UNIFIED TAXONOMY OF COMPETENCES FOR VERIFICATION OF STUDENT'S SKILLS

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Abstract

Skills, which students have to manage, are divided on a lower and higher taxonomic (»competent«) level, which allows differentiation and individualization in the lessons. It also allows easier monitoring and verifying of skills. The combination of taxonomies in all three fields, cognitive, affective and psychomotor has been searched and combined in competent taxonomic levels, which allows development and verification of student's skills on a lower and higher taxonomic level. Special attention was on verification and assessment of student's knowledge, where it can be found out once more that the greatest emphasis is on the knowledge, whereas skills are put in the background. Derived from introduced taxonomies, Bloom's cognitive and affective and Dave's and Simpson's psychomotor the lower and higher competent taxonomic level were defined and unified taxonomy of competences was developed. The paraphernalia was made, which allows monitoring and evaluating of student's skills on cognitive, affective and psychomotor field at technical subjects. Paraphernalia is transferable also on those fields of education, where student's skills are important.
Key words: *unified taxonomy for competences, students' skills, generic competences.*

Introduction

In the field of education the concept of taxonomy was first introduced by Bloom in his work Taxonomy of educational objectives: Handbook I, The cognitive domain (Bloom, 1956). The concept was very well accepted mainly between curriculum developers, researchers and teachers and other specialists in the field of education (Anderson & Sosniak, 1994). Besides Bloom's taxonomy, Gagnej's, Harlen's, Call's, Timss's and Biggs-Collin's taxonomies, which are very similar to Bloom's one, have launched.

Why is taxonomy so important in the process of education? The answer is simple. We do not only wonder how much students know, but also which skills they manage and when and where can they use them. It is important, how they understand gained knowledge, how they use it in novel situations and how they solve problems. The taxonomy classifies educational goals due to the level of difficulty. With taxonomies we determine the amount and quality of knowledge. The teacher forms descriptors, with which he concretes chosen taxonomy. Descriptive measures must be superior to the taxonomy. We can use different taxonomies for the same object, which depends upon goals, contents and activity (Lipovšek & Polšak, 2012).

The process of education necessitates to plan those exercises and activities, which lead to understanding and usage, or that they lead to higher mental processes. Different classifications

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PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 72, 2016

of taxonomic knowledge definitely help us. Taxonomies bring in the educational process order and hierarchy. They are a principle at assembling activities. We can check different levels of knowledge with them.

Bloom's taxonomy of goals of education in Slovenia has influenced on curricular development and verification of knowledge for decades. Some critics have also been said per it. Justin (the leader of the centre for international comparative researches of knowledge at Pedagogical institute Ljubljana) says that professional texts and even official school documents often deform taxonomy. The original version of Bloom's taxonomy is also controversial. Authors of taxonomy are leaning towards the principle of students' autonomy, however this principle refers to their explanations only on psychological dimension of learning. Bloom's group equated knowledge with information, although simultaneous epistemic theories claimed almost commonly that knowledge consists of concepts. Therefore, taxonomy does not consider the fact that all knowledge is perspectival (Justin, 2008).

Marjanovič Umek (2008) finds out that teachers just copy taxonomic rates into the criteria for assessment for several times.

Wintertn connects taxonomies and skills. He says that in the process of development of European taxonomy of skills, competences, qualifications and professions occurs a frame, which will allow surpassing of sectoral and national specialties, but at the same time it will harmonize the fields of education and work. Taxonomy has to be suitably theoretically supported and simple for practical use (Winterton, 2011).

The European Commission, which is developing a new European taxonomy of skills, competences and profession, which will be describing the most relevant skills, competences and qualifications for several thousand professions (European Skills, Competences and Occupations taxonomy – ESCO), is also giving a big emphasis on developing skills.

It is typical for all taxonomies that authors divided them in three fields: cognitive or epistemic, psychomotor and affective, emotional field. Fields are being interwoven between themselves and they are not able to insulate. For example; when a student is making a product, he must have certain knowledge about material and its characteristics. He also has to control handling with tools, devices and machines. He is also expressing feelings of fear, joy, and gladness on completed product. Therefore all three fields are intervolving. All taxonomies are arranging levels hierarchically, from simplest to most complex. Every higher level demands containment of lower. This level of usage is the indicator if the students have assimilated certain knowledge and also understood it. This is the level to which every teacher should »lead« every student (if we speak about competent student), regardless of his abilities.

It has been found out that it is very difficult to use only one taxonomy, which would make that possible for us. With a research there was invented a combination between Bloom's taxonomy, which covers cognitive and affective field and the R. H. Dave, E. Simpson in A. Harrow taxonomy, which covers psychomotor field and it is named Unified Taxonomy of Competences (Table 1).

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 72, 2016

Table 1. Unified Taxonomy of Competences (Pešaković, 2014).

UNIFIED TAXONOMY OF COMPETENCES

BLOOM'S TAXONOMY FOR COGNITIVE FIELD
+
BLOOM'S TAXONOMY FOR AFFECTIVE FIELD (Bloom, Krathwohl and Masia)
+
TAXONOMY FOR PSYCHOMOTOR FIELD – Dave
+
TAXONOMY FOR PSYCHOMOTOR FIELD– Simpson

=

Level	Lower level		Higher level	
COGNITIVE	memorization, understanding,, use		analysing, evaluating, creating	
AFFECTIVE	accepting of stimuli and initiatives		characterizing of values, conscious belief and behaviour	
PSYCHOMOTOR	Dave: imitation, manipulating and accuracy	Simpson: perception, preparing, guided response, mechanism and complete open response	Dave: pronounciation, naturalisation	Simpson: adaptation, development and realisation of new activity

UNIFIED TAXONOMY OF COMPETENCES	
Lower level	**Higher level**
1. PERCEEPTION AND IMITATION of shown **2. PREPARATION AND GUIDED ACCURATE RESPONSE** at which cognitive activities are being exposed, like knowledge, understanding, use and cooperative learning	**3. ADAPTATION AND DEVELOPMENT OF NEW ACTIVITY** (upgrading shown activities independently, improving them) **4. ANALYSING AND EVALUATION OF SHOWN ACTIVITIES** **5. CREATION OF NEW ACTIVITY**

Skills on a lower level are based on students' repetition of shown skill from teacher's side. At the higher level students have to besides repetition of shown execution of skills, also upgrade them independently. In the research it was starting from Unified Taxonomy of Competences. On the base of Unified Taxonomy of Competences there were defined lower and higher taxonomic levels as an intersection of all three fields, so: cognitive, affective and psychomotor field.

The competent conceived taxonomic levels were defined as:

- lower: detection of shown and imitation of a teacher, preparation and leading accurate response, at which cognitive activities like knowledge, understanding, use and cooperative learning are being emphasized and
- higher: adaptation and development of new activity (shown activities to be independently upgraded, improved), which are exposing the need to analyse and evaluate shown activities and on the base of that making new activities. It is obligatory to consider suitable values at this.

In the analysis the intentness was mostly on the subject Technique and Technology, at which the skills are even more important and should be a part of an assessment. Table was upgraded with criteria and descriptors, which allow developing and evaluating certain competences – skills in all taxonomic fields (in cognitive, affective and psychomotor field). Unified Taxonomy of Competences at the lower and higher competence taxonomic level was the base for empirical research.

The empirical research was conducted in order to upgrade the process of evaluation of pupil's skills, which can be measured with direct observation and by the use of paraphernalia,

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 72, 2016

which was developed during the work. This allows verification and transfer of the results also in the other fields of education, in which student's skills are important and are a part of evaluation. With developed paraphernalia student's skills were evaluated and verified on the level of lower and higher cognitive and psychomotor goals. Paraphernalia and developed methodologies of measurements are allowing optimal implementation of the learning process – on this way the developed student's skills in a relation to the choice of educational work can be verified – for example, problem based approach and project way of work, which highly enable the development of student's skills. By verification the differences in the level of maintaining of certain student's skills between experimental and control group were being established.

Methodology of Research

General Background of Research

Experimental procedure was used, single factor experiment with departments as comparative groups was made. The emphasis was on direct observation of a students at execution of a certain task, so on the observation of students' skills. Triangulation was used for observation of the process and verification of achieving skills in the research.

With a pre-test, direct skill observation, there was found out in the experimental and control group an initial condition of certain skill on the lower and higher-order taxonomic level. In the experimental group four didactic approaches in the didactic procedure were used: project work, experiment, technical analysis and research approach. The training and demonstration of a certain skill was made. Students were practicing and drilling skills during didactic procedure. Classical lesson went on in the control group, where frontal method and methods like conversation, demonstration and work with a text were prevailing. There was no training for a certain skill.

At the end of the didactic procedure there was a post-test, direct observation, with which in the control and experimental group the final condition was found out, which consisted of:

- skills on lower level taxonomic level and
- skills on higher taxonomic level.

With comparison of pre-test and post-test we were finding:

- progress within skills on lower taxonomic level,
- progress within skills on higher taxonomic level,
- progress within skills depending from didactic approach.

Sample of Research

The research was held in the school year 2012/2013. 35 grade 6 students were included, aged from 10 to 11 years. They were distributed randomly in experimental (17 students) and control group (18 students). It was held from October to December 2012, altogether 14 lessons. 6 lessons were carried on as a Natural history day. The leading didactic approach was project work, where students with experiment, research approach and technical analysis went through paper materials and made a product.

Instrument and Procedures

The experiment was held in a classroom. The same teacher had a lesson for both groups, students' skills were evaluated by a supervisor from technical field. The observer has first checked managing of skills on lower and higher taxonomic level with a pre-test on every student. A student has shown how he would carry out certain skills. The observer enclosed the level of

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 72, 2016

managing of skills on the observation sheet. In the following didactic procedure the teacher made demonstration of a certain skill, which students practiced and drilled through guided didactic process. Then the after-test and finding out about managing skills after didactic process followed. The observer enclosed the rate of managing of a certain skill on lower and higher taxonomic level. The work in experimental group was a project and it contained a problem and a research lesson, experiment and technical analysis. Students trained and drilled certain skills before evaluating. In the control group the lesson went on traditionally, frontal, it was based on teacher's explanation and work with a text. There was no training of a certain skill.

For observing student's skills the metric instrument (observation sheet) was made. Because of higher reliability of measuring the triangulation has been used, since three subjects were included: the teacher, a student and a specialist from technical-didactic field.

Observation sheet (Table 2) was meant for direct observation of student's skills at executing certain skill. In the address part the name of generic competence is written. Then follows a definition of observed skill and the manner, how this skill is observed and on what they should pay attention. Containment of certain skill has been observed and assessed on lower and higher-order taxonomic level. Descriptors are written in a way that they can adapt to individual physical and thematic field. An observer enclosed the rate of containment of skill, where 1 meant that he does not manage, 3 that he partially manages, 5 that he manages a certain skill.

Table 2. Example of criteria with descriptors for observing student's skills.

	Generic competence**: THE ABILITY OF GAINING INFORMATION**	
	SKILLS: - **searching for information in bases, web pages, books, manuals, encyclopedias and so on**	
	HOW? ***Observation of individual student's skills and enclosing the rate of its managing*** We pay attention on the choice of source and the way of searching for information.	
	DESCRIPTORS	RATE OF MANAGING CRITERIA
LOWER LEVEL →	Student searches for information on already shown way.	**1 3 5**
→	Student searches for information only in one source.	**1 3 5**
HIGHER LEVEL →	Student searches for information on several ways.	**1 3 5**
→	Student searches for information on various sources.	**1 3 5**
		1 = does not manage 3 = partially manages 5 = manages

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 72, 2016

The data was computationally treated with the program for statistical data processing SPSS, on the level of descriptive and inferential statistics. On the level of descriptive statistics the following procedures were used:

- frequency distributions (f, f %) of descriptive variables (gender and final score),
- measures of middle values, measures of variation and measures of correlation,
- index of difficulty (p %).

On the level of inferential statistics the following procedures were used:

- χ2-test of hypothesis of independence (skills considering gender and final score at natural science and technique),
- t-test for independent samples of verification of differences in skills on lower and higher taxonomic level according to student's gender and group,
- t-test for dependent samples of verification of differences of initial and final condition at skills on lower and higher taxonomic level according to gender and group,
- the variance analysis for verification of differences in skills on lower and higher taxonomic level according to final score at subject Natural science and Technique.

The observation sheet was created by the help of science teachers and an expert from didactic field. With this the validity of an instrument was assured. The observation sheet was used twice before the research and the same results were gained. It can be assumed that the instrument is reliable. Objectivity has been provided so that the teacher and the observer did not affect on the implementation of the procedure, which was performed by the student. The sensibility was ensured with the inclusion of student's activities on the lower and higher taxonomic level.

Results of Research

Natural science and Technique is a subject in the fifth grade of primary school, where the contents of natural science and technique are interweaving. The difference between gender and final score at subject Natural science and Technique was being found out (between both groups). The highest final score was 5 (excellent), the lowest was 3 (good). Grades excellent and very good were arranged in so called higher final score, grade good to lower final score.

Table 3. Frequencies and structural percentages of students according to gender and group.

		Experimental		Control		Total	
		f	%	f	%	f	%
Students' gender	Male	11	64.7	12	66.7	23	65.7
	Female	6	35.3	6	33.3	12	34.3
Total		17	100.0	18	100.0	35	100.0
$\chi^2 = 0.015$ p = 0.903							

It has been found out that there is no statistically important difference between experimental and control group between genders ($\chi^2 = 0.015$, p = 0.903), which presents Table 3. Furthermore, it also was not at final score, since the average assessment of experimental

group is 4.11, and control group 4,00 ($\chi^2 = 0.23$, $p = 0.891$), which is presented more in detail in Table 4. Derived from this, both groups are equalized enough from this point of view.

Tabel 4. Frequencies (f) and structural percentages (f %) of grade 6 students according to gender, final score and group.

Student's gender			Experimental		Control		Total	
			f	%	f	%	f	%
Male	Final score	Good	5	45.5	5	41.7	10	43.5
		Very good	5	45.5	5	41.7	10	43.5
		Excellent	1	9.1	2	16.7	3	13.0
	Total		11	100.0	12	100.0	23	100.0
Female	Final score	Good	0	0.0	1	16.7	1	8.3
		Very good	0	0.0	1	16.7	1	8.3
		Excellent	6	100.0	4	66.7	10	83.3
	Total		6	100.0	6	100.0	12	100.0
Total	Final score	Good	5	29.4	6	33.3	11	31.4
		Very good	5	29.4	6	33.3	11	31.4
		Excellent	7	41.2	6	33.3	13	37.1
	Total		17	100.0	18	100.0	35	100.0
$\chi^2 = 0.23$	$p = 0.891$							

The difference between pre- and post- test (progress) in containment of a certain skill on lower and higher taxonomic level, according to student's gender, presents Figure 1.

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 72, 2016

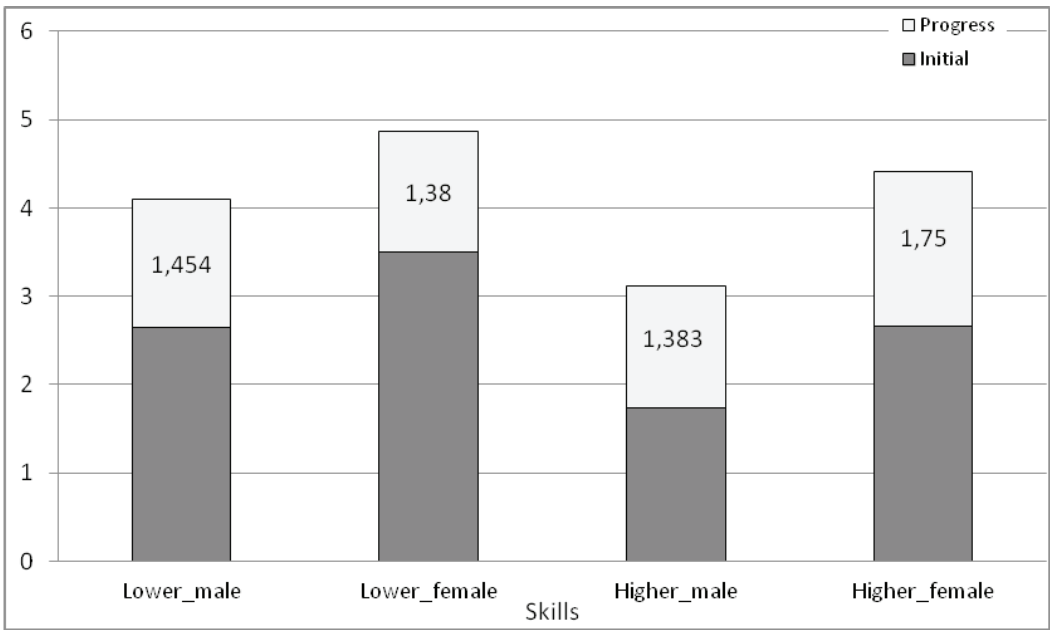

Figure 1: Initial condition and progress at containment of skills on lower and higher taxonomic level, before the experiment and after it – according to student's gender in experimental group.

The test of the difference of mean scores indicated that there exists statistically characteristic difference ($p < .005$) at males and females within final and initial condition in containment of skills on lower and higher-order taxonomic level. The results of the test of differences between initial and final containment of certain skills on lower and higher taxonomic levels according to student's gender, showed the following:

- On the lower taxonomic level is a greater difference within containment of skills between initial and final condition with males. The hypothesis that males on lower taxonomic level will achieve greater difference between initial and final condition, was confirmed.
- On the higher taxonomic level is a greater difference within containment of skills between initial and final condition with females. The hypothesis that females on higher taxonomic level will achieve greater difference between initial and final condition, was confirmed.

The difference within containment of skills at pre- and post-test, according to summative assessment, presents Figure 2.

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 72, 2016

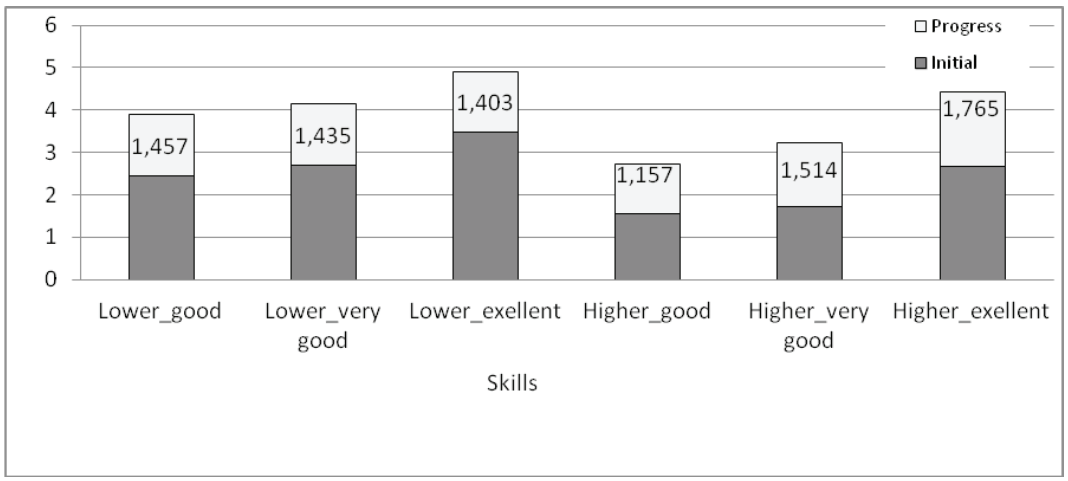

Figure 2: Initial condition and progress at containment of skills on lower and higher taxonomic level according to final score at subject natural science and technique.

The test of difference of arithmetic means indicated that there is a difference between pre- and post- test within containment of skills on lower and higher taxonomic level, it is statistically characterized difference ($p < .05$). The results of the test of difference between pre- and post-test of certain skills on lower and higher taxonomic level, according to final score, showed the following:

- On the lower taxonomic level the biggest difference is within containment of skills between pre- and post-test at students with final score good. Therefore, the hypothesis that on the lower taxonomic level students with higher final score (excellent) will achieve greater difference between pre- and post-test than students with lower final score (good), was disproved.
- On higher taxonomic level is the biggest difference within containment of skills between pre- and post-test at students with final score excellent. The hypothesis that on higher taxonomic level students with higher final score (excellent) will achieve greater difference between pre- and post-test than students with lower final score (good), was confirmed.
- On both taxonomic levels (together) is the biggest difference within containment of skills between pre- and post-test at students with higher final score (excellent). The hypothesis that on higher taxonomic level students with higher final score (excellent) will achieve greater difference between pre- and post-test than students with lower final score (good), was confirmed.

The test of difference of mean scores indicated that there is a difference between pre- and post-test within containment of skills on lower and higher-order taxonomic level, it is statistically characterized difference ($p < .05$). The results of the test of difference between pre- and post-test of certain skills on lower and higher taxonomic level, according to group, showed the following:

- On the lower taxonomic level the difference within containment of skills between pre- and post-test exists. Therefore, the hypothesis that students in experimental group on the lower taxonomic level will achieve greater difference between pre- and post-test than students in control group, was approved.
- Also on higher taxonomic level the difference within containment of skills between pre- and post-test of students according to group exists. The hypothesis that students

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 72, 2016

in the experimental group on higher taxonomic level will achieve greater difference between pre- and post-test than students in control group, was confirmed.

- On lower and higher taxonomic level there is a difference within containment of skills between pre- and post-test according to the group. The hypothesis that students in the experimental group on lower and higher taxonomic level will achieve greater difference between initial and final condition than students in control group, was confirmed.

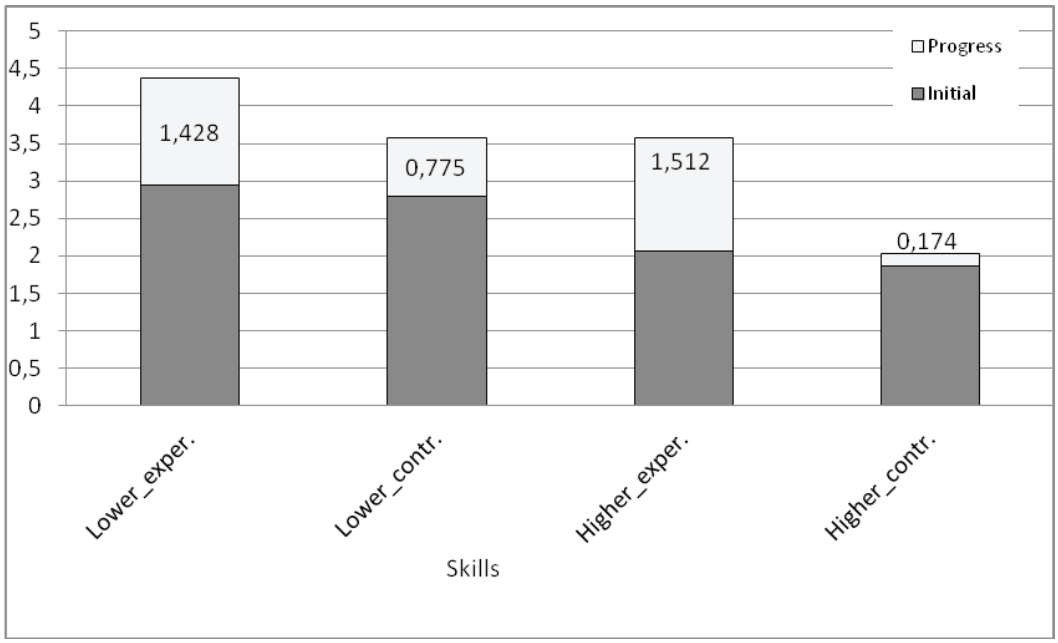

Figure 3: The difference within containment of skills on both taxonomic levels together before the experiment and after it – according to the group.

Discussion

The progress in containment of skills on both taxonomic levels together depends on student's gender. Males achieve greater progress in containment of skills on lower-order taxonomic level than females. Additional attention needs to be put in the development of skills with males on higher-order taxonomic level, mainly on the field of communication skills, where males achieved much lower progress than females.

The progress in containment of skills on both taxonomic levels together also depends on final score at subject Natural science and Technique in the fifth grade. Students with higher final score achieve greater progress in containment of skills on lower and higher-order taxonomic level than students with lower final score. Those students achieved greater progress in containment of skills on lower-order taxonomic level. Therefore, it is necessary to pay more attention to those students at developing skills on higher-order taxonomic level. Differences in progress in containment of skills on both taxonomic levels together are also between experimental and control groups. Project work is making greater development of skills on lower and higher-order taxonomic level possible, as traditional lesson is allowing it.

It was confirmed that with the project work, which is based on problem and research lesson (student – centred) achieves greater progress in developing student's skills than frontal work (teacher-centred). On all fields of developing skills, middle and high effect was achieved.

It is very important for a teacher that he plans his work in the class very well, since only then he can achieve desired progress with students (Cohen, 1988).

Conclusions

The research has some advantages. It was carried out in the class with randomly chosen students and next to the presence of experts from technical and educationally – didactic field. Made paraphernalia allowed verification of pre-containment of skills on both taxonomic levels, verification of post-condition and pursuit of progress at containment of skills on both taxonomic levels. Positive advantages of described research were shown:

- in designing of lower and higher-order taxonomic level of competences Unified Taxonomy of Competences, as a combination of three taxonomies (Bloom's, Dave's and Simpson's) on three fields, on cognitive, affective and psychomotor;
- in making of paraphernalia, which makes possible to verify skills on lower and higher-order taxonomic level, not only on technical, but also on other fields;
- in raising awareness of professional public – mostly primary school teachers, that developing and verifying of student's skills is urgent for an acquisition of competent qualified students, that will know when, where and which knowledge to use at a working place or in everyday situations.

The findings of the research can encourage Technique and Technology teachers that they could use substantively unallocated lessons in class for entering contemporary teaching methods of teaching and verifying in primary school lessons of Technique, with the emphasis on development on student skills and assimilating of suitable competences. It was proved with scientific method that this is the right way of teaching, therefore we wish that such teaching would be more intensely present at primary schools.

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PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
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100

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