The New Educational Review

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On Forming Key Competences within the ICT-supported Instruction in Higher Education

Abstract

The paper presents research results of the two-year pedagogical experiment comparing test scores in three subjects (Database Systems, Management, IT English) taught either in the ICT-supported way, or in the traditional face-to-face way at the Faculty of Informatics and Management, University of Hradec Kralove, Czech Republic. The main research objective was to find out whether ICT contribute to increasing learners' knowledge and consequently to forming key competences. Didactic tests as the main tool were used within the pedagogical experiment which followed the "pre-test – instruction – post-test – post-test2" structure. The research sample included 687 respondents. Obtained results proved there were no statistically significant differences in learners' knowledge in both approaches to instruction. The results were discussed from two important points of view: (1) teachers' and learners' ability to use the potential of ICT in teaching/learning and (2) the role of teaching/learning styles in the ICT-supported instruction.

Keywords: *ICT, key competences, online courses, e-learning, learning styles, Database Systems, Management, IT English*

Introduction

Modern information and communication technologies (ICT) have penetrated society, including the field of education. They have become its inseparable part, which brought crucial changes and produced substantial consequences. Social and political development in the Czech Republic in the last two decades has evoked numerous changes in the education system. General development towards democracy and information and knowledge society has transformed the existing structure of the education system, defined new competences reflected in the learning content, called for new teaching methods, organizational forms and other didactic means. These features are slowly but steadily being included in the new education system, which is hardly to be imagined without the implementation of modern technologies (Šimonová et al, 2011; Baron-Polańczyk, 2008).

Resulting from the above-mentioned, the research was carried out at the Faculty of Informatics and Management (FIM) University of Hradec Kralove (UHK), Czech Republic, dealing with the question whether ICT contribute to the process of instruction, as expected by their supporters and rejected by the opponents.

Research Design

The research focused on the impact of the ICT-supported instruction on the increase in students' knowledge. The main objective was to compare the level of students' knowledge developed within the ICT-supported way of instruction with the traditional face-to-face instruction and find out whether the ICT contribute to increasing learners' knowledge, thus forming key competences.

Research Hypotheses

Resulting from the research problem, the main hypothesis was stated as follows:
H: Students reach a higher level of knowledge in the ICT-supported instruction in comparison to the face-to-face way.

The research was held in three subjects – Database Systems (DS), Management (M) and IT English (IT E), so the main hypothesis was divided into three partial ones:

H1/H2/H3: Students of FIM UHK reach a higher level of knowledge in the ICT-supported way of instruction in comparison to the face-to-face way in the subject of Database Systems/Management/IT English.

Research Method and Tools

The main research method was a pedagogical experiment. Two educational strategies were applied – the process of instruction was organized either in the ICT-supported way (i.e. in online courses) in experimental groups, or in the face-to-face way (i.e. by attending face-to-face lessons where ICT were not used) in control groups. Finally, data (i.e. test scores) were collected and statistically processed, obtained results interpreted and discussed.

Didactic tests as the main tool were used within the pedagogical experiment running in three above-mentioned subjects, following the "pre-test – instruction – post-test – post-test2" structure. The entrance level of learners' knowledge was detected by the pre-tests in each subject, the final knowledge was tested by post-tests and after a three-month period the retention post-tests2 were applied to evaluate the learners' knowledge after the given period. The tasks were defined on Niemierko's Taxonomy (1979) in Database Systems, on Tollingerova's taxonomy (Tollingerova et al., 1986) in Management and revised version of Bloom's taxonomy of educational objectives (Anderson et al., 2001) in IT English. The didactic tests were piloted, the results and possible changes were discussed within the IT, Management and Applied Linguistics departments; then the tests were adjusted to the requirements and re-piloted. Task characteristics were calculated for each item covering the difficulty, Upper-lower Index, Tetrachoric Coefficient, Point Biserial Coefficient. Test reliability was set by the Kuder-Richardson formula. Calculated values and numbers of tasks in single didactic tests are presented in Table 1. The test validity was considered by the expert groups consisting of academic staff of the related departments of FIM UHK; all the tests were recognized reliable and valid.

Table 1. Didactic tests: tasks and reliability

	Pre-test		Post-test		Post-test2	
	tasks	reliability	tasks	reliability	tasks	reliability
Database Systems	7	0.77	15	0.8	15	0.8
Management	8	0.72	12	0.75	12	0.75
IT English	32	0.85	32	0.85	32	0.85

The collected data were processed by the NCSS2007 statistic software. The hypotheses were verified by two tests: the parametric equal variance t-test for the normal data distribution and the Mann-Whitney test for difference in medians (Z-value).

Research Sample

The research sample included students of Bachelor's study programme of Applied Informatics and Master's study programme of Information Management who enrolled on the subjects Database Systems, Management and IT English in the 2009/10 and 2010/11 academic years. All the subjects included in the research belong to the compulsory ones taught in the first year (Management and IT English) and in the second year (Database Systems) of study. The experimental and control groups were formed by a random choice (i.e. following learners' schedule preferences).

A total of 772 respondents were included in the research sample at the beginning of the experiment, 687 of them went through the whole experiment.

Process of Instruction

In the experimental groups the process of instruction was organized in the ICT-supported way, i.e. after the starting tutorial at the beginning of the term the students acquired the learning content from online courses for each subject. The courses were organized in the virtual learning environment (VLE WebCT), which had been designed specially for the educational purposes, i.e. it provided all tools required for running the process efficiently. All the courses underwent university accreditation before being used first.

In the control groups, the students attended face-to-face classes managed by teachers, where no ICT were implemented in the process of instruction. They worked with textbooks (which included text recordings in IT English).

The pedagogical experiment was held within one semester, i.e. a three-month period. The identical learning content was provided to the experimental and control group participants in each subject. The tools used in single groups are listed in Table 2.

Table 2. Tools implemented in the process of instruction.

Experimental group	**Control group**
Study materials	
• full texts structured for distance learning • presentations • animations • video-recorded lectures (in Database systems only)	• textbook/s
Tests	
• relating to each topic: online tests with immediate feedback – self-tests (to verify whether the student understands the topic, results available to the learner) – tests (to verify whether the student understands the topic, results available to the student and tutor) • credit test: face-to face	• relating to each topic: – printed version, feedback provided by teacher within the following class – oral questions during/after the class, immediate feedback provided by teacher • credit test: face-to-face

Experimental group	Control group
Assignments	
• submitted online, evaluated by tutor, feedback provided online	• submitted face-to-face, evaluated by teacher, feedback provided face-to-face within the following class or office hours
Communication: Discussions	
• online in VLE (asynchronous)	• face-to-face in class and office hours
• Skype (synchronous, in pre-defined hours)	
Communication: E-mail	
• for both educational (feedback, discussions …) and other purposes	• not for educational purposes (e.g. for excuses from lectures, etc.)

Attendance of face-to-face classes was compulsory in the control groups and was monitored (one absence was accepted; 94% of the students were present in Database Systems, 97% in Management, 93% in IT English).

The person of teacher in the control groups and of tutor in the experimental groups was identical in each subject.

To prevent the impact of side effects on research results, all the participants were instructed and agreed on not using other sources than those provided to them within the experimental/control group. Above all, the control group participants did not have access to online courses.

Research Results

Below, the main statistical results are presented and the process of verification of the hypotheses is described.

The null hypotheses were set as follows:

H_{01}/ H_{02}/ H_{03}: There is no statistically significant difference in the test scores in the experimental and control groups in Database Systems / Management / IT English.

The collected data were processed by the NCSS2007 statistic software applying the t-test and Z-test. The research results presented below are structured according to the subjects – Database Systems, Management, IT English.

Research Results in Database Systems

The test results in Database Systems are displayed in Tables 3, 4 and Figures 1, 2.

Table 3. Descriptive statistics, Database Systems, year 1

	N	Mean	SD	Min	Max	Modus	Median	Norm	t	Z	H0
Pre-testC	65	1.98	2.16	0	7	0	4	N	0.0557	−0.2511	**Accepted**
Pre-testE	109	2.00	1.93	0	6	0	2	N			
Post-testC	46	11.39	2.34	6	16	10	11	N	1.2929	−1.3541	**Accepted**
Post-testE	65	11.95	2.20	8	16	14	12	N			
Post-test2C	46	14.90	2.80	6	20	14	15	N	0.5108	−0.5195	**Accepted**
Post-test2E	65	15.83	2.61	7	21	17	16	N			

Table 4. Descriptive statistics, Database Systems, year 2

	N	Mean	SD	Min	Max	Modus	Median	Norm	t	Z	H_0
Pre-testC	61	3.2	1.49	0	6	3	3	CR	−0.9936	1.1666	**Accepted**
Pre-testE	66	2.9	1.57	0	6	3	3	CR			
Post-testC	61	7.2	1.88	3	10	6	7	CR	0.5583	−0.5098	**Accepted**
Post-testE	66	7.4	1.77	3	10	9	8	CR			
Post-test2C	61	29.3	5.35	20	41	32	29	CR	0.9570	−1.0008	**Accepted**
Post-test2E	66	30.2	5.30	20	40	34	30.5	CR			

Legend: Experimental group: E; Control group: C; Number of respondents: N; Standard deviation: SD; Norm (normality test): N (normal distribution), CR (cannot reject normality), R (reject)

Figure 1. Results of pre-test, post-test and post-test2, Database Systems, year 1

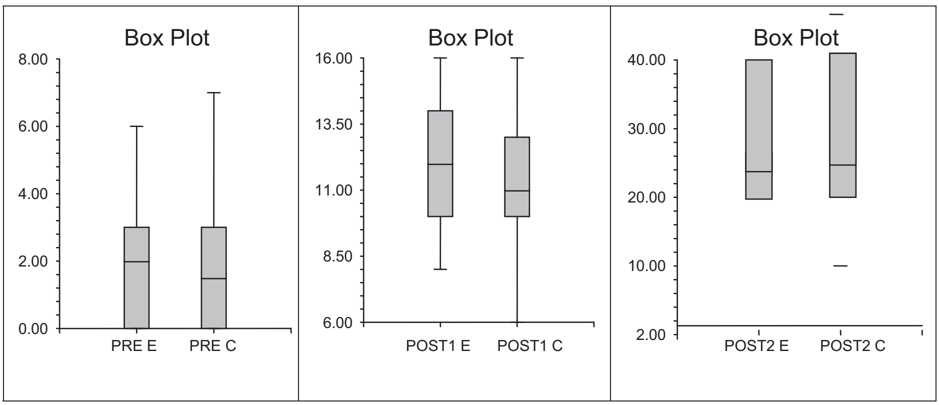
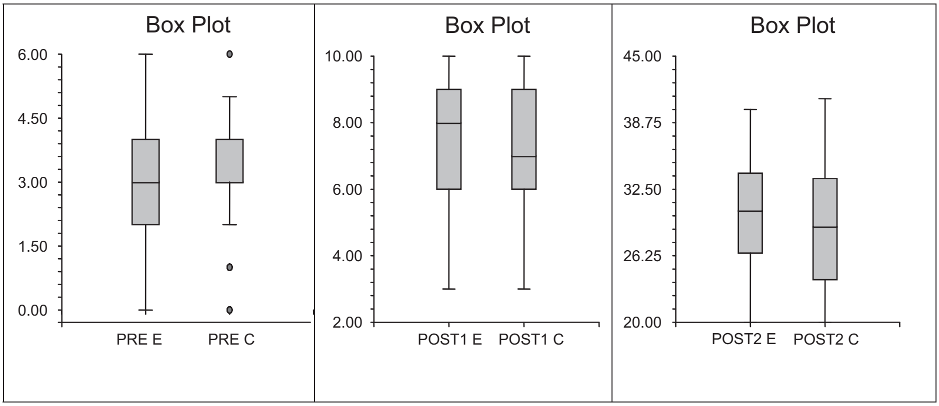


Figure 2. Results of pre-test, post-test and post-test2, Database Systems, year 2



Research Results in Management

The test results in Management are displayed in T5, 6 and Figures 3, 4.

Table 5. Descriptive statistics, Management, year 1

	N	Mean	SD	Min	Max	Modus	Median	Norm	t	Z	H0
Pre-testC	37	2.9	1.98	1	5	3	3	N	−1.2858	−1.3474	**Accepted**
Pre-testE	35	2.4	1.54	0	5	2	2	N			
Post-testC	34	9.3	2.48	3	14	10	9.5	N	−0.2314	−0.1078	**Accepted**
Post-testE	32	9.2	2.56	0	13	–	9	CR			
Post-test2C	34	9.3	2.48	3	14	10	9.5	CR	−0.2576	0.0974	**Accepted**
Post-test2E	32	9.4	2.00	4	13	–	9	CR			

Table 6. Descriptive statistics, Management, year 2.

	N	Mean	SD	Min	Max	Modus	Median	Norm	t	Z	H_0
Pre-testC	39	2.5	0.91	1	4	2	3	N	0.6438	−0.4969	**Accepted**
Pre-testE	44	2.6	1.16	0	6	2	6	N			
Post-testC	38	9.1	2.48	3	14	9	11	CR	0.2722	−0.2303	**Accepted**
Post-testE	42	9.2	2.56	4	13	9	9	N			
Post-test2C	38	9.1	2.57	3	14	9	9	N	0.0640	0.0328	**Accepted**
Post-test2E	42	9.1	2.65	4	13	8	9	N			

Figure 3. Results of pre-test, post-test and post-test2, Management, year 1

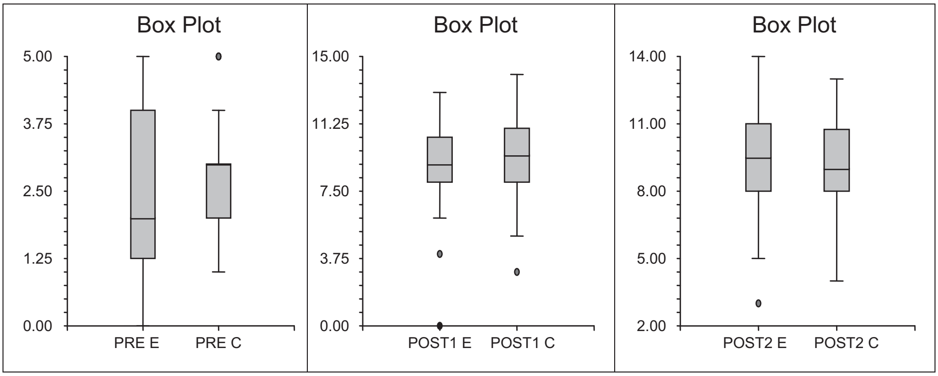
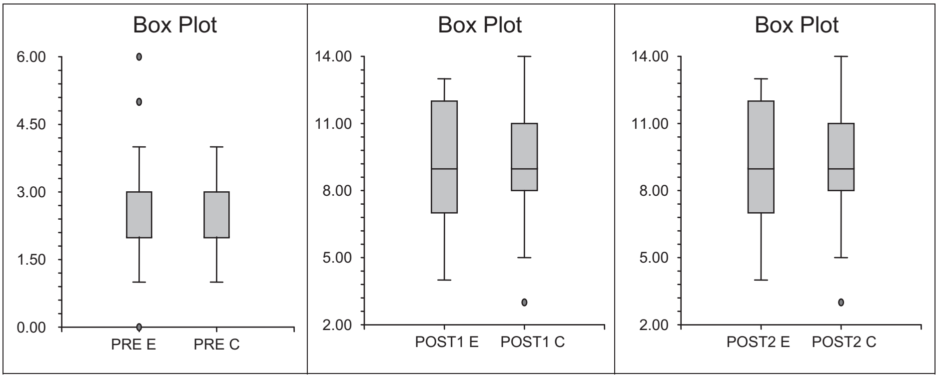


Figure 4. Results of pre-test, post-test and post-test2, Management, year 2



Research Results in IT English

The test results in IT English are displayed in Tables 7, 8 and Figures 5, 6.

Table 7. Descriptive statistics, IT English, year 1

	N	Mean	SD	Min	Max	Modus	Median	Norm	t	Z	H0
Pre-testC	66	40.3	2.5	24	57	–	40	N	−0.9553	1.4449	**Accepted**
Pre-testE	90	42.7	2.3	18	61	29	41	CR			
Post-testC	66	93.8	3.3	82	103	–	95	N	−1.2278	0.8518	**Accepted**
Post-testE	90	92.2	3.1	68	112	96	93	N			
Post-test2C	66	92.8	1.3	66	103	103	99	N	0.5929	1.2728	**Accepted**
Post-test2E	90	93.6	1.9	80	104	97	95	CR			

Table 8. Descriptive statistics, IT English, year 2

	N	Mean	SD	Min	Max	Modus	Median	Norm	t	Z	H_0
Pre-testC	66	30.2	2.7	8	71	29	29	N	0.7791	−0.8972	**Accepted**
Pre-testE	94	31.9	2.2	8	71	–	30.5	N			
Post-testC	66	91.4	2.70	68	112	96	93	N	0.1719	−0.4551	**Accepted**
Post-testE	94	91.6	3.1	68	112	96	93.5	N			
Post-test2C	63	92.6	1.4	67	108	98	95	N	0.5227	1.2374	**Accepted**
Post-test2E	84	93.3	1.3	81	105	97	94	CR			

Figure 5. Results of pre-test, post-test and post-test2, IT English, year 1

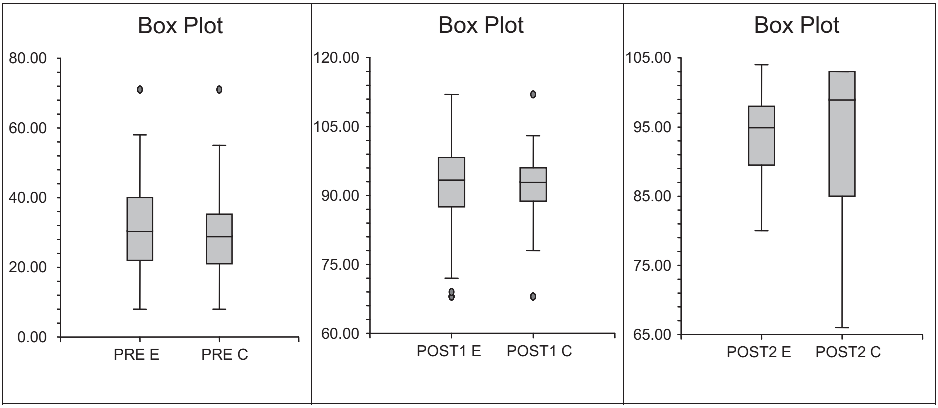
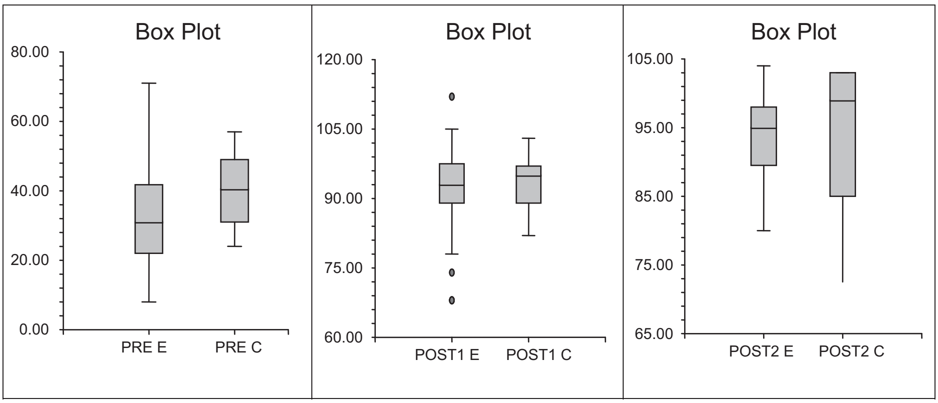


Figure 6. Results of pre-test, post-test and post-test2, IT English, year 2



As clearly seen in both Tables 3–8 and Figures 1–6, the test scores in all the three didactic tests (pre-test, post-test, post-test2) in all the three subjects (Database Systems, Management, IT English) are very close, so all the null hypotheses were confirmed. It means no statistically significant differences were discovered in the test scores. Thus, we can state that the test scores in all the experimental groups were comparable to the adequate test scores of the control groups. This result concludes that **the main hypothesis** *Students reach a higher level of knowledge in the ICT-supported instruction in comparison to the face-to-face way* **was disproved**.

Results Interpretation, Discussions and Didactic Recommendation

Despite our expectations the research results proved that students in the experimental group obtained the same test scores in the ICT-supported process of instruction in memorizing, understanding, developing new knowledge and applying it in problem situations as the students within the traditional face-to-face process of instruction. This means students reached the same level of knowledge in the ICT-supported process of instruction (i.e. teaching/learning in on-line courses within this research) as in the face-to-face instruction. In other words, teaching/learning via on-line courses does not provide a lower level of knowledge, which means that *the ICT-supported process of instruction contributes to forming and developing key competences of higher education learners in the same (comparable) degree as the face-to-face way of instruction does*. Above all, *other factors* (motivation, individual preferences, etc.) *mostly work in favour of the ICT-supported instruction*.

It should be emphasized that the process of instruction was held by qualified teachers (tutors) with special training for running the ICT-supported instruction (Kwiatkowska, 2012). The WebCT virtual learning environment is primarily designed for university (tertiary) education. It provides all tools necessary for simulating main phases of the instruction, i.e. motivation, explanation, fixation, evaluation for managing the process in such a way which provides adequate conditions for teaching/learning, and thus naturally contributes to forming and developing learners' key competences (Kostolányová, 2012). Some preconditions are required before the process starts, the crucial question is whether both teachers and students are able to realize what the potential of modern technologies is and to use it within the process of teaching/learning. Having undergone the starting period of hesitation, material and technical problems, it is high time we dealt with didactic aspects of ICT implementation into teaching/learning; and following questions should be answered.

First, are teachers really competent to apply suitable methods and forms of instruction, create and use appropriate didactic means which are offered by new technologies?

Second, are the new didactic means able to optimize the cognitive process of creating knowledge? Despite the expected answers being yes to both questions, this does not mean all students are able to reach better knowledge if new didactic means are applied.

Third, does the ICT-supported process of instruction meet individual learning preferences of each learner?

Experience of learners, tutors and designers re-started discussions on the role of learning/teaching styles under the conditions of the ICT-supported process of instruction. A qualified tutor and well-designed LMS, both meeting didactic requirements, provide such a learning environment which accommodates all learning style requirements and preferences. In 2000, Honey was a pioneer among those who researched the existence or non-existence of e-learning styles (Honey et al., 2000). He applied a questionnaire to 242 respondents of various learning preferences, who reacted to a long list of potential likes and dislikes about e-learning. The survey did not reveal significant differences, as Honey had expected, but it seemed unlikely to him that, e.g., learning 'at my own pace' and 'when and for how long' would have the same meaning for learners of different preferences. 'One size fits all' has never worked for clothes. Why should it for e-learning?' Honey concluded (2010, 2).

Following Honey's results, other researchers have been dealing with this topic (e.g., Coffield, 2004, Felder, 2010). In the Czech Republic, the Faculty of Education, University of Ostrava and Faculty of Informatics, University of Hradec Kralove have been focusing on this research field and have reached partial outcomes (Kostolányová, 2012; Šimonová, Poulová, 2012). Despite the fact that the research concepts of both teams arose from different concepts, future research activities and problems are planned to be solved in co-operation. Currently, the main research question is targeted on the role of IT literacy of university students, i.e. whether the higher level of IT competence results in higher level of learners' knowledge in the ICT-supported process of instruction and what the impact is of learner's preference for certain e-study materials and e-learning activities on the process of developing key competences (Cejudo, M.C.L., Almenara, J.C., 2013; Šimonová et al. 2011).

Conclusions

Current orientation of university education, which is changing under the influence of latest technology development and new key competences, can be researched from various points of view. The ICT-supported instruction has been spreading because of the growing popularity of modern technologies in general. Another reason is that this approach enables easier and more complex realization of the instructional process, offers a choice of place, time and pace for studying, allows for an individual approach to students preferring different learning styles. These are the key values important for the efficiency of the process. Material and technical requirements having been satisfied, attention should be paid to the didactic aspects of the instructional process. Generally, motivation and engagement of both the learners and teachers within the process of learning and teaching may influence all the processes and have a strong impact on the research findings.

In spite of the fact that almost all universities/faculties proclaim their support for the process of ICT implementation into education, the real situation differs substantially. Providing study materials and additional sources to the students, often in the form of pdf files and URL only, cannot be considered the learning process under any conditions. The term of e-learning consists of two inseparable parts where the *e-* means the ICT support to the process of *learning*, and neither of them can be omitted. However, as clear as this idea seems to be, there are still numerous (university) teachers who do not accept it in practice. That is the main reason why the problem of ICT implementation in education is still currently topical and continuous research activities are highly required.

From the above-presented it can be seen that it is important for students in the ICT-supported process of instruction to be aware of their learning styles, to know what their strengths and weaknesses are and to be provided with a variety of instructional methods to choose from. In the days of fast technical and technological development, globalization, demand for lifelong education, the importance of education is increasing and teachers' and students' awareness of learning styles may substantially contribute to the efficiency of the process (del Carmen Llorente Cejudo & Cabero Almenara, 2013). A wide database of e-activities and communication tools was provided by Churches (2010) in the form of Bloom's Digital Taxonomy of educational objectives. Being based of the original structure of six levels, the author lists numerous activities from lower to higher levels where every student of any learning style can accommodate his/her preferences and which can be applied to any learning content.

"If teachers are provided with modern technologies only- it does not change the situation much, but it can start new activities and approaches. Bringing computers to schools is less important than providing teachers with new ideas. Technologies do not aim at removing traditional educational methods and forms. The new technologies do not automatically bring positive changes into the process of instruction but they may contribute to increasing its effectiveness, under some conditions", Venezky and Davis stated (2002). Above all, as we propose reflecting our research results, tailoring the process of instruction to learners' preferences by using modern technologies should enable learners to reach the comparable level of knowledge in the ICT-supported process of instruction/learning and use other confirmed advantages of this approach.

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References

Anderson, L.W. et al. (2001). *A taxonomy for learning, teaching and assessing of educational objectives*. New York: Longman.

Baron-Polańczyk, E. (2008). Factors Differentiating the Information and Communication Technology Competences and Teachers' Activities Concerning the Design and Application of Multimedia Teaching Materials- Research Report. *The New Educational Review*, 16 (3/4), 21–34.

Bloom, B.S. (1956). *The taxonomy of educational objectives. The classification of educational goals. Handbook I: Cognitive domain*. New York: David Mc Key Company.

Cejudo, M.C.L. & Almenara, J.C. (2013). Blended learning: Attitudes, Satisfaction, Academic performance and online communication in processes of university training. *The New Educational Review*, 31 (1), 28–40.

Coffield, F. (2004). Learning styles and pedagogy in post-16 learning. *A systematic and critical review, Newcatle University report on learning styles*, Retrieved 01/10/2012, from http://www.lsda.org.uk/files/PDF/1543.pdf

del Carmen Llorente Cejudo, M. & Almenara, J.C. (2013). Blended Learning: Attitudes, Satisfaction, Academic Performance and Online Communication in Processes of University Training. *The New Educational Review*, 31 (1), 28–39.

Felder, F.M. (2010). Are learning styles invalid? (Hint: No!) On-Course Newsletter, September 27, 2010, Retrieved 19/10/2013, from http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/LS_Validity (On-Course).pdf

Churches, A. (2010). *Bloom's Digital Taxonomy.* Retrieved 12/10/2012, from http://edorigami.wikispaces.com/Bloom%27s+Digital+Taxonomy

Kostolányová, K. (2012). *Teorie adaptivního e-learningu*. Ostrava: Ostravská univerzita.

Kwiatkowska, W. (2012). E-learning in Academic Teaching- Research Report. *The New Educational Review*, 28 (2), 84–93.

Niemierko, B. (1979). Taksonomia celów wychowania. *Kwartalnik pedagogiczny*, 24 (2), 67–78.

Šimonová, I. et al. (2011). *Klíčové kompetence a jejich reflexe v terciárním e-vzdělávání*. Hradec Králové: WAMAK.

Šimonová, I. & Poulová, P. (2012). *Learning styles reflection within tertiary e-education*. Hradec Králové: WAMAK.

Tollingerová, D. et al. (1986). *K teorii učebních činností*. Praha: SPN.

Venezky, R.L. & Davis, C. (2002). Quo vademus?: the transformation of schooling in a networked world: (case study report), *OECD/CERI version 8c*. Retrieved 07/05/2011, from http://www.oecd.org