DE GRUYTER OPEN

DOI 10.1515/ptse-2016-0018 PTSE 11 (3): 174-193

Problem-Based Learning and Teaching in Construction-Oriented Secondary Vocational Education

Lajos Lászlóné Balogh Melinda Csepcsényi

csepcsenyine@gmail.com
(Székesfehérvári SZC Jáky József Vocational Secondary School, Székesfehérvár, Hungary)

Alice Bredács

alice.bredacs@gmail.com
(University of Pécs, Pécs, Hungary)

Received: 07.05.2016; Accepted: 21.08.2016

Abstract: *It is a commonplace view today that schools do not prepare students properly for solving technical problems emerging in an ever-changing world. As attested by various PISA surveys, Hungarian students can only retrieve their knowledge situations. Their self-regulated learning, problem solving and cooperative skills do not develop in accord with the requirements of their future career. Positive transfer effects are only slightly expressed in learning, especially in the long run.*

Keywords: vocational training, teaching, problem-based learning

Introduction

By long-term transfer we mean skill effects retained for longer periods, such as advanced thinking, creativity or the phenomenon that certain activities are learnt at school but will be used in an experienced fashion in the world of work (Csapó, 2002).

Students' attitude towards learning and knowledge has changed significantly over the past years which requires response from vocational schools and teachers (D. Molnár, 2010). Clearly, we need teaching methods that provide students with useful, practically applicable knowledge.

The present paper is a pilot investigation of how problem based teaching (PBT) can be applied in secondary construction-oriented vocational education. The research was carried out by *Lajosné Csepcsényi* teaching the topic “Traditional strutting” to her students. We shall use Bloom’s taxonomy of teaching material to demonstrate which levels the students can reach via the traditional and the problem-based teaching methods.

Characteristics of Problem-Based Learning

Since the 1970's and 1980's onwards more and more research in developed countries (first in Canada and the US, and later in Western and Northern Europe) has been dedicated to the more practically oriented problem-based teaching (PBT) and problem based Learning (PBL) approaching the issue from the student’s side. These approaches are still considered novel nowadays in Hungary. Some key prerequisites of Problem-based learning include flexible knowledge- acquiring capacity, a high degree of creativity, active and constructive learning based on experience and self-regulation, the acquisition of a problem solving- and cooperative techniques and advanced success-orientation (Fejes, 2011).

Problem -based teaching can be realized by curriculum restructuring, by developing a wide, varied methodological repertoire adapted to the new generations of students, by introducing process approach and new technical tools, and by adaptive education. These demands must be incorporated in pedagogical planning, but they also mean the changing of the learning environment; collaborative group work, inter alia, gets a crucial role in the organization of learning.

Problem-based teaching is a method of developing knowledge application and cooperative - skills, aimed at - among other things - preparing the student for practice, for solving workplace problems in dynamically changing conditions. Via problem-based learning students become more independent and confident. This is equally valid for extracting information, communicating ideas, and discussion- and interrogative skills. Roles are reinterpreted in this context. The teacher becomes more of a facilitator or tutor, controls, regulates, sets time limits and content guidelines, provides resources, gives guidance in the search for new resources, and can learn from individual cases.

The students in the problem-solving process should recognise the specific problems, have to carry out various cognitive and action operations, have to invent alternatives for finding information and problem-solving and even their metacognition improves (Falus, 2001).

The recognition of the problem requires the selection of facts concerning the problem in question from a collection of pieces of information, the identification of missing information or solution methods, ideas, action plans, and plans for checking. The associated responsibility strengthens self-regulating learning (Molnár, 2004), but it does not mean intense effort because, ideally, a good teacher - student relationship and a good learning atmosphere is associated with learning (Józsa, 2013).

Thus, to address the problems students need critical thinking (Bárdossy, Dudás, Pethőné & Priskinné, 2002), subsequent reflections (Szivák, 2010), hypothesising, rule following, probabilistic and creative ways of thinking. Well- and ill-defined problems, respectively, develop different ways of thinking. Poorly defined problems facilitate skills for identifying and clarifying problems, creative thinking, as well as motivation. They highlight the fact that problems can be simple or more complex, and that alternative solutions can be found. Therefore, teachers should get students confront both well- and ill-defined problems as both type occur.

A problem may be a situation "when some aspect of knowledge, skill, or strategy is missing for the solution that has to be provided, or modification of previous knowledge is necessary (for example, due to poor schemes and misconceptions)" (Bredács, 2015:12). This means that students need to realize what is missing for the solution, they need to be aware of potential alternatives, and they should try to apply the missing elements. In the case of bad schemes negative transfer effect prevails because they inhibit the good solutions. The detection of misconceptions is the most difficult, even though the problem -solving difficulties can call attention to them.

The criteria for the selection and formulation of a good problem have been spelled out by several researchers (e.g. Molnár, 2001b, 2004, 2005, 2013; Szögedi, 2012; Obermayer-Kovács & Magyar, 2012; Fejes, 2014; Bredács, 2015):

- Practical and in realistic context with reality.
- Does not only have a single, trivial available solution, therefore it improves creativity, as well as hypothesising.
- The complexity of the problem helps students' group work, so the problem is solved not by a single student, which determines the intensity of interaction and collaboration between members of the group. In practice, then, the difficulty of the problem and the available time are inversely proportional to each other.
- The task may be encountered in a specific context which may contain unnecessary, distracting additional information.
- Lack of knowledge is to be remedied by gathering information.
- The problem should not be transparent so that it will encourage students to catalogue the available information, to plan further work, and to carry out continuous self-testing.
- Promotes the development of higher level thinking skills, i.e. the analysis of the problem effects deep understanding and therefore easier recall.
- expects strategic solutions.
- The central question helps formulate the purpose of solving the problem (i.e. helps to discover the link between the problem and the purpose of learning).
- Can be divided into subproblems (this corresponds to the relevant topics to be examined).
- The problem should be interesting and possibly suitable for research.
- The information needed for problem solving may be extracted from various sources, for example, by using a computer.

As one of the most important capacities of problem-based learning is flexible knowledge acquisition, in planning the teaching process it should be instructive to consider related views by *Eva Gyarmathy*. Gyarmathy (2015) states that knowledge acquisition is via three skill levels: (1) obtaining information, (2) organising, cataloguing information (analytical thinking), (3) establishing information (processing one's own knowledge, raising to a higher level, to "explore "," create "," see through ", the formation of strong positive feelings). In these steps of the knowledge acquisition process, cognitive, meta-cognitive, affective and operational elements are strongly interlinked, of which especially the emotional and motivational elements are acknowledged these days (Réthyné, 2003; Habók, 2006; Józsa & Fejes, 2012).

In his 2002 study, *Peter Toth* compose the forms of thought and knowledge elements listed in this paper into a productive cognitive taxonomy. However, his system also contains categories beyond those mentioned above: conclusion and decision-making, as well as metacognition. In this system, the preliminary (declarative and procedural) knowledge, motivation (as problem sensitivity and goal requiring action), and metacognition provide pre-conditions for ways of thinking necessary for operational skills, and, in turn, for complex cognitive processes to build on. In the actualization stage, knowledge is recalled selectively, new tasks and problems are understood, which is essential for analysis and obtaining missing information. Thus a new combination of knowledge items is created for solving the task or problem. This is followed by the creation of the concept and planning the problem-solving process (in the form of operations and activities). In the realization phase the solution is carried out and the last step includes reviewing and feedback (Table 1).

Table 1. Theoretical model of productive thinking

Complex procedures	
Problem-solving o Understanding the problem o Comprehensive and clear goal setting o Considering possibilities o Collecting and organising relevant data o Forming concepts o Planning of action o Forecasting promising solutions o Selecting, planning the right solution o Supervision of the execution, and feedback	**Inference and decision-making** o objectives o Detecting relationships, boundary conditions, obstacles o Collecting relevant information, o Identification and analysis of alternative activities o Considering possible consequences o Forecasting results for each possible consequence o Choosing the most effective activity o implementation plan

Operational skills	
creative thinking • fluency • flexibility • originality • analysis and synthesis skills • curiosity • ingenuity • Risk -taking • Focusing on essence, constructive solution	critical thinking • interpretation of the cognitive tasks or problem • Understanding, interpreting knowledge • Estimating the accuracy and relevance of knowledge • Identification of assumptions and differences • Detection of discrepancies and erroneous inferences

	• evaluation and derivation of inductive inferences • deductive judging of conclusions and forecasting validity • Using strategies to compare, to oppose, to improve, and to strengthen arguments and ideas

Grounding (preconditions)			
Factual knowledge		Motivation and disposition • Individual traits • attitudes • confidence • Self-esteem • endurance and concentration • strong personal commitment • getting rid of inhibitions • easy identification of relationships	Metacognition • • Goal Setting • • a range of strategies • Selecting, using strategies • • feedback • • self-assesment, self-monitoring, self-examination
Knowledge	Skills		

Source: Tóth, 2002:86, Figure 2

The second table places creative thinking, which is broken down into further hierarchical knowledge units, on the basis of metacognitive knowledge and commitment to the problem. This set of operations gives a wide range of theoretical and practical operations, furthermore some motivational and emotional manipulations begin. It is important that pupils should be able to select and apply those knowledge items which are the most suitable for the task. Since the transfer effect does not appear spontaneously between knowledge elements, students should be familiarised with each of them during the lessons (Table 2).

Table 2. Complex cognitive model of problem solving

Problem-solving			
Critical thinking	**Analysis** • Recognition of Schemes • classification • recognition of assumptions	synthesis analogical thinking • Summary and organization • Hypothesising	**Creative thinking**
	Evaluation, " exploration " • Considering the relevant knowledge • Defining criteria • Identification of priorities of criteria • detection of false conclusions • verification, monitoring	**Elaboration, „discovery”** • expansion, extension of existing knowledge • Modification of existing knowledge, concretisation • Creating new conceptual categories	
	Search for relations • Comparison • logical thinking • inductive and deductive inference	recognition of relations • originality,fluency of thinking • cognitive flexibility • intuition • Heuristic thinking	

Existing knowledge		Commitment to the problem	Metacognitive knowledge
Declarative	Procedural		

Source: Tóth, 2002. p. 88, Figure 3 (Translation by L.D.).

In problem-based teaching the curriculum needs to be changed, it becomes interdisciplinary in character and thus more difficult and labour-intensive to create. It demands greater creativity of the teacher as well because a full mapping between the complex reality and the relations of its elements is impossible. Problem-based solutions require smaller groups and better facilities. Learning assessment and evaluation aspects also need to be changed according to Toth's system. In addition to the knowledge to be acquired it should also be examined how much of the problem-solving process can be seen by the student, how holistically he or she approaches the problem, and how transferable his/her knowledge is. The more ways of assessment are used, the more effective the assessment is.

A problem with Problem-based measurement and evaluation is that the solution is hard to quantify, it is hard to measure the level of the acquired knowledge. According to the Public Education Act, students' performance must be qualified with marks on a five-point scale. However the evaluation of problem-solving is more nuanced. For instance, the following options are possible:

- ➢ Students prepare a partial plan, quote, model, etc.
- ➢ Practical exam, with tangible results. This method is used in testing technicians where the exam organizer includes a particular profession -related problem in the exam questions.
- ➢ Members of the group evaluate joint work as well as each other's contribution
- ➢ Self-assessment.
- ➢ The tutor evaluates the job, since he or she has followed the solution process.
- ➢ Oral reports.

Finally, we get to the general characteristics of problem-based curriculum, which should take into account the problem itself (i.e. more specifically, a series of problems which means teaching content as well), the purpose of solving the problem, the students' knowledge and skills, the tools and methods of knowledge acquisition and skill development, as well as the assessment of problem-solving:

- ❖ The educational content is organized around a few central problems that students solve as a project, expanding topics one by one.
- ❖ There is consistency between learning objectives, requirements, tasks, problem-solving methods and prior knowledge of students.
- ❖ The learning process is systemic, and the process steps can be described.
- ❖ It is important to organise learning appropriately, since there are frequent deviations from commonly known organizational forms.
- ❖ There are manifold tools that can be assigned to different stages of learning
- ❖ Assessment is varied because it incorporates self- and peer-evaluation, as well as evaluation of individual and group results.
- ❖ Problem-solving improves personality (e.g. autonomy, activity, responsibility, perseverance, professional and general knowledge) and group activity (acknowledging different points of views, getting

to know various learning strategies, cooperation, detecting learning weaknesses and strengths) in a complex way.

- ❖ Technical communication improves since concepts and anticipated results need to be interpreted constantly.

In general, we talk about two types of problem-based teaching. With problem-based learning, students will learn about the problem before learning the information. This distinguishes it from problem-centred learning. Problem-based learning starts with raising the issue. Students should recognize and articulate the specific problem, they should decide whether the issue is a problem at all. The decision is made difficult by the fact that they do not have prior knowledge to solve the problem. They form groups, summarize previous knowledge about the problem, and collect ideas concerning hypothesising or solving the problem. They set up a plan for solution and assign tasks while undertaking roles. E.g. the *actor* coordinates team work and allocates further tasks; the *sceptics* questions the results achieved and/or the actions planned thus urging the group to set up several alternatives and to check sub-results; the *teacher* who explains results and points out relations. Arguments are inevitable during team-work therefore a team member might need to assume the role of *peacemaker*.

After the assignment of tasks and roles students collect information separately and then jointly select the necessary bits and look for correlations. They use the information to set up a solution and argue for the results. Problem-based learning is only complete if students assess their work in the end, the most important questions being whether they have solved the problem, and whether they have solved the original problem (Molnar, 2005). The method works well if students move forward by teaching each other, which has a positive effect both on the work of teacher and the students taught. Importantly, students themselves take responsibility for the acquisition of knowledge and for understanding the material (Utecht, 2003), so students become active participants of the learning process.

Employers' expectations of newly qualified technicians and opportunities offered by vocational training

In the spring of each year several construction companies contact the Vocational Training Centre of Székesfehérvár Jaky Jozsef Secondary School looking for freshly graduated technicians who are able to independently perform the tasks involved in the construction site immediately. However, the business expectations concerning early stage technicians are exaggerated. In schools students do not learn in real-life conditions. Even though they are provided with as much construction site visits and hands-on training as possible these are not able to fully replace the experience acquired on the construction site. Training provides students with basic skills that will help them to start solving problems emerging in the workplace. Due to the faster and faster emerging new technologies, students' skills become outdated faster and faster. Schools are no longer only responsible for the transmission of knowledge, but also for preparing students to integrate new information into their previous knowledge and professional experience.

The greatest change over the past years in vocational training was in examination requirements. Module-based education should imitate practical tasks that the technician will encounter in the workplace: complex examinations require full knowledge transfer. The transfer of knowledge makes it possible for young people to be able to bridge the gap between school learning and application in the workplace. However, this is only true for the specific field where the student got practical training, other fields of knowledge remain associated with school context. If someone wants to work in another field, it is not enough to refresh acquired but faded knowledge, but for the transfer of knowledge to become successful it is also necessary to acquire the ability of self-learning (Molnar, 2002).

In current educational practice sample task drilling has become a habit. To solve the tasks students, learn algorithms. The result is that students can not cope with a task in a new context alone, or the solution takes much more time. After a while, students expect to get ready-made solving algorithms, but the tasks become boring for them this way. They often say, "why am I to learn this, I won't need it anyway." Some teachers ignore the fact that students can access the information to be learned in seconds by using ICT (information communication technology). Students also feel that the school does not prepare them for life, which in turn affects their motivation.

A nationwide initiative designed to help students gain useful knowledge in workplace setting has been adopted in road-construction and maintenance technician training. According to the core programme, students should spend eight classes per week on a construction site and to complete a road construction sub-task. The programme explicitly sets out the main issues that the student should learn in these lessons.

However, in practice it is difficult to carry out. Most construction companies cannot undertake to get students complete the tasks set by the central programme. Due to the specific nature of the construction industry, tasks cannot be well adapted to the curriculum because of influence from work orders, weather, etc. Entrepreneurs are not able to have students working in the work area due to safety considerations, either. This type of education is an extra burden on entrepreneurs even though students would benefit considerably from the experience of a working day. Businesses do not accept students even on a weekly basis in the work area. Only a few contractors agree to have students working on the construction site five times per academic term. For students, even that is significant experience because they can apply their knowledge in a new environment under the leadership of the trainer. However, such learning can not be considered a realization of problem-based learning because students do not have an opportunity to search for information on the spot and this is likely the same for any other similar vocational training school.

In the case of other vocations there is no opportunity for the students to gain work experience either. Thus, the transfer of knowledge that the employer would expect of early-stage technicians is not achieved during the studies, but rather later in the workplace. Another way for students to gain experience is a continuous 160-hour training to be completed on a construction site. The aim of the training is to deepen the knowledge acquired in school.

One would think that students who participate in vocational training already have knowledge and dedication concerning a trade. But this is only true for some students, in general beginners only have curiosity, and idealized notions of a specific craft. Some students have certain knowledge and experience owing to relatives or friends working in the sector in question so they have expectations about school training. From the parents' point of view preparation for future work is most important.

The teacher's task is very complex: promoting transmission of knowledge, getting students to understand and like their trade, to apply their knowledge, and arousing interest and motivation are all important. The teacher must adapt to the learners by exploiting results-oriented educational methods that meet the specific features of the age group.

Problem-centered teaching is thus plausible for vocational training, although for beginners, realistic problems are too complex, thus new information needs to be tailored to their prior knowledge It is important to consider what problems they are likely to meet during their future work. Here, we stress "problem" because there are no two identical buildings or constructions. There may be analogies between jobs, but to solve a specific problem will require not only knowledge transfer, but also a high degree of creativity. This is very difficult to teach with traditional teaching methods or to simulate. Teachers using the problem-solving method should promote knowledge transfer by establishing such general skills and thinking for their students, besides subject content, that will be readily applicable in their future work (Tóth, 2002). However, care should be taken that students encounter a wide range of thinking strategies, not just one.

The new generation and the demand for new vocational learning methods

Business expectations predict that more practice-oriented vocational training is needed, in which the student also acquires competences such as complex problem solving, independent work, self-monitoring, social skills, and more. From 2007 the development of proactive abilities, entrepreneurship, effective and independent learning skills, social and civic competences have been required by the National Curriculum.

Although some of these skills can be acquired by cooperative learning, in another part of group tasks teachers are still setting limits on creative thinking, even though complex technical thinking and creativity should be established at school. This prepares them to solve problems emerging in construction activities. By solving clearly defined narrow-scope tasks students do not acquire new skills, they will, at most, be able just to apply previously acquired knowledge and will not be able to use their knowledge in real-life conditions.

Overall, it is rather difficult for students to acquire professional thinking requiring inductive, deductive, creative and critical thinking at the same time. They must create categories explain concepts detect regularities and discover parallelisms between tasks (Csapó, 1994). Creating categories includes recording and analysis of initial data, as well as goal setting.

Csepcsényiné found, that students in the group often fail to analyze or even to understand the task. It follows that they are not capable of drawing up a solution plan and finding and then implementing a solution algorithm while constantly self-monitoring. Elaborating a solution plan is a time-consuming and painstaking task for them which requires rethinking the whole issue.

In recent years the classroom motivation of the majority of students has decreased dramatically. It is difficult to draw and maintain their attention with traditional teaching methods. Students are most likely to be motivated by tasks that are considered by them useful in some way, and/or tasks that can be completed in reasonable time. Students are willing to devote less and less time to a task. They become frustrated in the absence of immediate results and success. Therefore, they often prefer easier tasks which they will certainly be able to solve, and in less time, thus achieving immediate success (Tari, 2010, 2011). Most of today's high school students would like to reach their goals by using the least possible energy and they do not accept the fact that the problems must be solved to improve their knowledge. More attention can be extracted if they are given a task to which ICT tools may be applied.

Students in the classes studied by Csepcsényiné also lost interest quickly when they got stuck solving a problem. They immediately asked for the teacher’s help or for the solution when they could not use the teacher’s guidance. Similarly, they also became uninterested when given a complex task. Usually, they asked if such tasks would be included in the tests or where they would encounter similar challenges later in life.

Based on these problems it is worth examining how school workroom lessons are different from classroom lessons. Will students perform better in more life-like situations in the workroom than in the theoretical lessons coupled with hands-on workroom activities?

Workroom activities at the Székesfehérvár SZC Jaky Jozsef Vocational Secondary School last for at least two classroom lessons’ time. This allows students to complete more complex, time-consuming construction sub-tasks, tasks that they like working on, and tasks that yield tangible results. Students are very proud of such completed subtasks (Figure 1).

Figure 1. Student workroom products. Completed sub-tasks: construction of fence footing and placement of lintel (Pictures by Zoltan Erdősi, technician candidate)

Workroom practice traditionally takes place as follows:

- ✓In the beginning of training the instructor explains the tasks to be performed and discusses the work processes, the use of necessary tools.
- ✓Then the instructor demonstrates the new work stages, use of equipment or machine
- ✓In the rest of the practical training students, in groups of two or three, construct the particular structural component, auxiliary structure, or road surface section.
- ✓Student work is constantly monitored by trainer, if necessary, s/he gives instructions or re-demonstrates an activity.
- ✓After completion of task the trainer assesses work, sometimes according to a five-point scale.

Students can decide which specific work activity they wish to complete but their decisions are influenced by the particular building materials, tools and time period provided. This spoils creativity - but without such limits practical work would not be possible. Creativity may exist on several levels. If we provide frameworks, it is often easier, and frameworks are required for the workflow and knowledge to base. If students have already met a practical work process in the workroom they will be more active during the theoretical discussion of the issue, they will be more confident.

Learning through practice is more effective than textbook knowledge acquirement (Zsolnai & Kasik, 2010). This does not mean that everything should be learnt in the workroom, it simply entails that there is a need to change teachers' and students' attitudes. To practice a trade requires complex thinking of the students. This requires both the acquisition of pieces of information and the capacity to interconnect them thus facilitating knowledge transfer first between subjects in the school then in a workplace environment. Work effectiveness in the workroom forecasts directions for theoretical education to move in to motivate students.

Vocational training gives the possibility of the application of a method that supports the transfer of knowledge, the mastery of complex thinking and teaches students to work independently so that it also enhances social competences, which is essential for vocational training. At the beginning of the training students still do not have these skills – even adult learners only have them partially –, they need to be formed and improved gradually. Unfortunately, it often does not reach the level expected by prospective employers, so during training preparation for the vocational exam is also a task. Most vocational examinations still prioritize factual knowledge, consequently there is no need for students to apply what they have learned under new circumstances, and to link new information to what has been already acquired (Molnar, 2001).

Presentation of the results of construction training through specific curriculum

Analysis based on Bloom's taxonomic system

Below we discuss how the issue of *traditional strutting* can be integrated into classroom teaching. Due to anomalies of the educational system the issue is taught both for 10^{th}- graders and for 13^{th}-graders. The 10^{th}- graders encounter the topic for the first time whereas 13^{th}-graders have already learnt about it. What follows is an analysis of the material to be taught based on Bloom's taxonomy (Bloom, Englehart, Furst, Hill & Krathwohl, 1956).

Thinking Level

Knowledge: Students should master basic concepts necessary for strutting structures, and technological processes. These are: excavation, trench, row of planks, straps, strutting frame, basic strutting types, natural slant angle, earth pressure, minimum element size. In this phase, learners should recollect knowledge about the dimensions of wooden products and about construction machines, as well as an earth excavation cycle.

Understanding: As a next step of learning, students are given photos, and should recognize the type of strutting or technological process pictured. In their own words, they should cite the relevant work safety regulations concerning the machines in question.

Application: Students should calculate the amount of material required for a simple, regular excavation or trench. They need to know the contents of the strutting plan, and the relevant notations. The solution of the problem is a bill of materials which lists the amount of separate wooden items needed in appropriate units of measurement. Students need to create simple sectional, top-view and side-view drawings of strutting.

Analysis: The recognition of elementary types of complex excavation strutting. Comparison of different types, recognition of identity, differences, power play of strutting. Sketching and interpreting dynamic diagrams based on specific examples.

Synthesis: Students should prepare an excavation strutting plan in accordance with a partial utility installation plan, taking into account the type of the available machine. They also should specify the necessary actions and the sequential order of the workflow design.

Evaluation: Student must carry out self-assessment during the design phase, reflected in the state of plan at the time of submission. The plan shows how demanding the students are with respect to their own work, how they can recognize shortcomings against the background of the plans of others, and how they can spot the elements to be changed when an idea is not appropriate.

Emotional-volitional level

Arousing attention can be achieved by presenting pictures showing the steps relevant to the given technological process. Such pictures can familiarize students with basic concepts, functions of strutting components, and their relationship to one another. The ultimate goal (the plan) is to convince students to pay attention to the lesson.

Reaction: Students' willingness to cooperate is expressed in taking notes, making drawings, and asking questions relating to the issue.

Assessment: Emergence of job awareness and sense for quality, completion of small tasks (for example, material quantity calculations.).

Organization: Working towards optimal completion of drawings and calculations, demand for compliance with standards.

Behavior and reflecting values: Awareness of the task, endurance of monotony, and sensitivity to quality, which is essential for the proper preparation of plans.

Psychomotoric level

Imitation: Learning about the basic elements of strutting work, students must copy drawings from the blackboard into their copybook. Methodologically, this means that the teacher explains structures line by line, taking short pauses, so that students can work simultaneously with him/her.

Manipulating: understanding the structure reduces the number of unnecessary auxiliary lines and deletions while drawing. The drawings become more transparent.

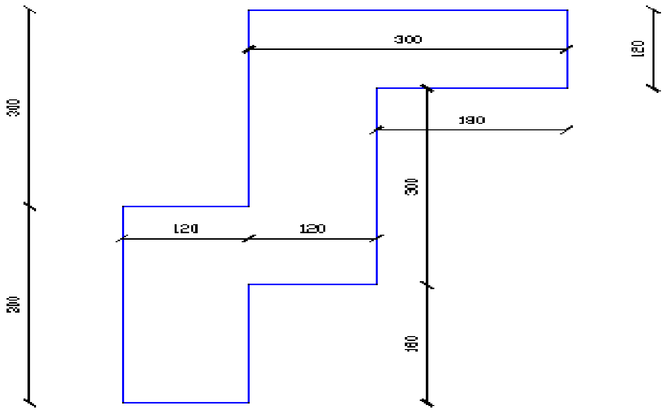
Articulation: Elements of the structure are drawn in technological order, with few unnecessary auxiliary lines. Model drawings are completed accurately.

Automation: The basic strutting elements are drawn automatically; structural dimensions and materials are represented. Based on model drawings, individual, unique plans are designed.

By the end of the school term students' cognitive level reached *application*. The teaching method was traditional frontal teaching both for grade 10 and grade 13. Three theoretical lessons were devoted to the purpose and functions of traditional strutting elements, and the structure of each type. This was the information phase. Then the most commonly used types were put on the board. The cornerstone of architectural subjects is the preparation of drawings for various structures, drawings. Thus, students do not only have to show what elements a structure consists of, but also, what steps are needed for the drawing, and what notations and scaling are needed. On the emotional-volitional level we managed to arouse students' interest and elicit response by getting students to copy drawings, and to ask questions about the structure. While drawing, students recognize difficult phases, so they can ask questions throughout the activity, deepening their understanding.

After understanding the basics in the drawing lessons – six lessons for both groups – application followed: the task was to design strutting for a specified trench. Each student could choose a trench-plan and a strutting type of the possible variants to work with. The problem was to choose an auxiliary structure whose implementation is viable. This requires a knowledge transfer between theory and design. A variant of the task is shown in Figure 2.

Figure 2. Possible variant of the Traditional strutting's planning task



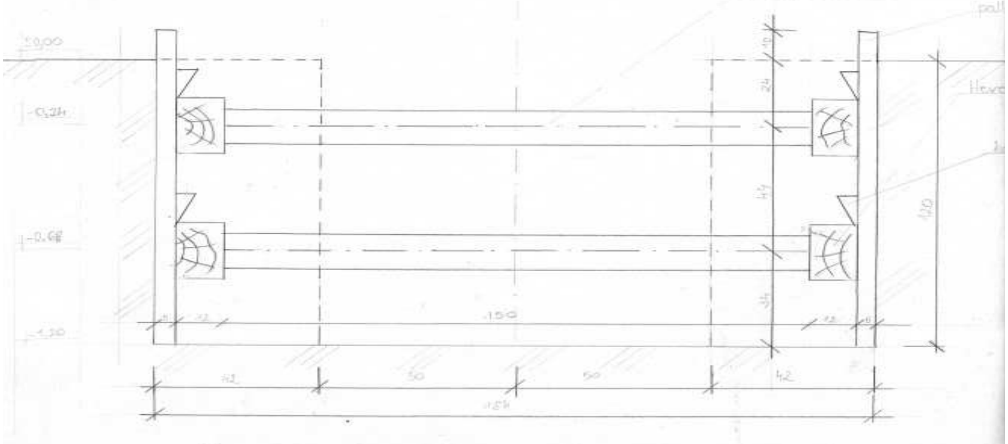
(Fig. own)

Experience from previous classes shows that students prefer to work on a task of their own choice. Students had to adapt a familiar strutting type for a trench of specific size.

The task should have required transfer of previously acquired knowledge and skills, e.g. technical drawing, spatial vision. It was found, however, that independent application of knowledge was difficult for the students. They had not been able to connect new information and new task to previously acquired knowledge, they needed the teacher's guidance, especially in the beginning of the task. The students began completing the task by drawing the section for which they had model pictures in the textbook. They had to modify the textbook model in accordance with the trench dimensions in the task, but they needed constant help and assessment from the teacher. Again, there were rather different levels of knowledge application: the students' spatial vision had not been developed enough, so in the drawings made in different views they could not identify strutting elements by themselves, thus they kept shifting from application level back to the level of understanding with teacher's assistance.

The mandatory elements of technical drawing were not always fully displayed, there was a lot of incomplete dimensioning and annotation. This does not mean, however, that the students do not know the rules. Dimensioning and the labelling of elements are time-consuming and monotonous work. Students will get bored after a while, so self-monitoring cannot evolve. Figure 3 shows a part of Nikolett Rakk's strutting plan produced in the 2013/2014 academic period.

Figure 3. Section of trench-propping



(Nikolett Rakk, Class 10)

Nikolett is a hard-working, talented student, with advanced task-awareness and self-regulating learning. At first glance, the drawing shows the development of psychomotor skills: the student's skills are situated between articulation and automation. She drew accurately using few extra lines, automatically employed material annotations, applied line thickness properly, provided dimensioning and annotations. Nikolett's emotional-volitional level is more developed than her peers' - at least in this taxonomy- but this claim is ambiguous because it involves the teacher's prior knowledge, it cannot be inferred from the drawing.

Of course, such statements can be done, but they should not be integrated into the analysis of the drawing. One should indicate that it comes from previous teaching experience. The drawing task was accompanied by simultaneous consultations so knowledge application could only be tested against a new task. The main objective of the drawing task is not to gain new knowledge but to facilitate the transfer of knowledge - in this case it is realized within the specific topic.

Due to the transformation of vocational education, on graduation, students obtain specific qualifications enabling them the occupy various work positions. The above-described traditional information-communicating method should be complemented, if possible replaced, with problem-based learning. Students in the future will have to reach a higher level of the taxonomic system of knowledge than students taking vocational exams today.

Improving the curriculum towards workplace requirements

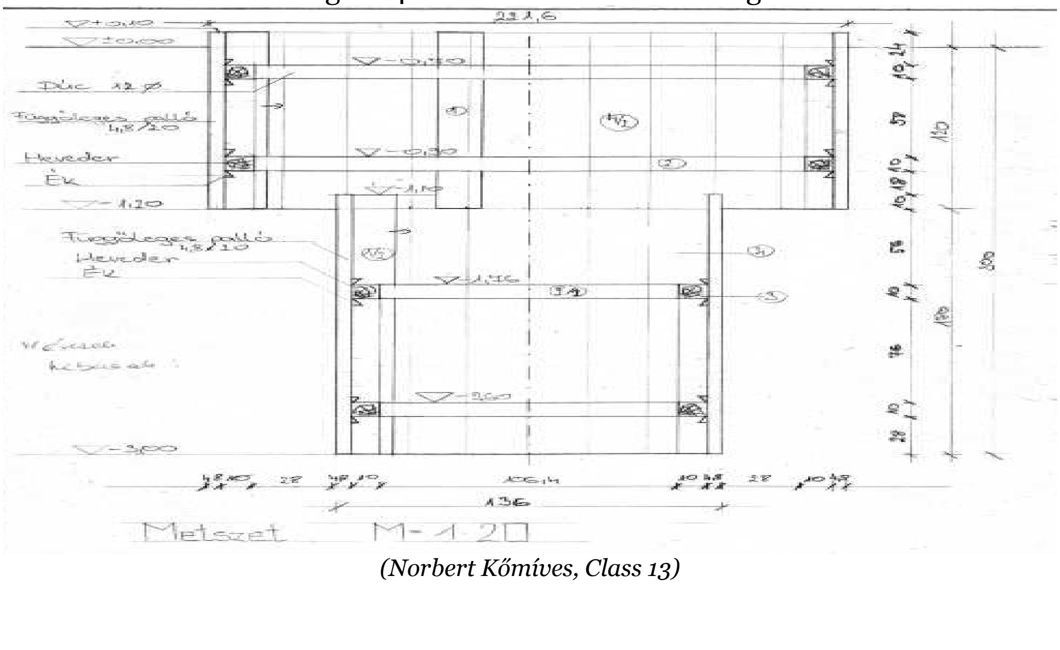
The present architectural technician training to be changed lasts for two years. Students in class 13 meet a lot of information that has been taught to them previously during their studies, however it is discussed at a higher level in technician training. The teacher's responsibility is to not only repeat known information, but also to put it in a technical context, and to facilitate knowledge transfer between subjects. This age group is more motivated by tasks that they will encounter during their future career.

Relearning previous information is considered unnecessary by them, even if their knowledge is incomplete.

13th-grade students had already encountered the task of traditional strutting requiring the skills described above. The problem was basically identical with the task given to 10th-graders but it was complemented with realistic elements like excavator bucket size, complexity of trench dimensions (stepped trench) and the function of the trench (public utilities). The students also had to specify the amount of material to be ordered in accordance with the budget, as well. Changing and restructuring the task requires switching from one cognitive medium to another during solution. The more emphasis this fact is given, to the more extent students' thinking flexibility can be improved (Tóth, 2002). This task cannot be called problem-based learning, because it was preceded by communication of information so it just requires the application of the knowledge gained. The difference lies in the organisational and technical drawing skills involved in the task. The students were free to choose a trench plan and a strutting type, but other data to be used were assigned randomly. The technician candidates did not only have to complete the basic tasks, but they had to combine several systems. The formulation of the problem follows the traditional school tasks semantics, with richer information content, though, approaching problem-based tasks. The bucket size of the excavator was decisive as to the solution.

In choosing the task, student were more careful to couple a trench plan with a matching problem. However they ignored the organisational data, as they could not establish a connection between the data and the task. Formal assessment also revealed that students were not able to transfer their organisational knowledge acquired in the building management lessons to a specific task, teacher's help was needed. After understanding the problem and its relevance to the task 13-graders applied their knowledge about struttings more readily than 10th-grade students. Figure 4 shows the work of Norbert Kőmíves, grade 13, reflecting routine use of technical drawing skills.

Figure 4. Section of trench strutting



(Norbert Kőmíves, Class 13)

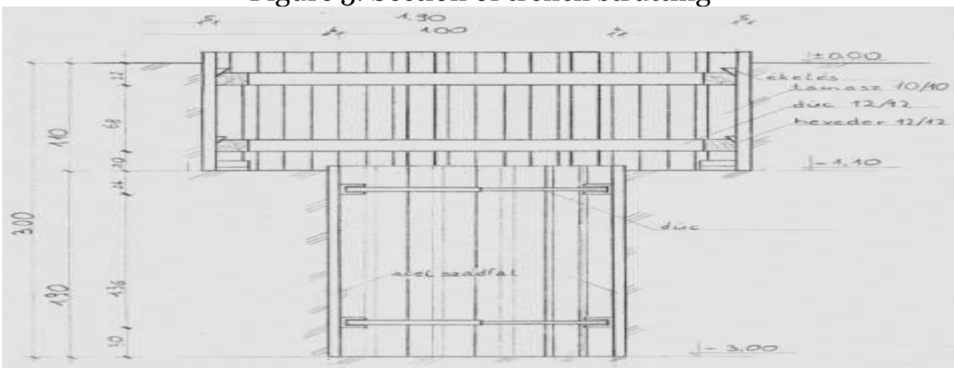
With help from the teacher, Norbert reached the cognitive level of synthesis. In addition to the drawings, he completed the amount of materials calculation, although he was not able, even at this stage, to link building management to the particular structure: he only specified the amount of material to be ordered, the item-based list for budget proposal was not provided. The student did not reach the level of assessment, he did not realize that the solution does not fully match the task. At the same time, he reached the behaviour level which reflects demanding vocational values. He completed all task components, with apparent endurance of monotony His drawings were clear, transparent, dimensioning and annotation was almost complete. His solution was unique. Material designation was correct and complete, he reached the level of automation. If we examine the development of problem solving skills, it is likely that he will cope with a similar task easily.

In summary, formal assessment of students and observations revealed that students did not identify the inherent problems of the task, their structure design was based on algorithms. During task completion, students developed a need for self-learning, as well. Students tried to acquire the information concerning the annotations and the combination of propping types to be used in the plans from the textbook, figure collections, and the teacher's explanations. This is a step towards knowledge transfer, but complex thinking has not evolved yet.

The strutting task as a problem

The subfields of the vocational subjects are very diverse, with multiple degrees of difficulty. Figure 5 shows the work of Károly Esze who interpreted the task as a technical problem. He posited questions already on choosing the task. He especially objected to not being allowed to use some modern structure when a deep trench work was needed, According to him, sheet piling suited the task better. Students prefer to work on a project when they can exploit their own ideas and creativity, even though they need reinforcement from the teacher. That is why Károly was permitted to use any other strutting system. He gathered material on the Internet, while constantly classifying it with respect to relevance and applicability to the project. Help was only needed when he did not understand how individual structural parts join together, or when he was uncertain about the correctness of his own solution. He was continuously monitoring his work during design. Károly reached the highest degree on all the three levels, so he will presumably be able to comply with employers' requirements.

Figure 5. Section of trench strutting



(Károly Esze, Class 13)

A further question is what levels can be distinguished in problem solving. We will need to examine the entire class, but conclusions should not be drawn until students' problem-solving strategies have been observed in the context of several tasks. Problem solving always began by understanding the task. All tasks had to be presented in realistic context, which initially was unusual for the students, so it was necessary to discuss the problem-solving process after the presentation of the task for all the students in the class. However, after that students started to work more autonomously. Károly implemented his own idea. A few students began to complete the task independently, they worked out technical details by adapting figures from textbooks. They only asked questions about the formal requirements of the plan. In their case we could see transfer of knowledge realized. The majority of the students, however, needed continuous control from the teacher, because they had not learnt any solution algorithm during the theoretical classes. With these students, we divided the task into subtasks and outlined the interconnections of plan components.

Conclusions

Prospective employers have rather high expectations about technicians, which calls for response from schools. Students' attitude towards learning has changed significantly, so teachers' attitudes and the methods should be modified, too. Very often, students only encounter school tasks, which are designed for the acquisition of a specific material. Thus when the same task appears in a workplace context, even understanding it is problematic for the early stage employee. This training practice should be stopped and more realistic approaches should be adopted from the very beginning of training, as we attempted to illustrate with the above examples. Tasks should be related to future work, and should be tailored to student's specific age characteristics and prior knowledge.

Problem-based learning and teaching requires commitment, perseverance, and methodological experience in curriculum development from the teacher. On the other hand, students should be aware of the rules of the method and be committed to self-regulatory learning. These skills should be developed from the early school years.

References

Bloom, B. S., Englehart, M. B., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives. The classification of educational goals.* Handbook I: Cognitive domain. New York: David McKay Company.

Bárdossy I., Dudás M., Pethőné Nagy Cs., & Priskinné Rizner E. (2002). *A kritikai gondolkodás fejlesztése*. Pécs: PTE Neveléstudományi Intézete.

Bredács A. M. (2015). *A hagyományos és az IKT-vel támogatott mérés és értékelés a szakképzésben*. Retrieved from http://www.tankonyvtar.hu/hu/tartalom/tamop412b2/2013-0002_a_hagyomanyos_es_az_ikt-vel_tamogatott_meres_es_ertekeles_a_szakkepzesben/HI/shijs03g.htm [04.05.2016].

Csapó B. (1994). Az induktív gondolkodás fejlődése. *Magyar Pedagógia*, *94* (1-2), 53-80.

Csapó B. (Ed.) (2002). *Az iskolai tudás*. Budapest: Osiris.

D. Molnár É. (2010). A tanulás értelmezése a 21. században. *Iskolakultúra*, *20* (11), 3-16.

Falus I. (2001). Gondolkodás és cselekvés a pedagógus tevékenységében. In Báthory Z., & Falus I. (Eds.), *Tanulmányok a neveléstudomány köréből* (pp. 213-234). Budapest: Osiris.

Fejes J. B. (2011). A tanulási motiváció új kutatási iránya: a célorientációs elmélet. *Magyar Pedagógia*, *111* (1), 25-51.

Fejes J. B. (2014). A kontextus szerepe a tanulási motiváció kutatásába – az elmélet és a gyakorlat távolságának egy megközelítése. *Magyar Pedagógia*, *114* (2), 115-129.

Gyarmathy Éva (2015). Diák3.0 – A határtalan lehetőségek generációja. *Oktatás-Informatika*, *5* (1), 32-42.

Habók Anita (2006). Motiváció, tanulás és tanítás. *Iskolakultúra*, *16* (2), 137-140.

Józsa K. (2013). *Az elsajátítási motiváció*. Budapest: Műszaki.

Józsa K., & Fejes J. B. (2012). A tanulás affektív tényezői. In Csapó B. (Ed.), *Mérlegen a magyar iskola* (pp. 367-406). Budapest: Nemzeti Tankönyvkiadó.

Molnár Gyöngyvér (2001a). A tudás alkalmazása új helyzetekben. *Iskolakultúra*, *11* (10), 15-26.

Molnár Gyöngyvér (2001b). Az életszerű helyzetekben történő problémamegoldás vizsgálata. *Magyar Pedagógia*, *101* (3), 347-372.

Molnár Gyöngyvér (2002). A tudástranszfer. *Iskolakultúra*, *12* (2), 65-74.

Molnár Gyöngyvér (2004). Problémamegoldás és probléma-alapú tanítás. *Iskolakultúra*, *14* (2), 12-19.

Molnár Gyöngyvér (2005). A probléma-alapú tanítás. *Iskolakultúra*, *15* (10), 31-43.

Molnár Gyöngyvér (2013). Mindennapi helyzetekben alkalmazott problémamegoldó stratégiák változása. *Iskolakultúra*, *23* (7-8), 31-43.

Obermayer-Kovács N., & Magyar D. (2012). *Korszerű probléma-megoldási módszerek*. Retrieved from http://ttk.nyme.hu/fmkmmk/tamop412/Documents/Tananyagok/Átkonvert tananyagok pdf-exportja/Korszerű probléma-megoldási módszerek.pdf [12.02.2016].

Réthy Endréné (2003). *Motiváció, tanulás, tanítás. Miért tanulunk jól vagy rosszul?* Budapest: Nemzeti Tankönyvkiadó.

Szivák Judit (2010). *A reflektív gondolkodás fejlesztése*. Budapest: Magyar Tehetségsegítő Szervezetek Szövetsége.

Szögedi Ildikó (2012). *A probléma alapú tanulás, mint új gyakorlati készségfejlesztő módszer az egészségügyi felsőoktatásban*. Retrieved from http://ltsp.etk.pte.hu/portal/wp/File/Doktoriiskola/Tezisfuzetek/-Szogedi_ertekezes2.pdf [22.01.2016].

Tari A. (2010). *Y generáció*. Budapest: Jaffa.

Tari A. (2011). *Z generáció*. Budapest: Tericum.

Tóth P. (2002). A problémamegoldó gondolkodás fejlesztésének módszertana. In Tóth Péter (Ed.), *Műhelytanulmányok* (pp. 85-92). Budapest: BME GTK.

Utecht, J. R. (2003). *Problem-Based Learning in the Student Centered Classroom*. Digital Media. Retrieved from http://jeffutecht.com/docs/PBL.pdf. [10.02.2016].

Zsolnai A., & Kasik L. (Eds.) (2010). *A szociális kompetencia fejlesztésének elméleti és gyakorlati alapjai*. Budapest: Nemzeti Tankönyvkiadó.