, core qualifications and transferrable qualifications, are difficult to be supplied with an European definition. However, certain properties can be attached to key qualifications.

- Key qualifications offer means for fast and efficient acquisition of specialist know-how.
- Key qualifications are more abstract than qualifications characteristic of certain profession or sphere.
- Key qualifications will allow the employees to respond efficiently (by taking initiative) to changes that take place in their work.
- Key qualifications will allow employees to control their own career.
- Key qualifications represent competence acquired that will allow a student to reach a break-through or a higher level.

These properties can be used to define an individual's competence.

Over the last two decades, a model described by five factors (Five –factor model, FFM) to study the relations between personality and work-related performance. These five personal factors are: neuroticism, extrovertedness, openness to experiences, agreeability and responsibility. Meta-analyses, conducted since 1991, have evidenced important relations between personality and work-related performance [84].

It seems that work results are, above all, linked to responsibility or work discipline. Extrovertedness and emotional balance or emotional discipline (the opposite of neuroticism) are prerequisites for achieving success in work. Openness to experiences, however, has conflicting nature. Work results can be rather estimated on the bases of personal characteristics than cognitive abilities. People with internal peace and balance (higher mental discipline) are more free and creative in their actions. Apart work, they also visualise and achieve their objectives.

Motivational properties of occupational competences mean general tendencies of object of interest and motivation. Object of interests refers to motivation of activities. Occupational interest has been used in two ways for study purposes. First of all, an attempt was made to identify vocations/jobs, where requirements established to work and the attitude, preferences and objectives of the person studied are a good match. In case of the other approach [61], works and specialities have been categorised in accordance with different orientations (e.g. according to the Dutch hexagone, realist, investigative, artistic, social, conventional and enterprise-oriented).

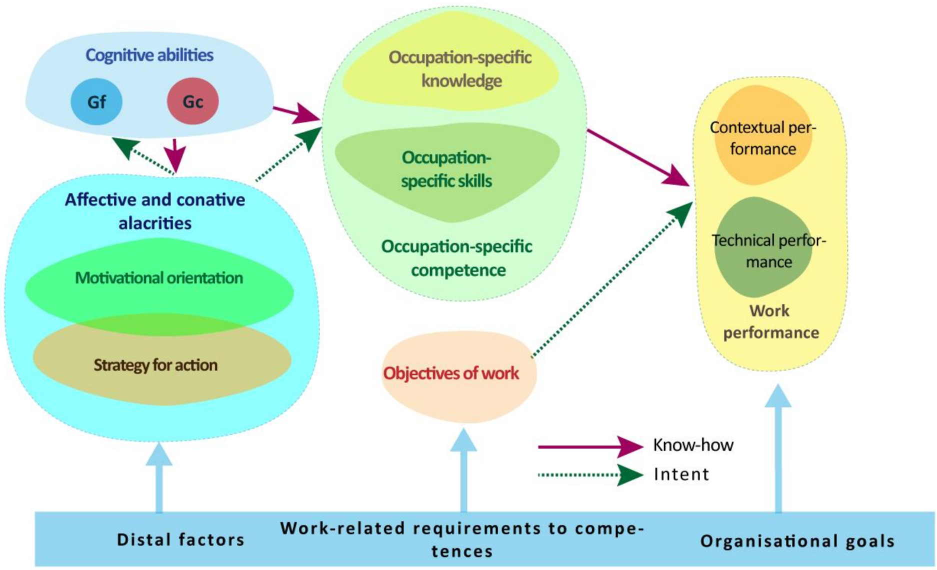

Figure 3.2 Model of occupational competence [61]

Figure 3.2 illustrates occupational competence and the background abilities/readiness to explain work performance. Working will depend on the task, needed in the process, which launches the work. Occupational competence is here treated as capacity of an individual, the real competence. Its components are occupation-specific baggage of knowledge and occupation-specific skills. Against the background of occupational competence, know-how (knowledge and skills) is cumulated through earlier life and abilities (including education and experience).

Development of competences is a constant process, involving individuals adopting and improving their skills to achieve more and more success in one or another sphere. Development of abilities and competences and acquisition of know-how will form a "chain" that the figure above describes as a path of know-how.

Competence stands for proven ability, for the purposes of ECVET and EQF, to use knowledge, skills and personal social and/or methodological abilities in work-related or learning situations and for specialty-related and personal development. The terms of responsibility and dependence are used to describe competence.

3.1.2 Intelligence and Competence

Intelligence and competences are closely linked. For example, Sternberg [85] has compared intelligence and related abilities to competence that play a material role in the development of specialist skills. According to Sternberg, IQ tests serve to measure abilities of individuals that can be developed.

Individual characteristics – for example, physical intelligence and abilities – represent an outcome of genetics and environment. Genes can be used to explain individual differences. The influence of competence and development of specialist skills on the evolvement of intelligence is impossible to measure. Thinking skills can be suggested as an example of combined effect of genetics and environment: for example, noticing and identification of problems, creation of strategies for solving problems, representation of information, guiding of resources and monitoring and assessment of solutions to problems. Sternberg [85] comments that "if we describe these meta-components of thinking as intelligence, we must also admit that intelligence is a "form" of developing competences that determine the development level of specialist skills".

Affective (*caused by affect, highly emotional, excessive)* and conative (*cognitive, perceptive)* alacrities are very much needed, from one hand, to apply professional skills and from the other hand, for the maintenance and updating of professional skills. The influence of affective-conative factors on know-how is marked, on Figure 3.2, with the definition "path of intent". For the purposes of occupational development, the central alacrities are, among others, performance motivation, assessment of effectiveness, internal orientation on objectives and thinking and self-regulation skills [86]. Zimmermann ja Kitsantas [87] pay attention to volitional processes: they discuss the hidden dimension of individual competence, by which they mean individual's skill to adjust its learning and activities. Distal factors (earlier life), role requirements, related to work and organisational objectives will form a contextual framework that will, from one hand, determine alacrities and the development and shaping of competences and performances.

Work performance (Figure 3.2) is divided into technical and contextual performance. Technical performance may be related to objectives of a worker. Contextual performance will promote the effectiveness of social and organisational network and psychological climate, thus supporting the achievement of goals of the entity, commissioning the work, or labour market subjects. Entrepreneur or enterprising person will internally add up the requested work performance and personal contextual performance. Entrepreneur will perform the requested work, building his company up at the same time.

3.1.3 Summary

Competence and competencies are synonyms. The earliest approach the qualification date back to the industrial era and need expansion by the definition of quality in such a way that it would make sense in the information era where students are not prepared only to enter labour market (as someone performing the work, determined by labour market requirements), but to be an active person, capable of taking responsibility for his or her life programme in full and also for the realisation of dreams and visions.

In the information society where jobs are no longer long-term, but depend on tasks to be fulfilled, and the approach to competence needs to be adjusted, based on automated application processes, used in production, to enhance the adaptability of personalities.

Qualification is officially recognised competence, i.e. there has been assessment and it is evidenced by a certificate and a register. Qualification, required at work-place, may be lower than the real competence of the person concerned.

Based on information era requirements, the definitions of competence, competency and qualification are summed up in the best possible way by the term occupation.

3.2 Learners' Self-Regulation Theory

Self-regulation is one of the central issues of engineer studies. Self-regulation implicates ideas, feelings and actions that are planned and linked, cyclically, to the achievement of personal goals [88]. Meta-cognition plays an important role in learning. In addition, the way we assess ourselves and affective reactions also have some influence on self-regulation, for example, doubts (lack of faith) and fears that are linked to performance situation. The ay we assess ourselves also covers self-efficacy – a learner has his/her own vision of his/her organisational abilities and performance of actions that are needed to cope with a specific duty – explaining the individual's motivation to adjust his or her performance [89].

Students, working with self-regulation, are therefore actively participating in learning process: they adapt their ideas, feelings and activities to meet the objectives, established for learning. S/he plans activities and obtains feedback during learning process, observing the efficiency of learning methods and responding to feedback gained. Zimmermann [90] states that "learning is not something that happens to a learner, instead, this is something that a learner makes to happen". Therefore, learning outcomes are also expressed outside the learner him/herself.

According to socio-cognitive theory, self-regulation is linked to situations. The skill of self-regulation is therefore not a general characteristic/alacrity or development level achieved. Also, not all learners do regulate, studying all subjects or different fields, their activities in the same way [91]. Whereas certain self-regulation processes (for example, establishment of an objective) can be applied in numerous different situations, a learner must understand how these processes can be efficiently managed for learning different subjects and themes.

Self-regulation rely on the assumption that learners are aware of the influence of self-regulation processes on learning outcomes. Different theoretical trends are, however, characterised by different details. Zimmermann [92] compares different theoretical approaches to self-regulation, applied during learning, and characterises each theory according to the solution that it offers to the following questions:

1. What motivates learners for self-regulation?
2. Which processes help to develop learners' perception of themselves?
3. Which key processes do learners use to achieve their learning outcomes?
4. How is learner's self-regulation influenced by social and physical environment?
5. How can a learner develop his/her self-regulation?

Shortened version of answers, given to these questions, is assembled into table (Table 3.1). Only some of the approaches, describing self-regulation, are discussed below.

- Learning is a cyclical process, involving learners observing the efficiency of learning strategies and responding, using self-control, to the feedback that they're given. The feedback may include invisible change in interpretations concerning "me" or some visible changes in one's actions, for example, replacing one learning strategy for another. Phenomenological aspect emphasises changing interpretation levels in 'me'-evaluation, interpretation of oneself and self-actualisation. The aspect of operant conditioning pays attention to specific details, for example, the use of memory techniques, controlling one's activities and self-awarding or strengthening.
- Self-regulation theories open aspects and explain the reasons, how and why learners adopt certain self-regulation process, strategy or reaction. According to operant conditioning theory, in the case of self-regulation we're dealing, in conclusion, with controlling external award or punishment contingencies. According to the phenomenological approach, learner is motivated by self-evaluation or self-interpretation. Between these two extremes we can fit a number of theories that emphasise the success experiences, reaching objectives, self-efficacy and assimilation of definitions.

Table 3.1 Self-regulation processes in different theories (Nissilä, S-P [93] referring to Zimmermann 1998; 2000;2001)

Theoretical aspect	**Motivation**	**Selfunder-standing**	**Key process**	**Social and physical environment**	**Self-regulation ability and development of skills**
Operant conditioning	Reinforcing irritation	Won't pay attention, except self-reactions	Self monitoring, control and evaluation	Model learning and reinforcement	Shaping behaviour and elimination of unimportant irritants
Phenomenol-ogical theory	Self-actualisation	Role of me-image	Self-respect and me-identity	Subjective observations within environment	Development of me-constructions
Informa-tional processing	Information with emotional colour	Cognitive self-monitoring	Information processing and storage	Influences on information processing	Developing the alacrity, needed to process information
Socio-cognitive theory	Efficiency appraisal, expectations regarding outcomes and objectives	Making observations about oneself and monitoring	Making observations about oneself and reactions	Model learning and learning based on incidental experiences	Development as an outcome of social learning
Deliberation, intent	Expectations/ values (pre-requisites for deliberate action)	Control of action (not as much control of psychological condition)	Cognition, motivation and emotion control strategy	Controlling disturbing factors in learning environment	Developing the pre-requisites for the implementation of deliberate strategies
Constructiv-ist theory	Solving cognitive conflicts and curiosity	Meta-cognitive observation	Construction of schemes, strategies and individual theories	Solving social conflicts and creative learning	Restrictions to the implementation of self-regulation processes by development stage

• Different self-regulation theories give different answers to the question, why learners succeed or fail with their self-regulation. For example, constructivist approach emphasises the development levels of meta-cognitive alacrities, while cognitive theories emphasise learner's different interpretation of usefulness of strategies and the wish to apply certain strategies, identified with this interpretation. Socio-cognitive theory pays special attention to self-efficacy, expectations to outcomes and the role of objectives in learning [61].

• Development of self-regulation skills requires practice. When learners don't consider the acquisition of such skills as important, they have also no motivation for self-regulation. Different theories differ by outcomes they emphasise. For operant conditioning, the focus is on external outcomes while other theories focus in internal outcomes, for example, achievement of success or management experiences. Phenomenological theories, however, like constructivist theory, consider the development of learner's identity to be important and also its role in improving learning motivation [61].

Self-regulation is highly important for learner's activities, it is needed to survive and to achieve one's objectives and realise dreams with quality, in other words, to lead a better and higher quality life.

Basic knowledge and skills, needed for self-regulation, form a certain model or platform (page 88), which the parties, involved in learning process, can jointly use for mutual communication and information and data exchange involved. One singularity must be considered when comparing students of technical specialties to other students – they need a language more schematic, drawings, diagrams and models, as this method of comprehension is more natural for them.

3.2.1 Self-regulation Model

Learning, based on self-regulation platform, is often observed as a cyclical process. This is a contemporary method; seven time-related stages can be observed in the cycle, similarly to the 7E learning process model:

1. **Involvement – preparations, acknowledgement of the question raised**
2. **Creating interest – emergence of interest and attention**
3. **Investigation – observation, getting the wow-experience**
4. **Explaining – deciphering**
5. **Specification – particularisation**
6. **Extending – generalisation and using the learnt information beyond the current limits**
7. **Assessment – self-reflection**

Pintrich (2000) classifies the spheres of self-regulation, additionally, depending on whether we're dealing with regulation covered cognition, motivation/affect, behaviour or context [86]; [94]. Diversity of self-regulation is illustrated by Table 3.2.

The periods of preparation and creation of interest also include the period of planning and activation and here we can distinguish analysis of learning task and assessment linked to self-regulation. Good self-regulators study the material to be learnt, establish themselves personal objectives and consider the strategies that would be most useful for learning. Motivational assessments also include self-efficacy and expectations with respect to outcomes.

Table 3.2 Links between self-controlled learning stages and spheres of self-regulation, goal-orientation and internal interest [86]; [95].

Stage	**Cognition**	**Motivation/affect**	**Behaviour**	**Context**
Involvement – preparations	Establishment of an objective acknowledgement of 'why' question (acknowledgement of the problem)	Goal orientation Effectiveness assessment Image of simplicity and complicacy of the learning material	Planning efforts and time-management Planning self-control activities	Definition of a task Definition of context
Creating interest - emergence of interest	Activisation of meta-cognitive knowledge Activisation of earlier learning experiences	Importance and meaning of learnt material Enhancing interest	Launching efforts and time management Launching self-control activities	Looking for links between tasks and real world
Investigation - observation	Observation of meta-cognitive knowledge	Observation of motivation and emotional status	Making efforts and experimenting with time management and monitoring need for assistance	Observing the contents of a task
Explaining – elucidation	Choice of a cognitive strategy needed to regulate thinking and learning	Choice of strategy needed for motivation and management of emotional condition	Elucidation of learning process Use of well-known terms, definitions and theories	Elucidation of a task
Specification - particularisation	Implementation of a cognitive strategy, needed to regulate learning and thinking	Implementation of a strategy needed for motivation and management of emotional condition	Increasing/decreasing efforts Particularisation of theory Persistence, giving up	Changing or explaining the task
Extending – generalisation	Attributive assessments	Affective responses	Looking for assistance Presentation and use of the results achieved	Changing the context and withdrawal from the situation
Assessment – self-reflection	Cognitive assessments	Affective responses	Considering alternative activities	Assessing the task Assessing the context

Learner's self-efficacies facilitate his/her motivation to remain committed to self-regulation and carry out self-control, self-assessment and identification of goals. Expectations with respect to outcomes (faith regarding the outcomes to be achieved) will give motivation for self-regulation if positive while negative or insecure expectations with respect to outcomes will inhibit self-regulation. Learners oriented on goals, emphasising the development of competence (learning objectives), are more successful than those competing for achievement or grades (performance objectives). Internal interest will help to continue efforts needed for learning even if there is not external support and encouragement available.

Action control or management strategies will help learners to focus on task at hand and optimise their performance. By directing one's attention and focusing, learners defend their will to learn, defend themselves against different disturbing factors and competing wishes. Focusing on what's important will also offer protection from disturbing factors in the environment [97]. Learners will make their decisions regarding the learning method and strategy. S/he may test his/her skills, by asking oneself questions or using mental images. Proficient learners can exercise self-management, mental images, time management, organisation of learning environment and employ the assistance of others in learning process. The efficiency of strategic processes will depend on self-observation: learners must observe not only their own activities but also the surrounding conditions and their possible influence. In relations with he surrounding, it's important for students to create visual images of their mental images or use the visualisation tool.

Self-observation and also keeping an eye on the context will help individuals to obtain information about their development. Of course, observing one's activities can also distract and the learning process may therefore suffer. Form the other hand, skills that have become proficiency will require less and less deliberate monitoring and the implementation of a skill will become a routine or automatic. As a consequence, self-observation will be transferred to a more general vision (or level or goal) and also to sub-conscious level, relating oneself (like an onlooker) to learning environment (external context) and outcomes of one's activities. Development of permanent habits will allow to direct activities that were originally conscious, to sub-conscious level.

Students with poor learning skills; those unable to visualise strongly enough, having a weak discipline where it comes to the implementation of mental goals (limited internal peace) or unable to match their objectives (for example, processes, tasks and works with more specific applications), may become overloaded with detailed information. Their internal feedback may be overloaded. Central self-control form includes taking notes and writing down problems.

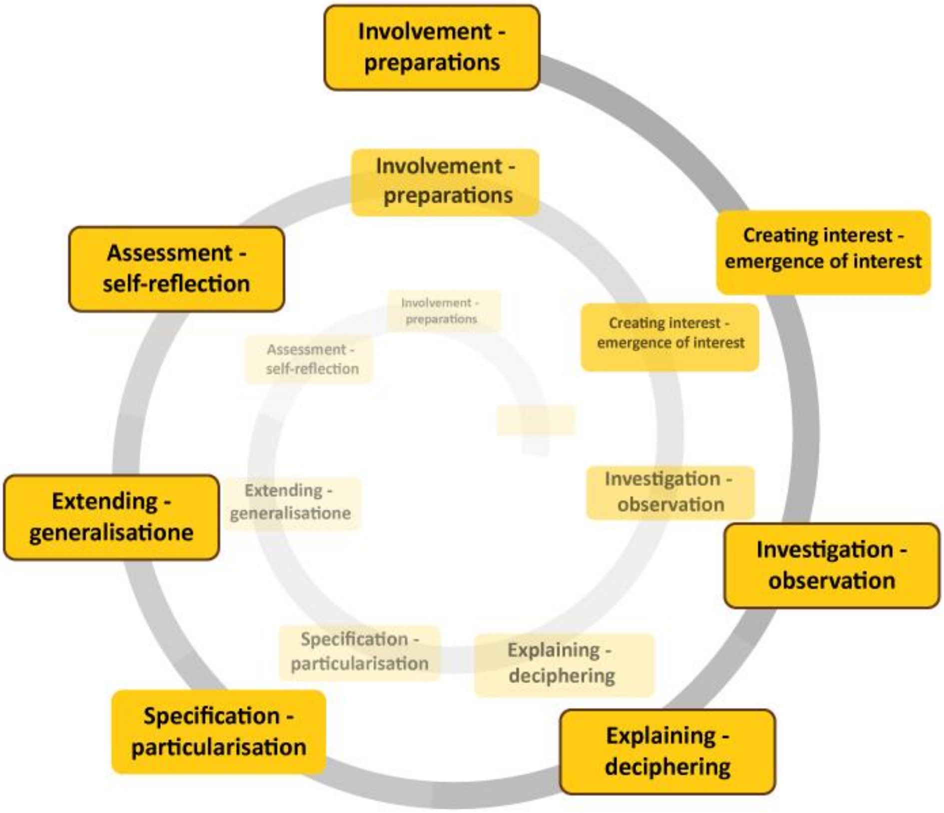

Figure 3.3 Learning, based on self-regulation, using 7E model

The self-reflection stage is divided into self-assessment and reflective reactions. In the case of self-assessment, an individual will compare information, obtained by self-observations, to external standards or objectives. S/he wants to obtain quick feedback on how s/he has done with achieving objectives, established for others or him/herself, compared to other learners. Attributive interpretations are linked to self-assessment: learners will try to interpret the reasons for their successes or failures. For example, they may blame their failure on their lack of talent or too little effort or losing the focus.

Attributive interpretations may also take to positive reflective responses (self-reactions). Learners may interpret too little effort as the reason of their failure and therefore, make even more effort. However, if they blame their own limited abilities for their failure, responses will be negative. Attributive interpretations also show what could be the possible reasons of mistakes, made in the learning process [98]; [87]. Positive reactions will strengthen positive interpretation of oneself as a learner, for example, faith in one's abilities and opportunities, learning orientation and internal interest in the task at hand. Commitment to a task will be also improved.

Experiencing peace or success is an important process, related to self-reactions, as people are willing to commit to a learning that will result in positive feelings and experiences. From the other hand, they attempt to avoid negative emotions and feelings, for example, fear of failure [89]. Another form of self-reaction may be adaptive or defensive model of action. Good self-regulators can adapt the model to the situation and circumstances [99]. Poor self-regulators attempt to hide from disappointment and protect themselves. Defensive responses are, for example, helplessness, delaying, avoiding the task, cognitive non-commitment and apathy [100].

3.2.2 Summary

Self-reflection stage of the learning process may result in updating the applied *modus operandi*, questioning the former routines and getting them replaced for new routines that match the circumstances better. Efficient methods are visually structured and diversified, allowing for diversified observation.

For example, students may visualise their self-regulation models. Visual model allows to analyse and identify mistakes in the self-regulation algorithm. For example, everybody wants to achieve success, but may will avoid failure at the same time and are therefore afraid to take any action (to make the first step), as they visualise their choices as shown on Figure 3.4:

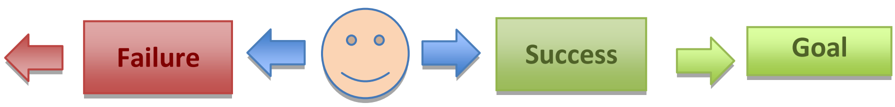

Figure 3.4 Self-regulation model, visualised by an apprehensive student

It's obvious that once new knowledge is obtained, the scope of practical experiences is still limited. Those striving for quick success must first overcome failure and only then, success can be achieved. Therefore, those who are smarter, use the sequence, depicted on Figure 3.5, to achieve success:

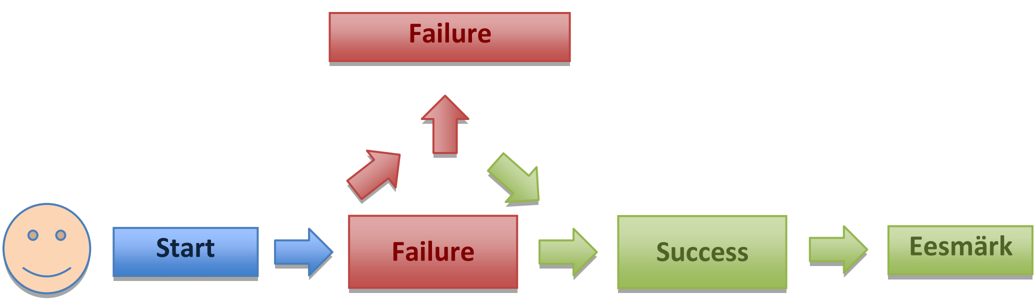

Figure 3.5 Self-regulation model, visualised by a bold student

3.3 Investigation and Analysis of Competence-based Education of Students of Technical Specialties

Development of self-regulation skills

When observing the development of self-regulation, we encounter many disturbing factors that have been discussed in different studies, in universities. Unfortunately, this topic has not been studied much. Several barriers, known as the “barriers to learning”, are encountered in the learning process. For learning as a process to continue, it’s important to overcome the barriers to learning. In Estonian language, “barrier” means an obstacle, an obstruction [5], and therefore, obstructions to learning are defined as barrier to learning.

In universities, learning takes place, on long-term bases, within a formal learning environment, involving formal rules and restrictions, and students must cope with changes in academic behaviour, which also involves overcoming certain barriers. Context of a university requires, compared to earlier studies, more responsibilities and taking personal control of learning and students have no complete overview of the situations that really take place in the university [101].

In university, barriers to learning incur frequently, due to long study period, formal environment and academic behaviour. Therefore it’s important for the students to understand the nature of barriers to learning and factors that may cause them, and the lecturers being able to support students in overcoming the barriers to learning. Student and lecturer should co-operate for the purposes of learning process [102]. The best possible way for lecturers to support students is to teach them self-regulation skills, like self-management [101]. To develop self-regulation in students, lecturers should develop more efficient learning strategies, like planning, control and guiding learners to analyse their work [103]. This means that students must understand – responsibility in coping with barriers to learning lies with him/her and lecturer can only support the processes for overcoming the barriers.

Barriers to learning are studied within three different dimensions, as follows [104]:

1. emotional (characterised by resistance to learning);
2. cognitive (wrong learning can incur);
3. social (there are limitations to oneself, mental defence against learning).

Regardless of the fact that the barriers to learning may incur in various dimension of learning or at the same time in all three, table 3.3 has been prepared, providing an overview of the types of barriers to learning to be distinguished, their nature, reasons, possible forms of expression and the ways for supporting students [105].

Table 3.3 Overview of types of barriers to learning, their reasons, forms of expressions and alternatives for supporting coping [105].

Type of barrier to learning; identifying dimension	Nature of barrier to learning	Reasons causing barriers to learning	Expression of barrier to learning	Possible available to lecturers for supporting overcoming the barriers to learning
EMOTIONAL Defence against learning (defence of regular consciousness, defence of identity, defence against the feeling of fatigue	Defence mechanisms for maintaining mental balance	- Factors that threaten, limit, violate the maintenance of mental balance - Changing identity - Learning impulses that we encounter on daily bases - Authorities indulging inappropriate behaviour with no reason (dictatorship), lack of democracy (unpleasantness) - Helpless in a given situation	- Underesti-mation - Harmonisation - Rejection - Scapegoat mechanism (projecting) - Anger - Sadness - Despair - Low self-esteem - Opposing behaviour towards authorities	- Motivation - Development of will - Offering positive emotions - Accommodation and understanding - Fair treatment - Step-by-step changes - Giving freedom of choice - Involvement in decision-making process - Linking tasks to practice - Making compliments - Avoiding accusations - Giving an opportunity to express things we're proud of - Supporting in overcoming fears - Communication both in school and outside curricula
COGNITIVE Wrong learning	Students don't understand what knowledge the lecturer is attempting to convey or students interpreting information in a way different than conveyed by the lecturer	- Gaps in earlier knowledge - Excessive involvement/time problems - Fear of knowledge outcomes - Excessive interpretations in text - Mis-understandings - Leaving learner "alone" in the learning process - Unawareness of what is right and what is wrong	- Mis-understanding - Failed focusing - Non-understanding - Inability to grasp the information - Cocky attitude - students assuming that they know enough about the material	- Expressing support and understanding - Attaching meaning and importance to the materials for the student - Clear and unambiguous expression of oneself - Avoiding giving too much information too quickly - Using techniques that facilitate focusing - Encouraging to ask questions - Explaining the benefits, provided by learning process - Pointing attention to development issues of students - Involvement of students - Acknowledgment of students' expectations

SOCIAL Resistance to learning (active resistance, passive resistance)	Fear of changes that result from learning and are considered unacceptable by the student	- Modesty and restrain in self-improvement process - Conflict situations - Applying pressure - Unpleasant subject/teacher/ mentor - Acquisition of new ideas/skills/ understandings - Attempt to restore inner balance - Reality does not coincide with earlier experiences	- Resistance to co-operation with mentor/ instructor - Disturbed orientation within the learning environment and stability - Confusion - Frustration - Cognitive and emotional problems - Anger/rage - Aggression - Wanting something else	- Facilitation of communication and co-operation - Respecting the experiences, coming with changes - Supporting changed understanding - Maintaining hope and motivation - Supporting overcoming the earlier negative experiences - Teaching self-regulation skills - Avoiding pressure - Asking students for feedback - Giving freedom - Visual description of action plan

Supporting overcoming **emotional barriers to learning** mostly involves overcoming the defences. According to Illeris [106], the alternatives for overcoming emotional barriers to learning are related to motivation, developing will and offering positive emotions.

Supporting overcoming **cognitive barriers to learning** mostly involves overcoming the problems of wrong learning. As wrong learning is deeply internal process of a student, it's very difficult for lecturers to recognise the issue and then support the student in overcoming the barrier [107]. The alternatives for supporting wrong learning mostly involve avoidance of gaps (in knowledge) and supporting understanding, focusing and positive aspects [105]. Getting practical experiences is also of big help.

Supporting overcoming **social barriers to learning** mostly involves overcoming resistance. The lecturers can help in overcoming resistance in students by supporting communication, avoiding limited objectives (have the courage to dream!) and overcoming earlier negative experiences by using visual examples.

3.3.1 Summary

Coping with barriers to learning is mostly related to the abilities of lecturers to develop self-regulation skills in students and their own empathy. Lecturers can't support students with overcoming barriers to learning, if the students don't understand the importance of self-regulation and the principles for its implementation. Therefore, it would be necessary for a lecturer to pay attention to self-regulation skills, seeing that a student is acknowledging and controlling his/her behaviour, feelings and thoughts, to achieve the required academic goals

[108]. The chapter can be summarised as follows, based on the conducted analysis and studies [105]:

- Self-regulation skills of students need to be developed for the students to be able to take control of their learning and establishment of objectives, thus making it easier for them to overcome the possible barriers to learning. By doing this, the barriers to learning will be overcome by the student and lecturers will only support students in the process for overcoming the barriers to learning.
- For that purpose it is necessary to give the students and lecturers general yet visual picture of the learning process, learning and teaching. Studies have shown that lecturers and students are unaware of real self-regulation processes in education, learning, reasons for the barriers to learning and the ways for coping with the barriers.
- For improving the efficiency of learning, a student must be capable of better structuring and visualisation of mental images. It is also useful to visualise real activities and functions, not just geometric objects. Weak links of spatial performance (activities) of framework structure of geometrisation processes to the framework of describing geometric objects (x,y,z-axes) can become a problem here.
- Visual teaching materials can be used efficiently to search for problems to emotional, cognitive and social problems.

Chapter 4 Empirical Part – Study of Special Education Situation of Students of Technical Specialities

4.1 Purpose of the Study and Methodology Used

In today's world, labour markets (including Estonian labour market) have become highly flexible and it's impossible to predict, very accurately, the structure of knowledge and skills of human resources that the markets would need. Predictability of career of employees, sustainability and security regarding the future are replaced, step by step, by more mobile forms of employment. Increasing large number of jobs have become temporary. The borders between specialities are changing or about to disappear altogether [109]. Such development of labour market is actively supported by globalisation of economy and the loss of borders in Europe. The last reason allows employees and entrepreneurs to work and look for jobs in other countries, apart their home country.

Students respond to changing economic conditions actively and more and more of them combine work and studies. Students need higher education but are willing to work, part or full time, already during their second academic year. Such a model of convergence of working and learning is very widely spread among students of the European countries [110]. Students understand that to become independent, they will first need a job with high salary and then they have to be ready to leave the labour market and enter it again, if necessary.

Adaptation of education system with changing labour market is slow. Students and graduates of institutions of higher education often lack personal specialty-related and financial goals. Personal financial planning is of short-term nature. For maintaining security, people often hang on to their jobs and only aim for getting paid monthly. Often, the need to balance permanent commitments to personal assets, which are crated during specialty-related activities, is not developed enough. Entrepreneurism and business skills – the ability and readiness to support oneself and other by creating new jobs – also need development [111].

Estonian Ministry of Education, the State examination and Qualification Centre (now called Foundation Innove) and the Estonian Qualifications Authority have developed vocational education standard and occupational qualification system [54]. These provide that the learning substance of the vocations, taught at universities, must match the current version of the occupational qualification framework and real-life needs of the students. Most of the needs are determine by professional associations and associations of entrepreneurs of different spheres. Such an approach is clearly aimed at consistent communication with the labour market.

First part of the study focuses on theoretical principles and backgrounds of specialty-related training and in-service training of students, above all, students of technical specialties, students of vocational educational institution, employees of companies, analysing the factors influencing improved efficiency of specialty-related training, and conclusions of general nature were drawn.

The next important goal of the research was to establish the efficiency of specialty-related education of students of technical specialties, followed by new proposals for correcting the identified problems. As the result of the analysis, the work includes a new, improved questioning methodology that consists of the following stages:

- analysis of efficiency indicators of specialty-related training and selection of the most important (restriction of criteria);
- identification of standard values and allowed ranges of values;
- development of a questionnaire and holding interviews;
- implementation of analytical methods, specified in chapter 4.1.1 (page 99), to process the collected data;
- visualisation of results and drawing conclusions.

Practical questionnaire was organised for the students and stakeholders involved in their training process.

Questionnaires (forms) were drawn up for interviewing students of technical specialties, students of vocational educational institutions and employees of enterprises to explain their attitude towards the learning process, different perception of teaching and learning, principles and criteria, choice of a training venue and trainer/lecturer.

Conclusive positions, stated in the theoretical part of the study, are the bases for selecting the variables investigated and empirical data. Well-known analytical methods were used during data processing stage.

The final part of the chapter focuses on analysing perceptions, related to teaching and learning, providing an overview of proposals (based on research results) for organising the teaching of technical specialties.

One part of the study involves the establishment of the current situation in learning process of students of technical specialties. The following tasks were established for the collection and analysis of empirical data:

- What is the opinion of students of technical specialties, lecturers and employers of the learning process?
- How important is practical work considered and what should be the proportion of practical and theoretical learning?
- Do the knowledge, skills and applied training of today’s students meet the expectations of employers; what are the main deficiencies?

- What are the visions of employers of graduates of institutions of higher education; what should be their specialty-related and occupational training?
- Explaining the training system that would support the development of specialty-related competence of vocational school teachers in the best possible way?
- What is the vision of students, lecturers and employers of the scope of responsibility and independent activities?
- Analysis of the results achieved and comparison of the outcomes with the positions, established in theoretical part of the work, to assess their accuracy and relevance.

4.1.1 Choice of Method

A questionnaire was used for initial collection of empirical data; semi-structured questionnaire, including open and closed multiple choice questions, was used for getting the answers. The questionnaire was formalised, using e-forms [112].

The questionnaire was the primary tool for the collection of data that will be used to collect (empirical) data, needed for the study. The opportunity of creating a large database is usually considered the first benefit for questionnaire-based investigation methods: many people can be involved and many questions can be asked [113].

The method of questioning was chosen according to the problem studied. The learning process of technical specialities is mostly based on studying, describing and comparing the understanding, needs, expectations of the target group. The problem studied requires analysing of both qualitative and quantitative information; this is made possible by analysing semi-structured methods.

Questionnaire represents the main data collection method for gathering the empirical data, needed for the study. The opportunity of creating a large database is usually considered the first benefit for questionnaire-based investigation methods: many people can be involved and many questions can be asked.

Investigation method, suitable for determining the efficiency of training, was chosen on the bases of investigation goal, considering the feasibility of works, considering the tasks established, and the assumed accuracy of the answers to be gathered. The process of teaching technical specialties is usually based on studying and describing the target group and comparing the understanding, available from their members, to theoretical positions, needs and expectations. The problem investigated expects the analysis of qualitative and quantitative information, which is also made possible by analysis of a semi-structured [112] questionnaire.

Semi-structured questionnaire was used to avoid the data obtained being superficial, giving the respondents an opportunity to supplement the multiple choice answers, suggested by the researcher, with their own opinions and statements, but also to justify their choices and communicate personal views and proposals, regarding in-service training. This will allow to discover new rules and laws and then specify the theory.

The use of an e-questionnaire allows to collect large volumes of data from different areas with little time, reach the desired respondents easier while the respondents can complete and return the questionnaire at the most suitable time for them. Speed and convenience for data collection are the main advantages of this method. However, big loss of questionnaires is the main disadvantage. The loss depends on the group of respondents and studied issue. Usually, 30-40 per cent of the questionnaires sent out are returned. If the questionnaire is sent, by mail, to some restricted target group (in the given case, to teachers of institutions of vocational education) and focuses on issue important for them, higher share of returned questionnaires can be expected [113].

4.2. Development of a Questionnaire and Collection of empirical Data

4.2.1 Implementation of the Questionnaire

The process included the following stages *(Figure 4.1)*:

- attaching purpose to empirical part, questioning and questionnaire;
- development of the questionnaire and organising a trial questioning; pilot study was also used to control the suitability, language etc. of the questionnaire;
- implementation of approbated questionnaire and collection of data;
- interpretation and analysis of data and drawing conclusions.

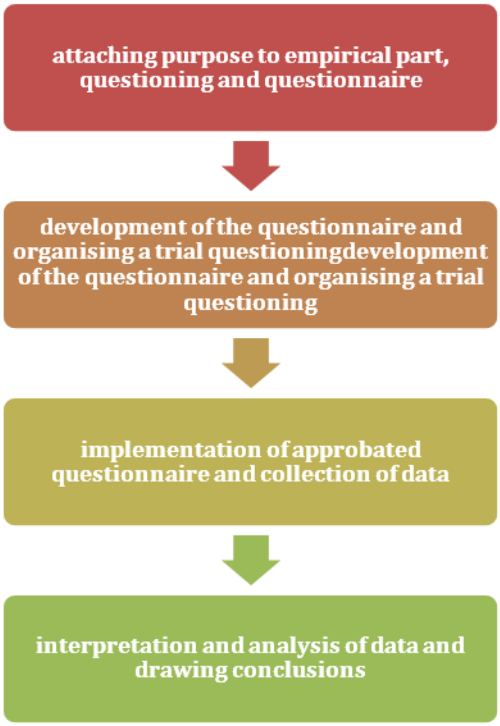

Figure 4.1 Implementation stages of the questionnaire

The following will be observed during questioning:

- avoiding interference with studies and related activities;
- provision of information about the questionnaire to be implemented;
- the author of the questionnaire will be giving the students feedback by e-mail;
- no pressure must be applied on the target group or any other sort of influence applied in the answering process.

4.2.2 Development of the Questionnaire

The questionnaire will include questions of four types:

1. open questions (no. 1, 2, 5, 6, 10, 11), only questions are asked and some empty space left for writing the answer, allowing to give a more substantial answer to more complicated question, using a free form (for example, 'list three field of work or tasks where you have problems with performance and where better specialty-related knowledge or skill would contribute to coping?), not limiting the respondents to multiple choice answers, suggested by the researcher;
2. questions with multiple choice answers (no. 1, 2, 3, 4, 7, 8, 9 12, 13, 17,

18, 21, 22, 23, 24). Every question comes with numbered alternative answers; the respondent is expected to mark one or several alternatives, as required (for example, length of professional record of working as a teacher);
3. questions based on levels or ranges (no. 12, 13, 14, 15, 16, 17, 18 and 19). Statements are present, accompanied with ranking of different strength and the respondent will choose the most suitable version (for example, if 4-point range would be used: 3 – useful and 2 – useful and not useful, 1 – not useful 0 – don't know).

The questionnaire consists of several parts to facilitate the employment of empirical data.

- I part (question 1) is aimed at the collection of demographic information.
- II part (question 2) is aimed at explaining the need for general in-service training.
- III part (questions 3-6, 11) is aimed at establishing the form of training and presentation of course, considering the current learning and teaching experiences.
- IV part (questions 7-10) is aimed at determining the automation level of Estonian enterprises.
- V part (questions 12-13) is aimed at the ideas, expectations and needs of the respondents with respect to automation of production and respective specialty-related terms and definition.
- VI part (questions 14 - 15) is aimed at the theoretical and practical skills implementation skills, depending on the needs of the company.

International domain, www.eformular.com, was used to implement the questionnaire.

The questionnaire is available from the following addresses: http://www.eformular.com/eduard/dok-kys-yliopilane.html ja http://www.eformular.com/eduard/dok-kys-oppejoud.html

Testing (approbation) of the questionnaire took place in 26.03-28.03.2012. Three students completed the electronic questionnaire. The purpose of the pilot questionnaire was to test and approbate:

- feasibility of the electronic environment: position of questions and alternative answers on the screen, related convenience of answering, comprehensiveness of technical details (drop-down menu, radio buttons, text sections etc.);
- clarity of questions and how they were understood; unambiguousness and length of questions, use of works in the questionnaire, restricting the questions;

- observing the completion of the questionnaire allow to observe semantic feedback and ranges of answers, number of alternative answers and either growing or declining trend.

The author modified the following questions as the result of approbation:

1. Question 1. The author added separate background information for lecturers (I'm a lecturer of an institution of higher education or vocational educational institution) and students (at vocational educational institution, institution of higher education, small or medium sized enterprise).
2. Question 1 through question 2 were all given in bold font in the e-form. The author used a common form for all the questions.
3. Question 13: author added one more multiple choice answer, "don't know".
4. Questions 14 through 19 author added one more multiple choice answer, "don't know".

4.2.3 Stages for the Implementation of the Questionnaire

1. Questionnaire about the learning process of technical specialities was held for the students and learners in 03.03-20.03.2012 and 01.03.-03.03. On … 2012, the information, including electronic web reference http://www.eformular.com/eduard/ was sent, in total, to 40 students of Tallinn University of Technology, 40 students of Tallinn Industrial Education Centre and 20 in-service training participants.

2. Questionnaire about the learning process of technical specialities was held for the lecturers and occupational trainers on 03.03-20.03.2012 and 01.03.-03.03. On … 2012, the information, including electronic web reference http://www.eformular.com/eduard/dok-kys-oppejoud.html was sent, in total, to 20 lecturers of Tallinn University of Technology and 16 occupational trainers of Tallinn Industrial Education Centre.

3. Questionnaire about the learning process of technical specialities was held for employees on 03.03-20.03.2012 and 01.03.-03.03. On … 2012, the information, including electronic web reference http://www.eformular.com/eduard/ was sent, in total, to 20 specialists, working in the area of electricity and automation. The choice was made among the members of the Estonian Association of Electrical Enterprises (EAEE).

4. Of the 156 notices sent to occupational trainers, 36 questionnaires were returned.

5. Electronically completed questionnaires were returned to E-form data file directory:

a. students and learners
http://www.eformular.com/alusta_andmefail_statistika.php3?vorm=dok-kys-yliopilane&tegevus=alusta_andmefail_statistika&data2sql=1

b. lecturers
http://www.eformular.com/alusta_andmefail_statistika.php3?vorm=dok-kys-oppejoud&tegevus=alusta_andmefail_statistika&data2sql=1

c. employers
http://www.eformular.com/alusta_andmefail_statistika.php3?vorm=dok-kys-tooandjad&tegevus=alusta_andmefail_statistika&data2sql=1

As data was saved, the information was recorded in Office Excel 2007 spreadsheet processing software.

6. Initial data processing and drawing conclusions.

7. Establishing the credibility of the study (to avoid accidental ensuring results) and validity of the survey.

8. Drawing final conclusions and making summaries of the study.

4.3 Analysis, Interpretation and Discussion of Empirical Data

Some of the most interesting outcomes will be listed below:

2 question of the study: Would you be interested in gaining additional knowledge in the following subjects? 28 students responded. Proportion of interests represented is shown in Figure 4.2.

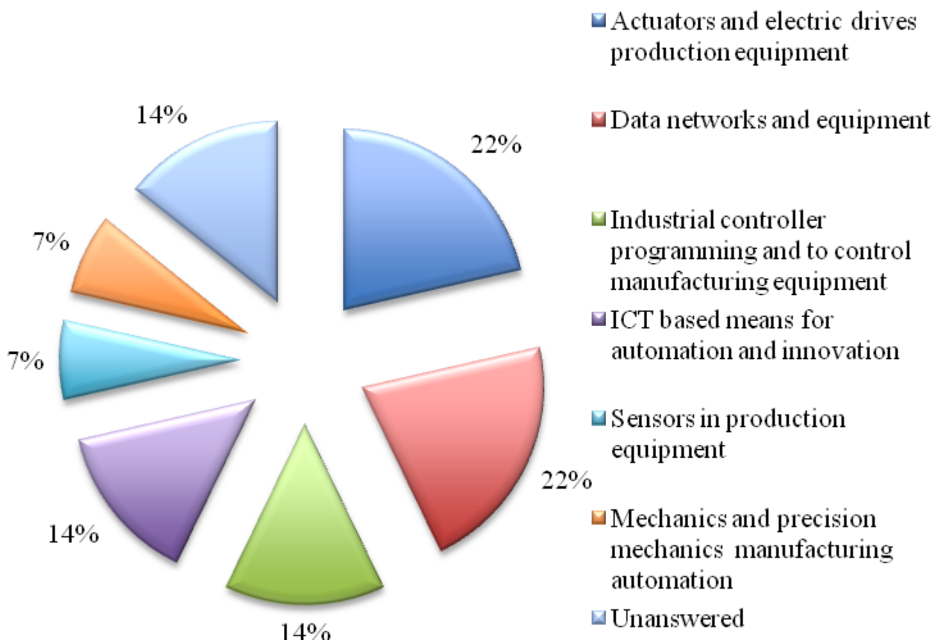

Figure 4.2 Distribution of interests of students in different specialties

The following answers, depicted on Figure 4.3, were given by the representatives of employers (20 respondents).

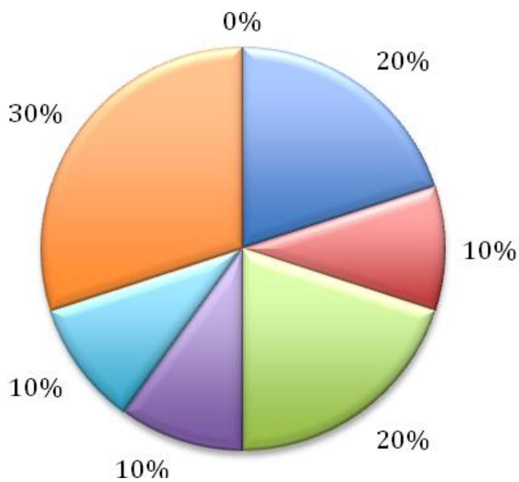

Figure 4.3 Interest, shown in stuff of enterprises in different subjects

Here we can see that depending on the specificities of enterprises, the focus will be given on different subjects. However, in the case of subjects [Actuators and electric drives production equipment], the opinions of students and employees coincide. The part of the study that investigates the need for and proportion of practical and theoretical investigation and the implementation of such skills in a company, gave interesting results. The following figure illustrates questions 14, 15 and 16 of the survey.

Question 14 of the study. Does the theoretical training of students meet the needs of the company? Results are depicted in Figure 4.4.

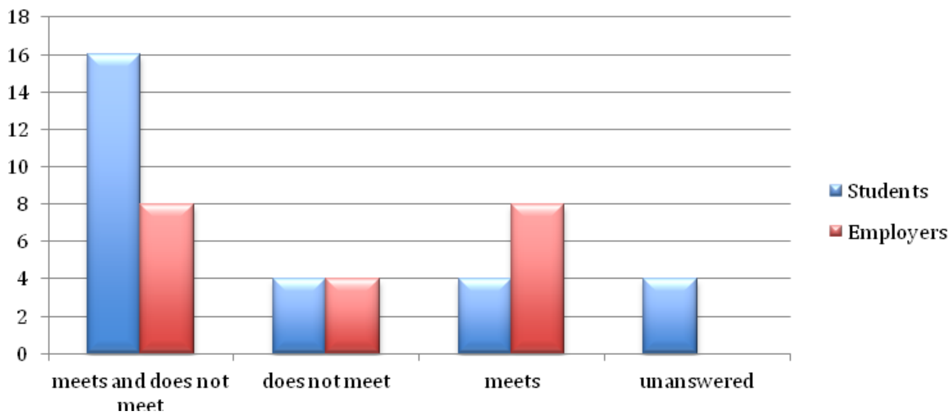

Figure 4.4 Assessment of theoretical training

14% of the students and 20% of the employees of enterprises gave negative answer to this question; 57% of the students and 40% of the employees of enterprises answered [meets and does not meet] while 14% of the students and 40% of the employees of enterprises gave a positive answer.

15. question of the study. Does the practical training of students meet the needs of the company? Results are depicted in Figure 4.5

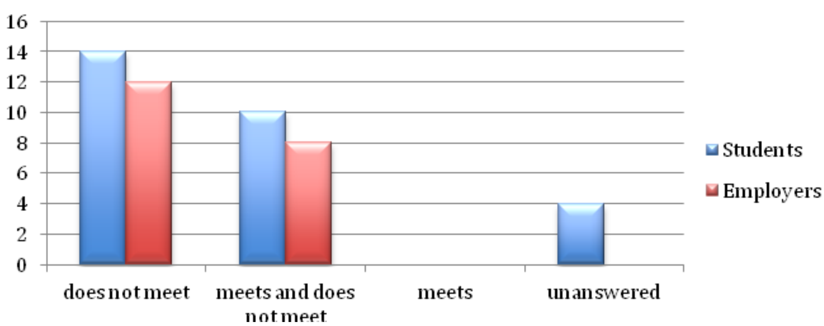

Figure 4.5 Practical skills

50% of the students and 60% of employees of enterprises gave negative answer to this question, 35% of the students and 40% of employees of enterprises responded by using [meets and does not meet] option, so there were no positive answers.

16. question of the study. Does the practical implementation of theoretical knowledge and practical skills students meet the needs of the company? Results are depicted in Figure 4.6.

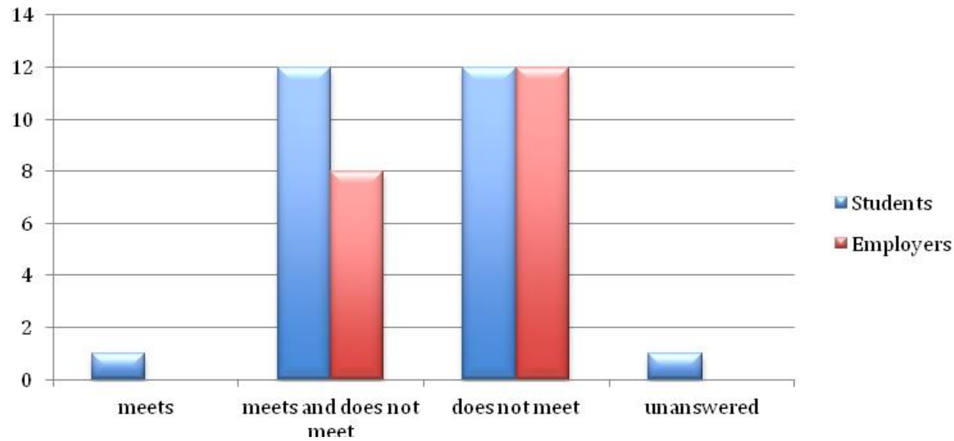

Figure 4.6 Implementation of theoretical knowledge and practical skills

Here it was told whether the practical implementation of theoretical knowledge and practical skills students meet the needs of the company, 46% of the students and 60% employees of enterprises gave negative answer to this question, 46% of the students and 40% of the employees of enterprises gave [meets and does not meet] answer, which allows to draw negative conclusions.

4.4 Summary of Questioning Results, Conclusions

Engineers have received a contemporary training in their specialty, but immediately after graduation they will learn that their professional training is insufficient and they have no occupational training.

Apart specialty-related and occupational training we also need work-focused training for coping in real life. Occupation will determine individual's position on vertical task distribution line. Research specialists and professors can never replace responsible specialists in the sphere of power engineering.

The study shows that apart theoretical training, the proportion of practical training needs to be increased. The knowledge of students on the implementation of knowledge needs to be improved. This can be done by using teamwork (group work), where students will apply their theoretical knowledge to solve practical tasks. Teamwork is, in itself, the fastest way to developing personality and teamwork skills and, what's most important, will help to use the implementation of theoretical and practical skills (APPENDIX 2 page 196) and summaries of interviews are available from (LISA 3. KÜSITLUSTE KOKKUVÕTEpage 196).

The following problems were highlighted during the study:

- academic knowledge is poorly integrated with practical skills and the focus of education is often on academic training while it's not clear whether this meets the expectations of employers;
- students lack working experience; the curriculum for obtaining academic education only includes a small proportion of practical internship;
- teaching/ training methods are not attractive for students and won't encourage them to take initiative and use academic knowledge in enterprises.

As the consequence of the study it was found that is necessary to pay information to the following objects and subjects:

- implementation of knowledge and skills classifications that would consider the demands and needs of enterprises and therefore, requirements to knowledge contents of in-service training for employees of enterprises and students;
- use of teaching didactics that matches effective (the newest, fastest and cheapest) teaching methods (technologies) and study of related trends;
- using a recognised ontology to structure and visualise mental images of learners and lecturers. General visualised picture of the learning process, learning and teaching must be given to the students to achieve this goal;
- more specific modelling of data.

Graduates of institutions of higher education will be employed and therefore, they have the right and duty to take responsibility. Obligations must be met, goals and directions established and tools chosen for achieving these objectives in every job and occupation. Young engineers don't often make a distinction between a job and occupation. As their education is limited, young people often fail to understand that tasks are fulfilled and work performed independently in occupations and only the job given will be done independently in work places.

Chapter 5 Development of Study Methods and Visual Training Materials for Actuators

5.1 E-learning Environment and Its Structure

Universities and applied and vocational educational institutions, but also large companies are developing more and more e-learning materials and e-learning courses, all for the purpose of enhancing the quality of traditional learning and enhance the efficiency of learning. The quality and value of information, included in e-learning courses, depend, above all, on the interests of representatives of different target groups. They all have their own requirements and expectations to the quality of the contents. The main desire of the lecturers is to offer goods and interesting e-learning courses that would meet the demands of the participants, but also the expectations of educational institutions and employers (enterprises).

When designing learning activities for a course, one must consider the abilities of the target group, i.e. the learners and course designers, and technological and technical resources available. The recipients of information must be taken into consideration, when planning the presentation of information, merged into the course. If the information is presented to a course developer or lecturer, we are speaking of teaching design or teaching material, considering his or her angle of approach. However, if information is presented to a learner, were speaking of learning design or learning material. In the case of teaching design, the developer and lecturer will be designing the teaching space and recommended (value-adding, effective) teaching paths. In first stages of learning design, students design their learning paths themselves, depending on their interests and the opportunities, offered by teaching space.

Substantial planning is of key importance for designing a new course. The generally acknowledged and practice-confirmed learning design rules should be observed for designing e-courses E http://htk.tlu.ee/infdid/opik/ptk33.html and the related stages.

Teaching design represents a systematic project that helps the authors of the course to design a course (subject or application) plan, based on learning and teaching principles, plus teaching materials, design course activities and the basics for quality assessment. Most naturally, the expected learning outcomes must be defined for the course. During the course (implementation), both process and performance evaluation must be used. The course description must include the terms and conditions for successful passing of course and the assessment must be linked to expected learning outcomes.

Main stages of projects can be usually implemented during a certain period of time, simultaneously, but they will end in certain time sequence. For the purposes of teaching design and learning design projects, it is possible – and, for the purpose of general understanding, even recommended – to use equal models, whenever possible, for defining the main stages. In the following we are about to describe two models that can be used for both teaching design and learning design purposes.

There are many learning design models and we are going to view two ADDIE models (ADDIE model was created by the American Society of Training and Development (ASTD) and involves five stages: analysis, design, development, implementation and evaluation [114]; [115]:

The five stage learning model, depicted on Figure 5.1, includes the following stages:

- analysis – involving the analysis of needs and contexts of the target group (learners);
- design – involves defining the learning objectives, choosing the types of media used, preparing the structure for the substance of the course and learning process plan or models;
- development – resulting in completed e-learning course, incl. whole set of teaching materials with instructions;
- implementation – this is the most decisive and, also, the most difficult part of the ADDIE model. In this stage, everything that has been done, will be implemented in real life, with real students;
- evaluation – a stage that is important for ensuring the quality of the course. More specifically, evaluation is not a single effort, but a process that will continue during the implementation of whole ADDIE model. It has been specified as the last stage only for giving final assessment to the course designed.

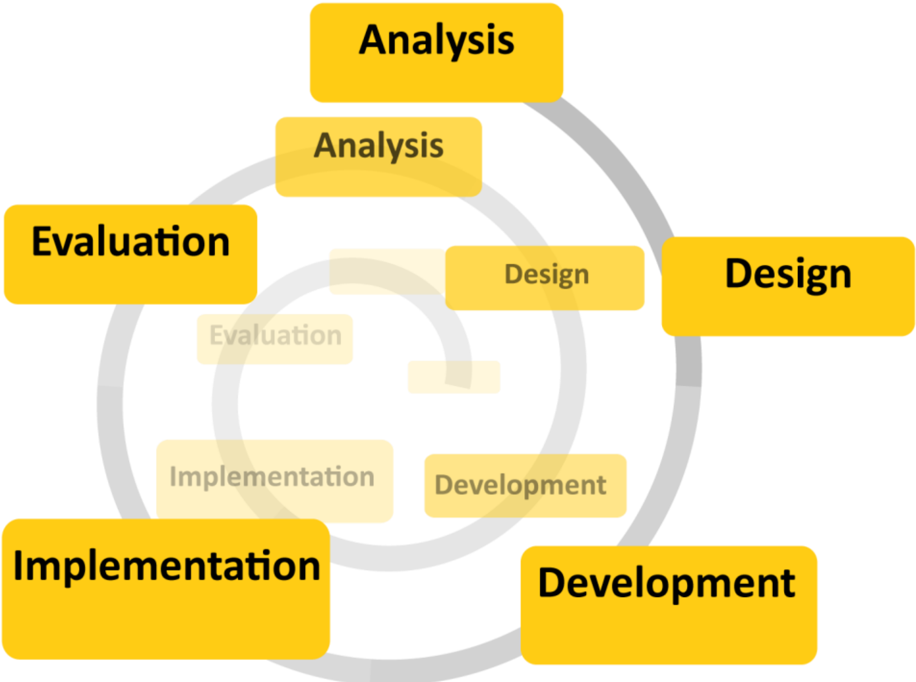

Figure 5.1 Five stage (5E) learning model [132]

Seven stage learning model will add two more strategic stages: assembling a team and selection of appropriate methods and media [115]. Stages/elements or the model are depicted on Figure 5.2:

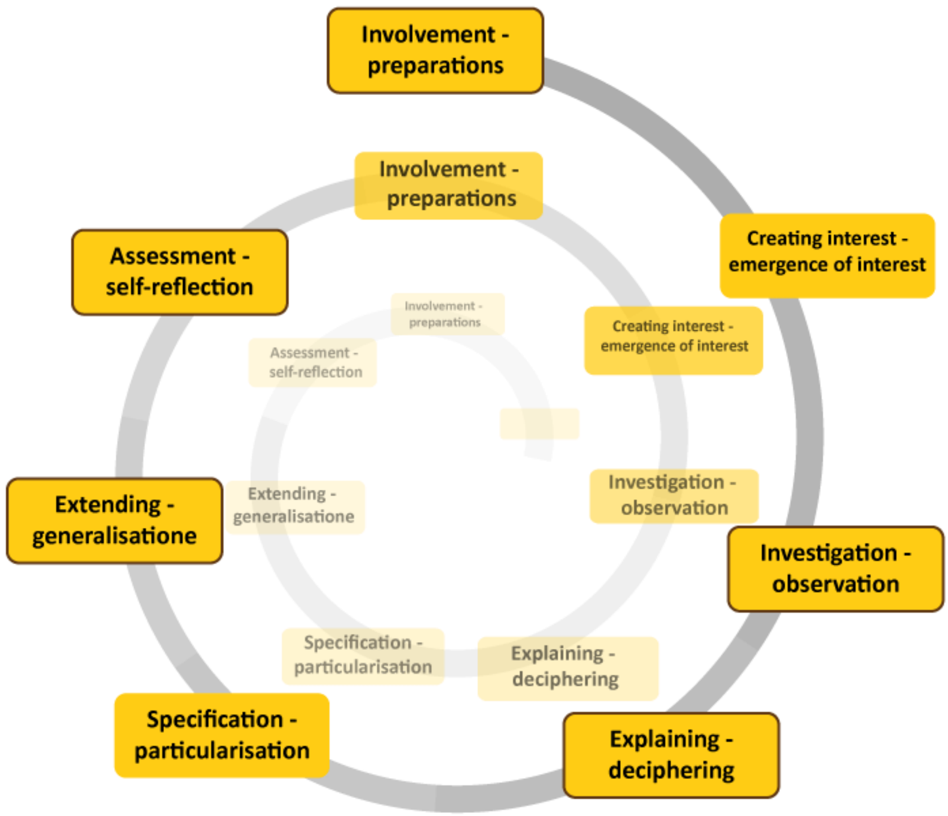

Figure 5.2 Seven stage (7E) learning model [116]

Stages of the seven stage learning models are described below [116].

1. Assemble a Team

Designing, development and implementation of an e-learning course usually involved teamwork. A team should consist of the following specialists of different fields:

- project manager (team leader);
- experts of different specialties (teachers, consultants, assistants);
- education technologists (pedagogic, teaching didactics specialists);
- web designers and ICT (information communication technology) specialists.

At universities and vocational educational institutions, education technologists, multimedia and information technology specialists are offering methodological and technical assistance to academic staff for designing and testing out e-learning courses. Learners and students participate in testing and implementation of the course.

Education technologist will help:

- with recommendations about preparing and designing the teaching materials;
- to select the most appropriate methodologies and methods for the courses;
- to design technical aspects of the course;
- to plan the support, needed by students at different implementation stages of the course;
- to improve the courses further, based on the feedback received.

2. Determine the Need and Audience for the Course

Information is collected to determine the need for the course. Here it is important to take the professional levels, defined by qualification framework, into consideration (page 48), with the general requirements identified. It is important to know whether appropriate teaching materials are available for teaching and learning the course. If yes, it has to be checked whether the materials are sufficient and relevant.

Analysis of the needs involves the following activities:

- identification of required needs/skills/attitude;
- assessment of real situation;
- assessment of the gap between real and desired situation;
- listing of priorities – which questions/subjects/problems should the course address, above all. Drafting a list of requirements.

Different methods are used to analyse the needs: reference to literary sources, discussions with experts, questionnaires, tests.

If possible, group discussions are organised to determine the needs and expectations of learners. It is important to learn and determine, what will be the target group (learners) and which factors have influence on the target group:

- demographic factors (e.g. the number of students, their age, language and region);
- motivational factors (e.g. learning objectives, expectations, hopes and fears, relevance of the course for their work);
- learning factors (e.g. learning styles and their preferences, cultural or social factors) etc.;
- factors related to background information (e.g. former contacts with the studied subject, can the students share relevant experiences, what are their former beliefs or prejudices);

- availability of resources (e.g. what types of media can be used and what are the support systems, are they accessible? How much time is available, in reality, to learn the subject or finish the module? Who will be funding?).

The following questions must be answered to analyse the target group [117]:

1. Who are the participants of the course (learners)?
2. What former knowledge, needs and skills do the students have?
3. Are they motivated to learn?
4. How big a group can be taught under the considered circumstances?
5. Do the authors (creators) of the course have to develop the learning skills of their audience first? The learners don't necessarily master the methods of independent and resource-based learning in the very beginning.
6. What are the technical resources available to learners (computers, access to Internet, required extra tools etc.)? What can you say about the participants' skills for using these tools?

3. Outlining the Objectives of E-learning

Clearly defined learning objectives or outcomes represent one of the first and most important steps in designing an e-learning course, as the rest of the project's action plan will rely on it. This will be followed by defining the learning outcomes of the course and formulation of required initial knowledge. The learning activities and technological resources will be then outlined.

Objectives of the course and learning outcomes must be outlined in a structured way. They need to be well-formulated (described at a number of levels). For example: dream: life goal; mission; benefits of a learning project etc.). Objectives and learning outcomes help the team in charge of preparing the course to design the course, its stages and efficiency of the learning process, being of assistance for choosing the suitable learning environment, teaching methods and evaluation methods.

Learning objectives and learning outcomes are meant to give learners and overview what to expect of the course and what they should focus on during the course (implementation). The wording should be detailed enough, describing the new acquired skills and knowledge and also showing the context where the learners can (could) use the skills.

Structural scheme of a course substance should be defined, based on analysis of learners, vision, objectives of the course and desired contents.

As the structure of an e-learning course is outlined, we must see that the substance meets the following requirements [117]:

- suitable volume;

- matching the course level, work load etc. academic requirements;
- relevant and presented in an understandable way;
- growing and reinforcing knowledge and skills, based on earlier knowledge and skills;
- logically structured and sequenced;
- interactive;
- possibility to "zoom in – zoom out" the contents presented to open the context;
- allowing for further updating by both pedagogic methods and subjects.

Ideas and principles that the learners encounter during earlier learning stages should also facilitate learning at later stages.

There are several opportunities available for learners to sequence the substance; spiral sequence is just one among many – concepts of contents are repeatedly discussed during the course, taking them to a more complex level every time (e.g. overview – substantial study - analysis) [118].

4. Selection of Appropriate Media and Methods

In web-based environment, learning process will vary in accordance to the used tools and student's learning path within the learning space will be difficult to determine [119]. Different software tools and their visual user interfaces (e.g. social software) have become a part of a web-based learning environment. Teaching does not mean solely transfer of information. This will also involve some filtration and guiding the attention. In a described situation, more and more attention should be given to planning, organising (conducting), co-ordinating learning for the purposes of e-learning, and sequencing, guiding student's learning path, using the earlier defined learning tasks and activities [117].

The individuals, designing (implementing) the course, must have certain principles for using different technologies. They should discuss, with technical expert and education technologists, which technical tools and devices will be most suitable for their course.

The following aspects must be considered for selecting the technology [117]:

- availability;
- easy to use;
- options for active involvement of students;
- interaction;
- adaptation;
- suitability for co-operation;
- compatibility with tools and software, used at the company;
- compliance with standard.

Possible technical tools [117]:

Learning Management Systems – these are complex systems that include tools for structuring the course, presentation of the contents of the course (files, learning modules, media sets), communication (forum, mailbox, chat room), performance of learning activities (tasks, tests, group tolls) and course management (learning records, supervision of participation). Moodle, IVA, VIKO or Blackboard (until year 2012) learning environment is available to the members of Estonian e-university or e-vocational school;

Tools for creating teaching materials – multimedia tools. The use of multimedia represents one of the alternatives for creating a good web page. This may involve questionnaires, animations, drawings, films, interviews, audio clips and regular photos or images.

Multimedia may be also useful, offering, for example, simulations of scientific experiments, interactive presentations and educational games. Multimedia may represent a quick and simple tool to make different scientific phenomena better understandable. Here we will observe different multimedia tools and options available for their use.

The following materials are used to design e-learning courses (Figure 5.3):

- text-based materials – e.g. Oowriter, MS Word, CMSimple, Edicypages, Weebly, eXe, CourseLab, Lectora, MyUdutu etc.;
- slides –e.g. Ooimpress or MS PowerPoint etc.;
- audio material (audio clips) –e.g. Audacity;
- video materials – e.g. Camtasia Studio, Windows Movie Maker;
- animations – e.g. Adobe Flash, Gimp;
- screen videos (recordings) – e.g. Camtasia Studio;
- multimedia presentations – e.g. MS Producer, Camtasia Studio;

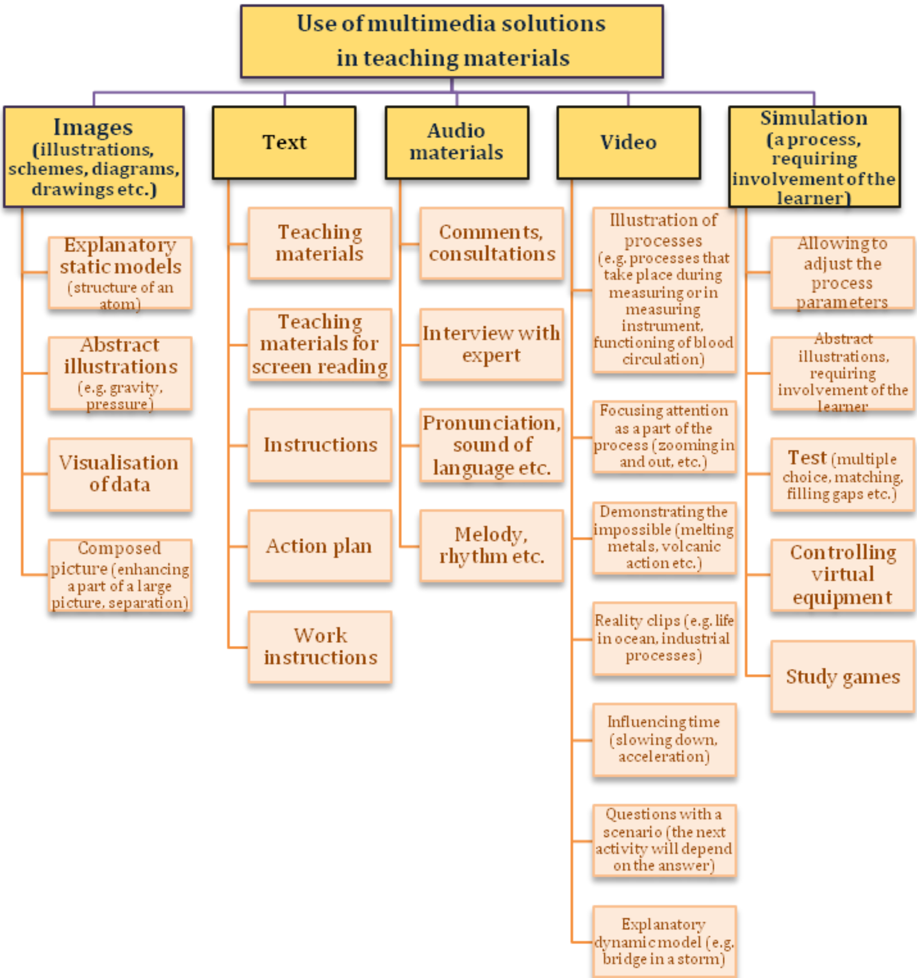

Figure 5.3 Use of multimedia applications in teaching materials [120].

Communication tools – these have huge influence on creation of community or team atmosphere and establishment of academic relations. Efficient use of these tools may decide whether the specific learner can cope with passing of the course or not. Therefore, course designers must pay lots of attention to choosing and using the communication tools. Communication tools are divided into two classes [117]:

- synchronous tools – devices used in real time (for example, MSN, Skype, chat rooms of web-based learning environment, Horizon Wimba tools, e.g. classroom live);
- asynchronous tools – devices used at different times (forum in a web-based environment, e-mail).

Once the teachers and learners have defined learning tasks for the learning process, co-operation tools will be needed.

Co-operation tools – electronic means of communication have offered new options for co-operation and establishment of social networks, diminishing the differences of distance learning and face-to-face learning even more. Course designers must know, which tools can be used, considering the current technical resources and preferences of the target group (learners). Co-operation tools are available in web-based learning environments (forum, tasking tools that can be used for group work, Wiki). Apart the options already mentioned, various social software can be used as co-operation tools; today, lots and lots of attention is given to cloud services (Wikis, time web and other co-operation tools like Google Docs, Google Apps).

For achieving a learning process as diversified as possible (offering different learning paths to students), the use of different pedagogic approach is recommended. We recommend using the following:

- Problem-based teaching. This method involves analysing problems or cases, practical thinking, adoption of decisions and solving of problems. It is recommended to describe a real problem that would be interesting to students, matches their experiences and learning objectives and is complicated enough to justify analysis;
- Co-operation based teaching. In the case of this study method, group work is the most suitable tool; group members will be jointly responsible for fulfilment of their tasks and this will develop responsibility and trust in students;
- Community-based teaching – here people with either shared hobby or learning the same subject must be combined to allow them to learn new knowledge during mutual communication. Web-based communication tools will allow students to discuss study-related troubles and problems with each other. This can be compared to mutual support that participants of face-to-face learning offer each other.

When designing a course, one of the most important issues is related to the assessment of the learners – or which evaluation methods should be used? Evaluation should be based on learning outcomes and must be planned before any teaching materials are prepared.

Key questions for the development of a successful evaluation strategy [117]:

- Which knowledge, skills and attitude will be assessed?
- At what point of the course will assessment take place?
- How will the assessment be done?
- Who will prepare the evaluation materials, requirements, criteria?
- Who will assess?

- Which feedback will be given to the students (grades, comments – model answers etc.)?

Most applications and processes of e-learning courses include numerous tasks that will be given for the learners to solve at regular intervals during the learning process in general. Tasks will be only efficient if the learners can get, apart grades, also constructive feedback.

5. Designing Your Activity for the Course

Project manager will form a team to design a course. For the team, designing activities will represent a substantial development game, resulting in a specific application or a course with a certain name. During the team game, the contents, developed by course designer (teaching materials, tests, instructions etc.) will be transferred to e-learning environment. The course of each and every game can be viewed on step by step bases, as an application, at a certain development stage.

Hierarchic contents of a course (modules, components) and implementation (processes, tasks, works, activities) and their visual form of presentation will have considerable effect on learning experience of students. A team, designing the e-learning course, must present the contents in a way that is compatible with academic requirements and matches the level that is customary for the learners who are well aware of electronic tools [117].

The following e-learning standards must be observed for the creation of teaching materials:

- IMS (IMS Global Learning Consortium) http://www.imsglobal.org/
- SCORM (Sharable Content Object Reference Model) http://en.wikipedia.org/wiki/Sharable_Content_Object_Reference_Model

Compliance with standards allows to export and import the materials from and to different learning environment.

Copyright laws must be definitely taken into consideration for designing, implementation and using of a e-learning course. Contents of the course must list the contribution of all the authors. Each and every part of the material must be marked, unambiguously and visibly, with the names of the authors of materials. Personal rights of authors and proprietary rights, made available under a licence, must be protected and restricted applicable to the used of materials, created by third parties (including the students), must be observed. All the teaching materials don’t have to be created by course designer; it is possible to use available materials under a special license [e.g. Creative Commons – http://www.creativecommons.ee]. If the name of the author of the works used, title of the works and name of publisher is shown, as required, lawfully published materials can be cited and referred, using motivated volumes and observing the requirement of transferring the general idea of the referenced or cited works (the Copyright Act, https://www.riigiteataja.ee/ert/act.jsp?id=13246706).

The following principles should be used for the development of e-teaching materials [117]:

- different alternative multimedia tools and solutions will be used for the presentation of teaching materials;
- the contents of e-learning course must consider the needs and specificities of the learners. Participation in a course is also possible with a poor Internet connection;
- e-learning course is reliable, accurate and appropriate. The name of the designer is clearly indicated and the information of educational institution referenced, as required by the Copyright Act;
- teaching materials can be used with different web browsers (Mozilla Firefox, Microsoft Internet Explorer) and operation systems (Microsoft Windows, Linux, Mac OS);
- teaching materials are presented in correct language;
- teaching materials are suitably structured into smaller parts.

There are several different options for the implementation of e-learning courses. For a teacher, it would be the easiest to implement the course in some web-based learning environment.

The term “web-based learning environment” includes all the systems that are needed for managing web-based studies.

Web-based learning environment focuses on tools that are used to store, communicate and submit e-teaching materials to the learners. The properties of web-based learning environment influence the nature of studies, methods for communicating with learners and the work of teachers and learners [117].

Web-based learning environments are used to [117]:

- present course-related teaching materials; the materials may include text, pictures, videos and sound;
- for communication between learners and teachers and mutual communication of learners by means of forum, mail-box, chat room or shared information board;
- facilitate learning, using information search engines, dictionaries, databases of photos, reference to materials available from web;
- assess the students (tests and tasks);
- administrate the course (management of learners and learning outcomes, statistical information concerning the activities of learners).

The members of Estonian e-University and e-Vocational School can use the following environments:

- Moodle http://www.e-ope.ee/opetajatele/keskkonnad ;
- IVA http://ekeskkond.weebly.com/
- VIKO http://viko.edu.ee/.

Teachers can obtain pedagogic and technical consultations from education technologists and/or assistance for creating e-learning courses in web-based learning environment.

E-laboratories can be established for more complicated and complex courses – provided that the required tools are available. E-laboratory may be a tool to enhance quality and support blended learning.

Testing of the course is one of the stages of designing the course, aimed at identifying whether teaching methods and materials meet the established objectives. Testing allows to determine strong and weak points of a course.

There are several methods for testing the course; they can be used either separately or in combination. The most common methods are listed below:

1. involving a more experienced colleague to review the course;
2. testing with target group representatives. It is recommended to choose 2-3 future students who will be given special tasks for testing the course in the learning process that is carried out [117];
3. use of a special pilot group. Employees of enterprises, participating in in-service training courses or teachers, capable of assessing the suitability and level of teaching materials and tasks etc. and give adequate feedback, represent a good target group;
4. replacement of e-learning for blended learning, i.e. although the course is planned to be implemented, using e-learning tools only, blended methods will be used at the first time, involving a smaller group, to obtain better feedback during the course.

Course manager should obtain feedback in the following spheres as the consequence of testing the course:

- course structure and design;
- contents – appropriateness, relevance, compliance with original knowledge and organisation;
- efficiency of learning work – learning productivity within the time frame, specified for the course, activeness, attention and courage to express oneself of the learners, usefulness of discussions, adequacy and learning speed of the materials;
- use of technology – positive aspects, problems, opinion of the technology to be used;
- communication – opportunity to communicate with other learners and teacher, communication quality and quantity;
- tasks – their usefulness, level of complicacy, time requirements, efficiency of giving feedback;
- tests – their relevance, level of difficulty, feedback;
- support to learners – assistance of tutors, technology, services of libraries and computer labs, availability of teaching materials;

- teacher – his/her leading role, organisational abilities, preparation, enthusiasm, openness.

Testing becomes especially useful if the course will be used wit large groups and it would be especially difficult to modify the course during studies.

6. Implementing Your Learning or Study Programme

Apart high-level teaching materials, strong technological support to learners and good technological infrastructure, e-learning courses must be also implemented skilfully. Different models that support not only the pedagogic structure but organisation (implementation) of the course and design in general can be used for the learning process. For example, it is recommended to use the 7E model (figure 5.4), described above, which is always introduced at the beginning to any course to the learners, for students of technical specialties.

The description of stages of 7E model is the following:

- **Involvement** – at this stage, motivation and encouraging of learners is important. The stage ends once learners have posted their first messages.
- **Creating interest** – at this stage, initial knowledge is given, linked to existing knowledge, and links with real life are explained. Socialisation will take place in e-learning environment. Communication tools offered by web-based learning environment will offer an opportunity for participants to communicate with each other. Real socialisation will depend on planning of discussions and the efforts of tutor. During the course, learners must feel that they belong to a close-knitted group that facilitates commitment and focusing.
- **Investigation** – information exchange is taking place. At this stage, learners will realise the volume of materials, available from web. They will love immediate access to information and quick information exchange.
- Explaining –e-learning process, terms and definition, terminology will be explained. Here we may encounter a danger that too much information will scare the learners, therefore, the tasks of a tutor or teacher involve enhancing the self-confidence and enthusiasm of learners. Participants must interact with course contents and also the tutor and other learners.
- **Acquisition of knowledge** – this is the most interactive part of web-based course, involving active, intensive and public communication of participants.
- **Specification** – this involves further discussions and generalisation, specification of terms and definitions. Suitable theories will be employed to understand links between definitions (incl. dynamic changes, facilitated by links). Ideas and opinions about subjects will be defined, letters of other participants are read and answered.

- **Extending** – channelling learning outcomes into new spheres. Learners will only obtain limited information from discussions and examples of other learners, but they will expand their own views, supplement concepts and theories, get new ideas and enhance their perception of course materials for both themselves and other learners. Therefore, information is not only shared, but knowledge is expanded and also applied, where appropriate. If applicable, new business ideas are generated and business plans devised to introduce innovative ideas in enterprises or products into production.
- **Assessment** – evaluation of what the students know and can do. Giving the evaluation and making reviews. At this stage, the results of learning process at every stage of the e-learning course will be assessed and feedback is given. It will be discussed, how was the co-operation; technology (incl. theory) used will be assessed, complete with the influence of technology employed on the achievement of objectives and recommendations are also given for further improvement of the course.

Figure 5.4 Learning process of an e-learning course, implemented by means of 7E model

As for e-learning, it has been established that one of the main factors that can be employed to increase the number of course graduates, is the support offered by entities, implementing the course. Depending on the number of students, scope of work and opportunities available, support person or a tutor can be involved for the implementation of the course. In the best cases, students will have their own mentors who have already passed the learning processes.

Teachers, mentors and tutors must fulfil the following roles for e-learning purposes [117]:

- technical – assistance, related to computer and learning environment, available to course participants. The students will be explained IT knowledge upon offering technical support.
- managerial – learning process management. From organisational aspect, it's very important to monitor the activeness of course participants and constant bases and pay them attention.
- social – crating a supporting environment between course participants. The social role of a teacher and a tutor serves the objective of contributing to creation of common atmosphere within the group and to make participants feel that they are expected personalities at the course, free to express their wishes and opinions.
- pedagogical – pointing attention to important materials, managing independent work and giving feedback. In a pedagogical role the participants of e-learning course must be supported, as they are performing their tasks, and then assess both the learner's learning process and the final outcome.

7. Course Evaluation

Evaluation serves to ensure further development of the course. ADDIE model can be used to evaluate the e-learning courses, assessing both analysing, design, development and implementation stages of the course. Quality requirements must be also observed for the course assessment purposes. Contents of the course, implementation methods and interaction should be also taken into consideration for evaluation purposes. The following methods can be employed:

- external evaluation – external evaluators will review the course implementation, offering feedback on development work and evaluating the course in general. In some cases, external evaluation can represent comparative evaluation with other similar courses or expert evaluation.
- internal evaluation, involving:
    - collection of information on the use of e-learning tools and materials by students and analysis of the data collected;
    - submission of documented feedback, gained during the supervision and evaluation process, which will later allow to improve and adapt the course.

Different methods are available for internal evaluation:

The most efficient is self-analysis of the course. Questionnaire represents the simplest methods.

Regardless of whether external or internal evaluation is used for assessment purposes, the evaluation still represents the process for the collection of data that is used to highlight the strengths of the course and draw conclusions on changes that are needed to improve the course [117].

5.2 Teaching Stands for the Development of Practical Skills and Their Use

The teaching stand described is prepared for students learning to use industrial programmable controllers and actuators at automation courses. Multifunctional production automation stand (MFS) represents one component of a blended learning system (Figure 5.5;Figure 5.6).

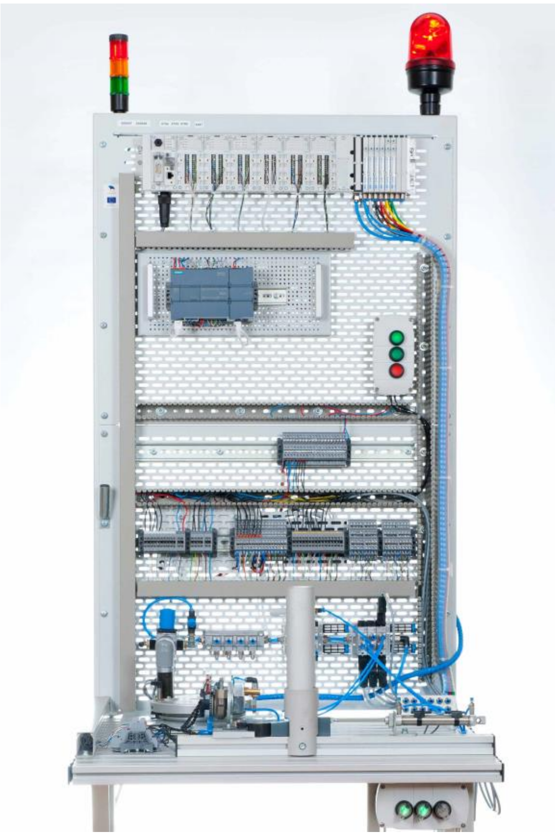

Figure 5.5 Multifunctional MFS stand

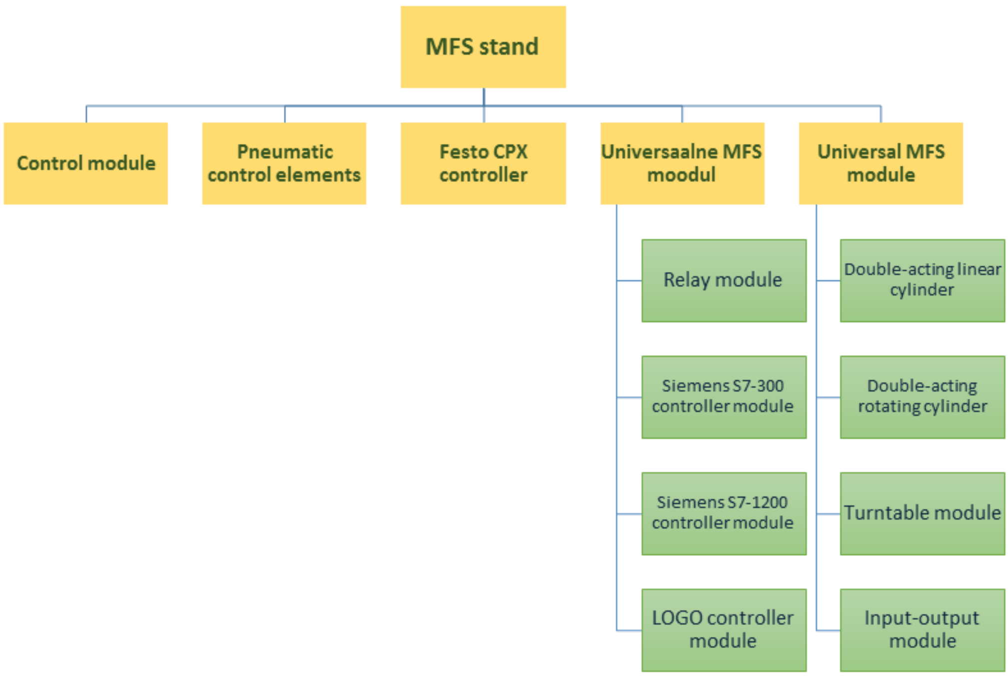

Figure 5.6 Structural diagram of MFS

- MFS stand
    - Control module
    - Pneumatic control elements
    - Festo CPX controller
    - Universal MFS module
        - Relay module
        - Siemens S7-300 controller module
        - Siemens S7-1200 controller module
        - LOGO controller module
    - Actuator module
        - Double-acting linear cylinder
        - Double-acting rotating cylinder
        - Turntable module
        - Input-output module

The purpose of building a learning stand is to offer the students different practical tasks and a variety of solutions for such tasks.

Experimental learning stand, used for practical studies, must meet the following conditions:

- simple and easy to understand construction;
- clear overview of the principles, processes and operation of the piece of equipment concerned;
- multifunctional, allowing to prepare different learning tasks and their practical launching within the framework of a technical process;
- allows to use different pedagogical didactic study methods (individual learning, group work, project-based work);
- matches acknowledged learning and teaching models;
- allows to develop practical skills within the framework of blended learning process.

Upon visual observation, flexibility of technological processes, run with the stand, stand out immediately. The following modules can be taught and learnt, using the stand:

- Pneumatic automation – learning to control, use and install pneumatic systems (pneumatics and electropneumatics), using industrial components (pneumatic valves, actuators) and the proper installation methods. As the result, the learner:
  - will understand the problems of pneumatic control systems;
  - will be capable of solving problems schematically;
  - will be capable of providing the connections, needed for solving the problems, using industrial tools and methods and related industrial components.
- Electrical engineering control technologies – electrical engineering control technology stand is used to study the installation and operation of relay control devices. Schemes of automated systems will be used, including pneumatic and electrical engineering components. After performing the tasks, the learner:
  - will understand the industrial schemes of automated systems;
  - will be capable of solving possible problems that may incur with relay control systems;
  - will be capable of installing industrial components of relay control equipment;
  - will be able to troubleshoot the systems and eliminate identified defects.
- Programmable Logic Controllers – the stand is intended for programming different easily interchangeable programmable logic controllers (Siemens LOGO, Siemens S7-300 and S7-1200) (programming commands; AND, OR, R/S, timers, counters comparators) and connecting the devices. The following will be learnt about the programmable controllers:
  - Troubleshooting for construction and installation errors;
  - Getting to know the software; programming instructions will be studied, using hardware settings, made by software;

    - Simple programming tasks will be solved;
    - Programme settings, diagnostics and testing.
- Movement detectors – practicing the installation, adjustment and troubleshooting of most common contemporary analogue and digital movement detectors of modern automated equipment that perform linear and angle movement. After performing the tasks, the learner:
    - has mastered the methods for mechanic installation of most common industrial movement detectors in different installation spheres;
    - can design the structures and principles of measuring systems of different types of detectors;
    - can perform electrical connections of different connections of various detector types to electrical measuring and adjustment systems, using the instructions, issued by manufacturer of detectors and install detectors into the given measuring range;
    - will learn to monitor signals transmitted by analogue and digital measuring and adjustment systems in such a way that error compensation of linear detector can be performed within compensation and adjustment system and perform troubleshooting, using suitable measuring instruments.
- Visualisation – for that purpose, visualisation software will be used (Siemens SIMATIC Panel Touch HMI touch screen panel and related software, Siemens STEP7 TIA WinCC). The following will be learnt about text and operator displays:
    - types of text and operator displays;
    - installation (identification of constructional and installation errors);
    - software (getting to know the software);
    - object-oriented programming;
    - displaying the variables; trends and moving mages; solving simple exercises; testing).
- Industrial information networks – automated industrial networks – the stand will be used to learn about the installation and use (operability) of modern automated unresolved (dispersed, divided) control systems used in industrial automation networks. After performing the tasks, the learner:
    - will understand (interpret, comprehend) the structure of control systems, executed with dispersed data bus and/or Profibus – networks;
    - will know network components of different type and can use the related terms and definitions;
    - can use connecting signals, added to data communication process of data bus and/or Profibus network types, to different network components;

    - can build up an integrated working industrial automation network, using automation circuit diagrams and lists of parameters.
- Operation of automated systems – the stand will offer excellent opportunities for investigating automated systems and their operation. After performing the tasks, the learner:
    - can install components of automated systems;
    - can troubleshoot the system;
    - can adjust the settings of flexible production module programmes;
    - can adjust and fine-tune automation systems; experimenting with flexible production volumes;
    - can use measuring instruments and related software and perform the required measuring operations.

Almost all the inputs and outputs of the stands are open, easy to grasp and control for both the learner and the teacher. Students can connect detectors and actuators into real inputs and outputs of the controller, using terminal blocks and observing the supplied schemes and diagrams.

Therefore, the stand will give students and overview of possible methods for connecting elements into automated systems and preparing control systems controlling the systems, using pneumatic valves, detectors, programmable controllers and industrial information networks.

5.2.1 Construction of the Stand

The stand (MFS - Multifunctional stand) (*Figure 5.7*) consists of two constructional components: control module and actuator module (*Figure 5.8*). Actuator module includes pneumatically controlled input module, installation module and electronically controlled turntable/rotating disk and turntable/level modules. Feeding and re-positioning of the work piece and placing it into turntable module will take place within this module.

Integrated control modules are divided into different control units: relay block (*Figure 5.9)*, LOGO control block (*Figure 5.10*), Siemens S7-300 (*Figure 5.11*) and S7-1200 control block (*Figure 5.12*).

Control module allows students to study logic modules: logic modules, installation of modules (construction and troubleshooting); programming (students will learn to use software, programming exercises are done and programmes fine-tuned)

Special attention must be given to easy interchangeability of programmable PLC) controllers, which makes the given stand universal and unique. The construction and simple changing of controller assembly panels is illustrated by the following photos (*Figure 5.13. and 5.14.*).

5.2.2 Summary

As a part of the doctoral thesis, multifunctional production automation stand (MFS) has been built, intended for students learning to use industrial programmable controllers and actuators at automation courses. Multifunctional production automation stand (MFS) represents one component of a blended learning system.

The purpose of building a learning stand is to offer the students different practical tasks and a variety of solutions for such tasks.

Experimental learning stand, used for practical studies, must meet the following conditions:

- simple and easy to understand construction;
- gives clear overview of the principles and processes;
- multifunctional, allowing to prepare different learning tasks and their practical launching within the framework of a technical process; the stand will allow teaching and learning about different modules (for example: programmable logic controllers, electrical engineering control technologies, pneumatic automatics, sensor technology, industrial information networks, visualisation, operation and maintenance of automated systems etc.;
- allows to use different pedagogical didactic study methods (individual learning, group work, project-based work);
- matches acknowledged learning and teaching models;
- allows to develop practical skills within the framework of blended learning process;
- is low-cost, as far as learning expenses are concerned (compared to other equivalent stands) and easy to re-structure to match the development of curriculum and related technologies.

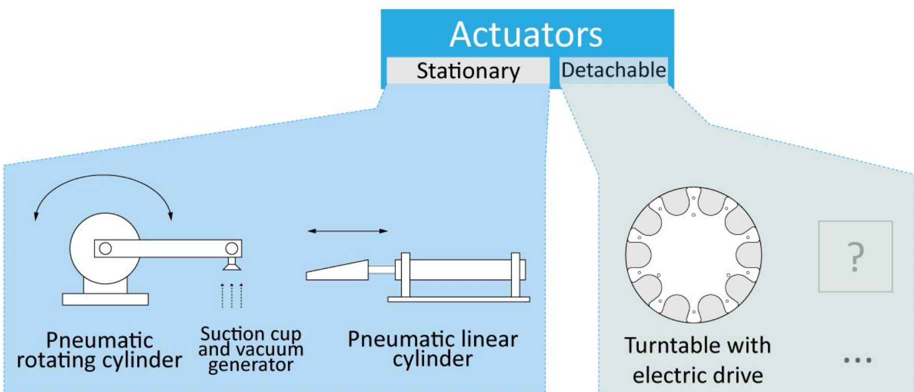

Figure 5.7 Structural scheme of actuator module of MFS stand

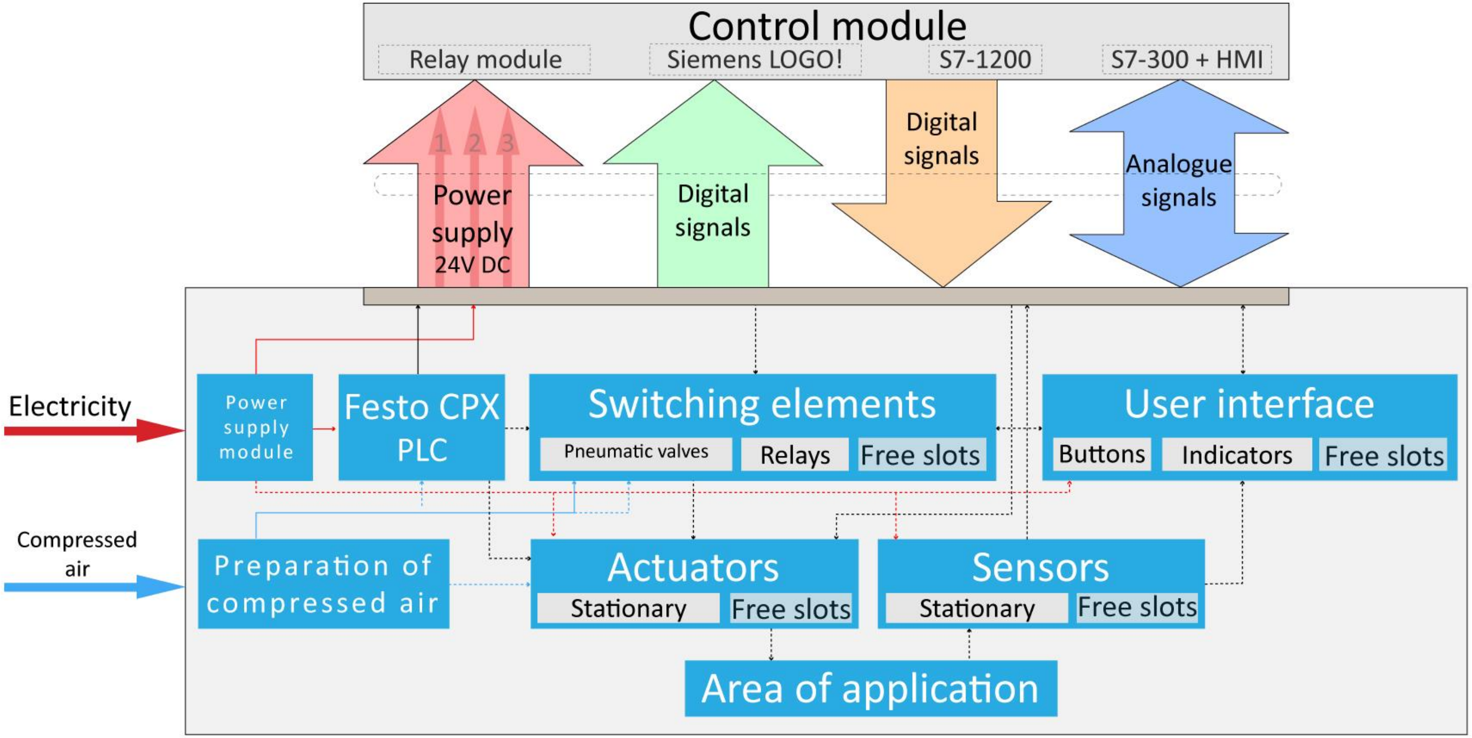

Figure 5.8 Structural scheme of a MFS stand

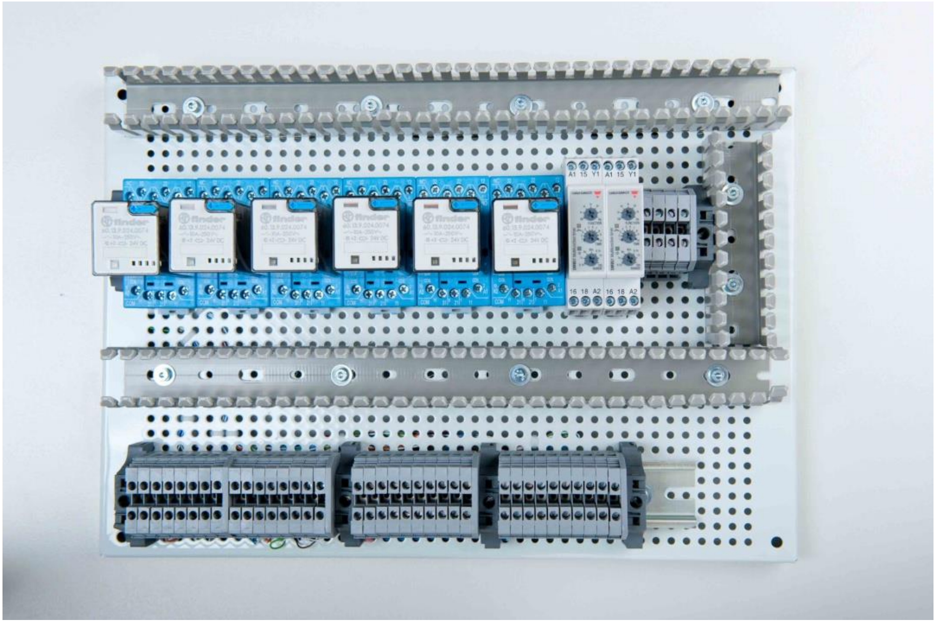

Figure 5.9 Relay block

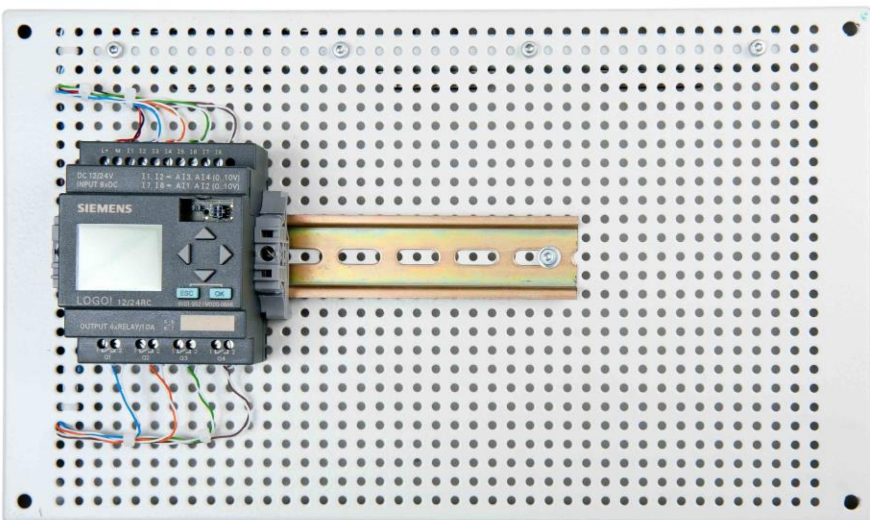

Figure 5.10 Siemens LOGO controller unit

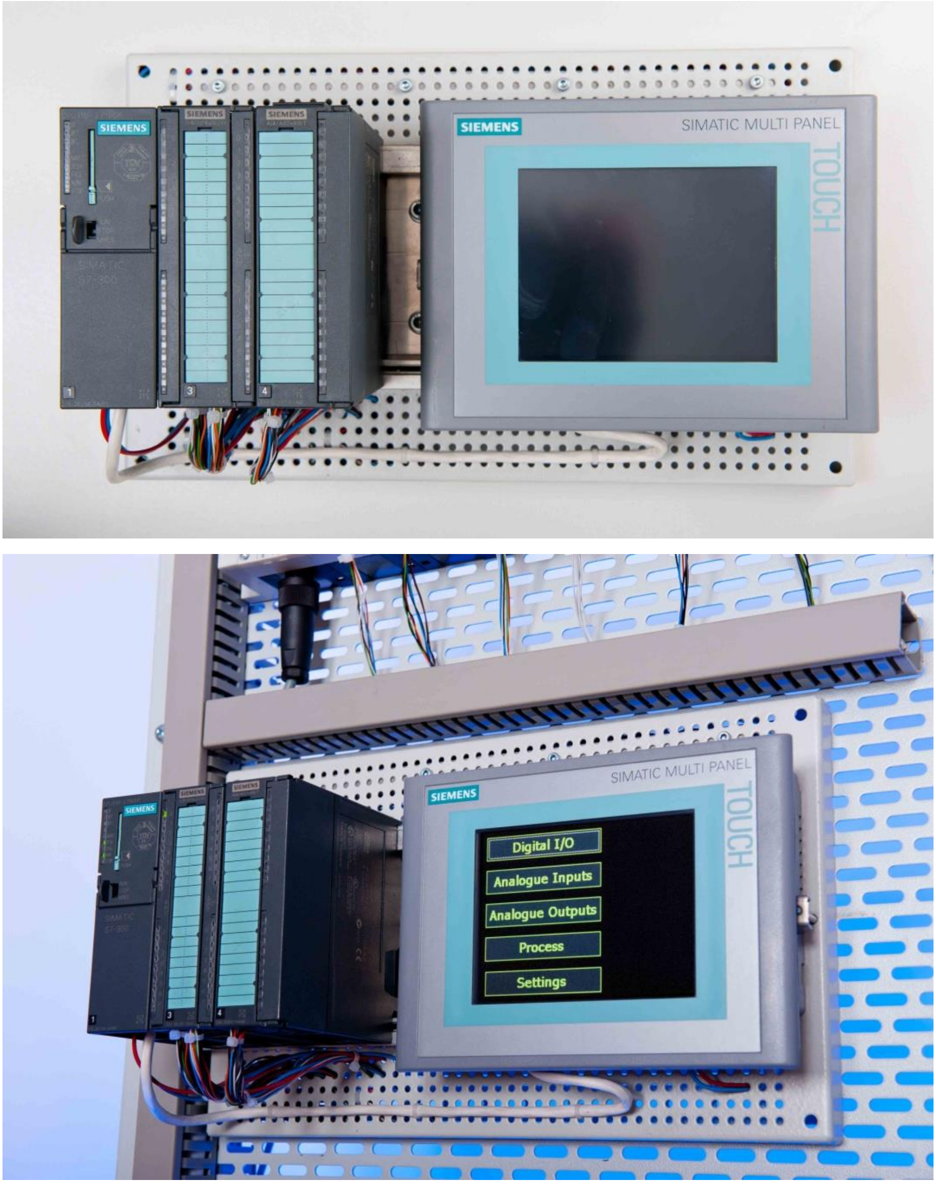

Figure 5.11 Siemens S7-300 controller and control block

Figure 5.12 Siemens S7-1200 controller block

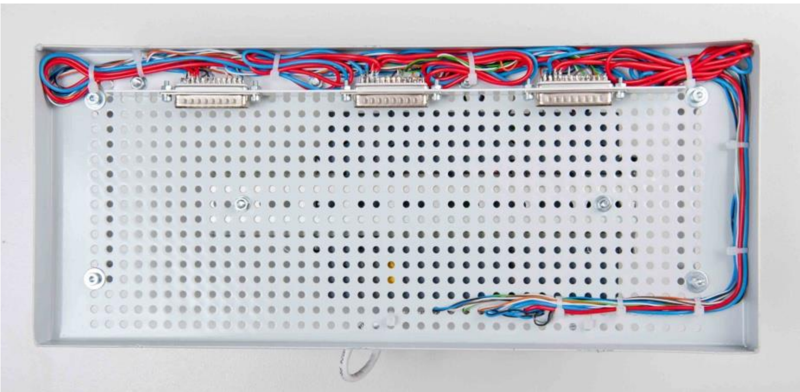

Figure 5.13 Construction of controller assembly board

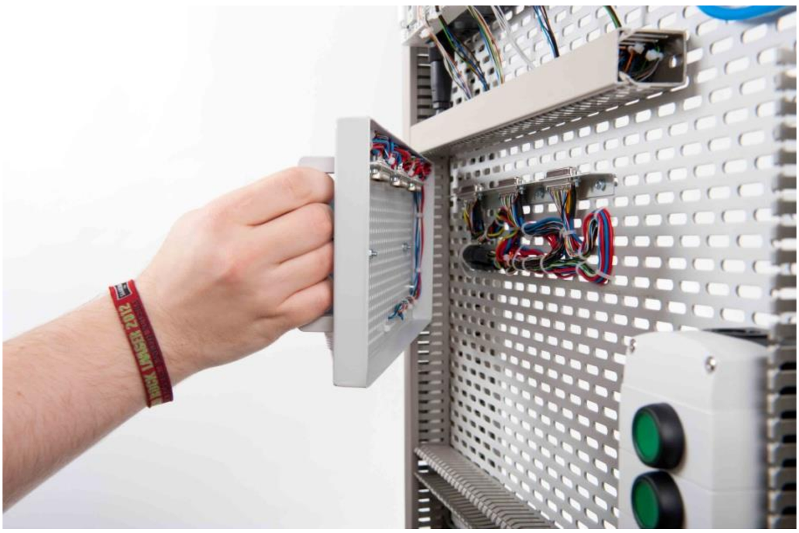

Figure 5.14 Installation of controller assembly board

5.2.1.1 CONSTRUCTION OF ELECTRICAL SYSTEM OF THE STAND

The stand gets its power supply from 230 V alternating voltage power supply network. One phase power supply cable with protective earthing is connected to a terminal block in a distribution cabinet behind the stand; from the distribution cabinet, the phase cable will be drawn to the main switch in front of the stand, connected, in parallel, to the first terminals of all three main switches. The cable then runs back to the distribution cabinet, in parallel, from all three switches and then to the mains adapter, where 230 V alternating voltage is transformed into 24 V constant voltage (Figure 5.15.). The constant voltage thus obtained is fed back to distribution cabinet. Here is should be mentioned that all the 230V components are covered/shielded to ensure the safety of students and students have practically no chance to be in contact with dangerous voltage.

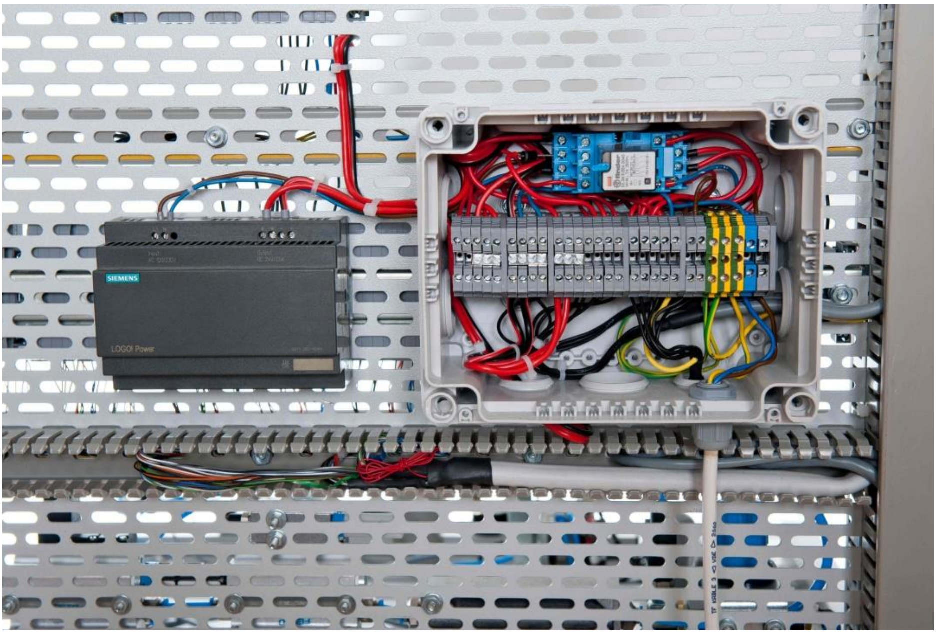

Figure 5.15 Power supply module of MFS stand

Power supply, coming from distribution cabinet, is divided between three separate switching groups:

- Power supply to be used for students and being in immediate contact with students;
- Power supply of detachable control module;
- Power supply of stationary industrial controller Festo CPX (*Figure 5.16*).

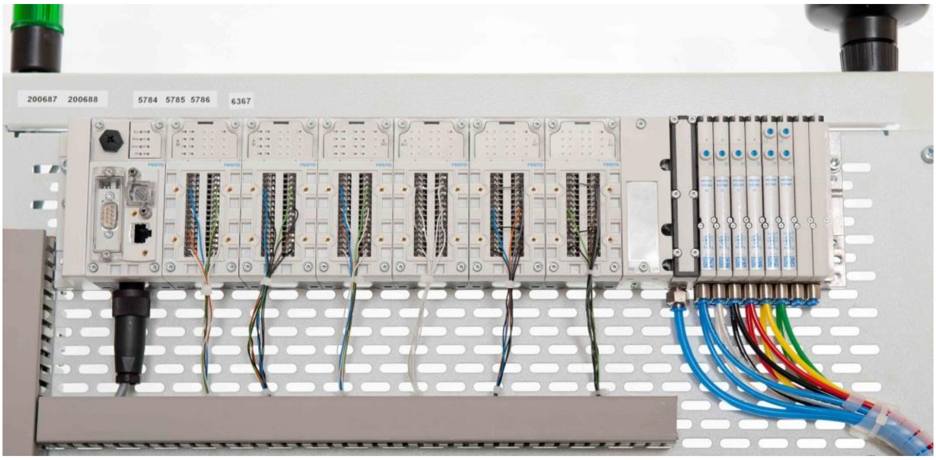

Figure 5.16 Festo CPX controller

There will be a tumbler switch with a LED indicator in front of the stand for every group. The power supply, which is meant to be used by the students, is brought out to the stand wall, bridged to terminal strip block, where the student can connect the plugs of equipment used by themselves. Power supply of the detachable control module and stationary controller is also divided into two: output power supply and logic module/input module power supply. It is possible to add selective emergency stop switch to the stand; when the circuit is interrupted, the relay inside the distribution cabinet will interrupt the both the power supply used by students and control module outputs, but the power supply of controllers themselves remains available. This will sure the safety of people in the case of programming errors and other possible problems, while allowing later to analyse the programme that was run by the controller.

Digital inputs of detachable control module and stationary controller are connected in parallel and connected to terminal strips in the lower part of the stand wall. The same applies for the outputs. Analogue signal outputs, however, are different and kept separately – both current inputs/outputs and voltage inputs/outputs.

5.2.1.2 Construction of Pneumatic Systems of the Stand

The pneumatic component of the stand includes compressed air preparation block (pressure regulating valve, water separator, pressure gauge), mechanically controlled 3/2-way pneumatic valve (for switching on air for the components and venting the valves), pneumatically and electrically controlled pneumatic valves, double-acting linear cylinder, double-acting rotating cylinder, vacuum generator and suction cup (*Figure 5.17*).

Valves of different type will offer different options for solving the exercises. Pneumatically regulated valves can be used to ignore electrical components of the stand when doing the exercising, using the pneumatic components, attached to the profile panel slots, as additional pneumatic valves, pneumatic end-switches or even additional pneumatic cylinders. Sample pneumatic circuit is illustrated in Figure 5.17.

Electromagnetically controlled valves can be used to control the application, assembled on the stand, either with relay circuit or industrial controller. If this is the case, the controller must be supplied with a suitable control programme that will run the stand. Of course, it is possible to combine both alternatives. Although the only moving parts of the stand are linear and rotating cylinder, there are many options for making them move. This will show the students that there are many different alternatives for solving the task at hand.

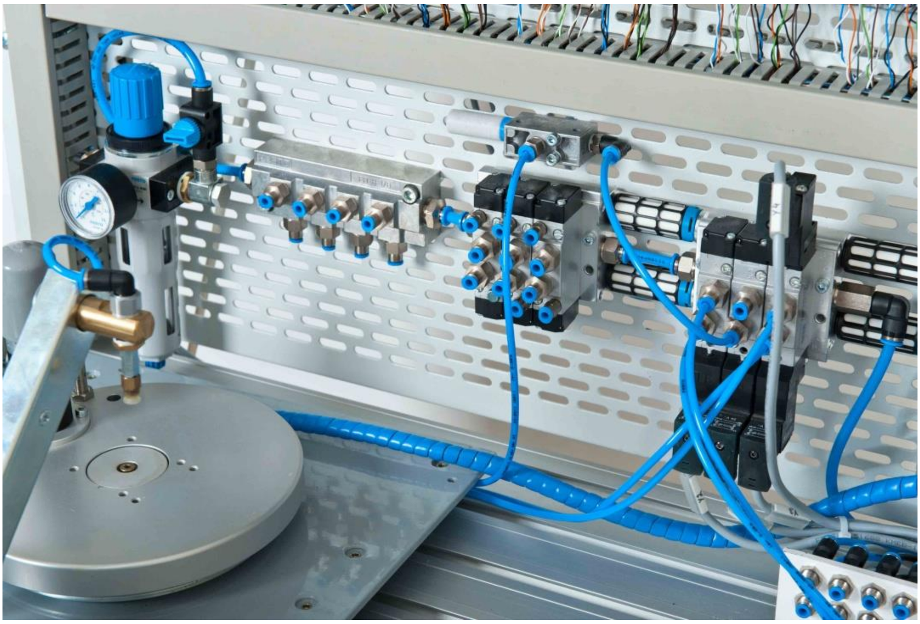

Figure 5.17 Pneumatic component of MFS stand

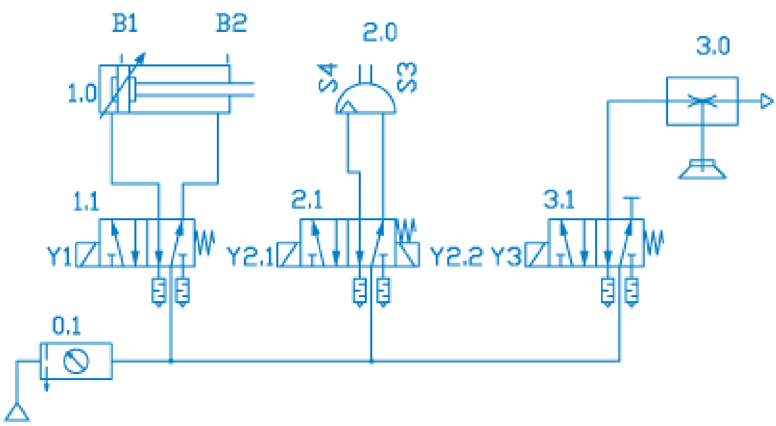

Figure 5.18 Scheme of pneumatic circuit of MFS stand

5.2.1.3 USER INTERFACE OF THE STAND

The user interface of the stand consists of three switches (power switches), three freely usable buttons with two contacts *(Figure 5.19)*, with LED indicators below, and illuminated bar or additional LED indicators. All the three switches are meant for switching the stand's power supply on and out. The buttons include on normally open and one normally closed contact, which means that when the button is pressed, one contact is closed while other opens. If possible, the contacts can be changed. These buttons are not connected to anything and the student can decide whether and how these will be connected. The same applies for indicators.

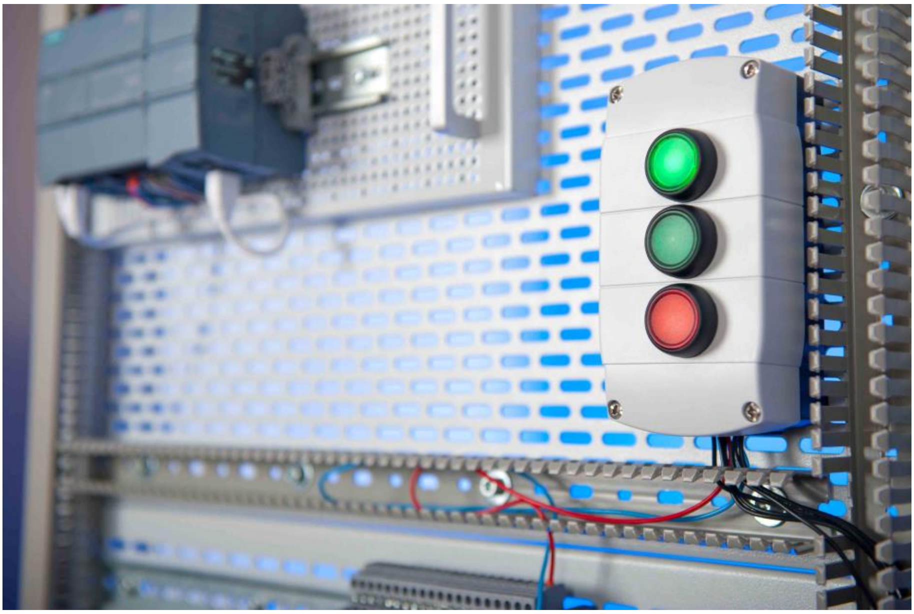

Figure 5.19 User interface switching block of MFS stand

Buttons no. 4, 5 and 6 include on normally open and one normally closed contact, which means that when the button is pressed, one contact is closed while other opens. If possible, the contacts can be changed. These buttons are not connected to anything and the student can decide whether and how these will be connected.

The drive module *(Figure 5.20)* will allow the student to investigate the components of pneumatic control system and drives, production automation systems and installation of components of automation system.

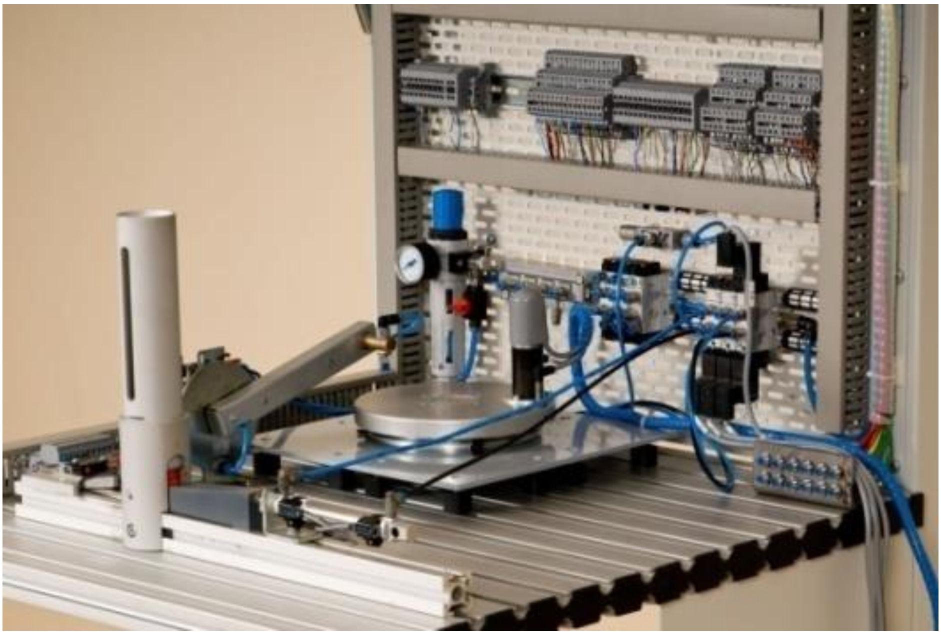

Figure 5.20 Drive module

5.2.2 Learning Process on MFS Stand

MFS stand represents an application which is used to implement technological processes. These processes may be used for learning purposes or for real practice.

I'm going to observe the learning process on practical experimental stand, using the 7E model *(Figure 5.21)* and the easiest approach would be to use a sample exercise, observing both the activities of a learner and a teacher for the purposes of learning process. The learning process is divided into tasks for the implementation, see Table 5.1*)*.

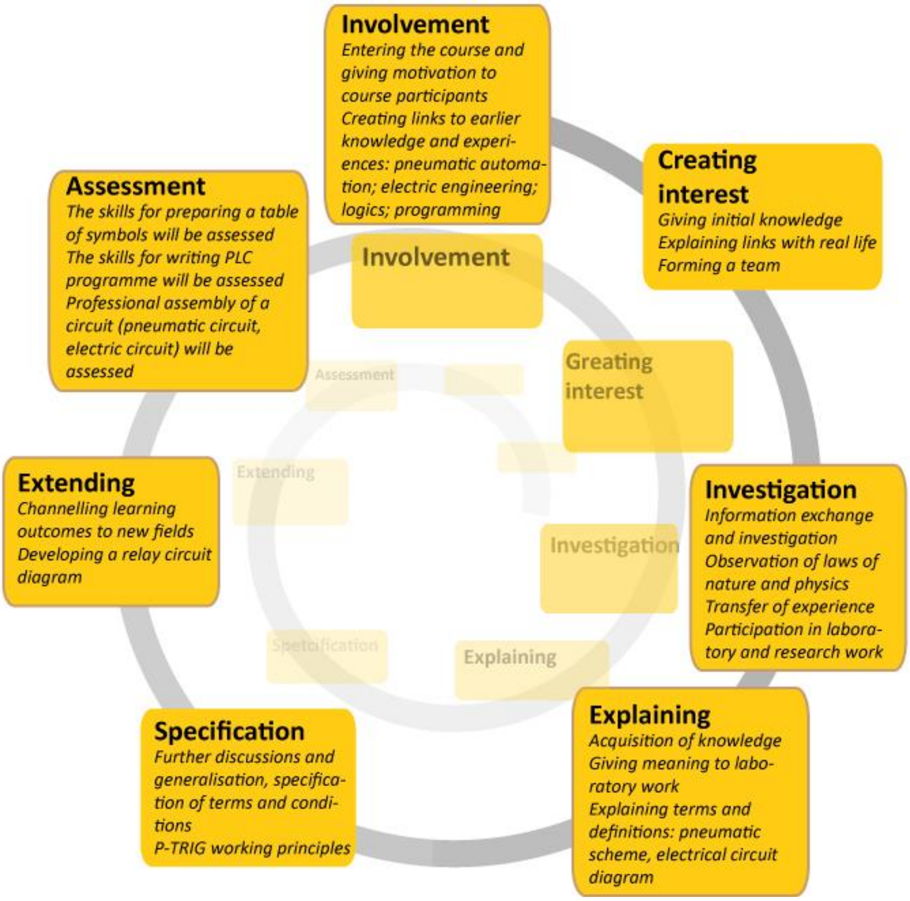

Figure 5.21 Learning process on experimental stand, using the 7E model

Table 5.1 Process: Controlling greenhouse window with one pneumatic cylinder

Task ***(a name that would motivate the learner?)***	**7E model**
Pneumatic cylinder is an actuator that will allow to convert compressed air energy or pneumatic energy into linear movement (straight movement) energy. In our example, we will be using a bi-stable pneumatic cylinder or a cylinder with a piston that has two stable positions at both ends of the cylinder. It does not have a spring and therefore, the rod moves both inwards and outwards, using the energy given by air. In the given application we will be using a cylinder that has a magnet attached to the piston to allow detection of the position of piston inside the cylinder (and whether the rod has emerged) with reed detectors.	**Involvement** Entering the course and giving motivation to course participants • Creating links to earlier knowledge and experiences: pneumatic automation,

Pneumatic valve is a component that is used to change the movement direction of compressed air inside pneumatic network. In the given case, the implementation of solenoid valve by air pressure will allow the piston of pneumatic cylinder to move out, pressurising the other end of pneumatic cylinder, which will result in the rod of pneumatic cylinder emerging (or vice versa, entering). Spring-returned pneumatic valve is used, therefore, once the solenoid valve is no longer energised, the valve will return to its original position. **Reed detectors** are contactless sensors (i.e. they don't have to be in immediate physical contact with the sensed object to catch the signal), consisting of a reed contact what will be switched by the adjacent magnetic field. **Solenoid valve** is a device that is used to convert electric energy into relatively shoryt mechanic movement. In the essence, we are speaking of electromagnet that will change the position of pneumatic valve in the given application (in most cases, pneumatic vale will include an amplification level, as the power gained from solenoid valves, meant for pneumatic valves, would be insufficient).	electrical engineering, logic and programming
Task description There is a window on the roof of the building (Figure 5.22). The window is too high to open and close it manually. The building is already fitted with pressured air network, therefore, pneumatic cylinder can be used to open and close the window. We also have a spare S7-1200 controller, which can be used to control the given application.	**Creating interest** Giving initial knowledge • Explaining links with real life, where similar schemes can be used • Socialisation, formation of a team

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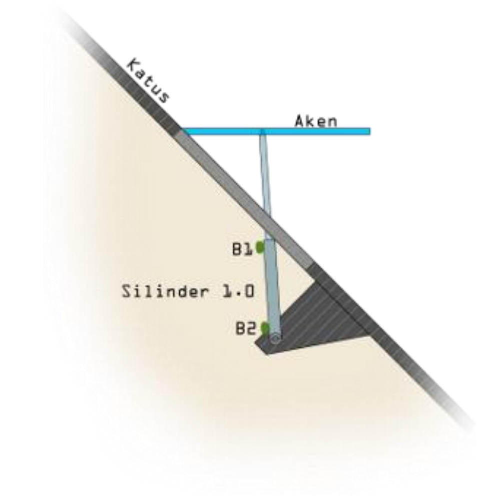

Figure 5.22 Installation of the application
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Figure 5.23 Control panel

Control panel

Control panel (Figure 5.23) has two buttons:

S1 – Opens the window

S2 – Closes the window

Under each button is a LED indicator, which will show the status of the window – for example, if window is closed, H2 is illuminated. As the window has two statues (open and closed), we must fit the pneumatic cylinder with two detectors (B1 and B2).

In practice, it won’t make much sense to use an expensive controller for such a simple application and
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Investigation

Information exchange and investigation

- Which inputs and outputs we’re going to use
- Transfer of experiences
- Participation in laboratory and research work
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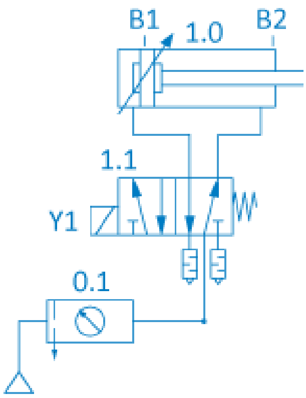
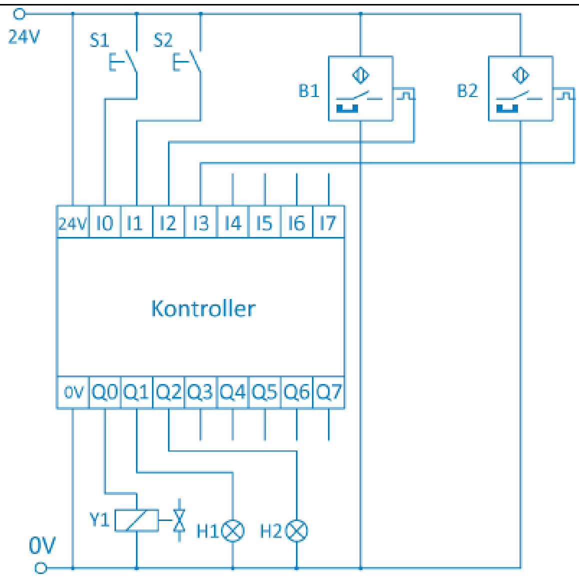
it would be cheaper to solve the situation by using relays or, in more complicated cases, special electronic board; however, the application must be as simple as possible for the first experiment.	
Pneumatic scheme In the given application, the force needed to move the window will come from compressed air network or actually, from a compressor somewhere. The given pneumatic scheme will allow us to guide the force and apply it as we need, using pressured air and energy that it releases when moving. We will use a double-acting cylinder with a rod long enough to open the window completely (1.0), pneumatic 5/2 way valve with a solenoid (1.1) and a source of air (0.1) for the pneumatic component of the system (Figure 5.24).  *Figure 5.24 Pneumatic scheme* **Electric circuit scheme** Electrical component of the system (*Figure 5.25*) consists of two normally opened pushbutton-switches (S1, S2), two reed detectors (B1, B2), two indicator-LEDs (H1, H2), one solenoid valve (Y1) and one Siemens S7-300 controller (with digital input/output modules).	**Explaining** Acquisition of knowledge. • Giving meaning to laboratory (practical) work • Explaining terms and definitions: pneumatic scheme; electric circuit scheme.

 *Figure 5.25 Electric circuit scheme*	
Preparing a PLC programme When pushbutton S1 is pressed, solenoid valve Y1 is activated. When you keep S1 button pressed down, there will be no attempts to switch the solenoid valve on repeatedly, as the consequence of positive front (P_TRIG instruction) identification. P_TRIG instruction will give M 0.0 bit a high value to remember earlier identified positive front and this bit is not reset before S1 button is released. When pushbutton S2 is pressed, solenoid valve Y1 is switched off. Once again, positive front identification will be used to avoid multiple switching-out operations. Values of detectors B1 and B2 will be transferred directly to lamps H1 and H2, almost as of they were electrically connected.	**Specification** Further discussions and generalisation, specification of terms and conditions: • P-TRIG operating principles etc.
Discussion resulting in a method that would allow to solve the given task easier and by a simpler methods, without using an expensive controller.	**Extending** Channelling learning outcomes to new fields.. preparing a relay circuit

List of symbols Variables that are used for PLC programme are given in table 9.1.1. Table 9.1.1. Variables of PLC programme	**Assessment** Assessment of what the students know and can do • The skills for preparing a table of symbols will be assessed • The skills for writing PLC programme will be assessed • Professional assembly of a circuit (pneumatic circuit, electric circuit scheme) will be assessed • Operation of the circuit diagram will be assessed

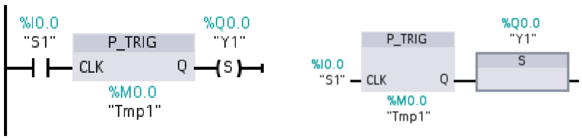
Symbol	Address	Data type	Comment
S1	%I0.0	BOOL	Button – Open the window
S2	%I0.1	BOOL	Button – Close the window
B1	%I0.2	BOOL	Detector B1 – Window open
B2	%I0.3	BOOL	Detector B2 – Window closed
Y1	%Q0.0	BOOL	Open the window (Solenoid)
H1	%Q0.1	BOOL	Green LED
H2	%Q0.2	BOOL	Red LED
Tmp1	%M0.0	BOOL	Memory bit for P_TRIG instruction
Tmp2	%M0.1	BOOL	Memory bit for P_TRIG instruction

Programme: Main [OB1]

PLC programmes are written, using LAD and FBD languages. Printout of the programme, in different languages, complete with comments, is presented below.

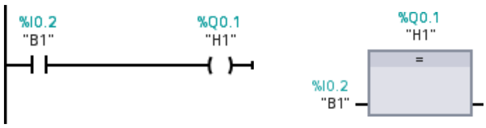
LAD (contact scheme) **FBD (logic scheme)**

Network 1: ***Pushing the cylinder forward***

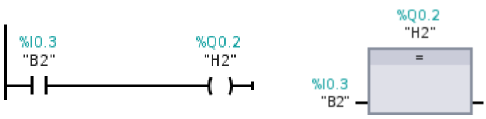


Network 2: ***Retracting the cylinder***

Network 3: ***Green LED***



Network 4: ***Red LED***



5.3 Symbiosis of Different Study Methods in Learning Process

Contemporary approach will allow the students to acquire and possess knowledge and skills separately, extending their scope of responsibility and independent activities to a further professional level or in other words, achieve growth of trust. For that purpose, the knowledge and skills of students are developed on the bases of fundamental principles, universal approach and practical orientation.

The following aspects are important for various professions in the sphere of automation and mechatronics:

- innovation – use of new methods to increase productivity, definition and solving of new fundamental problems and tasks in the sphere of automation and design;
- efficiency – successful professional activities and analysis of technical information;

- mobility – willingness to update existing knowledge and skills to become adapted to changing conditions; transfer of knowledge to other locations;
- perspective – willingness to continue with education, self-improvement, professional and personal development.

Students can develop these aspects most successfully by using the combined approach – or blended learning. Blended learning is based on an efficient "blend" of traditional and distant learning technologies and the use of innovative pedagogical teaching methods [110]. Blended learning is actively used for technologies, known from the sphere of distance learning, to support activities that take place in classrooms. [111].

General structural scheme of applications of automated production systems is of great help for the presentation of the structure of teaching materials and, above all, implementation algorithms *(Figure 5.26)* [56]. Developers/designers will use the terms and definitions of information, energy, and physical sciences in combination with production equipment development methods to create automated production systems. Blended learning will allow teachers to use Internet services that will involve students into active creative activities.

The following questions must be considered for the purpose of designing a blended learning course:

1. What sort of knowledge and skills (learning outcomes) does a learner needed to take a course (module) and what type of pedagogic tools are needed to achieve the desired result?
2. How should be the learner's "space" (virtual and face-to-face) organised?
3. How to create the necessary learning milieu?
4. Which tools does the teacher/lecturer need to support the choices, described above?

There are several models, suitable for presenting information to match the blended learning methods [121]. The most suitable is presented on Figure 5.26.

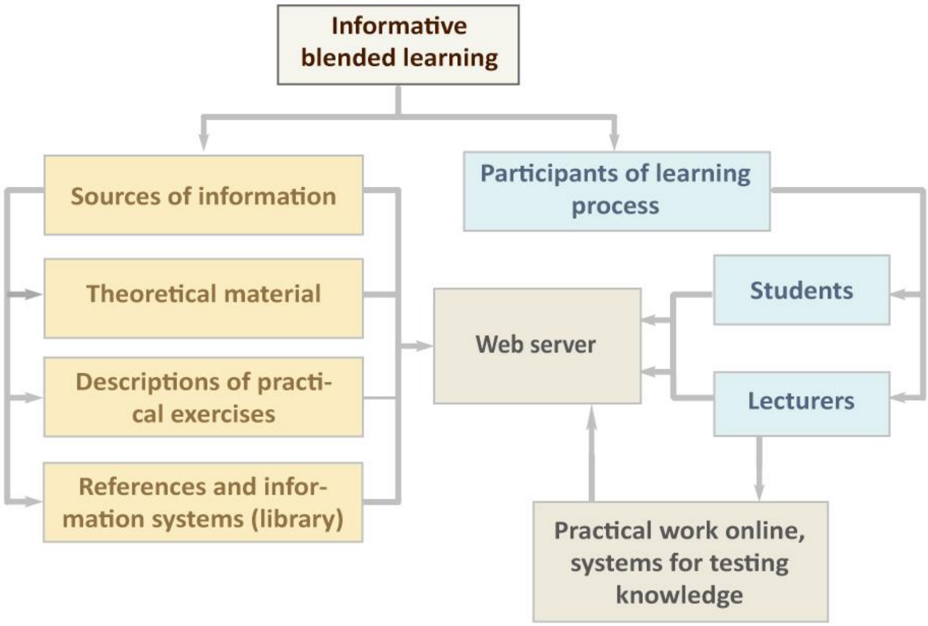


Figure 5.26 Structure of information model of blended learning methods

The following blended learning elements were employed to design the course:

- Parallel model – multi-channel presentation/display of teaching material (involving students choosing the channel most convenient for them);
- Sequenced model – modular presentation of teaching material (where the contents of a discipline/research field will be divided into relatively independent parts and presented in different ways).

After testing the elements of blended learning it was found that:

- The biggest learning effect will be achieved in Internet chat rooms and the maximum and the biggest efficiency will be provided by face-to-face/immediate communication/learning/studies;
- The biggest effect can be achieved by encouraging students to support each other by means of discussion forums;
- Subjects that represented the biggest challenge were discussed, using face-to-face methods, with teachers.

Communication channels that are used for the purposes of blended learning are depicted on Figure 5.27.

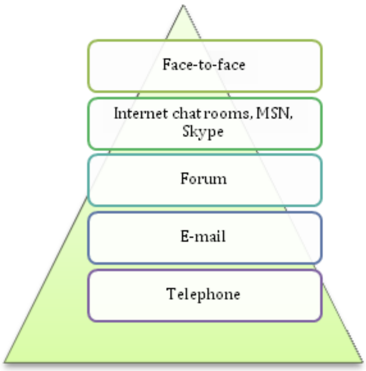


Figure 5.27 Course communication channels

The following sequence of development processes works well for a blended learning course design: “Desired product – Production process - Performance“ [122].

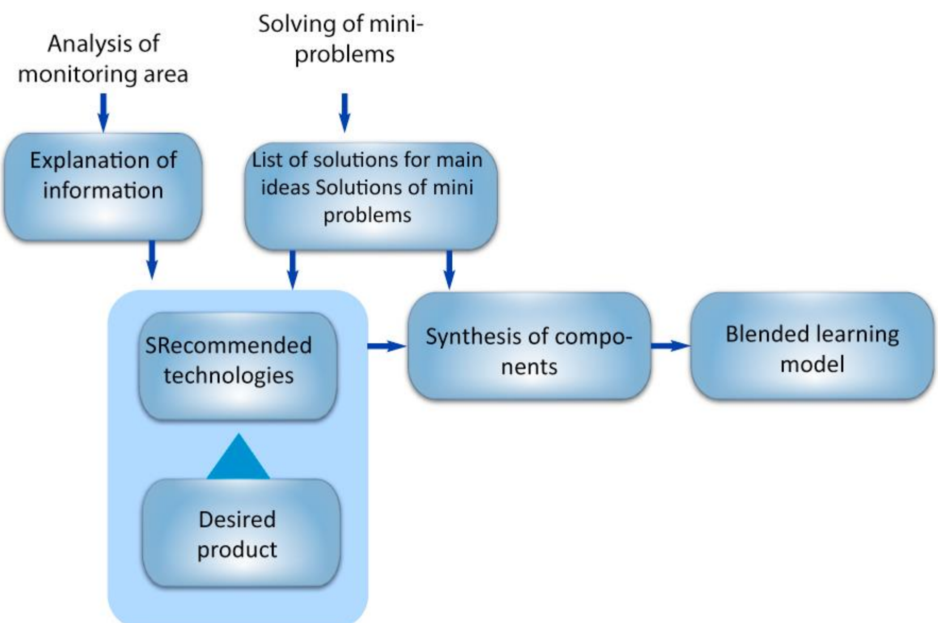


Figure 5.28 Construction of blended learning course

In the beginning it is important to determine and configure properly the requirements, resulting from a learning methods. This is done, using information obtained by analysing “monitoring area” and solving “mini problems” that emerge. After that it is possible to develop desired technology – a set of operations that are to be performed to obtain a final product. It is quite easy to use, as these operations are performed, information obtained by analysing “monitoring area” and solving “mini problems” that emerge. As a solution is allocated to each and every mini problem, it is beneficial to grasp the main idea.

Once all the situations have been analysed, it is possible to choose the most suitable solution that is then used to build a new learning model.

5.3.1 Blended Learning Model for Automation Course

This work relies, in part, on the outcomes of AutoMatic project (01.10.2009 - 30.10.2011). I participated in the development of the project myself, it was supported by the European Commission's lifelong learning „Leonardo da Vinci" education and culture programme. Five institutions of education and training and companies from four different countries took part in the project:

- Tallinn University of Technology (Estonia);
- Gabrovo University of Technology (Bulgaria);
- LUISS Guido Carli University (Italy);
- Multidisciplinary European Research Institute Graz (Austria);
- European Quality Centre Ltd. (Bulgaria).

The main purpose of the AutoMatic project was to develop curriculum and innovative teaching methods and materials for the sphere of industrial automation. These materials are used to teach and train employees of small and medium sized enterprises, by employees who want to find a job, and students. The following teaching materials were prepared:

- Sensors in industrial automation;
- Implementation of PLC /programmable controller/applications in industrial automation;
- Computer-based automation tools;
- Industrial networks and interfaces in industrial automation;
- Drives in industrial automation.

The following major problems were solved when developing an e-learning course to match the curriculum:

- Development of e-learning management software Moodle as a part of information space of the school;
- Design and practical development of physical modules and functional tools;
- Design and development of methods and teaching methodological materials to support blended learning process;
- Development of a new curriculum for mechatronics.

Five functional components are analysed and developed within the field of blended learning:

1. Students;
2. Lecturers;
3. E-learning course;
4. Practical technical tools (MFS stand);
5. Information and data communication tools (ICT).

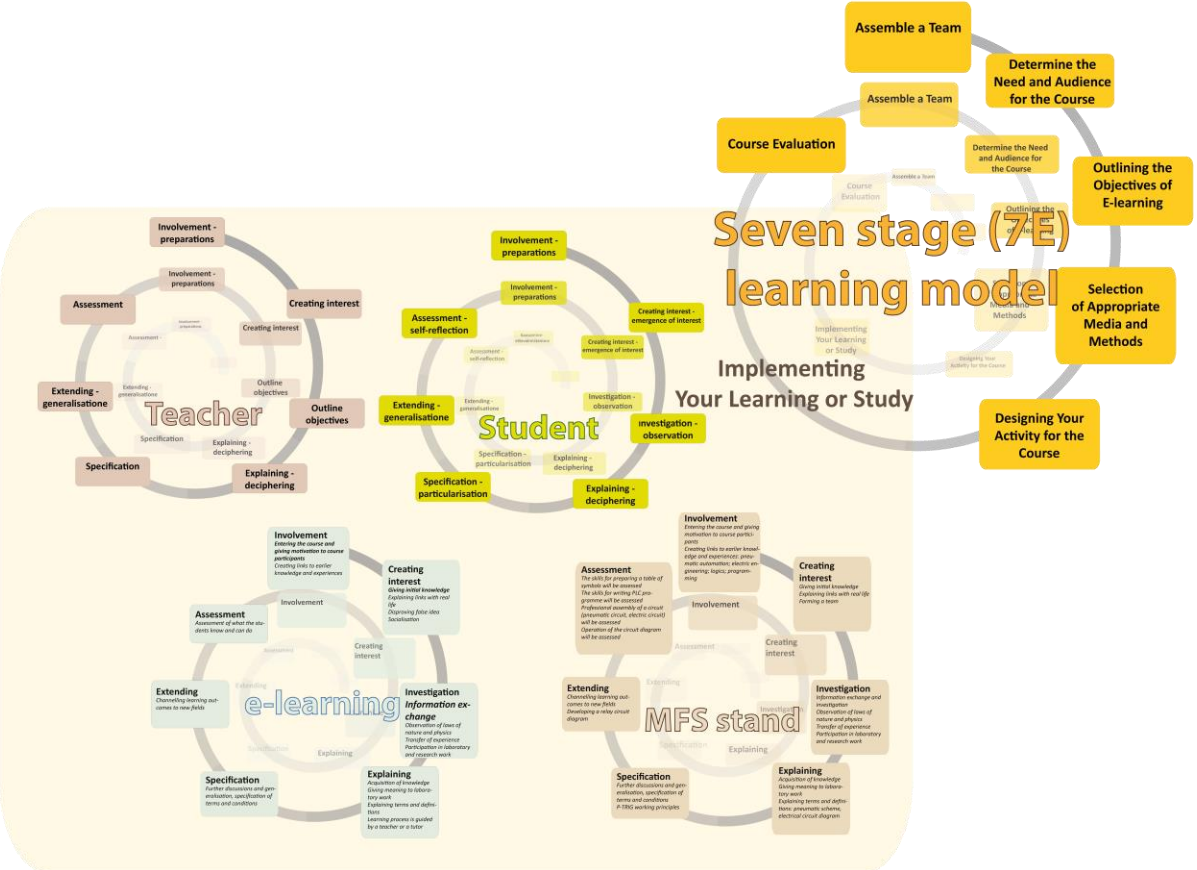


Figure 5.29 General structure of blended learning components

ICT tools are used for linking the first four components to form a complete blending learning course (Figure 5.30).

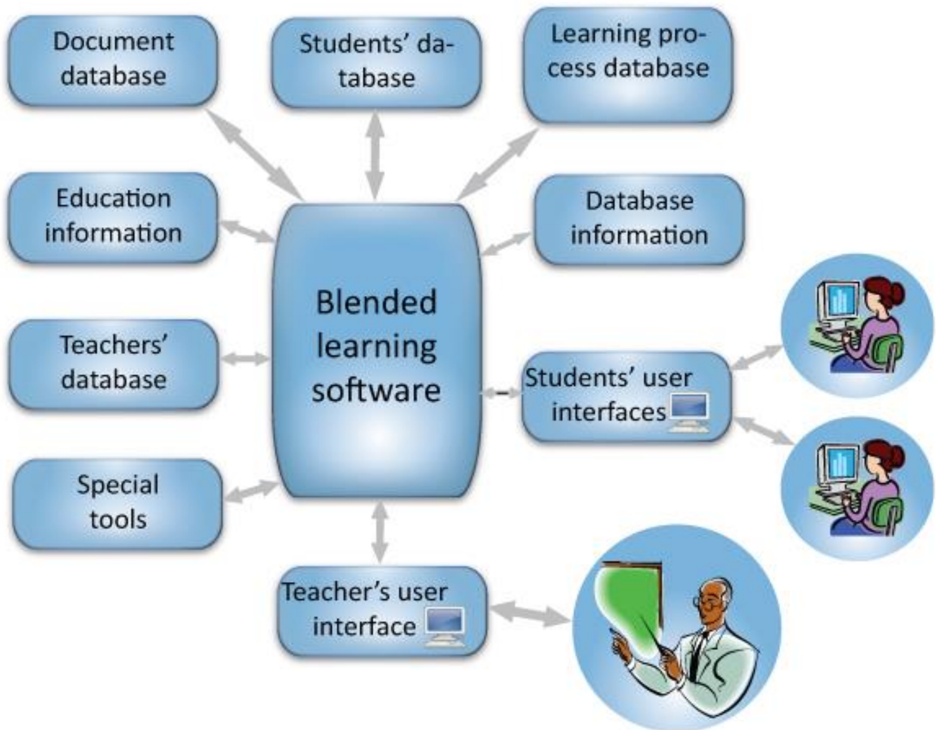


Figure 5.30 General structure of ICT tool, used for blended learning

Regardless of the learning process, it is most important for lecturers and students to focus on the expected learning outcomes. Learning outcomes play a central role for both the student, lecturer, evaluation of existing teaching materials, technological infrastructure and sustainability of the studies.

5.4 Summary

One of the main weaknesses of blended learning is usually too much focusing on ICT tools and therefore, databases and data administration in technical applications. Development of teaching materials is usually seen as the most important development outcome. People often forget about the student and professor and this will disperse the blended learning system as a complete unit.

Blended learning represents an efficient tool for studying and testing new pedagogical solutions. The following new results are obtained by employing blended learning:

- Design and development of blended learning as a part of school's information space, based on e-learning management software Moodle;

- Design and practical development of course modules;
- Design and development of methods and teaching methodological materials to support blended learning process;
- Conduct of practical studies. Component, involving the development of independent perception of students by independent earning. Development of interactive implementation skills for knowledge and skills of students;
- Introduction and implementation of blended learning technologies will result in the establishment of “e-learning course information base that is updated on regular bases”.

Chapter 6 Ontology of Information, Presented to Subjects, Participating in Learning and Teaching

6.1 Headline Idea of Six Dimensional Co-ordinate System

The transferred material contents of relations that emerge in people, machines and the space between them has a complicated nature. Complicacy is also reflected in structure of descriptions (or information) of semantic nature. Organisation and realisation are quite clearly distinguished in the structure of wholesome information, whereas architecture is also present in both. Components of real or working entities and links between them for information flow (or contents) are described together and visualised, using topological schemes. In descriptions of real or working entities, models and systems theories, organisation and realisation and organisational architecture and realisation architecture are, in essence, different yet still intertwined elements. When giving technical education to learners, a lecturer will communicate and present information to describe material components, limited to a certain system. The other part of the information, communicated to students, represents semantic movement that is realised in internal or mutual links of their components.

One of the important definitions that will help us to describe theoretic, modelled and real objects and semantic movement between them, is the dimension of a space (or a scope). There are many references, explaining the definition of a dimension. Physicists have played an important role in providing better understanding of dimensions and shaping the perception of us, subjects, of time-domain and material objects.

Semantic modelling of a dimension of relatively general nature will result in specific objects or coordinate axes that the subjects can use to measure properties of components of interest and different parameters of their movement. Co-ordinate system or a spatial object, drawn up, using lines that intersect in the same point, can be used for the purposes of visual comparison. Physical co-ordinate system can be used as reference object for measurements. [123].

René Descartes used visual object, consisting of straight lines that intersect and cross with respect to each other (x-, y- and z-axes) to model geometric objects within a geographic space. Using one's eyes, people see geometric objects that surround him/her within a three dimensional (geographic) space.

In 1843, William R. Hamilton, a mathematician, started to use a four-dimensional model of time-domain [124]. Fundamental constant c (speed of light) will allow users to geometrise time (ct) and thus make the dimension more visual. Length of time is visualised on diagrams, using a straight line; it's length is determined by initial and final time values. Geometrisation does not mean that the definition of time will become geometric. Standardised time-domain co-ordinate system is today used to identify and determine the value of any simple or complicated object. Motional content of the object cant be measured using only time and geographic axes. Also content etalons are needed

The movement (properties) of entities us are not geometric by nature. We must use the definition of multi-dimensional space to help us understand organisation and realisation of semantic movement.

Scientists have been waiting for a new dimension to be added to theory of general relativity since 1920, when Theodor Kaluza and Oskar Klein first recommended a theory of relativity that included a fifth dimension. The modern theory is well acquainted – and acknowledges – the concept of multi-dimensional space and even elementary particles not being just points, but instead, elements that may consists of very small strings [133]. At the moment, Space-Time-Matter theory with its extra fifth dimension is being studied; this was first suggested by S. Wesson and his colleagues. According to this theory, all material fields exist in fifth dimension and can be transferred through vacuum of large dimensions [128], [123]. Attempts have been made to link time-domain and realistic phenomena of electro-magnetism, using the fifth dimension [134], [124].

Spatial information that our senses provide allows our brain to visualise the composition of geometric objects and sense their relations (topology), however, we can’t yet determine the value of time, the value of all the different properties of movement observed (quantity of contents) and the value of such properties (quality).

Geometric subject and object, expressed within a geographic space, and their components are visualised by points and their topological relations – as pairs of points that have been attributed specific co-ordinates, which are obtained by measuring, involving co-ordinate system. Topological links between geographic points of subject and object (or resources) is described on Figure 6.1 [56]**.** At least two connections are to be used to obtain a topological relation.

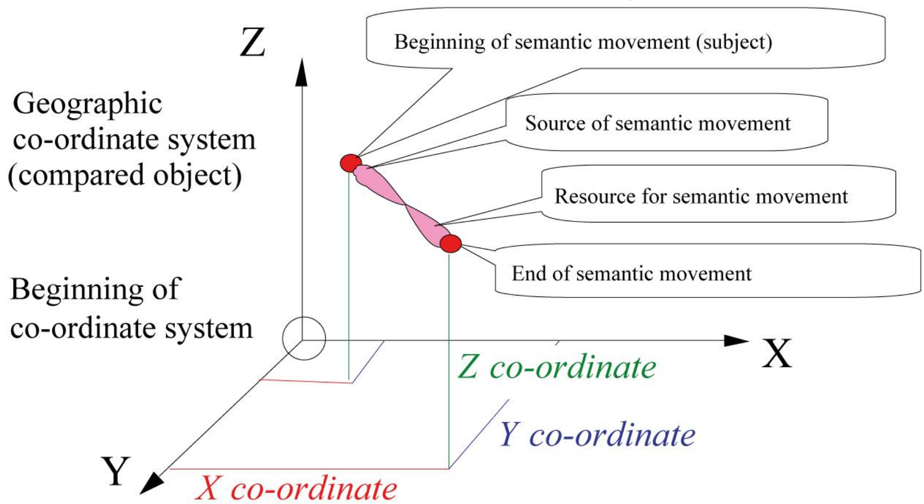


Figure 6.1 Group of geographic axis and logical substance of the term “movement” [56]

By using sight and sense of time, people will add dimension of time to geographic space. Visualisation of systems of five and more dimensions that are mostly mathematical and even more complex and complicated is quite difficult for an untrained learner.

The unsolved problem of modern education involves insufficiently defined visualisation and therefore, technical design specialists are taught to use, mostly, the four main known dimensions both for measuring, describing or synthesising the composition of subjects and objects and semantic movement. The four main dimensions are also used to describe the quality of movement that takes place in relations between objects. The use of such a methods will often result in long and clumsy descriptions.

It is said that a single good picture can convey more information on movement that an thousand words. People perceive the composition of world in forms and shapes, adding images to pictures and three-dimensional geometric shapes in their minds. Topological relations between a geometric system, theory, model, subject, object and their different parts (e.g. points) is described at schools, using the x, y, z axes that have been known for centuries.

Ines and arrows that serve to describe the nature of movement – at least to a certain extent – are used to visualise relations between points and the movement that takes place within such points. Such a three-dimensional (geometric) image will convey the nature of movement of an object, but not very accurately. Lines represent movement that remains, in fact, outside geographic space. The substance of an object moves within a space in a way more disperse and complicated that the points and lines can show for our eyes. Transformation of the movement that takes place (changes in quality of substance) is usually explained in teaching materials, using separate mathematic symbols and formulae.

As the scope of information technology expands and it us used, more and more, for giving education, we need better architectural methods and tools to ensure better understanding of information available as the volumes and complicacy level of information communicated changes. New methods for structuring should also allow to geometrise the values of time movement contents and complicated, dispersed semantic (intertwined) transformations. New software tools should help to make movement more visual in descriptions, available to subjects.

Complicacy of the movement that takes place within a system, theory, model, object, subject and their mutual relations – usually not grasped by the senses and untrained brain of a student – could be described with a co-ordinate system, developed, using completely new implementation of dimensions. The new triplet of implementation axes, made up of visually intersecting lines, is depicted on Figure 6.2.

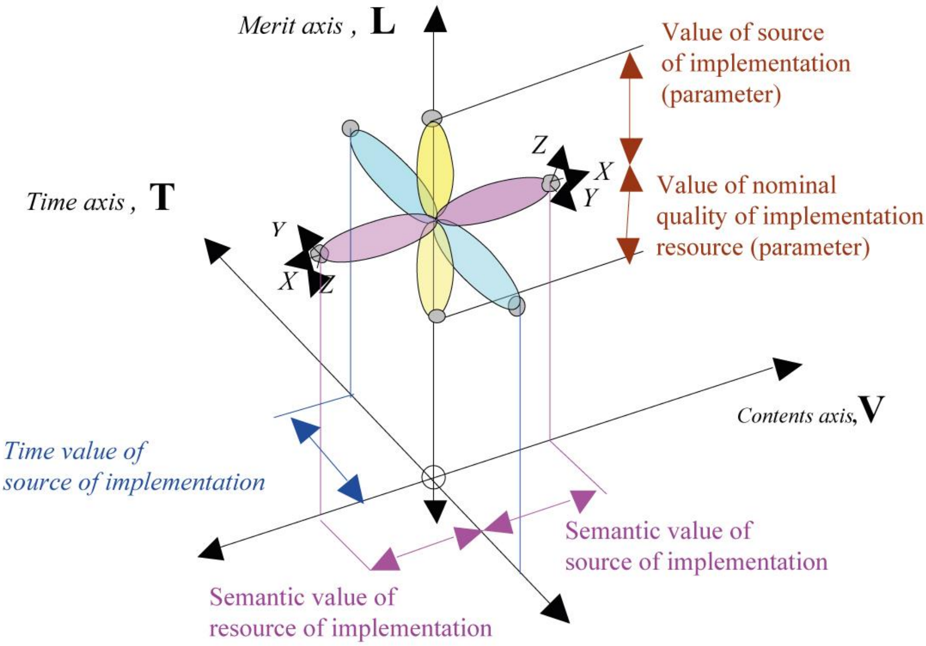


Figure 6.2 Group of implementation axes [56]

In the sphere of education, there us no widely acknowledged training or technical engineering science and engineering education methodology that would rely, for example, on six main dimensions.

Semantic parameters of a geometric object are expressed in geographic points. To describe the movement within a relationship, connecting two points (quantity of semantic properties), the contents of the axis (communication) of a new implementation co-ordinate system will be oriented to pass through the start and end point of the relationship observed. Let’s now imagine that the geographic space that we all know becomes a sub-space of a new implementation space. A student, in control and using a six-dimensional (6D) spatial model can express (geometrise, visualise), apart different geographic (geometric) points also the time of implementation, quantity of different parameters of movement and the different qualities of the different parameters. Therefore, s/he can think in six dimensions, without any difficulties. Visual description of six-dimensional movement is illustrated on Figure 6.3.

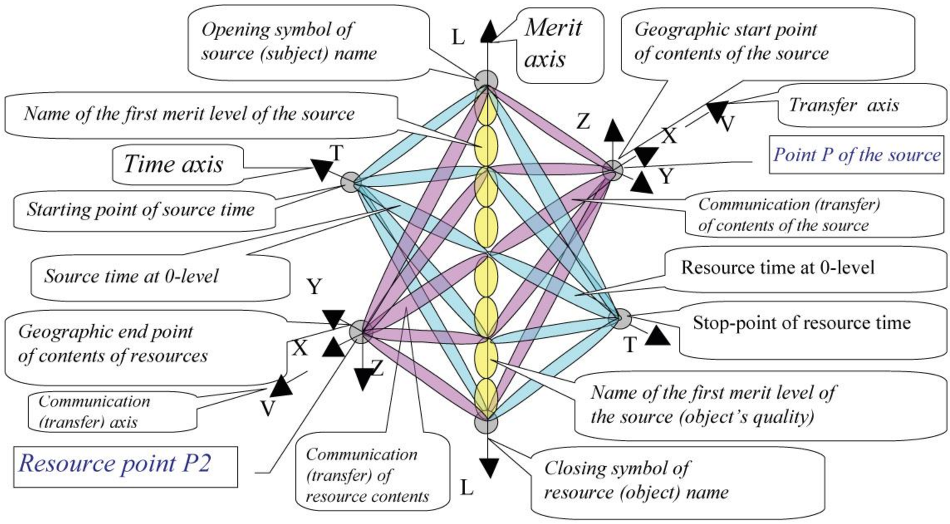


Figure 6.3 Visual description of a complex semantic movement within 6D-space [56]

Quite probably we're already using a six-dimensional spatial model to describe the composition and implementation of complicated objects on daily bases, but we won't notice this or pay it any attention as we've been nought taught to see a six-dimensional space.

In the sphere of education, a more general method of explanation will be needed for providing effective description of the organisation of material entities and implementation (realisation). The new, six-dimensional space and an appropriate visualisation method will allow us to use the data modelling opportunities and tools, created in information era [56]. The theory of a six-dimensional space is ontology, as this is based on observation and measuring of the movement of real life objects and subjects and facts, recorded in writing.

This doctoral thesis employs the aforementioned six-dimensional spatial model and implementation ontology, suggested as a novelty, for the purposes of visual description of semantic movement between entrepreneurs, employees and their tools and students acquiring education and their technical objects within the qualification system (where education and vocational system functions). This can be used not only to visualise geographic objects but also to geometrise the movement within objects and relationships between them, time of movement, values of parameters of contents transferred and value of properties, involved in the architecture of movement. As the value of transferred contents (parameters) or quality is submitted for perception and also visualised, using words, the new merit axis differs from the standard numeric axis by the divisions not marked with numbers, but names instead.

The following paragraphs and sections provide a short description of the six-dimensional spatial model and explanation of its possible ways of use for the purposes of development of visual teaching materials.

6.1.1 Definition of Co-ordinate System (Framework)

The definitions that are used for descriptive purposes are complicated in essence and they also have a structure. According to picture theory of Ludwig Wittgenstein, objects in pictures are recognised by people if they have identical "logical" shapes with real objects [125].

The example of movement, taking place in a six-dimensional space, depicted on Figure 6.3 can be used as the bases for visual description of movement between specific subjects and objects or parts thereof (for example, geographic points).

Implementation of mutually linked objects or semantic phenomena is usually scattered within space. Specific communication values are obtained, within different time intervals, for every parameter of different quality, in the are of movement that takes place by points of a geographic space. The better we distinguish parameters of objects (different quality of contents), the more intelligent we are. Reference object, called merit axis, can be used to distinguish and measure the quality of contents of subject. Name of the parameter is obtained as measuring result. More specific structure of merit axis and one specific ontology is visualised in Figure 6.4.

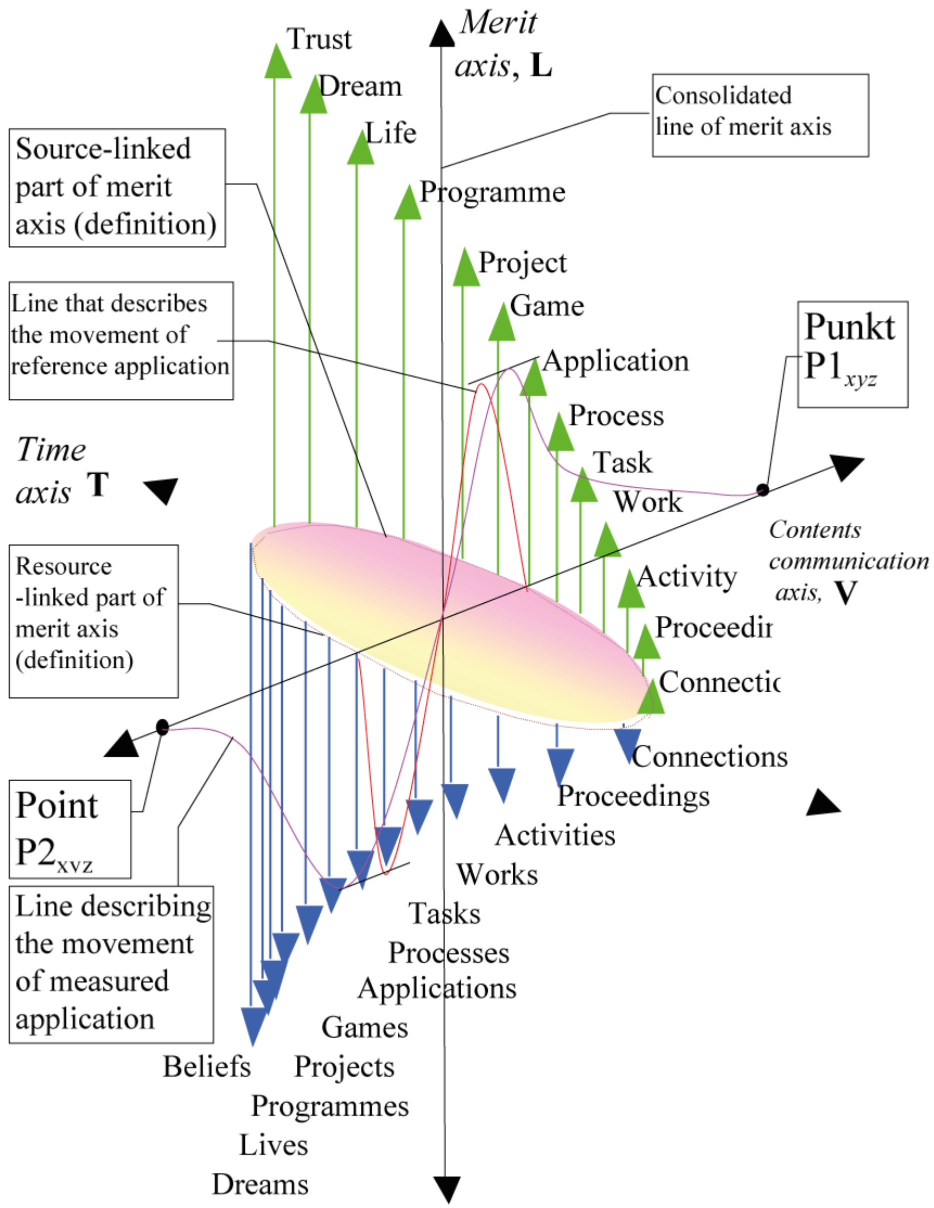


Figure 6.4 Structure and architecture of the value axis concept [56]

For example, a smart power grid can be imagined as an information-wise, energetically and massively implemented cluster. Such a power cluster has generators (sources) and distribution lines at the supply side and connection lines and loads (resources) at the demand side. Smart energy meters that measure the quantity of contents of movement will be installed between (into connecting points) of power suppliers and consumers. Values of different informational and electric parameters can be measured, for example, current, voltage, power, energy, price of one kilowatt hour and incurrence of failures. The visual ontology of merit axis (quality axis) of the implementation framework will determine different electric parameters (marked with different names) at different merit levels.

Merit axis can be integrate into a co-ordinate system that can be used, for example, to model power distribution networks or complex automated production equipment. Such an integrated development, design or simulation environment not only contributes to navigation within definitions discussed (including subjects and objects), but will also help to understand the structure of dynamics of the system. It is useful to implement the suggested architecture to simplify learning and to contribute to economic and safety-related performance [75].

6.1.2 Description of Implementation in Symbols

People use he language of symbols to sense/perceive the existing realism as a six-dimensional space. One of the reasons why people use the language of symbols is the need to explain why is the movement of an object present in so many different forms (different activities, proceedings, parameters) and why does the value of a parameter emerge in that very moment and such a geographic place.

Many people (including students) are subconsciously using different words (different symbolic values) to describe quality in complicated everyday situations, also some (merit) dimensions. However, they're clearly/obviously not informed of 6D space ontology (typical model) and as the consequence they use the same applied terms and definitions differently in different situations. Therefore, they lack an agreed hierarchy of applied terms to describe the implementation of something (an object) and, in general, to ensure similar thinking with other people.

Technical text with a meaning (as a subject) that describes the implementation of some object will also explain the names that are needed to obtain qualitative values of parameters of movement (or assumes the presence of hierarchy with names).

In the 6D framework observed, focus is on both the movement of material and substance (geographic communication of contents) and also the quantitative values of qualitative parameters. Quantitative values of content communication can't be separated from the description of the rest of the system. Quantitative value of each parameter will be measured, using the appropriate (mentioned, referred) standard.

Merit axis can be used to describe definitions, keeping the following on mind:

- Merit axis can be differentiated, implementation quality can be described (geometrised) as many visual layers with different names;

- The basic point of 6D framework is hidden into the depths of substance;
- Deep structure of subject and all the basic activities involved are unknown for modern physicists;
- Human brain can sense the dimension of merit and is capable of creating mental systems, involving values of both physical, energetic, informational and dream quality, using it;
- Life cycle is the name of a high quality concept, model or physical body.

6.2 Description of Learning Process, Using 6D Spatial Model

Development of knowledge and creativity can be expressed by integrating spaces of two different type. These two types are geographic and implementation space. Geographic space is a sub-space (distillate) of implementation place. It's static by nature. Movement is implemented by spatial connections that exist between subject and object or, if we adjust the definition, between sources and resources.

It is often difficult to understand the contents of teaching materials of technical subjects (e.g. automation). In cases like that, learning should be structure, using the 6D co-ordinate system. 6D system is mentally perceived, visually displayed and also an object that can be related to reality, helping to describe and integrate not only geographic properties, but also descriptions of implementation (interactions).

Modern approach to learning includes the acquisition of knowledge and skills as an interaction or complex process. Competence of students is developed by applying universal main principles in practice.

The most important parameters of occupational competence of industrial automation specialist and mechatronic are given below:

1. Creativity – cognitive activity of students, analysis of technical information, formulation and fundamental/basic solving of new problems in the sphere of automation;
2. Innovation and efficiency – successful implementation of outcomes of creativity by means of professional activities in both personal life and in enterprise;
3. Mobility – willingness to enhance the level of existing/current knowledge and experiences to adapt them to changing economic conditions;

4. Perspective/prospects – willingness to continue education, self-improvement, professional and personal development.

Blended learning is the most appropriate learning methods for the implementation of these objectives. From today's point of view, blended learning is based on en effective "mix" of traditional and distance learning technologies and innovative pedagogic teaching methods. In the information era, employees, involved in production of products, are taking part in in-service training on regular bases. This means that people will need different educational tools (resources, equipment/supplies) and their distribution systems and also a common platform for communication and co-operation [129].

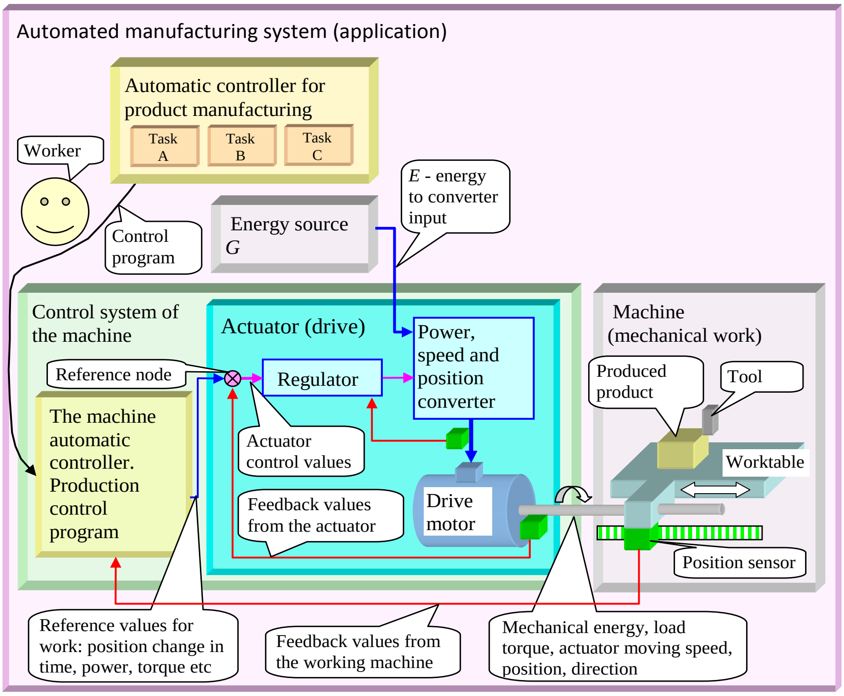


Figure 6.5 Structure of automated production system [129]

Definitions/concepts, used for the purposes of contents of education, are structured. For example, Figure 6.5 depicts a scheme of general structure of automated production systems that can be used as teaching material [135]. Innovative developers will use information, energy and physical/material production technologies with modern development methods for the creation of an automated production system. People, automated control systems and controlled energy device/equipment (mechanic, in part) will be integrated during system development. New production equipment will allow to manufacture more complex products during a shorter period of time. The innovative technologies, used to manufacture the products, will also become more complex.

Modern approach to learning and teaching employs existing and newly emerging teaching methods, but official/formal language and related terminology is often forgotten. Mastering a language represents an abstract process which is used by teachers and students to acquire the ability to perceive and understand information and also to produce and consume words or symbols of some other type to communicate with each other. Material contents move, for the subject, expressing illustratively, behind the symbols. The contents are located in the space between objects and subjects, not in their respective geographic points. The use of language in different situations requires for teachers and students to adopt new and different tools and methods. Tools often contain syntax analysers that do not consider the meaning of words used and semantic analysers that will attach interpreted meaning to the symbols of formal language. These tools are all used in combination, for example, a symbolic expression will represent, in reality, the quality or quantity of contents or time values.

Figure 6.6 represents a three-dimensional (3D) view of syntactic units that are organised around formal language. We should understand that terms (and expressions) of formal language represent specific semantic value that is called “quality”. Values of symbolic terms are different. Therefore, we need a new dimension to define the value of quality of symbolic contents.

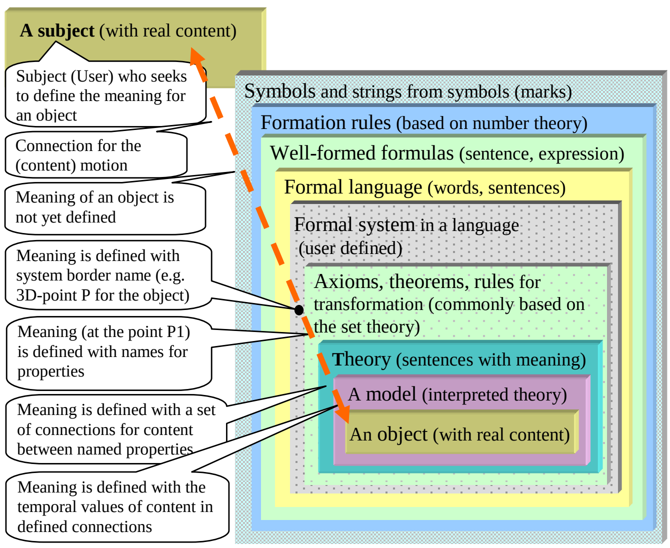


Figure 6.6 Organisation of syntactic units; top quality level of formal unit is an example/model [56]

Theory represents a formal system that includes a set of sentences in a formal language. Scientists work with formal/official theories. Scientific theories are usually more complicated that laws or regulations.

Theories have many parts and they will probably change as developing science will make new data and analytical tools available on regular bases. Real experiments are used to prove theoretic thesis (statements. Theory is a tool of science. Scientists or other subjects – like students – will “view” objects of interests through “glasses of theory”. The viewer is linked to units of real material by means of symbolic units. The structure of a formal mask is visualised on Figure 6.6.. Figure 6.7 depicts a scientists who views real object of interest through syntactic unit („3 D formal mask“).

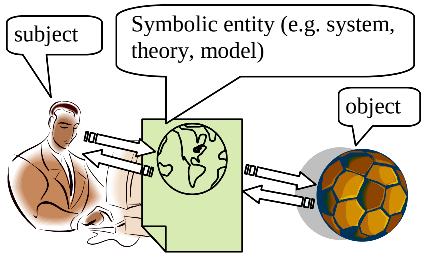


Figure 6.7 Formal theory is a “semi-transparent symbolic mask“ [56]

Well-known theoretical system, based on five axioms, is, for example, the Euclidian geometry. According to a method, resembling Euclidian, each and every scientific theory involves a set of semantic concepts and statements that are true or assumed to be true. Meta-physical theory is more restricted, i.e. less things are possible meta-physically, than logically possible. Meta-physical theory can reflect some of the (deep) facts about the worlds, being the foundation of knowledge. Such an accurate relation to physics and physical abilities is an issue of discussion between teacher and students.

According to the definition, 3D geographic space represents a sub-space of a six-dimensional (6D) space. More complex movement becomes obvious, for the viewer, as a geometric object in a geographic space. 3D points specify (quantify) interminable number of small (condensed) locations within the 6D space where movement exists. The reason of movement always lies beyond these 3D points.

6.3 Description of Learning Methods, Using the Framework of Six-dimensional Space Framework

We could view learning as an interactive movement that includes information exchange between student and teacher by a diversified visual interface between learning tools, for example, using the *Moodle* user interface. During the dialogue, student and teacher will be linked by different channels (see system 1, Figure 6.8) that can communicate values also at higher quality levels. Skilful teacher can convey his/her practical skills, using system 2 user interface (Figure 6.8) and channels that formed values at lower levels.

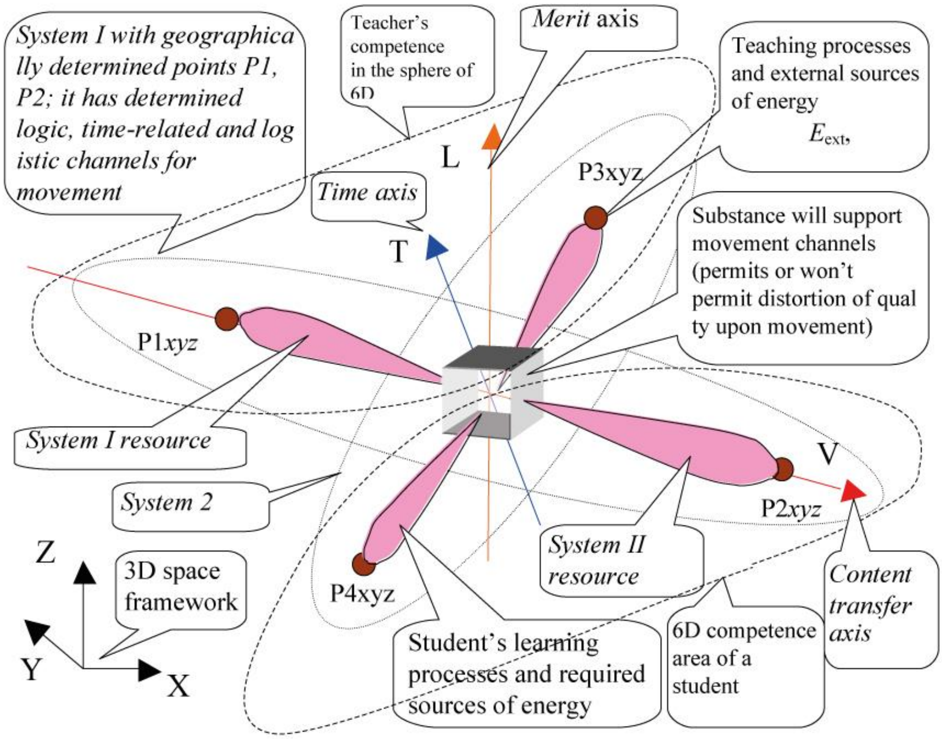


Figure 6.8 Dialogue between student (P1 system 1) and teacher (P2 system 1) also involves teaching and learning tools [56]

According to implementation ontology, quality is determined for resource-based measured physical, energetic or some other qualitative value, i.e. something with a name value. Communication value and realisation time can be also determined for this value.

Geographic points can be linked to components of hierarchic composition that will jointly form a working system, for example, element, component and module. Element is a so-called "black box". This consists of at least two points (every one of them contains substance), two internal connections and a certain quantity of working substance around them. Substance will transform unknown movement that are not a part of the system (Figure 6.9).

If we were to study teaching and learning more specifically (systematically), we have to present the merit values of learning process subjects on axes more accurately (teacher Figure 6.10, student Figure 6.11, ICT solutions Figure 6.12, practical tools Figure 6.13 and e-learning environment Figure 6.14). The values of substance, communicated between parties, should ideally allow immediate synchronisation with each other. In real learning process, these subjects are working at different moments of time. Therefore, intermediate recording devices are needed. Communication transfer will also largely depend on dynamics of learning process dialogue and its components.

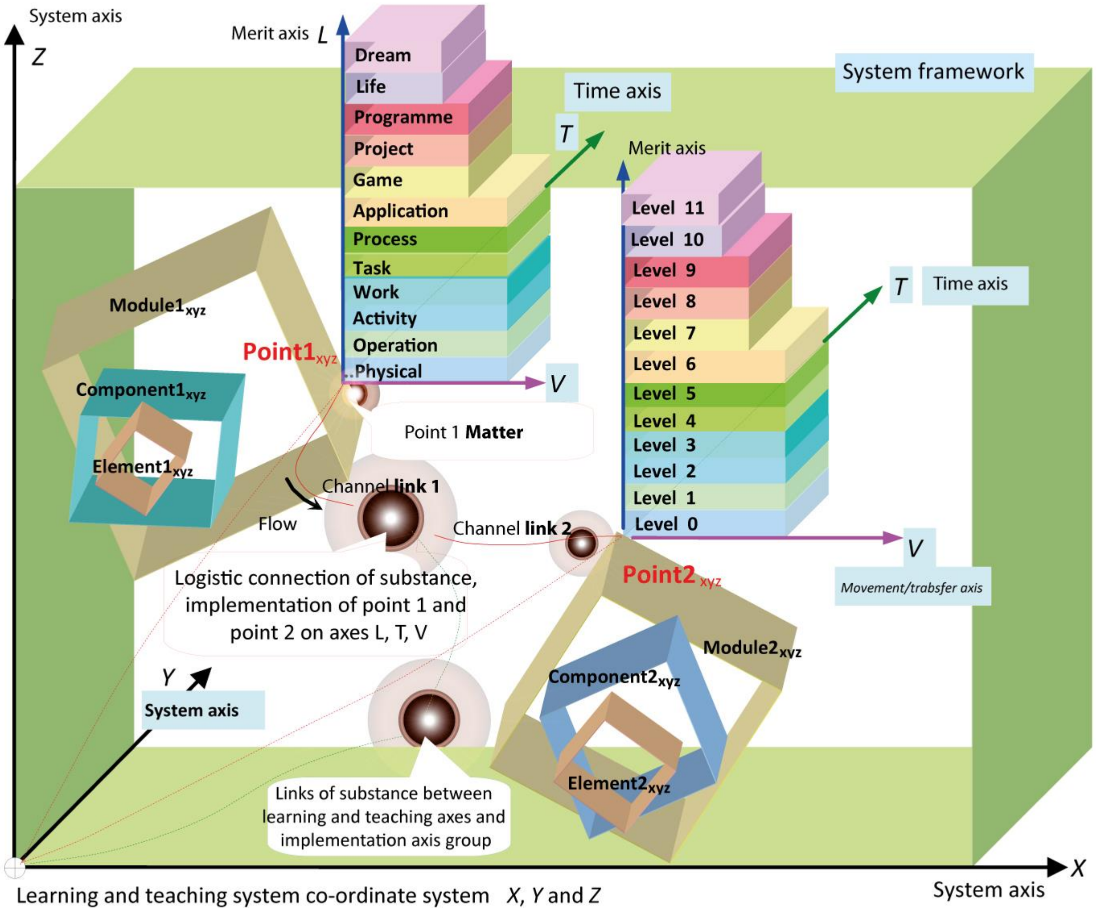


Figure 6.9 Illustration of six-dimensional space framework [56]

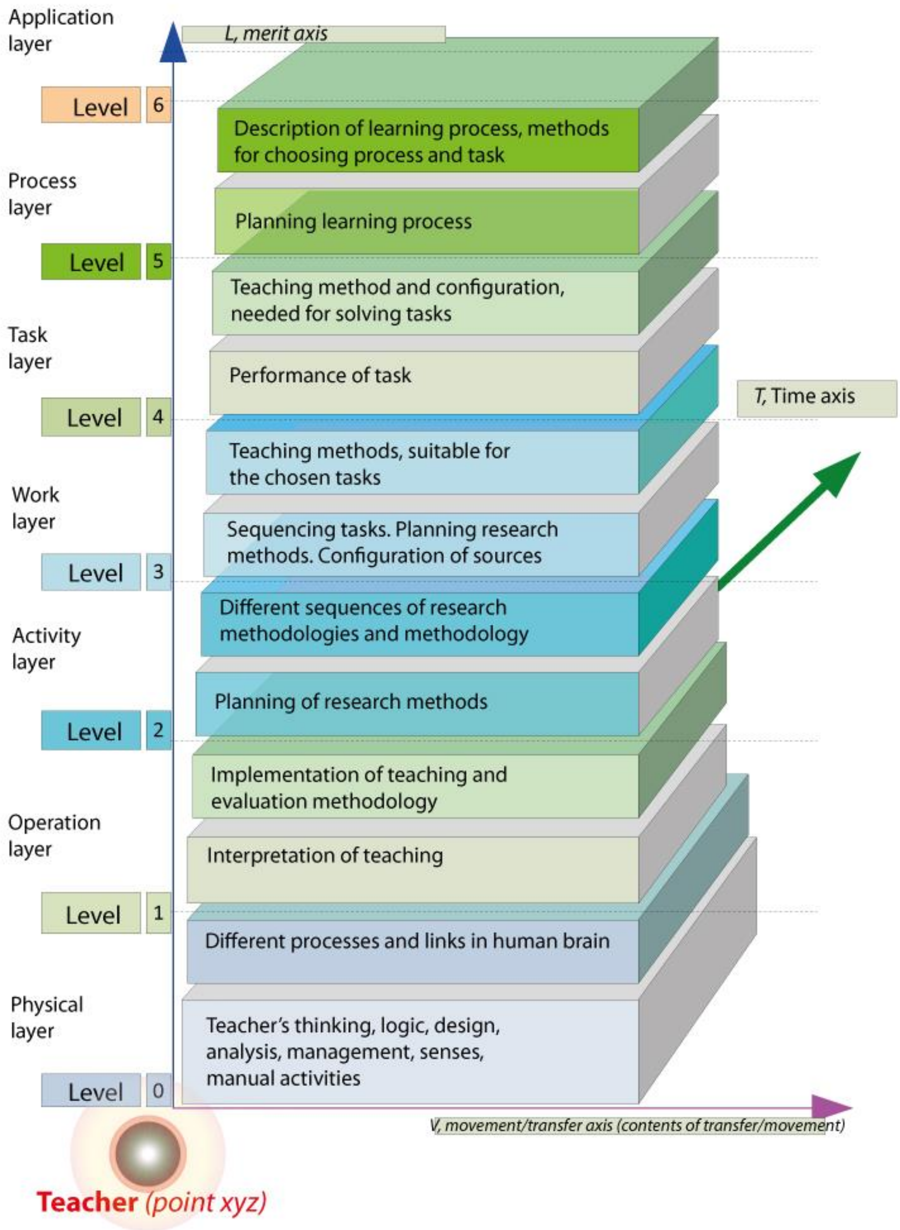


Figure 6.10 Teacher's value axis [74]

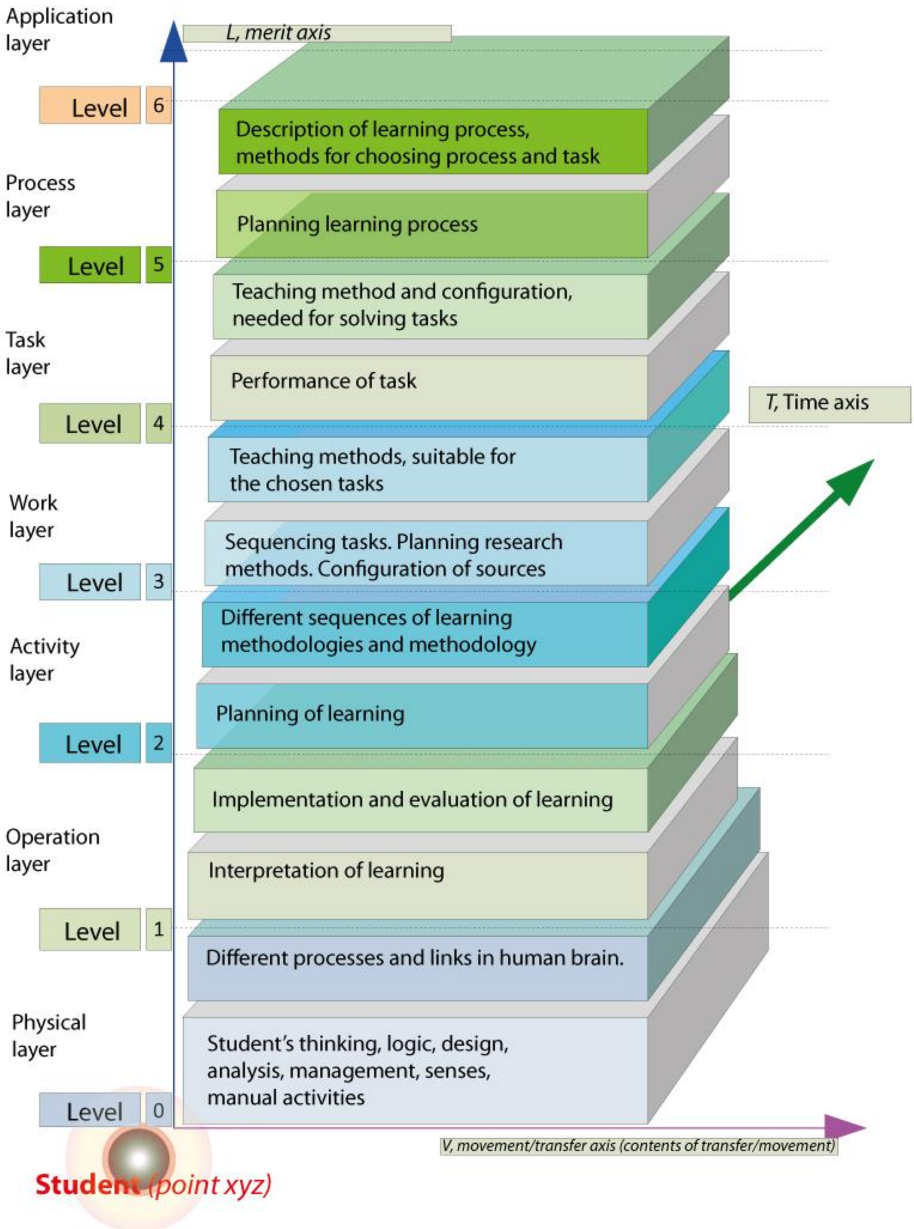


Figure 6.11 Student's value axis [74]

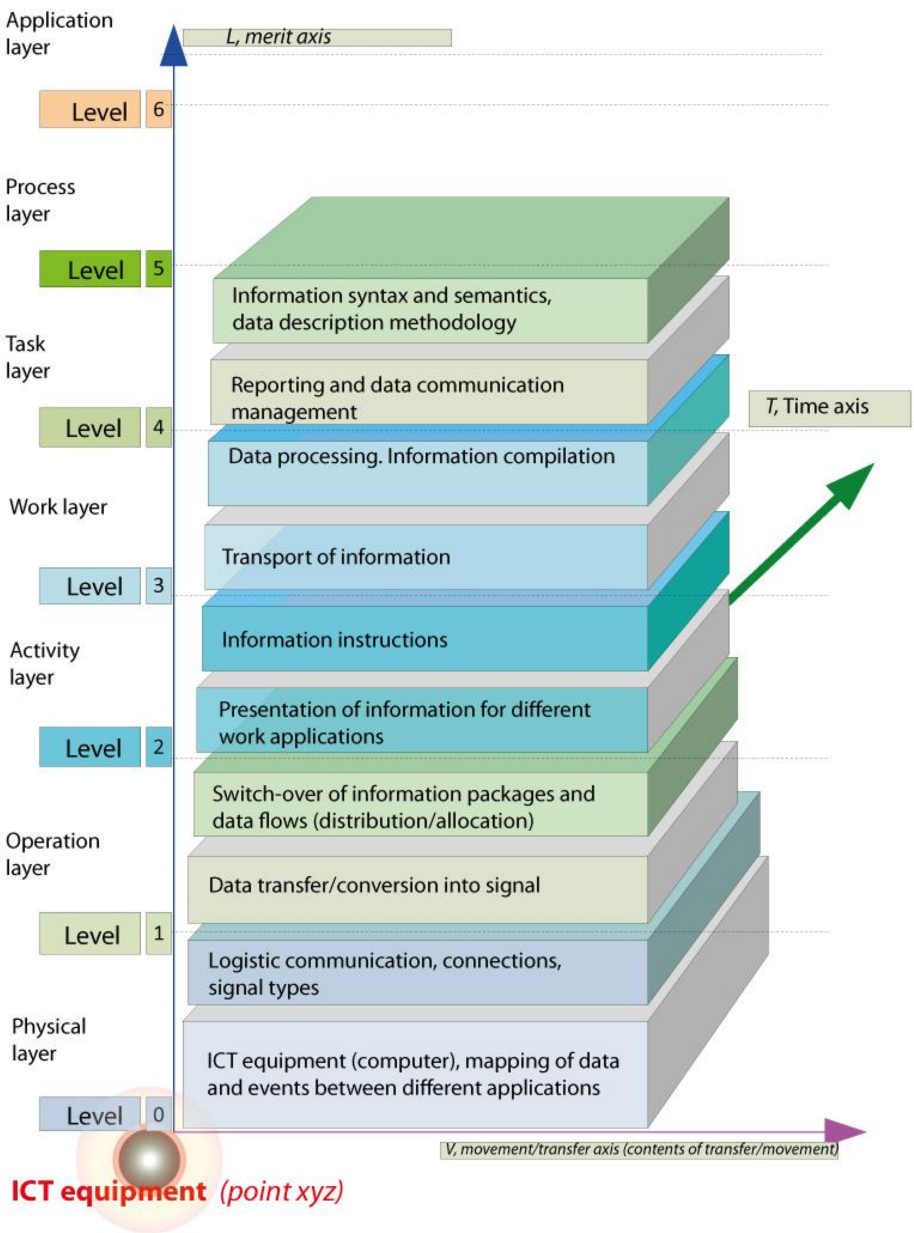


Figure 6.12 ICT value axis [74]

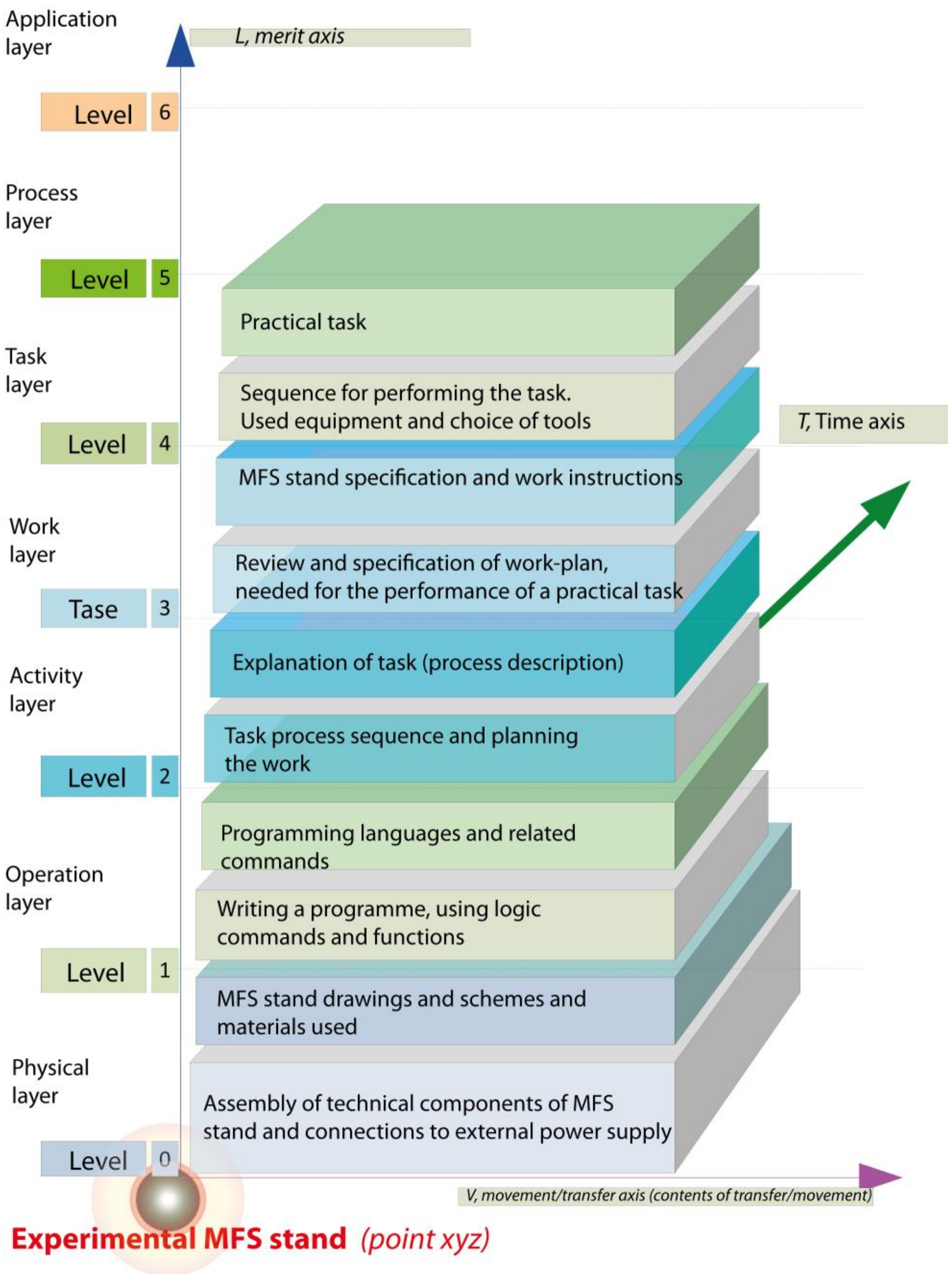


Figure 6.13 Experimental stand (MFS) value axis [74]

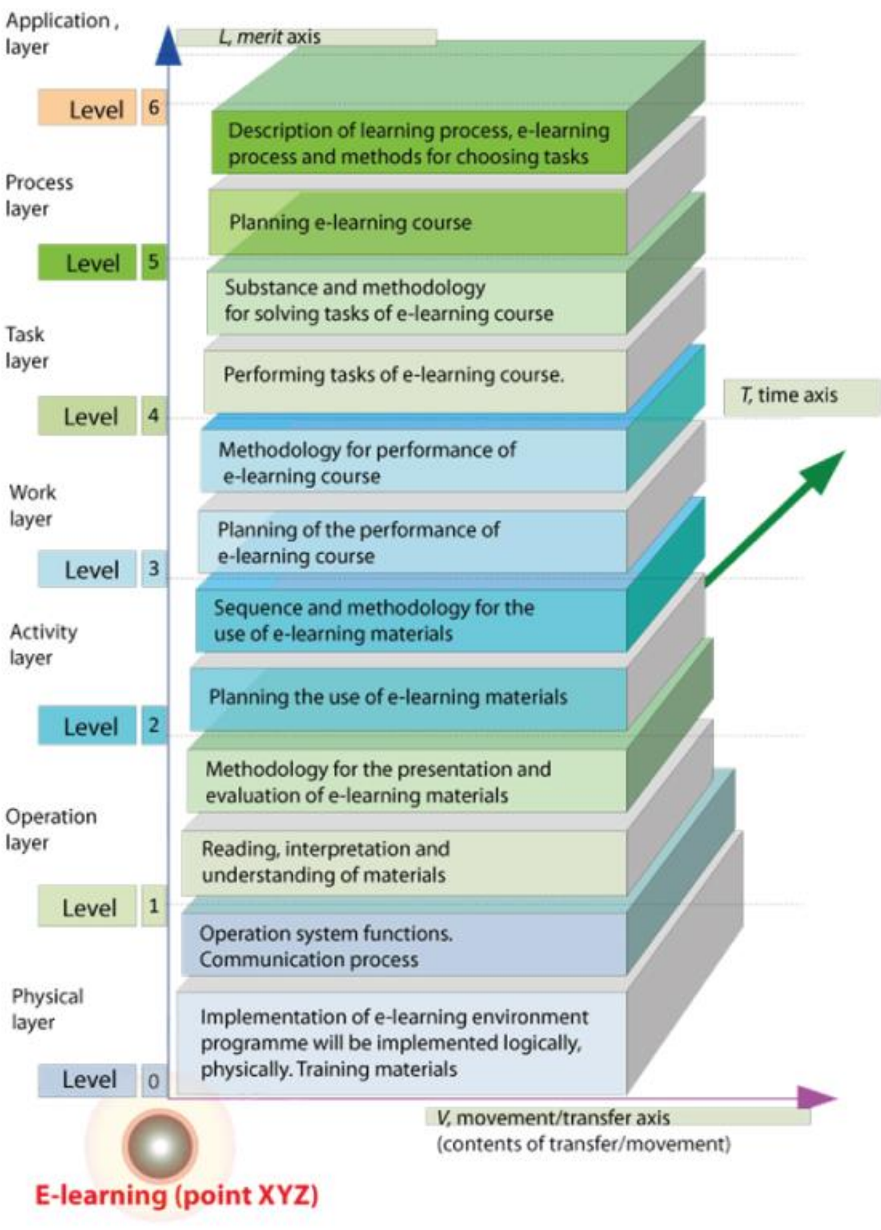


Figure 6.14 E-learning value axis [75]

6.4 Summary

This chapter provided a visual description of teaching-learning systems of a school, using a 6D co-ordinate system, involving integration of students, computer, e-learning environment, multifunctional production automation experimental MFS stand and applications, used by teacher in learning process, for the acquisition of education.

The 6D space concept is used as a part of education technology to explain, effectively, the informative and energetic interactions in a communication process between teachers and students. The structure can be used to describe different equipment that are used in industrial automation and mechatronics.

Innovative 6D thinking methods will help teachers and students to organise/structure their knowledge more efficiently, contributes to teaching and learning value factor and accelerates adaptation with rapid changes that take place in labour market.

Main views for the performance (implementation) of dynamic were explained, illustrated and presented visually, using the new 6D co-ordinate system.

The new 6D co-ordinate system is implemented into descriptions of learning system that vocational education students (students of technical specialities can use in due course of theoretical training and practical work in the field of industrial automation and mechatronics.

Teaching and learning process can be grouped and defined to different value levels in accordance with the presented 6D space architectural model.

Chapter 7 Summary and Recommendations

Conclusions and results, achieved as the consequence of scientific research and development work, are defined in the following sections:

1. **Mutual data exchange between labour market subjects and objects was studied, using a six-dimensional (6D) spatial model ontology as the bases.** New generalised information model was developed.

It was investigated, in the sphere of automation, how does the knowledge, skills and high quality (credibility) of students of technical specialties emerge in the teaching process.

For more specific and systematisation of problems, models of knowledge, skills and credibility were developed and used to study their implementation in the sphere of automation with the purpose to describe the profiles for competence, using an eight-level qualification framework and modern information modelling tools, and investigate how does the knowledge, skills and high quality (credibility) of students of technical specialties emerge in the teaching process.

The following observations and conclusions were made during the work:

- The occupation of electricity engineer is determined in Estonia by relatively narrow means. The diploma of electricity engineer will be awarded in the sphere of generation, transmission and distribution of electricity energy. The requirements, established for an electricity engineer, are mostly of descriptive nature. There are no data models.
- Apart general requirements to professional levels, we need to determine special requirements, established to the competence of electricity engineers working in spheres, related to energetic, so as to specify the vocation of electricity engineer more accurately.
- There are no descriptions of requirements to knowledge, skills and credibility of engineers in other technical fields, related to electricity energy.

2. **New, seven stage visual method has been crated for the provision and acquisition of research-based knowledge** to and by students of technical specialities, ensuring acquisition of subject-related (required) new information, new skills (practical experience), wisdom (experience-based theoretical generalisation), qualification of knowledge and skills (evaluation of knowledge and skills) obtained, followed by extended operation in sphere of purposeful implementation.

Independent learning of students and self-regulation, exercised during the learning process, was observed, involving the abandoning of former routines and getting them replaced for new routines that match the circumstances better.

Efficient methods are visually structured and diversified, allowing for diversified observation. Visual model allows to analyse and identify mistakes in the self-regulation algorithm. For example, everybody wants to achieve success, but may will avoid failure at the same time and are therefore afraid to take any action (to make the first step), as they visualise their choices in a wrong way.

Barriers to learning represent a problem; coping with barriers to learning is mostly related to the abilities of lecturers to develop self-regulation skills in students and their own empathy. Lecturers can't support students with overcoming barriers to learning, if the students don't understand the importance of self-regulation and the principles for its implementation.

The following conclusions can be drawn on the bases of the analysis conducted and earlier studies:

- Self-regulation skills of students need to be developed for the students to be able to take control of their learning and establishment of objectives, thus making it easier for them to overcome the possible barriers to learning. By doing this, the barriers to learning will be overcome by the student and lecturers will only support students in the process for overcoming the barriers to learning.
- For that purpose it is necessary to give the students and lecturers general yet visual picture of the learning process, learning and teaching. Studies have shown that lecturers and students are unaware of real self-regulation processes in education, learning, reasons for the barriers to learning and the ways for coping with the barriers.
- For improving the efficiency of learning, a student must be capable of better structuring and visualisation of mental images. It is also useful to visualise real activities and functions, not just geometric objects. Weak links of spatial performance (activities) of framework structure of geometrisation processes to the framework of describing geometric objects (x, y, z-axes) can become a problem here.
- Visual teaching materials can be used efficiently to search for problems to emotional, cognitive and social problems.

It's obvious that once new knowledge is obtained, the scope of practical experiences is still limited. Those striving for quick success must first overcome failure and only then, success can be achieved.

The activities of teachers within the learning process was observed; they often perceive often describe their profession by using parameters that include academic knowledge and professional competence (doing certain things well), positive and proper attitude towards students and good communication skills. All this is very useful, however, as their experiences increase, teachers will start to shift their focus from single components to more general aims, goals, mental values and principles. The following is needed for the presentation of such values and principles:

- Supporting dynamic and also visual approach to learning and teaching. For a student, this will mean an education that can adapt to quickly changing requirements, influences values and activities;
- When giving a specific lecture, lecturers should treat the learning process, happening in the classroom as a complete entity. Apart good knowledge of facts a professor will also need the ability of sensing the subject taught as a summation;
- creation of adequate and explaining models that will take the lecturer from regular routine and task context to details and back, where appropriate, is needed for better development of thinking skills and ability to create connections to context.

6. **A new visual methods is developed for navigation in a structure of complex specialty-related information, used to teach and learn various subjects to and by students of technical specialties, and a new model for geometrical description of content of information flows, using 6D spatial model.** Semantic bases for the visualisation of complex semantic information flows or a visual framework will be based on a six dimension spatial model, which, according to critical spatial theories, is used to merge (combine) objectively defined material space or "spatial practices" and subjectively defined mental, cognitive space or "spatial representation"; and a third, hyper space or the combination or extension of the first two into additional dimensions, which will allow movement of semantic tools (information or data with meaning) between points of material and mental four dimension space. Real, mental and hyper-real exist, in parallel, within the space of representations.

   The new visual method will allow to create, communicate and submit information in a more intelligent and understandable way and can be therefore used in numerous fields, including:

   - in organisations, providing research based education, for providing new knowledge, more efficient transfer of knowledge from a researcher to lecturers, students or employees of enterprises. Innovative 6D thinking methods will help teachers and students to organise/structure their knowledge more efficiently, contributes to teaching and learning value factor and accelerates adaptation with rapid changes that take place in labour market;
   - acquisition of knowledge and skills, needed for planning and implementation of specialty-related career of the youth that vocational education students (students of technical specialities can use in due course of theoretical training and practical work in the field of industrial automation and mechatronics;
   - for the establishment of requirements, needed in professional organisations to prove competence;
   - for the development and specification of descriptions of occupations and specialty-related jobs, created by entrepreneurs, which can be grouped

and defined to different value levels in accordance with the presented 6D space architectural model;

- for product development efforts of enterprises, automation of production, preparation and marketing of products. The 6D space concept can be also used to describe a variety of physical settings that exist in industrial automation and mechatronics.

The 6D space concept and units that provide the appropriate foundation are used as a part of education technology to explain, effectively, the informative and energetic interactions and the structure of the communication process between teachers and students.

This paper provides a description of an integrated teaching-learning system, involving integration of students, computer, e-learning environment, multifunctional production automation experimental MFS stand and applications, used by teacher in learning process, for the acquisition of education.

4. A new classifier of knowledge and skills was developed, then used to device a new classification of knowledge and skills.

Graduates of institutions of higher education will be employed and therefore, they have the right and duty to take responsibility. Obligations must be met, goals and directions established and tools chosen for achieving these objectives in every job and occupation. Taking responsibility is avoided, as this has not been demanded before; adoption of decisions will require work-related and professional competence and taking responsibility for one's work of young engineers.

The development of this paper involved a study to investigate the level of education of students and employees of enterprises and the requirements established to the content of their knowledge; the results were used to draw the following conclusions and submit proposals:

- In the information society where jobs are no longer long-term, the approach to competence needs to be adjusted to enhance the adaptability of individuals. The earliest approach the qualification date back to the industrial era and need expansion by the definition of quality in such a way that it would make sense in the information era where students are not prepared only to enter labour market (as someone performing the work, determined by labour market requirements), but to be an active person, capable of taking responsibility for his or her life programme in full and also for the realisation of dreams and visions.
- Engineers have received a contemporary training in their specialty, but immediately after graduation they will learn that their professional training is insufficient and they have no occupational training. Graduates of institutions of higher education will be employed and this will result in

the right and duty to take responsibilities, which is, regrettably, avoided as this therefore, they have the right and duty to take responsibility, which has not been demanded before; adoption of decisions will require work-related and professional competence and taking responsibility for one's work of young engineers.

- The study shows that apart theoretical training, the proportion of practical training needs to be increased. The knowledge of students on the implementation of knowledge needs to be improved. This can be done by using teamwork (group work), where students will apply their theoretical knowledge to solve practical tasks. Teamwork is, in itself, the fastest way to developing personality and teamwork skills and, what's most important, will help to use the implementation of theoretical and practical skills.

The following problems were highlighted during the study:

- academic knowledge is poorly integrated with practical skills and the focus of education is often on academic training while it's not clear whether this meets the expectations of employers;
- students lack working experience; the curriculum for obtaining academic education only includes a small proportion of practical internship;
- teaching/training methods are not attractive for students and won't encourage them to take initiative and use academic knowledge in enterprises;
- weak links between academic knowledge and business; learning process and curricula don't favour the development of entrepreneurship;
- Study information systems are extensive databases that provide the opportunities for the collection, statistical processing and maintenance of data, yet fail to offer the tools for modelling curricula.

As the consequence of the study it was found that is necessary to pay information, at didactic level, to the following issues:

- implementation of knowledge and skills classifications that would consider the demands and needs of enterprises and therefore, requirements to knowledge contents of in-service training for employees of enterprises and students;
- use of teaching didactics that matches effective (the newest, fastest and cheapest) teaching methods (technologies) and study of related trends;
- using a recognised ontology to structure and visualise mental images of learners and lecturers. General visualised picture of the learning process, learning and teaching must be given to the students to achieve this goal;
- feature of applicability should be added to the existing databases (learning information system ÕIS; e-learning environments etc.) to allow modelling of learning process at multiple dimensional level;

- it is necessary for bachelor's and master's study graduates to acquire the knowledge, skills and responsibility and independent operating skills to a level that would allow them to apply acquired competences, efficiently, in real life.

5. **Teaching and learning methods have been developed for the acquisition of specialty-related qualification of students of technical specialties, involving the (most suitable) methods for communication and acquisition of knowledge by students of technical specialties**, that are suitable for studying the most effective (newest) teaching methods (technologies) and their development trends.

One of the main weaknesses of blended learning is usually too much focusing on ICT tools and therefore, databases and data administration in technical applications. Development of teaching materials is usually seen as the most important development outcome. People often forget about the student and professor and this will disperse the blended learning system as a complete unit.

Blended learning is understood as a combination of face-to-face learning and teaching involving technological tools. We must observe blended learning, for teaching technically complex and complicate disciplines, as a special symbiosis of methodologies. Here, apart face-to-face and information communication tools we need to employ technical tools that are meant for developing practical skills. Blended learning is not a new phenomenon in higher education. Only the understanding of the number of components to be combined and blended can be described as new.

Five main fields need to be analysed in the sphere of blended learning:

1. Students and their self-regulation;
2. Pedagogic skills and methods of lecturers (instructors);
3. ICT (information communication) technology and the opportunities it provides for visualisation of mental models and real objects;
4. E-learning courses and study objects and their structure and feasibility;
5. Main technical tools for practical studies and their feasibility for the purposes of real-life work procedure and operations.

Every single institution of education has to decide, relying on selection criteria determined earlier, upon the ratio of face-to-face and e-learning to be adopted, attempting to achieve a result that is, didactically, most justified. Regardless of the combinations, it is always most important to focus on the expected learning outcomes. Learning outcomes play a central role for assessing the sustainability of learner, culture, available teaching materials, (technological) infrastructure and teaching work.

Blended learning represents an efficient tool for studying and testing new pedagogical solutions. The following new results are obtained by employing blended learning:

- design and development of blended learning as a part of school's information space, based on e-learning management software
- design and practical development of functional course modules;
- design and development of methods and teaching methodological materials to support blended learning process and development of technically complex mechatronic and automation materials;
- development of independent perception of students by independent earning.
- introduction and implementation of blended learning technologies will result in the establishment of "e-learning course information base that is updated on regular bases".

Final version of blended learning was developed within the framework of the „AutoMatic" project (launched on 01.10.2009 and completed on 30.10.2011) and serves to facilitate organisation of independent work of students. Within the framework of the project, different **virtual e-learning environments** were developed for students for learning and for lecturers for teaching.

To see the complete picture we need to employ individual's ability to acquire graphic information at a faster pace to obtain a quicker and easier overview of the processes that take place in reality. For that purpose, we must give the students and lecturers a visual overview of the learning process, learning and teaching.

6. **Practical training stand** for learning and teaching actuators, PLC programming and information networks. Universal practical training work station, its different parameters, deficiencies and compatibility for practical training will be investigated.

Universal experimental stand has been developed for students of automation courses to investigate programmable controllers and actuators. Multifunctional production automation stand (MFS) represents a part of blended learning system.

The purpose of building a learning stand is to offer the students different practical tasks and a variety of solutions for such tasks.

Experimental learning stand, used for practical studies, must meet the following conditions:

- simple and easy to understand construction;
- gives clear overview of the principles and processes;
- multifunctional, allowing to prepare different learning tasks and their practical launching within the framework of a technical process; the stand will allow teaching and learning about different modules (for

example: programmable logic controllers, electrical engineering control technologies, pneumatic automatics, sensor technology, industrial information networks, visualisation, operation and maintenance of automated systems etc.;

- allows to use different pedagogical didactic study methods (individual learning, group work, project-based work);
- matches acknowledged learning and teaching models;
- allows to develop practical skills within the framework of blended learning process;
- is low-cost, as far as learning expenses are concerned (compared to other equivalent stands) and easy to re-structure to match the development of curriculum and related technologies.

7. **Practical in-service training courses for employees of small and medium-size enterprises.**

Practical in-service training courses for employees of small and large scale enterprises. New curricula was developed, considering the research results, obtained by implementation of theoretical part of the work, and 7E model. Course materials for in-service training of employees. Testing courses and related study of students was conducted on the bases of curriculum.

As the consequence of the study it was found that is necessary to pay information, at didactic level, to the following issues:

- implementation of knowledge and skills classifications that would consider the demands and needs of enterprises and therefore, requirements to knowledge contents of in-service training for employees of enterprises and students;
- use of teaching didactics that matches effective (the newest, fastest and cheapest) teaching methods (technologies) and study of related trends;
- using a recognised ontology to structure and visualise mental images of learners and lecturers. General visualised picture of the learning process, learning and teaching must be given to the students to achieve this goal.

References

[1] Ü. Vooglaid, „Teel kodaniku ühiskonna poole," *Kultuur ja elu,* 2002.

[2] S. Rossi, „Ettevõtlusõppe kontseptsioon," Majandusministeerium, 2009.

[3] Tallinna Ülikool, „Haridusterminoloogia," Tallinna Ülikool, 2010. [Võrgumaterjal]. Available: http://haridusterminoloogia.wikispaces.com/.

[4] O. Aarna, „Kvalifikatsioonisüsteemi uue kontseptsiooni ja kvaliteeditagamise süsteemi väljatöötamine," ESF programmi „Kutsete süsteemi arendamine, Tallinn, 2008.

[5] Eesti Keele Instituut, „Eesti õigekeelsussõnaraamat EÕS," 2006. [Võrgumaterjal]. Available: http://www.eki.ee/dict/qs/.

[6] O. Aarna, „Eesti kvalifikatsiooniraamistik," *Eesti Kutsekoda,* 2009.

[7] EUROPEAN COMMISSION, „European Inventory – Glossary," 2012. [Võrgumaterjal].

[8] S. Kera, Kasvada kaasinimeseks– saada inimlikuks. Sotsiaalne õppimine ja inimese kõlblus., Tallinn: TPÜ Kirjastus., 1999.

[9] J. Koro, Aikuinen oman oppimisensa ohjaajana., Jyväskylä: Jyväskylän Yliopisto., 1993.

[10] Vabariigi Valitsus, „Kõrgharidusstandard Vastu võetud 18.12.2008 nr 178 RT I 2008, 57, 322 jõustumine 01.01.2009," 2008. [Võrgumaterjal]. Available: https://www.riigiteataja.ee/akt/13255227?leiaKehtiv.

[11] T. Good ja J. Brophy, Contemporary educational psychology, New York: Longman, 1995.

[12] A. Reber, The Penguin dictionary of psychology., London: Penguin Books.

[13] Eesti Infotehnoloogia Sihtasutus (EITSA), „Haridustehnoloogia sõnastik," 2012. [Võrgumaterjal]. Available: http://wiki.e-uni.ee/htsonastik/.

[14] E. Krull, „Õpetajate pedagoogiliste tõekspidamiste ja arutlusviisi sõltuvus koolikogemusest.," *Haridus ja sotsiaalne tegelikkus,* p. 52–60., 2000.

[15] R. Mezner, Mind space and time stream, Meeleruum ja ajavoog., Tallinn: Eesti Transpersonaalne Assotsiatsioon, 2012.

[16] A. Kidron, 122 õpetamistarkust, Tallinn: Kirjastus Mondo, 1999.

[17] B. Skinner, „The Science of Learning and the Art of Teaching," *Educational Review 24,* pp. 86-87, 1954.

[18] B. Skinner, „Teaching Machines," *Science 128,* pp. 969-977, 1958.

[19] R. Kuhlen, Hypertext. Ein nicht-lineares Keskmise zwischen Buch und Wissensbank, Berliin: Heidelberg: Springer, 1991.

[20] K. Peerna, „Veebipõhise ja auditoorse õppe kombineerimine õhusõidukite juhtimise eriala õppes," Tartu Ülikool, 2010.

[21] H. S. W. N. Lindgren, Pedagoogiline psühholoogia koolipraktikas, Tartu: Tartu Ülikool, 1994.

[22] J. H. Flavell, „Metacognitive aspects of problem solving in L. Resnick (Ed.)," *The nature of intelligence.,* 1976.

[23] L. Suchman, „Notes on Computer Support for Cooperative Work," ACM Transactions on Office Information, 1989.

[24] L. Suchman, „Notes on Computer Support for Cooperative Work," *ACM Transactions on Office Information Systems,* pp. 320-328, 1989.

[25] M. Ally, „Foundations of educational theory for online learning. In T. Anderson & F. Elloumi (Eds.), Theory and practice of online learning.," *Athabasca, Canada: Creative Commons: Athabasca University.,* 2004.

[26] H. Gardner, Frames of mind – The Theory of Multiple Intelligences. 10anniversary edition, Trade paperback, Basic Books (AZ) .

[27] P. Teppan, „Kaasaja õpiteooriate lähtepunktid," 2002. [Võrgumaterjal]. Available: http://stud.sisekaitse.ee/Teppan/Opiteooriad/index.html. [Kasutatud 2012].

[28] E. Krull, „Pedagoogilise psühholoogia käsiraamat," Tartu Ülikooli kirjastus, 2000.

[29] B. A. Lankard, New Ways of Learning in the Workplace, Columbus (OH):: ERIC Digest 161. ERIC Clearninghouse., 1995.

[30] A. Holzinger, A. Pichler, W. Almer ja H. Maurer, „A Multimedia test-bed for examining incidental learning, motivation and the Tamagotchi-Effect within a Game-Show like Computer Based Learning Module," *Educational Multimedia, Hypermedia and Telecommunication, 2001, Association for the Advancement of Computing in Education,,* pp. 766 - 771, 2001.

[31] A. Holzinger, „Kognitive Grundlagen multimedialer Informationssysteme,“ *Basiswissen Multimedia, Band 2 Lernen:,* 2000.

[32] A. Holzinger ja H. Maurer, „Incidental learning, motivation and the Tamagotchi Effect: VR-Friend, chances for new ways of learning with computers,“ *Virtuality in Education, Abstract Book; p70, 1999, London: Elsevier.; presentation available at,* 1999.

[33] P. Dahlqvist, „Presentation Formats in Concept Formation: An Experimental Study[1],“ 2002. [Võrgumaterjal]. Available: http://www.dsv.su.se/~patricd/master_thesis.html.

[34] I. Kivi, „Virtuaalsed õpitarkvara,“ 2002. [Võrgumaterjal]. Available: http://lizard.artun.ee/~ivika/ma.html.

[35] E. S. Sarv, „Humanistlike pedagoogiliste süsteemide,“ 2009. [Võrgumaterjal]. Available: http://www.tlu.ee/opmat/ka/opiobjekt/pedsusteem/ped_exe/index.html.

[36] P. A. Dhillon ja J. M. Halstead, „Multicultural Education,“ *The Blackwell Guide to the Philosophy of Education. Ed. N. Blake, P. Smeyers, R. Smith, P. Standish,* pp. 160-161, 2003.

[37] K. Pata, „Kogukonnad ja sotsiaalsed võrgustikud,“ 2007. [Võrgumaterjal]. Available: http://www.slideshare.net/kpata/kogukonnad.

[38] L. Bannon ja K. Schmidt, „Taking CSCW Seriously Supporting Articulation Work,“ *Computer Supported Cooperative Work (CSCW): An International Journal, vol. 1,,* pp. 7-40, 1992.

[39] L. Salomon, „Partners in Public Service,“ *Government-Nonprofit Relations in the Modern Welfare State,* 1995.

[40] J. Urban Jermann, „EconomicDynamics Interviews Urban Jermann on Asset Pricing,“ *EconomicDynamics Newsletter, Review of Economic Dynamics, vol. 3(2), April.,* 2002.

[41] C. Bereiter, Education and mind in the knowledge age, Mahwah, NJ: Lawrence Erlbaum Associates, 2002.

[42] N. J. Gunther, „Unification of Amdahl's Law, LogP and Other Performance Models for Message-Passing Architectures,“ *International Conference on Parallel and Distributed Computing Systems,* pp. 569-576, 2005.

[43] S. Torrão, Blended learning: research reports & examples of best practices, Tartu Ülikool.

[44] C. Wiepke, Computergestützte Lernkonzepte und deren Evaluation in der Weiterbildung., Hamburg: Blended Learning zur Förderung von Gender Mainstreaming. , 2006.

[45] K. Vehkalahti, „Leaving useful traces when working with matrices.," *Research Letters in the Information and Mathematical Sciences, Vol. 8. Proceedings of the 14th International Workshop on Matrices and Statistics. (Paul S.P. Cowpertwait, ed.)* , pp. 143-154, 2005.

[46] Tuvikene, „Fish bioaccumulation and metabolism of complex mixtures from oil shale contamination in Estonia," *Hong Kong, China, November 10-13,* 2000.

[47] J. A. Pereira, E. Pleguezuelos, A. Meri, A. Molina- Ros, M. C. Molina-Tomas ja C. Masdeu, „Effectiveness of using blended learning strategies for teaching and learning human anatomy.," *http://www.ncbi.nlm.nih.gov/pubmed/17269953,* 2007.

[48] C. C. Chen ja K. T. Jones, „Blended Learning vs. Traditional Classroom Settings: Assessing Effectiveness and Student Perceprions in an MBA Accounting Course.," *The Journal of Educators Online, Volume 4, Number 1.* , 2007.

[49] T. L. Rummo, Tasemehariduse statistika käsiraamat, Tallinn: EV Statistikaamet, 2000.

[50] O. Aarna, E. Pilli, S. Granström, K. All, K. Toom, A. Valk, M. Udam, M. Kerem ja M. Merirand, „Eesti kvalifikatsiooniraamistiku sidumine Euroopa kvalifikatsiooni raamistikuga," 2011.

[51] Euroopa Parlament, „Euroopa Parlamendi ja nõukogu soovitus, 23. aprill 2008 , Euroopa kvalifikatsiooniraamistiku loomise kohta elukestva õppe valdkonnas (EMPs kohaldatav tekst)," Euroopa Liidu Teataja C 111 , 06/05/2008 Lk 0001 - 0007, [Võrgumaterjal]. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008H0506%2801%29:ET:HTML.

[52] O. Aarna, T. Annus, M. Heidmets, M. Lauristin, K. Loogma, E. Rebane, V. Ruus, M. Sutrop ja E. M. VernikTuubel, „Eesti hariduse viis väljakutset Eesti haridusstrateegia 2012–2020 taustamaterjal," 2011. [Võrgumaterjal]. Available: Eesti Koostöö Koguhttp://www.elu5x.ee/index.php?id=10783&highlight=,,Eesti,hariduse,viis,v%C3%A4ljakutset. [Kasutatud 2013].

[53] Eesti Vabariigi Riigikontroll, „Kontrolliaruanne "Täiskasvanute täiendus- ja ümberõpe"," 2010. [Võrgumaterjal]. Available: http://www.riigikontroll.ee/tabid/206/Audit/2155/Area/1/language/et-EE/Default.aspx#results. [Kasutatud 2013].

[54] Sihtasutus Kutsekoda, „The professional qualifications system.,“ 2006. [Võrgumaterjal]. Available: http://www.kutsekoda.ee/et/index.

[55] S. Rutiku, A. Valk, E. Pilli ja K. Vanari, Õppekava arendamise juhendmaterjal, http://primus.archimedes.ee, Toim., Sihtasutus Archimedes.

[56] E. Pettai, „A 6D space framework for description of distributed systems.,“ *Estonian Journal of Engineering.* , pp. 140-171, 2012, 18, 2,.

[57] Z. Raud, Research and Development of an Active Learning Technology for University-Level Educationin the Field of Electronics and Power Electronics (Aktiivõppetehnoloogia uurimine ja väljatöötamine kõrghariduse õppekavale elektroonika ja jõuelektroonika valdkonnas), Tallinn: Tallinna Tehnikaülikool Tallinn University of Technology , 2012.

[58] TTÜ nõukogu, „Tallinna Tehnikaülikooli õppetegevuse strateegia,“ 2012. [Võrgumaterjal]. Available: TTÜ nõukogu 17.04.2012 otsusega nr 62. [Kasutatud 2013].

[59] Sihtasutus kutsekoda, http://www.kutsekoda.ee/et/kutseregister/kutsestandardid/10422678/kirjeldus, 2005.

[60] P. Ruohotie, „Võtmekvalifikatsioonid töös ja hariduses,“ *Elukestev õpe : õppimise kutse nr. 1,,* pp. 75-87, 2008.

[61] P. Ruohotie, „The development of competence and qualifications as the objective of vocational higher education,“ *Elukestev õpe : õppimise kutse nr. 1, (2008),* 2002.

[62] W. J. Nijhof ja J. N. (. Streumer, „Key Qualifications in Work and Education. Dordrecht: Kluwer Academic Publishers Nijhof, W. J., & Remmers, J. L. M. (1989). Basisvaardigheden nader bekeken. (A closer look at key qualifications).,“ *Enschede: University of Twente, Department of Educational Science and Technology),* 2001.

[63] A. Brown, „Designing effective learning programs for the development of a broad occupational competence. In: Nijhof, W. J. & Streumer, J. N. (Ed's). Key Qualifications in Work and Education,“ 2001.

[64] N. Blagg, M. Ballinger ja R. Lewis, „Thinking Skills at Work. Sheffield: Employment Department).“.

[65] S. Pavlin, „Key Competences of Graduates to Function Well in the Workplace and Society. In: Pavlin, S. (Ed), Report on the Qualitative

Analysis of Higher Education Institutions and Employers in Five Countries: Development of Competencies in the World of Work and Education.," *HEGESCO: Ljubljana,* pp. 11-21, 2009.

[66] W. Mϋller ja Y. Shavit, „The Institutional Embeddedness of the Stratifi cation Process. In Shavit, Y. and Mϋller, W. (Eds), From School to Work: A Comparative Study of Educational Qualifi cations and Occupational Destinations (pp. 1–48).," *Oxford: Clarendon Press.,* 1998.

[67] J. S. Coleman, „Matching Processes in the Labor Market.," *Acta Sociologica 34(1),* p. 3–12., 1991.

[68] Herman G van de Werfhorst, „Educational Fields of Study and European Labor Markets," *Introduction to a Special Issue International Journal of Comparative Sociology August 2008 49,* pp. 227-231, 2001.

[69] Herman G van de Werfhorst, „Skills, positional good or social closure? The role of education across structural–institutional labour market settings.," *Journal of Education and Work 24(5),,* p. 521–548, 2011.

[70] K. Karu, Täiskasvanud õppija enesehindamine kui koolituse hindamise vahend ja koolituse mõju tegur, Tallinn: Tallinna Pedagoogikaϋlikool, Kasvatusteaduste teaduskond, andragoogika õppetool. [Magistritöö]., 2001.

[71] E. Reiska, T. Roosalu, A. Tamm, K. Täht ja M. Unt, KÕRGHARIDUSE TÄHENDUSED JA KÕRGKOOLIDE KOOSTÖÖ TÖÖANDJATEGA, Tallinn: Tallinna Ülikool, 2012.

[72] M. Urquiola, D. Stern, H. Horn, C. C. B. Dornsife, L. Williams, D. Merritt, K. Hughes ja T. Bailey, School to work, college and career, Berkeley: University of California at Berkeley; National Centre for Research in Vocational Education, 1997.

[73] R. W. Scholz, R. Steiner ja R. Hansmann, „Role of Internship in Higher Education in Environmental Sciences," nr Journal of Research in Science Teaching, pp. 24-46, 2004.

[74] E. Brindfeldt, M. Müür ja E. Pettai, „Description of Learning Methods Using Sixdimensional Space Framework.," *15th International Power Electronics and Motion Control Conference, EPE-PEMC 2012 ECCE Europe, Novi Sad,. IEEE, 2012.,* 2012.

[75] E. Brindfeldt, M. Mϋϋr ja E. Pettai, „Description of Teaching Processes Using Six-Dimensional Space Framework," *11th International Symposium PÄRNU 2012 "TOPICAL PROBLEMS IN THE FIELD OF*

ELECTRICAL AND POWER ENGINEERING" , pp. 164 - 169, 2012.

[76] E. Brindfeldt, A. Grinko ja M. Müür, „Course of automation in industrial processes based on the blended learning approach," *In: 10th International Symposium "Topical Problems in the Field of Electrical and Power Engineering", Doctoral School of Energy and Geotechnology II: 10th International Symposium ""Topical Problems in the Field of Electrical and Power Engineering * Doctoral School of Energy and Geotechnology II", Pärnu, Estonia, 10.01-15.01.2011. (Toim.) Rain Lahtmets. Tallinn, Estonia: Estonian Society of Moritz Hermann Jacobi, 2011, ,* pp. 187 - 192, 2011.

[77] D. S. Pugh ja D. J. Hickson, „Writes on organizations. London: Penguin Books Ruohotie, P. (1996). Professional growth and development. In: Leithwood, K. et al. (Ed's). International Handbook of Educational Leadership and Administration.," *Dordrecht: Kluwer Academic Publishers,* 1996.

[78] P. -. E. Ellström, „Kompetens, lärande och utbildning i arbetslivet. Problem, begrepp och teoretiska perspektiv. (Skills, learning, and education in working life. Problems, concepts, and theoretical perspectives.)," *Stockholm: Publica,* 1994.

[79] P. -. E. Ellström, „The many meanings of occupational competence and qualification. In: Nijhof, W. J. & Streumer, J. N. (Ed's), Key Qualifications in Work and Education.," *Dordrecht: Kluwer Academic Publishers Evers,* 2001.

[80] G. Atwell, „Towards a community of practice-VET professionals networking.," *Paper presented at the International Workshop: Towards a Vocational Education and Training Profession, held at the ITB,* pp. 20-22, 1997.

[81] G. P. Bunk, „Competentie-ontwikkeling in de Duitse beroepsopleidingen. Development of competence in German vocational education and training. Beroepsopleiding. No. 1, (8-15) Clancey, W. J. (1997). Situated Cognition: On Human Knowledge and Computer Representations.," 1994.

[82] B. Hövels, „Qualification and labor markets: institutionalisation and individualisation. In:. Nijhof, W. J & Streumer, J. N. (Ed's). Key Qualifications in Work and Education.," 2001.

[83] J. N. Streumer ja D. C. Björkquist, „Moving Beyond Traditional Vocational Education and Training: Emering Issues. In: Nijhof, W. J. & Streumer, J. N. (Ed's). Key Qualifications in Work and Education.," 2001.

[84] R. Kanfer ja T. M. Kantrowitz, „Emotion regulation: Command and Control of emotions in work life. In R. Lord, R. Klimoski, & R. Kanfer (Eds.), Emotions in the workplace: Understanding the structure and role of emotions in organizational behavior (pp. 443-472).," 2002.

[85] R. J. Sternberg, „Intelligence, competence, and expertise. In: Elliot, A. J. & Dweck, C. S. (Ed's). Handbook of Competence and Motivation," 2005.

[86] P. Ruohotie, „Motivation and Self-regulation in Learning. In: Niemi, H. & Ruohotie, P. (Ed's). Theoretical Understandings of Learning in Virtual University.," 2002.

[87] B. J. Zimmerman ja A. Kitsantas, „Developmental phase in self-regulation: Shifting from process to outcome goals.," *Journal of Education Psychology, 89,* pp. 29-36, 1997.

[88] B. J. Zimmerman ja A. Kitsantas, „The hidden dimension of personal competence: Self-regulated learning and practice. In: Elliot, A. J. & Dweck, C. S. (Ed's). Handbook of Competence and Motivation.," pp. 509-526, 2005.

[89] A. Bandura, „Self-efficacy: The exercise of control. Upper Saddle River,," 1997.

[90] B. J. Zimmerman, „Theories of self-regulated learning and academic achievement: A overview and analysis. In: Zimmerman, B. J. & Schunk, D. H. (Ed's). Self-Regulated Learning and Academic Achievement: Theoretical Perspectives. Mahwah, N.J.," 2001.

[91] D. H. Schunk, „Social cognitive theory and self-regulated learning. In: Zimmerman, B. J. & Schunk, D. H. (Ed.). Self-Regulated Learning and Academic Achievement: Theoretical Perspectives. Mahwah, N.J.:," 2001.

[92] B. J. Zimmerman, „Attaining self-regulation: A social cognitive perspective," 2000.

[93] S.-P. Nissilä, „Dynamic Dialogue in Learning and Teaching,," 2006.

[94] P. Ruohotie ja M. Koiranen, „In the pursuit of conative constructs into entrepreneurship education," *Journal of Entrepreneurship Education. No. 3,* pp. 9-22, 2000.

[95] P. Ruohotie, „The Development of competence and qualifications as the objective of education.," *In: Suortti, J.& Heikkinen, E. (Ed's). Mind, Science and Technology,* 2002.

[96] J. Kuhl, „Volitional mediators of cognitive behaviour consistency: Self-Regulatory processes and action versus state orientation.," *In: Kuhl, J. & Beckman, J. (Ed's). Action Control. New York: Springer,* pp. 101-128, 1985.

[97] B. J. Zimmerman, „Academic studying and the development of personal skill: A self regulatory perspective.," *Educational Psychologist, 33,* pp. 73-86, 1998.

[98] D. L. Butler, „Astrategic content learning approach to promotion self-regulated learning by students with learning disabilities.," *In: Schunk, D. H. & Zimmerman, B. J. (Ed's) Self-Regulated Learning: From Teaching to Self-Reflective Practice. ,* pp. 160-183, 1998.

[99] M. Boekaerts ja M. Niemivirta, „(2000). Self-regulated learning: Finding a balance between learning goals and ego-protective goals.," *In: Boekaerts, M., Pintrich, P. R. & Zeidner, M. (Ed's) Handbook of Self-Regulation. ,* pp. 417-451, 2000.

[100] M. H. Dembo ja H. Seli, „Students' Resistance to Change in Learning Strategies Courses. [," *Journal of Developmental Education, 27(3),* pp. 2-4, 2004.

[101] A. L. Wilson ja E. Hayes, „Handbook of adult and continuing education. San-Francisco: Jossey-Bass.," 2000.

[102] A. Bandura, „Self-efficacy mechanism in human agency," nr American Psychologist 37 (2): ISSN 0003-066X. DOI:10.1037/0003-066X.37.2.122. (p. 127), pp. 122-147.

[103] K. Illeris, „The three dimensions of learning: contemporary learning theory in the tension field between the cognitive, the emotional and the social.," 2002.

[104] S. Mõisavald, „Üliõpilaste õpibarjääride ületamise toetamine õppejõudude arusaamades," 2011. [Võrgumaterjal]. Available: http://andragoogika.tlu.ee/?page_id=142.

[105] K. Illeris, „How We Learn: An introduction to human learning in schools and beyond," p. 160, 2007.

[106] K. Illeris, „10 Transfer of learning in the learning society: How can the barriers between diferent learning spaces be surmounted, and how can the gap between learning inside and outside schools be bridged?," *INT. J. OF LIFELONG EDUCATION, VOL. 28, NO. 2 (MARCH–APRIL 2009),* p. 137–148, 2009.

[107] R. J. Wlodkowski, „Enhancing adult motivation to learn: A comprehensive guide for teaching all adults. 3rd ed.,“ , 2008.

[108] D. Stern, T. Bailey ja D. Merrit, „School-to-Work Policy Insights from Recent International Developments.,“ *Berkeley: National Center for Research in Vocational Education,* 1997.

[109] L. Chisholm, „Initial Transitions between Education,“ *Training and Employment in Learning Society,* pp. 6 -16, 1997.

[110] EUROPEAN COMMISSION, „Helping to create an entrepreneurial culture.,“ *A guide on good practices in promoting entrepreneurial attitudes and skills through education. EC,,* 2006.

[111] E. Brindfeldt, „Õppejõudude küsitlus e-formular.,“ 2012. [Võrgumaterjal]. Available: http://www.eformular.com/eduard/dok-kys-oppejoud.html.

[112] S. Hirsjärvi, Uuri ja kirjuta, Tallinn: Medicina, 2007.

[113] R. W. Bybee, J. Taylor, A. Gardner, P. V. Scotter, l. J. Carlson Powel, A. Westbrook ja N. Landes, „The BSCS 5E Instructional Model: Origins and Effectiveness,“ *Office of Science Education National Institutes of Health,* 2006.

[114] M. Ryder, „Instructional Design Models - Viie etapiline õpimudel,“ 2012. [Võrgumaterjal]. Available: http://carbon.ucdenver.edu/~mryder/itc/idmodels.html. .

[115] R. W. Bybee, J. Taylor, A. Gardner, P. V. Scotter, l. J. Carlson Powel, A. Westbrook ja N. Landes, „The BSCS 5E Instructional Model: Origins and Effectiveness,“ 2006.

[116] R. W. Bybee, „Achieving Scientific Literacy.,“ *Portsmouth, N.H.,* 1997.

[117] Arenduskeskus e-Õppe, „JUHEND KVALITEETSE E-KURSUSE LOOMISEKS,“ *http://www.e-ope.ee/opetajatele/juhend_kvaliteetse_e-kursuse_loomiseks,* 2010.

[118] D. Rowntree, „Teaching Through Self-instruction,“ 1990.

[119] T. Väljataga, „Enesejuhitav õppimine,“ *Loengukonspekt,* 2010.

[120] J. Koumi, „Designing Video and Multimedia for Open and Flexible Learning,,“ 2006.

[121] C. J. Bonk ja C. R. Graham, „The Handbook of blended learning: Global perspectives,“ p. 624, 2006.

[122] N. Shpakovsky, H. June Kim, E. Novitskaya ja V. Lenyashin, „Structural Scheme For Solving a Problem Using TRIZ," *http://www.triz-journal.com/archives/2002/01/f/index.htm,* 2002.

[123] P. S. Wesson, „The geometrical unification of gravity with its source.," *Springer, Gen Relativ Gravit, 2008, 40,* pp. 1353-1365., 2008.

[124] T. Liko, „Induced current and redefinition of electric and magnetic fields from non-compact Kaluza-Klein theory: An experimental signature of the fifth dimension.," *Physics letters B, Vol. 617,,* pp. 193-197, 2005.

[125] C. I. Stelea, „Higher dimensional Taub-NUT spaces and applications. Dissert. for deg. of Doctor of Ph," 2006. [Võrgumaterjal]. Available: http://uwspace.uwaterloo.ca/bitstream/10012/2956/1/cistelea2006.pdf.

[126] P. S. Wesson, J. Ponce de Leon ja J. Math, „Kaluza–Klein equations, Einstein's equations, and an effective energy-momentum tensor," *Phys., Vol. 33,* 1992.

[127] L. Fabbri, „Taking Kaluza seriously leads to a non-gauge-invariant electromagnetic theory in a curved space-time.," *Annales de la Fondation Louis de Broglie, Vol. 29, no 4,* pp. 641-649, 2004.

[128] B. Magee, „The Story of Philosophy.," 1998.

[129] E. Pettai, Tootmise automatiseerimine., Tallinn: Department of electrical institute., 2005, p. 336.

[130] E. Brindfeldt ja U. Lepiksoo, „Täiturseadmed tööstusautomaatikas (elektriajamid, pneumoajamid)," [Võrgumaterjal]. Available: http://www.tthk.ee/MEH/Taiturid_1.html.

Abstract (Summary) (Annotation)

Doctoral dissertation contains to develop the methods for structuring and selecting presentation of information, used to provide and obtain education, related to automation of production; the methods discussed will be those used by students of technical specialties to obtain the educational information and practical experiences that are inevitable to acquire the knowledge, skills, proficiency and attitude, matching the levels of professional qualification, required at different jobs.

Research-based specialty related studies dominate in universities although it is known that specialty can’t be applied in any occupation; personality will be applied, instead, and apart specialty-related preparation, individuals must have occupational and professional training. Which teaching methods and materials should be used to teach and to study technical specialties for the students of technical specialties to obtain the best education possible, i.e. for the university graduate to be able to apply its knowledge and skills in full?

As the level of complexity and scope of information, used in modern production and, above all, knowledge-intensive production, continues to increase, students will need better co-ordination between miscellaneous stakeholders, involved in education process – entrepreneurs operating in labor market, employees of companies, the state and educators – for efficient and fast development of systematic knowledge, skills, competences and attitude.

The most important result of the doctoral work is the develop of a new visual information model, teaching method and practical tools for extending the scope of knowledge, skills and independent work or research specialists, students and in-service trainees of technical specialties, involved in the qualification system, and for the intelligent implementation of such tools for the automation of production.

During in the period of doctoral work had made practical training stand for learning and teaching actuators, PLC programming, information networks and virtual e-leaning environment to the students for learning and to lecturers for teaching.

Lühikokkuvõte (annotatsioon)

Doktori dissertatsioon käsitleb tootmise automatiseerimisega seotud hariduse andmisel ja omandamisel kasutatava info struktureerimise ja valikulise esitamise meetodeid, mida kasutades saavad tehnikavaldkonna üliõpilased nende endi määratletud erialase karjääri edukaks teostamiseks vajalike teadmiste, oskuste, vilumuste ja hoiakute omandamiseks vajalikku õppeinfot ja praktilist kogemust vastavalt töökohtadel nõutava kutsekvalifikatsiooni tasemetele.

Edu saavutamiseks inseneritöös tuleb õppuritel lahti mõtestada oma olemus, soovid ja eesmärgid ehk unistused. Üliõpilane kavandab oma elus eesmärgile viivat karjääriteed omavahel seotud etappidena, millest osa võib teostuda paralleelselt. Pärast erialaste õpingute lõpetamist õppeasutuses selgub siiski sageli, et noorte kutsealane ettevalmistus on veel nõrk ja ametialast ettevalmistust ei ole ollagi. Ametialane ettevalmistus aga ei saa tekkida kuidagi iseenesest, vaid see omandatakse praktika käigus. See on eriti oluline töötamisel nüüdisaegsete, kõrgelt automatiseeritud tootmisseadmetega. Praktiliste erialateadmiste ja kutsekvalifikatsiooni täiustamise käigus õpitakse ka suhtlemist ning teiste juhtimist.

Kuna nüüdistootmises ja eriti teadmismahukas tootmises kasutatava info keerukus ja maht järjest suurenevad, siis on õppuritele süstemaatiliste teadmiste, oskuste, vilumuste ning hoiakute efektiivseks ja kiireks kujundamiseks vaja senisest paremat kooskõla nende harimisega seotud teiste osapoolte – tööturul tegutsevate tööandjate, ettevõtete töötajate, riigi ja koolitajate vahel.

Doktoritöö kõige tähtsamaks tulemuseks on arendada välja uus visuaalne infomudel, õppemeetod ja praktiline vahend kvalifikatsioonisüsteemi kaasatud tehnikaala teadurite, üliõpilaste ja täiendõppurite teadmiste, oskuste ja iseseisva tegutsemise ulatuse suurendamiseks ning intelligentseks rakendamiseks tootmise automatiseerimisel.

Doktoritöö käigus töötati välja Praktikaõppe stend täiturseadmete, PLC programmeerimise ning infovõrkude õppimiseks ja õpetamiseks ja virtuaalne e-õppe keskkond üliõpilastele õppimiseks ja õppejõududele õpetamiseks.

Lisad

LISA 1. KÜSIMUSTIK

Küsitluse läbiviimise vahendiks valiti rahvusvaheline domeen www.eformular.com.

Küsitlus üliõpilastele, kutseõppeasutuste õppuritele ja täienduskoolituses osalevate ettevõtete töötajate küsimustik asub aadressil: http://www.eformular.com/eduard/dok-kys-yliopilane.html

Küsitlus TTÜ ja kutseõppeasutuste õppejõududele ning ettevõtete töötajate küsimustik asub aadressil: http://www.eformular.com/eduard/dok-kys-oppejoud.html

Küsimustikule oli lisatud järgmine kaaskiri:

Ülikoolide lõpetajad võetakse tööle mingile ametikohale ja sellega kaasneb õigus otsustada ja samuti ka kohustus vastutada. mistahes ametikohal tuleb täita kohustusi ja ülesandeid ning seada sihte ja eesmärke, valida vahendeid eesmärkide saavutamiseks. Vastutamist püütakse vältida, kuna seda ei ole olnud vaja varem teha ja otsustamine eeldab noorelt insenerilt nii erialast ja kutsealast ajatundlikust aga ka ametialast vastutust.

On arusaam, et ametialane ettevalmistus kujuneb kuidagi iseenesest või saame seda omandada praktika käigus.

Käesolev uuring on mõeldud TTÜ üliõpilastele, ettevõtte töötajale:

- kes huvitub uute teadmiste omandamisest tootmise automatiseerimise valdkonnas,
- soovib oma erialase kvalifikatsiooni tõstmist,
- vajab ümberkvalifitseerimist lähtuvalt tööturu nõudmistest.

Uuringu eesmärk on jõuda selgusele kas stuudiumi käigus omandatavad teadmised ja oskused vastavad hilisemas tööelus tööandjate vajadustele.

Küsitlus on anonüümne ja täidetud ankeedi juurde ei salvestata ankeedi täitja informatsiooni. Kui Teil on küsimusi küsitlusele ligipääsu osas või tekib tehnilisi probleeme selle täitmisel, siis pöörduge julgelt minu poole eduard.brindfeldt@neti.ee, tel: 5247315

LISA 2. KOONDTABELID

Üliõpilastele, kutseõppeasutuste õppuritele ja täienduskoolituses osalevate ettevõtete töötajate küsitluse koontabelid (76 lk) asub aadressil: http://brindfeldt.ee/DOK_MATER/dok-kys-yliopilane_statistika.pdf

TTÜ ja kutseõppeasutuste õppejõududele ning ettevõtete töötajate küsitluse koontabelid (74 lk) asub aadressil: http://brindfeldt.ee/DOK_MATER/dok-kys-oppejoud_statistika.pdf

LISA 3. KÜSITLUSTE KOKKUVÕTE

Üliõpilastele, kutseõppeasutuste õppuritele ja täienduskoolituses osalevate ettevõtete töötajate küsitluse ettepanekud ja vastused küsimustele (lk) asub aadressil: http://brindfeldt.ee/DOK_MATER/TEST_KOMMENTAARID.pdf

TTÜ ja kutseõppeasutuste õppejõududele ning ettevõtete töötajate küsitluse ettepanekud ja vastused küsimustele (78 lk) asub aadressil: http://brindfeldt.ee/DOK_MATER/TEST_KOMMENTAARID.pdf

LISA 4. E-ÕPPE MATERJALID

Valminud uus sisu e-õppekeskkonnas aitab rakendada õppekava, milles on kaetud järgnevad teemad:

1. Täiturseadmed tööstusautomaatikas (elektriajamid, pneumoajamid) (http://www.tthk.ee/MEH/Taiturid_1.html ;
2. PLC programmeerimine (http://www.tthk.ee/PLC/) ja e-kursus “Programmeeritavad kontrollerid” moodle keskkonnas (https://moodle.e-ope.ee/course/view.php?id=5264) ;
3. Pneumoautomaatika (http://www.tthk.ee/PNEUM/) ja e-kursus moodle keskkonnas (https://moodle.e-ope.ee/course/view.php?id=5266);
4. Andurid tööstusautomaatikas (http://www.tthk.ee/MEH/Andurid_1.html);
5. Tööstuslikud infovõrgud (http://www.tthk.ee/INF/) ja e-kursus moodle keskkonnas (https://moodle.e-ope.ee/course/view.php?id=6296);
6. IKT kasutamine tööstusautomaatikas (http://www.tthk.ee/IKT/);
7. Raalprojekteerimine (http://www.tthk.ee/RAALP/) ja e-kursus moodle keskkonnas (https://moodle.e-ope.ee/course/view.php?id=5924);

Mehhatroonikaseadmed (http://www.tthk.ee/MEH/) ja e-kursus moodle keskkonnas (https://moodle.e-ope.ee/course/view.php?id=3962 .

LISA 5. ELULOOKIRJELDUS

ELULOOKIRJELDUS

1. Isikuandmed

Ees- ja perekonnanimi	Eduard Brindfeldt
Sünniaeg ja -koht	15.10.1962, Usbekistan
Kodakondsus	Eesti
E-posti aadress	eduard.brindfeldt@neti.ee

2. Hariduskäik

Õppeasutus (nimetus lõpetamise ajal)	Lõpetamise aeg	Haridus (eriala/kraad)
Tallinna Ülikool	2008	Hariduse juhtimine Magister
Tallinna Ülikool	2006	Kutsepedagoogika Bakalaureus
Tallinna Polütehnikum	1983	Tehnik-elektrik

3. Keelteoskus (alg-, kesk- või kõrgtase)

Keel	Tase
Eesti	emakeel
Vene	kesktase
Soome	kesktase
Saksa	algtase
Inglise	algtase

4. Täiendusõpe

Õppimise aeg	Täiendusõppe korraldaja nimetus
12.12.2012	Tallinna Ülikool – Kutseõppeasutuse õppekavanõustaja koolitus
08.03.2012	Eesti Koolitus- ja konverentsikeskus – Sõbralikud töösuhted
04.02.2012	EKKA – Kutseõppe õppekavarühmade akrediteerimine
12.02.2011	Tallinna Ülikool – Haridusasutuse juhtimine
22.04.2010	SA Innove ja Corpore AS – Kommunikatsioonikoolitus kutseharidusjuhtidele
10.04.2010	Riiklik Eksami- ja Kvalifikatsioonikeskus – Elektroonika ja automaatika valdkonnakoolituse seminar

10.02.2009	Riiklik Eksami- ja Kvalifikatsioonikeskus – Kutsehariduse sisuline arendamine
10.02.2009	Riiklik Eksami- ja Kvalifikatsioonikeskus – Ainekava arendamine koolis
25.09.2008	SA Innove – Eesti Kutseõppeasutuste kvaliteediauhind 2008

5. Teenistuskäik

Töötamise aeg	Tööandja nimetus	Ametikoht
2010 –	Tallinna Tööstushariduskeskus	Mehaanika- ja elektroonika osakonna juhataja (1.00)
2008 – 2010	Tallinna Tööstushariduskeskus	Õppedirektor (1.00)
2002 – 2008	Tallinna Tööstushariduskeskus	Elektroonika- ja mehaanika valdkonna juht (1.00)

6. Teadustegevus, sh tunnustused ja juhendatud lõputööd

- Kutseõppeasutuste „Elektroonika ja automaatika erialade riiklik õppekava” välja töötamine ja töögrupi juhtimine.
- Osaletud ”Tootmise automatiseerimise õppekava ja uuenduslike õppevahendite arendamine väikese ja keskmise suurusega ettevõtete töötajatele” rahvusvahelises Gabrovo projektis (Teemaks on pneumo- ja hüdrotäiturid) – 2009 kuni 2011.a.
- Energia- ja geotehnika doktorikooli interdistsiplinaarne uurimisprojekt Teema: „Toote valmistusmoodulite energiatõhus juhtimine” 2010–2013
- Elektroonika ja automaatika õppekavarühma nõukogu esimees
- Haridus- ja Teadusministeeriumi õpetajate atesteerimiskomisjoni liige

Appendices

APPENDIX 1. QUESTIONNAIRE

International domain, www.eformular.com, was used to implement the questionnaire.

Questionnaire for students, learners of vocational educational institutions and employees of enterprises, taking part in in-service training course, is available from the following address: http://www.eformular.com/eduard/dok-kys-yliopilane.html

Questionnaire for lecturers of TUT and vocational educational institutions and employees of enterprises is available from the following address: http://www.eformular.com/eduard/dok-kys-oppejoud.html

The following letter was added to the questionnaire:

Graduates of institutions of higher education will be employed and therefore, they have the right and duty to take responsibility. Obligations must be met, goals and directions established and tools chosen for achieving these objectives in every job and occupation. Taking responsibility is avoided, as this has not been demanded before; adoption of decisions will require work-related and professional competence and taking responsibility for one's work of young engineers.

There is an common understanding that occupational qualification comes by itself or it can be obtained during practice.

This study is aimed at the TUT students and employees of enterprises who:

- are interested in obtaining new knowledge in the sphere of production automation,
- want to enhance their specialty-related qualification,
- need to be re-qualified to meet labour market requirements.

The purpose of the study is to find out whether the knowledge and skills, obtained during studies, comply with the requirements of employers in later working life.

The questionnaire is anonymous and information of the respondent is not saved with the completed questionnaire form. If you have questions, regarding access to the questionnaire or technical problems with its completion, please don't hesitate to contact me: eduard.brindfeldt@neti.ee, tel.: 5247315

APPENDIX 2. CONSOLIDATED TABLES

Consolidated tables, including the summary review of the questionnaire for students, learners of vocational educational institutions and employees of enterprises, taking part in in-service training course (76 pages), is available from the following address: http://brindfeldt.ee/DOK_MATER/dok-kys-yliopilane_statistika.pdf

Consolidated tables, including the summary review of the questionnaire for lecturers of TUT and vocational educational institutions and employees of enterprises (74 pages), is available from the following address: http://brindfeldt.ee/DOK_MATER/dok-kys-oppejoud_statistika.pdf

APPENDIX 3. SUMMARY QUESTIONAIRE

Proposals, made on the bases of the questionnaire by students, learners of vocational educational institutions and employees of enterprises, taking part in in-service training course and answers to the questions (… pages) is available from the following address:
http://brindfeldt.ee/DOK_MATER/TEST_KOMMENTAARID.pdf

Proposals, made on the bases of the questionnaire by lecturers of TUT and vocational educational institutions and employees of enterprises and answers to the questions (… pages), is available from the following address: http://brindfeldt.ee/DOK_MATER/TEST_KOMMENTAARID.pdf

APPENDIX 4. E-LEARNING MATERIALS

The new contents of e-learning environment will help to implement a curriculum that covers the following issues:

8. Actuators in industrial automation (electrical drives, pneumatic drives) (http://www.tthk.ee/MEH/Taiturid_1.html ;
9. PLC programming (http://www.tthk.ee/PLC/) and e-learning course "Programmable Logic Controllers" in Moodle environment (https://moodle.e-ope.ee/course/view.php?id=5264) ;
10. Pneumatic automation (http://www.tthk.ee/PNEUM/) and e-training course in Moodle environment (https://moodle.e-ope.ee/course/view.php?id=5266);
11. Sensors in industrial automation (http://www.tthk.ee/MEH/Detectorid_1.html);
12. Industrial information networks (http://www.tthk.ee/INF/) and e-training course in Moodle environment (https://moodle.e-ope.ee/course/view.php?id=6296);
13. The use of ICT in industrial automation (http://www.tthk.ee/IKT/);

14. Computer-Aided Design (CAD) (http://www.tthk.ee/RAALP/) and e-training course in Moodle environment (https://moodle.e-ope.ee/course/view.php?id=5924);

Mechatronic equipment (http://www.tthk.ee/MEH/) and e-training course in Moodle environment (https://moodle.e-ope.ee/course/view.php?id=3962 .

APPENDIX 5. CURRICULUM VITAE

CURRICULUM VITAE

1. Personal data

Name	Eduard Brindfeldt
Date and place of birth	15.10.1962 Usbekistan
E-mail	eduard.brindfeldt@neti.ee

2. Education

Educational institution	Graduation year	Education (field of study/degree)
Tallinn University	2008	Master of Educational Management
Tallinn University	2006	Vocational Pedagogy
Tallinn Polytechnic School	1983	Technician-Electrician

3. Language competence/skills (fluent; average, basic skills)

Language	Level
Estonian	native language
Russian	intermediate level
Finnish	intermediate level
German	elementary
English	elementary

4. Special courses

Period	Educational or other organisation
12.12.2012	Tallinn University – Vocational Training Curriculum Advisor
08.03.2012	Estonian Training and Conference Centre – friendly relationships
04.02.2012	EKKA Accreditation of Vocational curriculum groups
12.02.2011	Tallinn University – Educational Institution Management
22.04.2010	Innove and Corpore AS – Communications Vocational Training for managers
10.04.2010	The National Examination and Qualification Centre Electronics and automation field training seminar

10.02.2009	The National Examination and Qualification Centre – Substantive development
10.02.2009	The National Examination and Qualification Centre – Development of school syllabus
25.09.2008	Estonian VET Quality Award for 2008

5. Professional employment

Period	Organisation	Position
2010 –	Tallinn Industrial Education Centre	Head of Department of Electronic and Mechanical Engineering
2008 – 2010	Tallinn Industrial Education Centre	Academic Director
2002 – 2008	Tallinn Industrial Education Centre	Head of the Department of Automatics

6. Research activity, including recognition and thesis supervised

- VET "Electronics and automation disciplines of the national curriculum 'development and management of the working group.
- We participated in "Production automation curriculum and innovative teaching aids development of small and medium-sized enterprises, workers' international project Gabrovo (The theme is Actuators) - 2009 to 2011
- Graduate School of Energy and Geotechnology interdisciplinary research project on a topic: "Product manufacturing modules energy efficiency management" 2010-2013
- Electronics and control engineering group chairman
- Ministry of Education and Science teacher evaluation committee

Publications

1. Brindfeldt, E.; Müür, M.; Pettai, E. (2012). Description of Learning Methods Using Sixdimensional Space Framework. 15th International Power Electronics and Motion Control Conference, EPE-PEMC 2012 ECCE Europe, Novi Sad,. IEEE, 2012. [ilmumas]
2. Brindfeldt, E.; Müür, M. (2012). Student and Employer Satisfaction Survey Concerning Acquisition of Production Automation Related Disciplines at Tallinn University of Technology. In: 12th International Symposium "Topical Problems in the Field of Electrical and Power Engineering * Doctoral School of Energy and Geotechnology II": 12th International Symposium "Topical Problems in the Field of Electrical and Power Engineering" and "Doctoral School of Energy and Geotechnology II", Kuressaare, Estonia, 11.06-16.06.2012. (Toim.) Rain Lahtmets. Tallinn, Estonia: Elektriajam, 2012, 56 - 59.
3. Brindfeldt, E.; Müür, M.; Pettai, E. (2012). Description of Teaching Processes Using Six-Dimensional Space Framework. In: 11th International Symposium "Topical Problems in the Field of Electrical and Power Engineering". Doctoral school of energy and geotechnology. II : Pärnu, Estonia, January 16-21, 2012 : (Toim.) J. Zakis. Tallinn: Elektriajam, 2012, 76 - 83.
4. Brindfeldt, E.; Grinko, A.; Müür, M. (2011). Some Aspects of Blended Learning for Tallinn University of Technology and Tallinn Center of Industrial Education. In: 7th International Conference-Workshop Compatibility and Power Electronics (CPE2011) Conference Proceedings: 7th International Conference-Workshop Compatibility and Power Electronics (CPE2011), Tallinn, Estonia, June 01-03, 2011. IEEE, 2011, 365 - 370.
5. Brindfeldt, E.; Grinko, A.; Müür, M. (2011). Course of automation in industrial processes based on the blended learning approach. In: 10th International Symposium "Topical Problems in the Field of Electrical and Power Engineering", Doctoral School of Energy and Geotechnology II: 10th International Symposium ""Topical Problems in the Field of Electrical and Power Engineering * Doctoral School of Energy and Geotechnology II", Pärnu, Estonia, 10.01-15.01.2011. (Toim.) Rain Lahtmets. Tallinn, Estonia: Estonian Society of Moritz Hermann Jacobi, 2011, 187 - 192.
6. Brindfeldt, Eduard; Müür, Margus; Pettai, Elmo. (2011). Description of Teaching Processes Using Six-dimensional Space Framework. 11th International Symposium PÄRNU 2012 “TOPICAL PROBLEMS IN THE FIELD OF ELECTRICAL AND POWER ENGINEERING” (164 - 169).Tallinna Tehnikaülikool

7. Brindfeldt, E.; Pettai, E.; Hõimoja, H.; Beldjajev, V. (2011). Изпълнителни устройства в индустриалната автоматизация. Izdatelstvo "EKS-PRES"
8. Brindfeldt, E.; Pettai, E.; Hõimoja, H.; Beldjajev, V. (2011). Aktoren in Der Industriellen Automatisierung. Izdatelstvo EKS-PRESS
9. Brindfeldt, E; Pettai, E.; Hõimoja, H.; Beldjajev, V. (2011). Täiturid tööstusautomaatikas. Tallinn University of Technology Press
10. Brindfeldt, E.; Pettai, E.; Hõimoja, H.; Beldjajev, V. (2011). Actuators in Industrial Automation. Tallinna Tehnikaülikooli Kirjastus
11. Brindfeldt, E.; Grinko, A. (2010). Servo drives - the use and importance in teaching mechatronics. EPE-PEMC 2010 14th International Power Electronics and Motion Control Conference. IEEE, 2010, T14-12 - T14-17.
12. Brindfeldt, Eduard; Grinko, Aleksandr (2010). Elements of TRIZ in the course "Building Automation". TOPICAL PROBLEMS IN THE FIELD OF ELECTRICAL AND POWER ENGINEERING (159 - 165). Pärnu, Estonia, June 14-19, 2010: Tallinna Tehnikaülikool
13. Brindfeldt, Eduard; Grinko, Aleksandr (2010). Flexible approach of professional competences in times of economic downturn. TOPICAL PROBLEMS IN THE FIELD OF ELECTRICAL AND POWER ENGINEERING (158 - 165). Tallinn: Tallinn Technical University
14. Brindfeldt, Eduard (2008). Kutseõpetajate erialase kompetentsuspõhise täienduskoolituse juhtimine ja korraldamine kutseõppeasutuses (Tallinna Tööstushariduskeskuse näitel). Tallinna Ülikool

DISSERTATIONS DEFENDED AT TALLINN UNIVERSITY OF TECHNOLOGY ON *POWER ENGINEERING, ELECTRICAL ENGINEERING, MINING ENGINEERING*

1. **Jaan Tehver**. Boiling on Porous Surface. 1992.
2. Salastatud.
3. **Endel Risthein.** Electricity Supply of Industrial Plants. 1993.
4. **Tõnu Trump**. Some New Aspects of Digital Filtering. 1993.
5. **Vello Sarv.** Synthesis and Design of Power Converters with Reduced Distortions Using Optimal Energy Exchange Control. 1994.
6. **Ivan Klevtsov**. Strained Condition Diagnosis and Fatigue Life Prediction for Metals under Cyclic Temperature Oscillations. 1994.
7. **Ants Meister**. Some Phase-Sensitive and Spectral Methods in Biomedical Engineering. 1994.
8. **Mati Meldorf**. Steady-State Monitoring of Power System. 1995.
9. **Jüri-Rivaldo Pastarus**. Large Cavern Stability in the Maardu Granite Deposit. 1996.
10. **Enn Velmre**. Modeling and Simulation of Bipolar Semiconductor Devices. 1996.
11. **Kalju Meigas**. Coherent Photodetection with a Laser. 1997.
12. **Andres Udal**. Development of Numerical Semiconductor Device Models and Their Application in Device Theory and Design. 1998.
13. **Kuno Janson**. Paralleel- ja järjestikresonantsi parameetrilise vaheldumisega võrgusageduslik resonantsmuundur ja tema rakendamine. 2001.
14. **Jüri Joller**. Research and Development of Energy Saving Traction Drives for Trams. 2001.
15. **Ingo Valgma**. Geographical Information System for Oil Shale Mining – MGIS. 2002.
16. **Raik Jansikene**. Research, Design and Application of Magnetohydrodynamical (MHD) Devices for Automation of Casting Industry. 2003.
17. **Oleg Nikitin**. Optimization of the Room-and-Pillar Mining Technology for Oil-Shale Mines. 2003.
18. **Viktor Bolgov**. Load Current Stabilization and Suppression of Flicker in AC Arc Furnace Power Supply by Series-Connected Saturable Reactor. 2004.
19. **Raine Pajo**. Power System Stability Monitoring – an Approach of Electrical Load Modelling. 2004.
20. **Jelena Shuvalova**. Optimal Approximation of Input-Output Characteristics of Power Units and Plants. 2004.
21. **Nikolai Dorovatovski**. Thermographic Diagnostics of Electrical Equipment of Eesti Energia Ltd. 2004.
22. **Katrin Erg**. Groundwater Sulphate Content Changes in Estonian Underground Oil Shale Mines. 2005.

23. **Argo Rosin**. Control, Supervision and Operation Diagnostics of Light Rail Electric Transport. 2005.
24. **Dmitri Vinnikov**. Research, Design and Implementation of Auxiliary Power Supplies for the Light Rail Vehicles. 2005.
25. **Madis Lehtla**. Microprocessor Control Systems of Light Rail Vehicle Traction Drives. 2006.
26. **Jevgeni Šklovski**. LC Circuit with Parallel and Series Resonance Alternation in Switch-Mode Converters. 2007.
27. **Sten Suuroja**. Comparative Morphological Analysis of the Early Paleozoic Marine Impact Structures Kärdla and Neugrund, Estonia. 2007.
28. **Sergei Sabanov**. Risk Assessment Methods in Estonian Oil Shale Mining Industry. 2008.
29. **Vitali Boiko**. Development and Research of the Traction Asynchronous Multimotor Drive. 2008.
30. **Tauno Tammeoja**. Economic Model of Oil Shale Flows and Cost. 2008.
31. **Jelena Armas**. Quality Criterion of road Lighting Measurement and Exploring. 2008.
32. **Olavi Tammemäe**. Basics for Geotechnical Engineering Explorations Considering Needed Legal Changes. 2008.
33. **Mart Landsberg**. Long-Term Capacity Planning and Feasibility of Nuclear Power in Estonia under Certain Conditions. 2008.
34. **Hardi Torn**. Engineering-Geological Modelling of the Sillamäe Radioactive Tailings Pond Area. 2008.
35. **Aleksander Kilk**. Paljupooluseline püsimagnetitega sünkroongeneraator tuuleagregaatidele. 2008.
36. **Olga Ruban**. Analysis and Development of the PLC Control System with the Distributed I/Os. 2008.
37. **Jako Kilter**. Monitoring of Electrical Distribution Network Operation. 2009.
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