Project NEDIA

Project number: 2014-1-EE01-KA202-000490

O2 REPORT

NEW TRAINING METHODS AND THEIR IMPLEMENTATION IN MODERN VOCATIONAL EDUCATION

Part II
CONCLUSION

in novel teaching methods and their implementation in practice

Introduction

In the project, new teaching methods are piloted as well as network support to innovation of training process. New possibilities to make training process more succinct, interesting and material more easily understandable to the youth are analysed and piloted. Developing new methodologies for teaching, the collaboration with the industry is in the important place as well as sharing best practices, methodological support, knowledge and resources. Today's technology is developing very rapidly and therefore machine tools depreciate very rapidly. The vocational educational institutions have to take it into account. Additionally, modern machine tools are very expensive. In small countries as Estonia, Latvia and Finland, the need for specialists with some certain competences is existing, but it is very low (e.g. only 5 persons in a year). This means that every educational institution cannot acquire new equipment every year or could not open a new curricula for such kind of specialists to be able to offer high-quality education that responds to the industry's needs, so other possibilities could be searched for. The solution is to employ new teaching methodologies and make collaboration with other educational institutions.

Today we are living in the information society. There has begun a new industrial revolution (Industry 4.0). We have a lot of information around us. Also the changes in the industry and society are very rapid. The students today are not the same as they were five or ten years ago. The demand for good workers is also not the same, as it has been a few years ago. The complexity of knowledge is needed.

The teaching didactics is a topic of investigation in this project phase. Didactics is a teaching method that follows a consistent scientific approach or educational style to engage the student's mind. The theory would be put together by analysis of different teaching methods and practicing these in the developed lectures.

We need new didactic methods, which would change the teaching process more effective. The effectiveness reflects by: more different skills, the opportunity to acquire new skills quickly, understanding of the nature of processes/systems more deeply and visually, having the ability to see things in real life, rapid learning from mistakes and not repeating these mistakes, ability to make conclusions. The effectiveness also lies in higher interest, readiness to adopt new knowledge, understanding the cause-and-effect relationship, independent thinking, the skill to compare different options and decision-making.

In this project phase, we plan to analyse new teaching methods and their effectiveness for use and compose respective methodology describing it. The aim of using new teaching methods is to make difficult and complicated processes and subjects more easily understandable.

The world, as well as the industry has changed a great deal over the past 10 years. In the industry, there has been an extensive use of digital technologies, in everyday life all kind of social networks are being widely used. There is enormous amount of information around us, and the amount of the

information is constantly growing, the rapid acquisition of it and decision what is necessary and what is not, is getting more and more complicated. The demands to employees constantly grow. Nowadays, it is not possible to perform only a specific task, but the employee is a part of the whole system.

According to that, it is necessary to start with a development of methodological process, which would be largely based on the use of digital techniques and the ability to use different materials, to be independent enough in decision-making, and at the same time have the experience of working in collective.

In this project, different didactic methods of organizing the teaching-process are described and analysed:

- Visual learning

- Dual learning

- Case-based teaching

- Problem based learning

- Error based learning

- Team-based learning

- Role-based learning

As a result of the activity new training methods are determined and analysed and evaluated the usability of the new training methods in the vocational education of mechatronics field.

VISUAL LEARNING

Visual learning is a teaching and learning style in which ideas, concepts, data and other information are associated with images and techniques. Graphic organizers are one of the visual representations of knowledge, concepts, thoughts, or ideas. Words can be used to further clarify meaning. Visualisation helps better to understand the problem. One of the first things the brain must do when acquiring new visual information is recognise the incoming material [Poldrack, R., Desmond,J., Glover,G., Gabrieli,J. The Neural Basis of Visual Skill Learning: An fMRI Study of Mirror Reading: Cereral Cortext. Jan/Feb, 1998].

Using graphic organizers improves student performance in the following areas [Vogel, R., Sary, G., Dupont, P., Orban, G. Human Brain Regions Involved in Visual Categorization. Elsevier Science (USA)]:

- Retention. Students remember information better and can better recall it when it is represented and learned both visually and verbally.

- Reading comprehension. The use of graphic organizers helps improving the reading comprehension of students.
- Students' achievement. Students with and without learning disabilities improve achievements across content areas and grade levels.
- Critical thinking. When students develop and use a graphic organizer their higher order thinking and critical thinking skills are enhanced.

An example of visualization in teaching is represented in Fig.1. On this figure in a very simple way is explained what a manufacturing process looks like. There is explained how from raw material we reach to a final product.

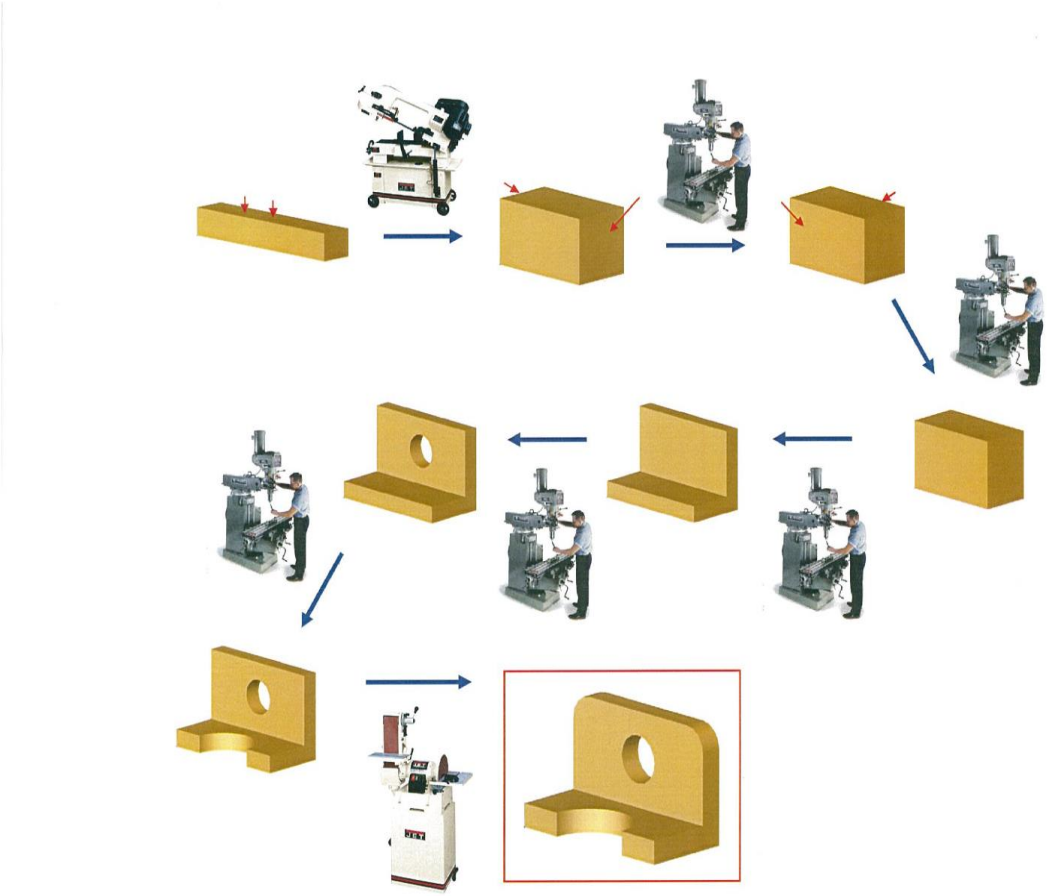


Fig.1. Visualizing a manufacturing process

The necessary explanations is possible to give in oral way or to add to the drawing.

During the project running we have studied the using of visual learning applications in study process. The participating schools are quite intensive in using visualization in a teaching process. However for preparation the teaching materials a lot of additional possibilities is existing. Internet and its

applications are giving a lot of new possibilities. Visualization is also to prepare some lectures in a video way and combine these in a teaching process. This we have practiced also in fulfilling the targets of our project.

Some visual learning cases from Liepaja school are given in Fig 2.

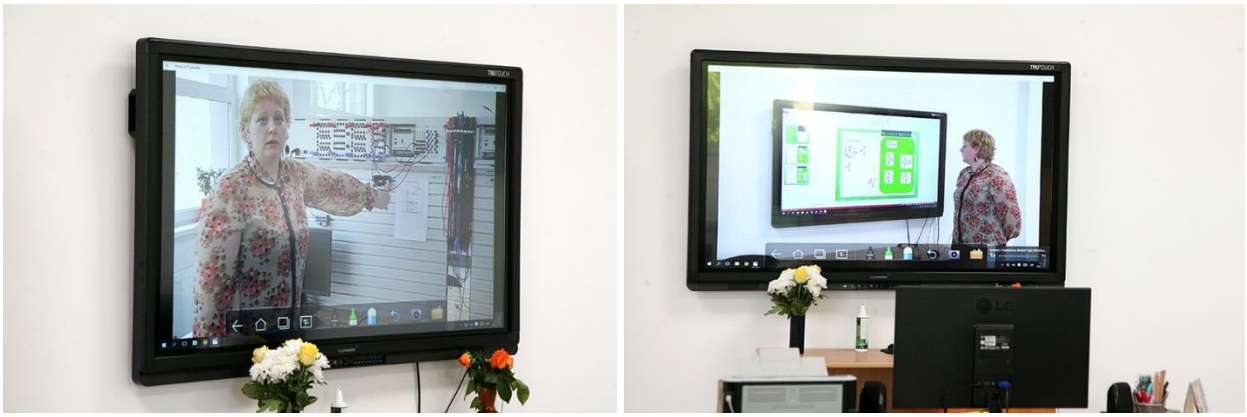


Fig.2. Visual learning examples from Liepaja school

DUAL LEARNING

A dual education system combines apprenticeships in a company and vocational education at a vocational school in one course. This system is most advanced in Germany, Austria, Denmark, and Netherlands. The basic idea is from medicine.

In France, the same amount of time is spent in practical training and theory, with the following possible systems:

- Half week in a company, half week at school
- One week in a company, one week at school
- Six months in a company, six months at school

The companies have provided a tutor or other responsible person for the students. Their duties are involved by daily tutoring and/or targeted training. In principle the dual training is running better in bigger companies.

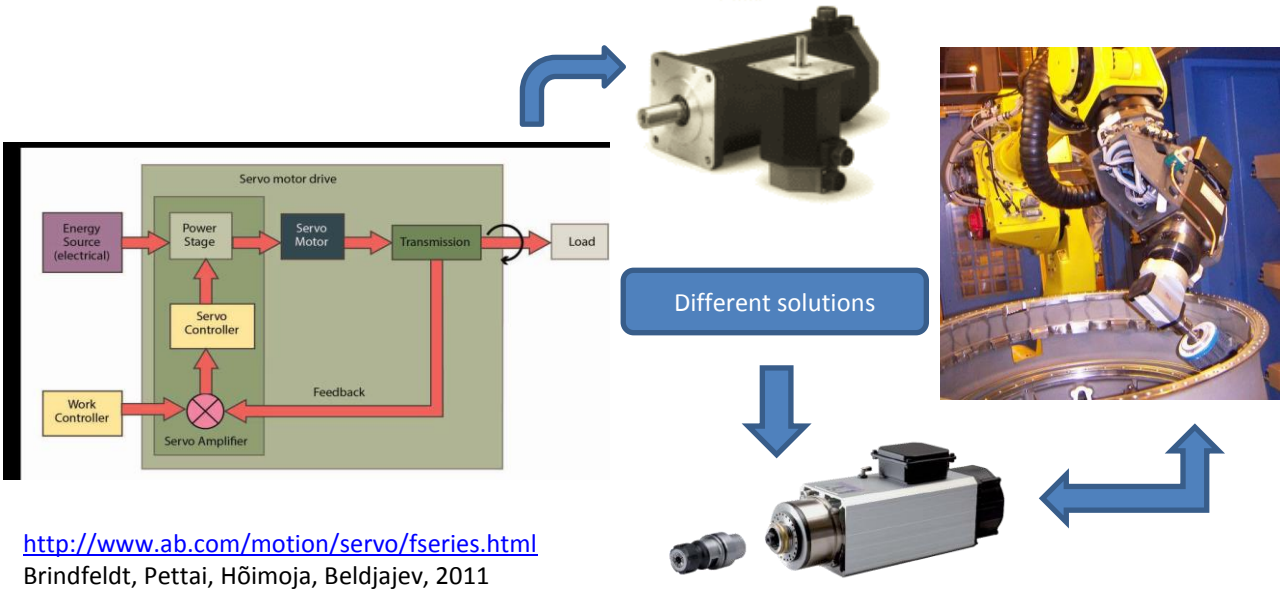
In Germany young people are taking vocational education and training courses at training sites and schools rather than in real companies, as for various reasons, companies are becoming less willing to take on apprentices. For example, FESTO (one of leading companies in the world) has built up a separate education centre for teaching, but not carrying out the teaching processes inside a company premises.

The reasons behind the lack of places on dual education courses include:

- Companies which take on apprentices have to follow a large number of regulations;
- The training itself is very expensive;
- The requirements for several positions have become more complex and many school graduates do not provide a fitting level of education;
- For the less complex positions only graduates with a very low level of education are willing to do it, but they are not able to keep up the course;
- Companies are sometimes also highly specialized and unable to train apprentices in all the required areas.

Program „Õpipoiss“ in Estonia and dual-teaching in Latvia has not started well. The main reasons are largely the same as in Germany. Small businesses simply lack the resources to organize the dual-teaching. There are no available workplaces for the students, nor personnel to use in teaching-process. Companies claim, that as they are paying the social security tax, it is the responsibility of the state, to provide trainings. In fact, the efficiency of apprenticeship depends on both parties – the companies' ability to organize the apprenticeship actively and specialty-oriented is as important as conscientiousness and activeness of the schools and students.

The possibility of dual-teaching in Estonia has been discussed with the Association of Estonian Boatyards, Federation of Estonian Engineering Industry, Estonian Electronics Industries Association and several other companies: AS Norma, Norcar BSB Estonia, Sumar Tools etc. All mentioned associations and companies have had quite modest emotions towards enterprise-centered and workplace-based teaching. Definitely, dual-teaching enables several positive outputs, but the emphasis is on organizational management. The equipment of industrial enterprises is expensive and overused. There is no point in carrying out the teaching process on machine tools that are old and not in use. Also, there are major personnel problems. Already, there is a shortage of qualified and competent labour. When employees with significant working experience and professionalism would start to get involved in the teaching process, then who would compensate the costs and help to do the work undone. The fundamental characteristics of traditional education and dual education are shown in Fig. 3.



http://www.ab.com/motion/servo/fseries.html
Brindfeldt, Pettai, Hõimoja, Beldjajev, 2011

Fig.3. Dual and traditional education basic characteristics

Advantages of the dual education are in this that the student is an employee of the company from the beginning and receives tasks according to his growing abilities. If a company is willing to make an employment-contract with the student after his dual education time, the company will get an employee who knows the company's workflow process in a good level. The student can also benefit the knowledge about hard skills and soft skills of more experienced co-workers. The student develops under real conditions. He/she can also see he/she is not able or willing to do this job quite early and not after the final exams.

The conclusion is, that at the moment, workplace-based education is not easy to organize, also there are certain hesitations in its effectiveness. It is mainly caused by the small size of enterprises and their scarce resources. Though, several experiences from Germany and France show that the situation in large countries is also similar - small enterprises in large countries show the same reaction towards dual-education, at the same time some of the large enterprises have successfully managed to put the dual-education into practice and find enough positive aspects in it.

For Estonia, Latvia and also Finland, the development of so called „technological teaching-centres" that would be partly (on certain fixed periods) staffed with specialists from certain respective fields, seems to be more effective.

Based on the dominant processes in companies, such technological teaching-centres should exist in fields below:

- Welding (process centered, as well as robot welding)
- Sheet metal processing (there are several sheet metal processing processes, therefore the rational distribution between different centres should be analysed)
- Mechanical processing (CNC; with CAD/CAM preparation)
- Mechatronics (industrial mechatronics, as well as process mechatronics in more general approach, also robotics and automation of production systems)
- Coatings in industrial sector and service sector (e.g. car service)
- Equipment maintenance and repair (nowadays, this area actually do not exist).

Different fields should be divided between vocational institutions and also integrated with the schools focused on engineering education. Modern equipment and processes in certain fields have become so complex, that boundaries between post-secondary vocational education and engineering education begin to fuse. Hence the need for a new approach and some revolution changes in teaching processes.

CASE BASED LEARNING

Case-based learning (CBL) is an instructional design model. The main features of case-based learning are:

- Learner-centered
- Collaboration and cooperation between the participants
- Discussion of specific situations, typically real-world examples
- Questions with no single right answer

From students is:

- Engaged with the characters and circumstances of the story
- To identify problems as they perceive it
- Connect the meaning of the story to their own lives
- Bring their own background knowledge and principles
- Rise points and questions, and defend their positions
- Formulate strategies to analyse the data and generate possible solutions
- May not agree, and sometimes a compromise is reached

In case-based learning a teacher is a facilitator and encourages exploration of the case and consideration of the characters' action in light of their own decisions.

The cases must be:

- Factually based
- Complex problems written to stimulate classroom discussion and collaborative analysis
- Involves the interactive, student-centred exploration of realistic and specific situations

Case-based learning is tightly connected with problem-based learning (PBL). PBL is driven by challenging, open-ended problems with no one „right“ answer. Problems / cases are usually context specific. Students work on self-directed, active investigators and problem-solvers in small collaborative groups or individually.

A key problem is identified and a solution is agreed upon and implemented. Teachers adopt the role as facilitators of learning, guiding the learning process and promoting an environment of inquiry.

PBL is a strategy for

- Developing critical thinking and creative skills
- Improves problem-solving skills
- Increases motivations
- Helps students learn to transfer knowledge to new situations

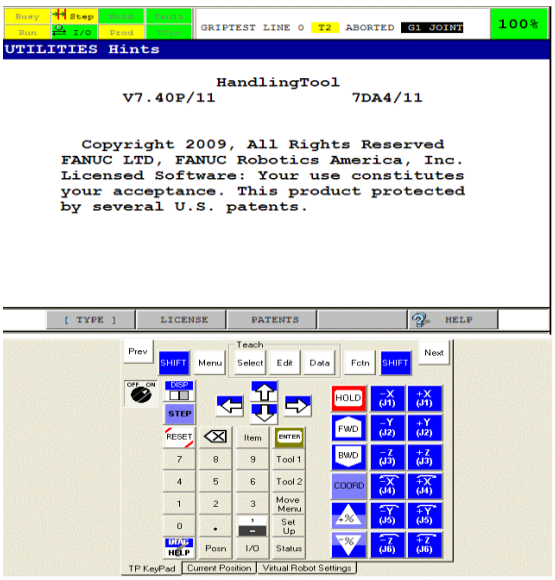
In problem solving exercises the basic assumption is that the students have the knowledge and skills required to arrive at a solution.

In problem based learning the problem is the starting point that enables students to identify for themselves new areas for their learning.

Problem-based learning is an instructional method of hands-on, active learning centred on the investigation of real world problems.

Problem Based Learning (PBL) is a pedagogical approach and curriculum design methodology. It is said that PBL is an effective methods for higher education. The feedback from the companies shows that it is very suitable also for professional schools and higher educational institutions.

Case based learning examples are presented in Fig.4.



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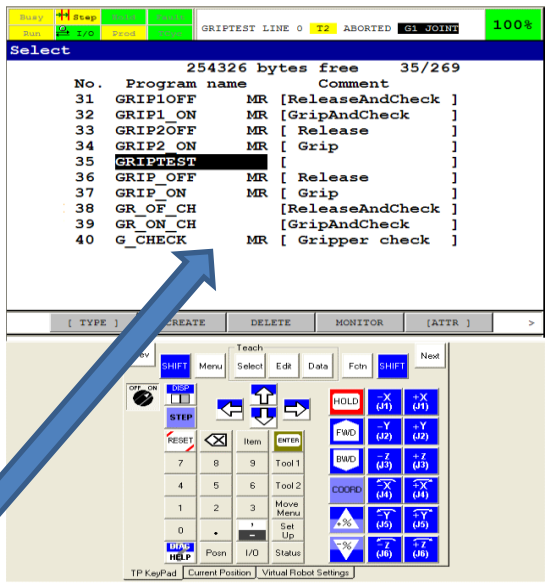
F2



Press Create ie F2- button

Fig. 4. A final product and tasks to be solved with the quality issues

As this example shows, there is a whole series of tasks, which must be paid attention to at the real production. This is a cause - effect relationship. Wastes occur in several ways. Not knowing which can be regarded as waste, we cannot avoid the possibility of its occurrence. Also, we have to be able to fix it concretely. Therefore, it is not enough if we just reflect the product, but there is a need to add something relevant to it (in this case, the necessary dimensions, with tolerance limits). After fixing the essence of the waste, it is necessary to identify its causes (improperly installed product, incorrect use of processing methods, lack of employee competencies etc.) After the discovery of defective products, one must somehow react. What are the possible models of behaviour (place the product into the box of defective products, perform the post-treatment of the product etc.)

When giving a lecture in that kind of analysing method, the themes will be more easily remembered by students and if some similar situations occur in real production, he/she will find the necessary behavioural patterns.

More and more the traditional lecture must be changed with case based learning (CBL) exercises or with problem solving learning. Also, elaboration and use of different educational games is feasible. IMECC has developed some production planning themed educational games and successfully used them in the teaching process at the university. Sometimes it is also mentioned, that CBL and PBL methods are more suitable for university studies. Taking into consideration the variety of different

situations in real production, the project team believes, that the use of CBL and PBL methods in vocational training is very effective. This is especially true in today's computerized world, where much information is actually available on the Internet. The idea of traditional and conventional lecture is starting to decline. Lectures should be replaced by prepared teaching materials, which students can use all the time and where useful/helpful internet links are also added. The lecture itself consists of pointing out situations and the clarification of their nature and root causes.

This project has shown, that the schools are moving in this way, but there is still a lot to do. There should be more methodical guidance, bringing out best practices, as well as more ambition and diligence. Ordinary lectures are boring to the present generation of youngsters. They want to understand the point of the lecture, the necessity of its acquisition and the practical use of the knowledge. Certainly, nowadays students are not just crammers, without realizing the significance of gaining the knowledge.

Companies have made it clear, that the biggest problem is the graduates` lack of ability to understand the real-work situations. Decision-making, analysis capacity and the ability to visualize „the big picture" is problematic. The technical analysis of the case must go hand-by- hand with the economical calculations. Every waste is causing a financial loss to the company. How does the net cost come, how to cover the unnecessary expenses, if they occur? These and also many other issues are often completely white spots for the labour market entrants. Even if discussed in the lectures, without identifying the clear problem situations and analysing the causes, they remain distant for students. Often seems, that the students actually have the theoretical knowledge, but its use and decision making is often overwhelming.

With Case-Based Learning students develop skills in analytical thinking and reflective judgement by analysing and discussing complex, real-life scenarios.

Problem Based Learning is both a teaching method and an approach to the curriculum. It causes of carefully designed problems that challenge students to use problem solving techniques, self-directed learning strategies, team participation skills and disciplinary knowledge.

Interesting further topics:

- Problem Based Learning Network (developing the networking with project partners and also with new partners - TTK University of Applied Sciences, Riga Technical Collage, etc. – we plan to jointly develop and exchange the CBL and PBL materials)

- Explore the possibility of cooperation at home and abroad (The International Journal of Problem Based Learning), to develop and introduce the topic more widely.

- To find ways, how the professional units (EML, MASOC, Technology Industries of Finland) could collect specific „cases" and produce practical educational materials of them.

TEAM BASED LEARNING

Team based learning (TBL) is the use of learning teams to enhance student engagement and quality of student or trainee learning.

The main purpose of TBL is to change the classroom experience from acquiring course content and concepts in a lecture-based format to applying course content and concepts in a team format. In other words, students spend their classroom time applying course materials rather than simply acquiring it. In a TBL course, classroom learning occurs in teams of 5 to 7 students. Teams are formed such that each group contains a variety of students in terms of skills and backgrounds. Students begin each TBL unit by studying assigned class material (readings, website tutorials, video demonstrations, etc.) prior to class.

Shifting from simply familiarizing students with course concepts to requiring that students actually use those concepts to solve problems is no small task. Making this shift requires changes in the roles of both instructors and students. The instructor's primary role shifts from dispensing information to designing and managing the overall instructional process and the student's role shifts from being passive recipients of information to one of accepting responsibility for the initial exposure to the course content so that they will be prepared for the in-class team work. Changes of this magnitude do not happen automatically and, based on past experience, may even seem to be dreams rather than achievable realities. They are, however, highly reliable outcomes when the four essential elements of TBL are successfully implemented.

These essential elements are:

- **Groups** - groups must be properly formed *and* managed,
- **Accountability** - students must be accountable for the quality of their individual *and* group work,
- **Feedback** - students must receive frequent *and* timely feedback, and
- **Assignment Design -** group assignments must promote both learning *and* team development.

When these four essential elements are implemented in a course, the stage is set for student groups to evolve into cohesive learning teams. This section briefly explores each of these elements.

Team based learning is not so much and widely used in professional schools. Team based learning is more used in some way in practical work in school workshop. Such cases we have seen in Raseko and also in other schools. But it is a topic to think more widely. There is a possibility to develop cases, which are necessary to solve in teamwork or even manufacturing games, where to organise a competition between teams. For example IMECC has developed some manufacturing games for students that are used in teaching process in Tallinn University of Technology.

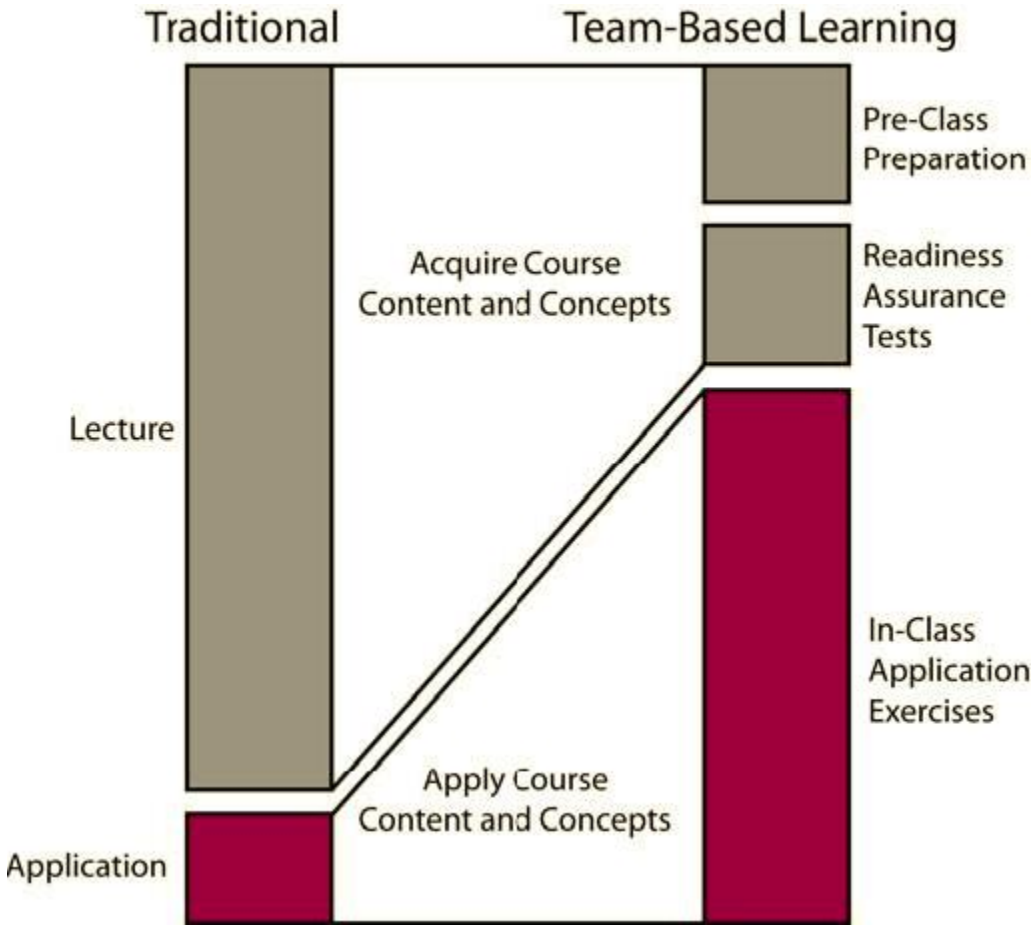


Fig. 5. Traditional and Team-based learning attributes

Team based learning has been suggested to help students who seem uninterested in subject material, do not do their homework, and have difficulty understanding material. The team based learning can transform traditional content with application and problem solving skills, while developing interpersonal skills. The team based learning in education can also be important for developing skills and abilities that are useful for understanding real life in:

- Workshop for fulfilling customers order
- Workplace for managing a task
- Company where many projects are running at the same time.

The term describes a process for teaching and developing people in the workplace. It is a set of developmental principles and routines embedded into the date-to-day processes of a work team such that team members continuously learn and develop. The development activities are not new, e.g., coaching, stretch assignments, review of lessons learned. However, such developmental activities are typically conducted in an irregular and inconsistent way. The benefit of team based learning is that

everyone in the team participates, because the activities provide other benefits that motivate the team to use them. That is, the team not only develop its people but also functions better.

EXPERIENCE BASED LEARNING

Experiential learning is a well-known model in education. Experiential learning is the process whereby knowledge is created through the transformation of experience. Experiential learning theory presents a cycle of four elements

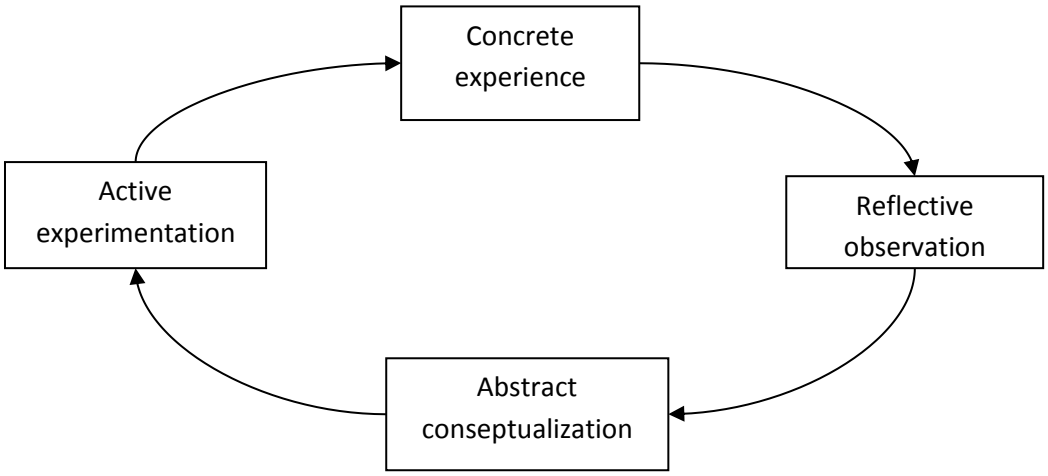
- Concrete experience
- Reflective observation
- Abstract conceptualization
- Active experimentation

The cycle begins with an experience that the student has had, followed by an opportunity to reflect on that experience. Then students may conceptualize and draw conclusions about what they experienced and observed, leading to future actions in which the students with different behaviours. This begins the cycle a new as students have new experienced based on their experimentation.

Basic list of criteria for experience-based learning:

- The goal of experience-based learning involves something personally significant or meaningful to the students
- Students should be personally engaged
- Reflective thought and opportunities for students to write or discuss their experiences should be ongoing throughout the process
- The whole person is involved, meaning not just their intellect but also their senses, their feelings and their personalities
- Students should be recognised for prior learning they bring into the process
- Teachers need to establish a sense of trust, suspect, open for the well-being of the students.

Experiential learning process is presented on the Fig.6.



http://serc.carleton.edu/introgeo/enviroprojects/what.html

Fig. 6. Experience-based learning

Learning theory and research have consistently concluded that learning opportunities providing a change to do or experience the educational input, result in higher learning gains and retention.

In learning process the main methods are: doing, seeing, hearing, discussing, feeling, and testing. According to a questionnaire and investigation made in North Carolina the preferred methods of teaching are as the following:

- Doing 70.1%
- Seeing 18.2%
- Discussing 6.5%
- Hearing 3.9%
- Feeling 1.3%
- Testing 0.0%

The efficiency of different teaching methods is presented on the Fig.7.

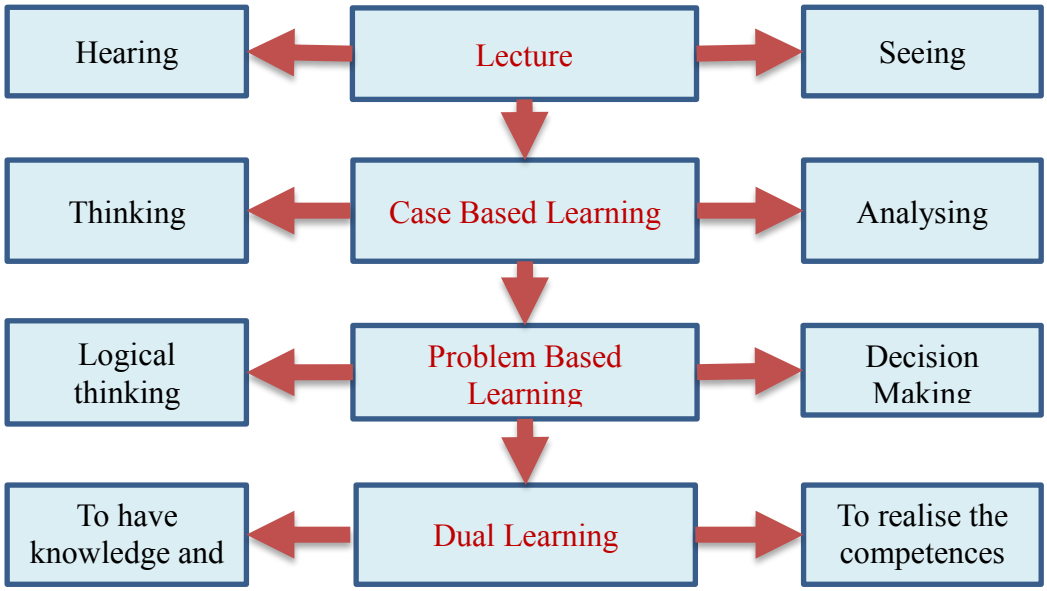


Fig.7. The efficiency of different teaching methods

PROJECT TARGET GROUPS

Target group 1

The main target group is vocational education schools in different levels (vocational educational institutions, professional schools, technical high schools), which have a curricula about the mechatronics. The subject is mechatronic, but the curricula could be different.

The closest target group is project partner schools who will pilot the new training methods and provide an assessment whether the new teaching methods might be useful in vocational education. After the end of the project, this target group could be broadened to other vocational educational institutions, too.

Developed new teaching methodology will enable to educate competitive specialists whom competences respond to industry's needs of today.

Target group 2

The second target group is companies of the industry of machine-building, metalworking and mechatronics, which use mechatronics systems and therefore need the specialists with different knowledge and skills. The companies of the field are represented in the project by participating

competence centres (IMECC, KTK). The needed competencies of today and in the nearest future (2020) in the mechatronics field are analysed in the framework of the project. This give an input for educational institutions to improve their training methods and curricula to respond to the companies' needs as well as for work groups elaborating occupational standards. In the project the structure and concept of the network of cooperation and competencies will be developed. Realization of this network in larger scale falls outside the scope of this project, but the idea is piloted on project partners.

Target group 3

The third target group is Qualifications Authorities who organize elaboration, development and renewal process of occupational standards. These are main parties who form the network of cooperation and competences.

Target group 4

The fourth target group are students. Lectures using new teaching methods are directed to students to make difficult and complex subjects more easily understandable, interesting and available and therefore students obtain competences that make them competitive in labour market.

Fig.8 presents graph of subjects with which we have attended in the Project.

The focus was on the analysis of different teaching methods and the feasibility of their use to obtain better outcomes. Teaching process is based on the teaching methods, where the focus is on the specific educational materials. To get a better overview of the results, sample training sessions were held and also feedback from the students was collected. Also, there has been a close cooperation with companies throughout the project.

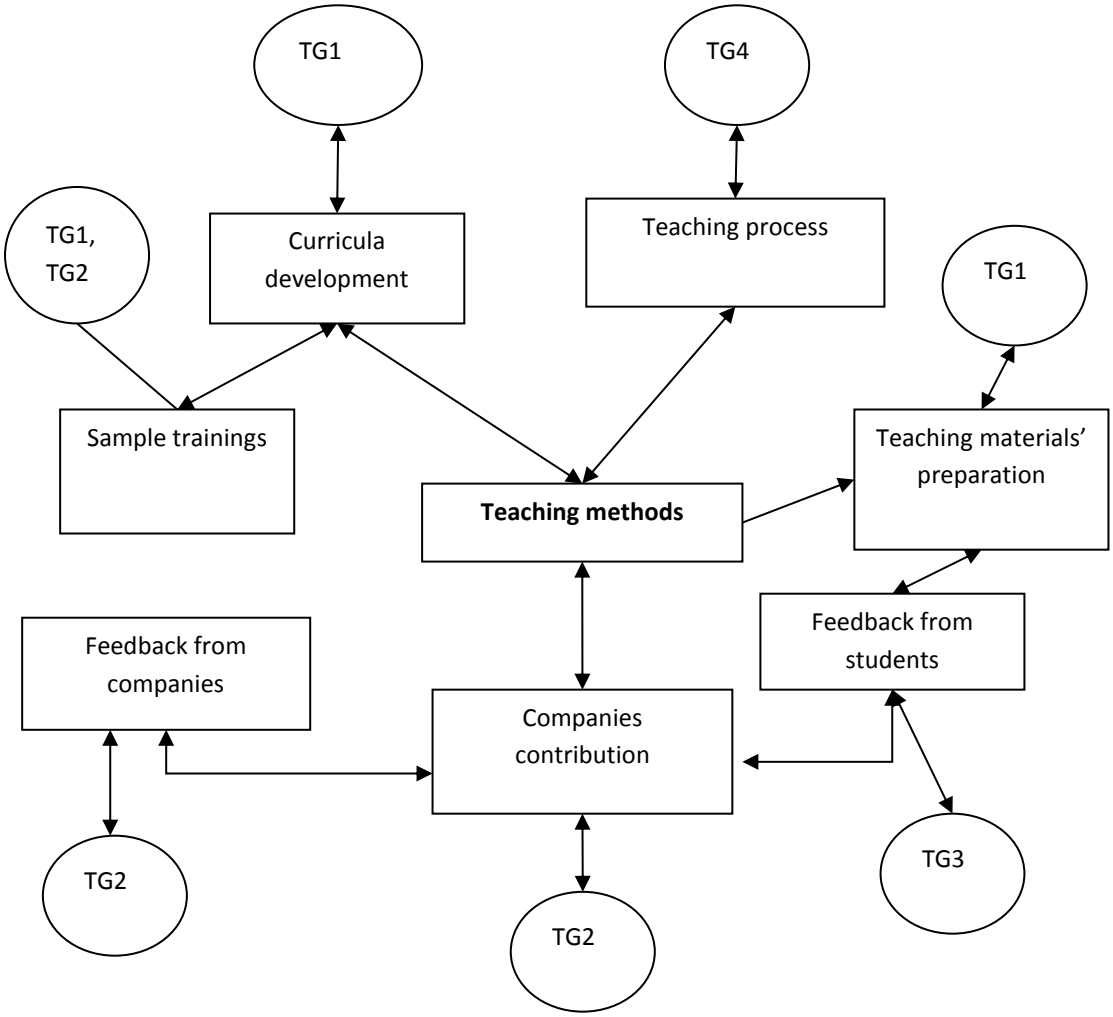


Fig.8. A graph of basic parts of the project (interaction of key players in the learning environment) (TG – target group)

After the project we have a hypothesis, based on the graph of education process.

The number of entrants and the percentage of graduates depend on:

- Schools' action-strategy
- The essence and contemporaneity of the teaching process
- The ambition and competence of the teachers

Z-GENERATION

Today's information society is characterized by:

- Knowledge economy
- Globalization
- Digital jobs

By 2020, we live in a hyper connected world, and already today, the main keywords are: speed, constant changes, high demands, instability, desire to constantly discover something new, digital solutions. More and more we have to take into account the characteristic features and significant differences between generations, when designing the learning process. Main generations, who have provoked significant changes:

- Born between 1965-1976, so called X-generation, who is characterized by staidness, entrepreneurship, situation assessment, independent thinking (Douglas Coupland „Generation X:Tales for Accelerated Culture“, 1991);

- Born between 1977-1997, so called millennium generation (Y-generation, network generation). Technology is a part of their everyday life. (Don Tapscott „Grown up Digital: How the Net Generation is Changing your World“);

- Born between 1997-2020, so called Z-generation. This generation can be characterized by hyper-networked world, need to be distinguished, everything has to be done quickly (due to computer games), having a good visual understanding (social media), the habit to deal with large amounts of information and data (Internet and digital world), internet of things (mobile cells are multifunctional and allow to deal with a great amount of operations) etc.

According to that, the present and the near future expectations of students are quite different from the expectations of previous generations of students:

- They expect freedom in every field, from freedom of choice to freedom of expression
- They like personal approach
- They examine everything new in detail
- From organizations, they expect respect and openness, when making their decisions, as well as selecting a job or designing their curriculum.
- They want to be entertained at work and at studying process as well as in personal life
- They are focused on cooperation and development of relations
- They feel the need to do everything quickly, and it does not involve only video games
- They are innovators, always trying to find novel ways to cooperate, learn, work and have fun.

It is inevitable, that every new generation brings along significant changes, different conceptions and new principles of attitude towards life. They need to be taken into account. When using the same teaching methods as 20-30 years ago, the conflicts are inevitable. According to that, the main idea of this project is to realize the necessity of changes and to find ways and opportunities to modernize the teaching process and apply new teaching methods.

Table 1. Main characteristics of the three generations

Generation	**Main characteristics**	**Crucial inventions**
X-generation Basic characteristic: Independence	Effectiveness, independence, decrease of balance in work- and personal life	Mobile phone, cybernetics
Y-generation Basic characteristic: Rapidness	Social activity, cyber literacy, tolerance, diversity, confidence, determination	Google, Facebook. Digital technologies in industry, industrial robots, CNC processing
Z-generation Basic characteristic: hyper-connectedness	Mobility, media skills, on-line life, e-society, speed, multitude of things, the desire to achieve	iPhone applications, Industry 4.0, Cyber Physical Systems, Internet of Things

Authors have pointed out three very important standpoints, which should be taken into account in development processes:

1. New generations consider it to be very important, that their employers would be able to develop their professional and life skills
2. The employer is likely to be chosen, based on how well he is able to provide the modern tools and technologies
3. Definitely, leaders, who are able to understand and take into account the diversity of age-related problems and to solve these problems, are being preferred.

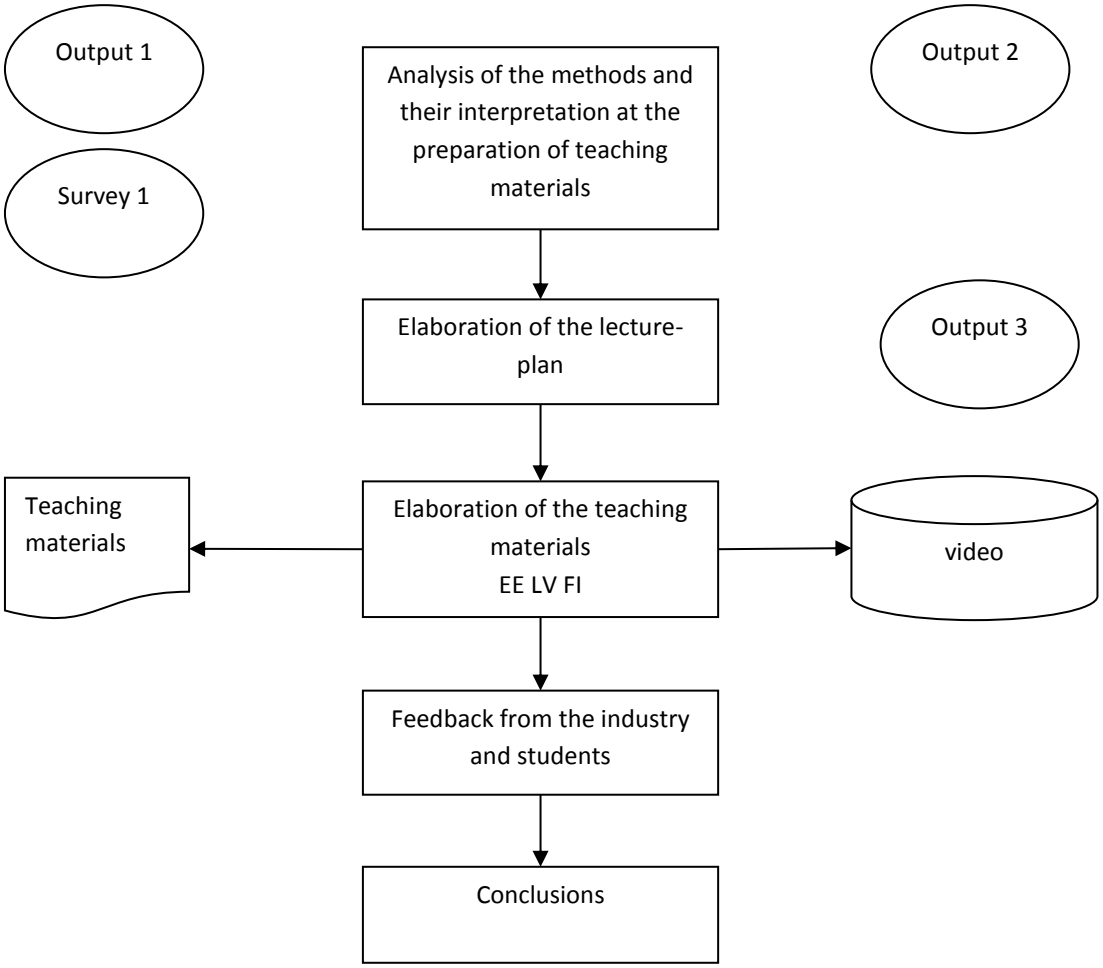


Fig.9. Main stages of the project implementation