New Technologies in Science Education

the monograph edited by:
Małgorzata Nodzyńska, Paweł Cieśla, Katarzyna Różowicz

New Technologies in Science Education

the monograph edited by:
Małgorzata Nodzyńska, Paweł Cieśla, Katarzyna Różowicz

PEADAGOGICAL UNIVERSITY OF KRAKÓW
KRAKÓW 2014

The monograph is edited by:
Małgorzata Nodzyńska, Paweł Cieśla, Katarzyna Różowicz

Rewievers

Cover:
Paweł Cieśla

ISBN 978-83-7271-879-2

Introduction

One of the basic research interest of science didactics is searching for changes in the scientific environment and surrounding word as well and their transformation and application into the teaching and learning process. At present we observe an exponential growth in HI-tech world that leads to the developement of new technologies. The term new technologies in educational context is very wide. It can be understood as:

application of modern research tools and techniques in the research from the border of psychology, pedagogy and neurology such as neurodidactical approach in cognition of receivng information by pupils;

new approach to distant learning with the developement of the new software that can be used and the developement of new contents for asynchronous teaching and learning;

the developement of blended learning;

application of new computer-assisted miniaturised and portable laboratory equipement in teaching;

the developement of virtual laboratories;

computer assisted traditional teaching in the classroom.

We use also the term new technologies as a synonym of basic information and communication technologies because they are still not so popular and widely used in teaching and learning as they should be despite they are realy not new and are well known.

This monograph tries to combine all the approaches and we hope that the reader will find something inspiring for the future scientific work.

Małgorzata Nodzyńska, Paweł Cieśla

Neurodidactical Approach to Research on Science Education

Roman Rosiek, Mirosława Ewa Sajka

Introduction

Dynamic development of new technologies such as information technology, electronics and their application in the field of education, has allowed a significant improvement in the process of teaching and learning, making student-teacher and student-lecturer communication much more interactive. The lecturer is provided with almost instantaneous feedback, and opportunity to gain more information about the students' level of perception, motivation and emotions in near real time, throughout the lesson or lecture.

Electronic systems supporting teaching are becoming increasingly popular, with more and more being used in university teaching as well as at the high school and junior high school level.

In this paper, we present the use of eye-tracking studies involving the monitoring of parameters such as PPG, EDA, EEG, HRV, Respiration, Temperature, EMG during the teaching process. We introduce research techniques used by our team – the Interdisciplinary Research Group of Cognitive Didactics working at the Pedagogical University in Cracow.

A Review of Neurodidactical Noninvasive Methods

We have undertaken research on didactics of science with the use of psychophysiological methods. They are based on noninvasive neurodidactical methods to monitor students' behavior while solving the tasks. In our research, we try to take into account the interdependence between emotions, or ways of behaving, and the functioning of brain or cardiovascular or respiratory system, by recording and analyzing the obtained parameters.

Electroencephalography (EEG)

The activity of nerve cells and the transmission of information are associated with generating electric potentials of the order in brain waves (in millivolts). However, we are able to record the average values of much smaller amplitudes from the surface of the head (in microvolts) because of the presence of other tissues (cell layers), bones of the skull as well as the scalp. We are also able to record the electrical activity of the brain, despite such small values of signal amplitudes,. The time analysis and frequency analysis allow us to gain a large amount of information concerning the state and activity of the respondent's brain. Brain waves are categorized in accordance to frequency and the corresponding activity [Sosnowski, 1993].

For example Delta waves, which are waves of high amplitude signals with frequencies ranging from about 0.5 to 3 Hz., are present in the deepest sleep and during deep meditation.

Theta waves with frequencies ranging from 4 to 7 Hz are the most common brain waves during meditation, hypnosis, intense dreams and intense emotions.

Alpha waves from 8 to 13 Hz in frequency are waves of variable amplitude. Their rhythm is characteristic for the state of relaxation, when we are lying with closed eyes before falling asleep and when we wake up.

Beta waves from 12 to about 28 Hz in frequency are waves of very small amplitude, and are asynchronous. We can characterize them as a rhythm of standby state and typical for the activity state, concentration, mental work and sensor perception.

Gamma waves are signals from 40 Hz to about 100 Hz in frequency and are present during physical activity and motor functions.

Figure 1 shows the EEG electrode assembly with the EEG gel injection during our experiment. Figure 2 shows the example of the EEG signal and its frequency analysis for one of the study participants. The data are processed and presented with the use of WinEEG software.

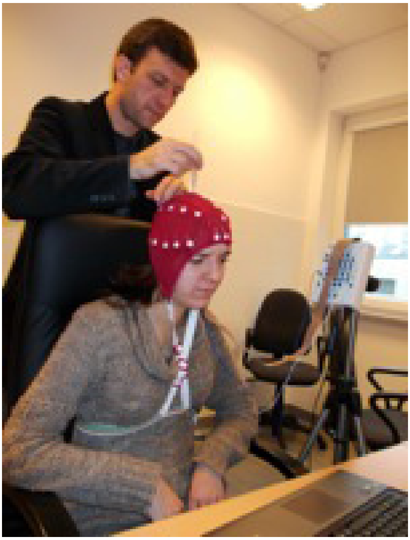

Fig. 01. EEG electrode assembly.

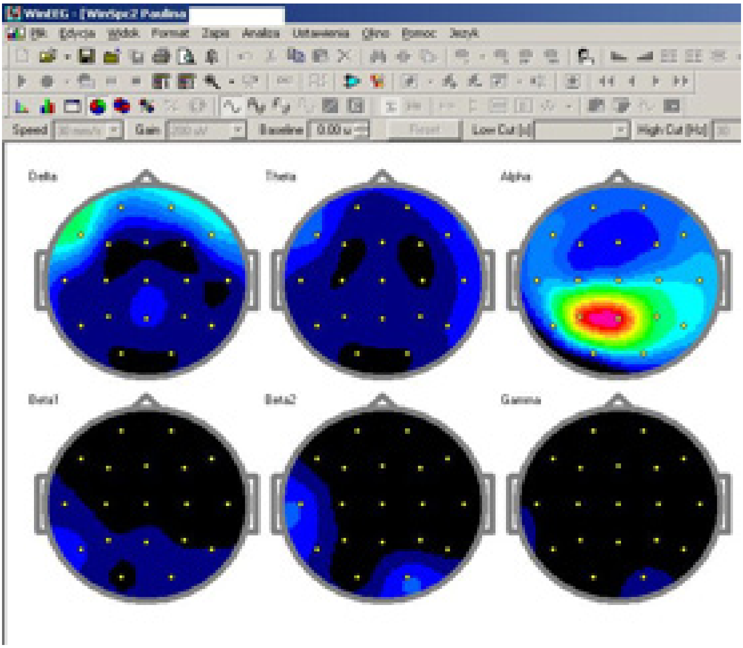

Fig. 02. Recording of the EEG signal and its frequency analysis for one of the respondents.

Electrodermal activity (EDA)

Electrodermal activity (EDA) is one of the easily measurable psychophysiological parameters. We measure the conductivity (expressed in µS) between the fingers of the left hand. Physiological change of the EDA is the result of the activity of eccrine or sweat glands which entails changes in the conductivity of the skin. Eccrine glands are distributed very unevenly on the surface of the human body [Sosnowski, 1993]. Their largest density is on the hands and feet.

Eccrine glands have a strong ability to react to psychological stimuli, in addition to their functions connected with temperature stabilization. Many authors [Sosnowski, 1993] claim that the glands located on the hands and feet have the ability to react mainly to mental stimuli, but their thermoregulatory functions dominate only in the range of relatively high ambient temperatures (exceeding 30°C). Other glands perform functions of thermoregulation in response to mental stimuli to a much lesser extent. There is also another view [Allen, Armstrong, & Roddie, 1973], which assumes that the high EDA activity of hands and feet can be explained because they are the location of the highest density of sweat glands.

Previous studies [VaezMousavi, Barry, Rushby, & Clarke, 2007] indicate that the electrodermal response is an excellent indicator of the body's response to new or changing stimulus. Although the EDA is a precise indicator of changes caused by the participant's activity or situational factors, the psychological interpretation of these changes is extremely difficult.

In Figure 03., we present the way we have measured EDA during our experiment together with other parameters. The electrodermal activity is measured between the index and ring fingers, while Blood Volume Pulse (BVP), described below, is measured from the thumb, and temperature from the middle finger.

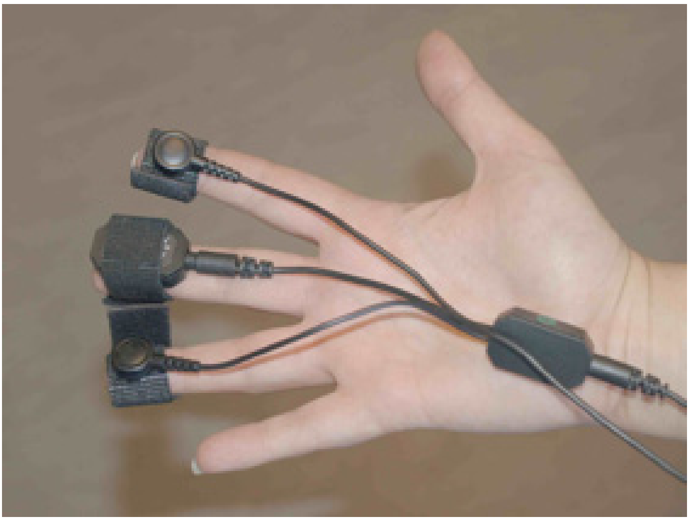

Fig. 03. Measurement of the electrodermal activity (index and ring fingers), BVP (middle finger).

Cardiovascular Activity: HRV (Heart rate variability), PPG (photoplethysmography), BVP (Blood Volume Pulse), IBI (Interbeat interval).

The circulatory system plays a very important role, bringing oxygen, water, minerals and nutrients, enabling the transport of hormones and metabolic breakdown products for all the cells of our body. The operation indicators of cardiovascular system, which are correlated with the nervous system, are the most significant for educational research purposes.

It is important to link the heart activity monitored during specific types of emotional and motivational activities [Acharya, Joseph, Kannathal, Lim, & Suri, 2006]. An increase in cardiovascular activity is not only associated with physical activity and movement. The system strongly reacts to any task stimuli, not just those related to physical effort [Sosnowski, 1993].

Psychologists studying the responses of the cardiovascular system apply measurement techniques developed in medicine to their field of knowledge [Sosnowski, 2002]. Carrying out this kind of research involves analysis of the impact of psychological factors on the work of cardiovascular system in healthy people. The basic and widely known indicators which enable non-invasive monitoring of the heart are: the heart rate (pulse), blood pressure and the electrical activity of the heart (ECG).

In our research, we focused on the flow of blood and analyzed the changes in blood flow through a finger. The reason for this type of test is associated with a very small number of artifacts, compared to the traditional ECG, which requires the participant to be motionless for a prolonged period of time while the electrical activity of various muscles of the body are being recorded.

Another important reason for analysis of the blood flow in certain places of the body (BVP) is the view formulated by Sokolow and followed by other research which attempted to verify the idea of the orienting and defensive reactions. This indicator is often used by researchers in relation to changes in the peripheral flow, and used as an indicator of stress or arousal during processing. We use a photoplethysmograph (PPG) as an indicator of BVP (see Fig. 04), which is mobile and ensures simple application.

Fig. 04. Photoplethysmograph.

Respiration (RESP) and temperature (Temp)

Changes in the frequency and amplitude of breath are a great indicator of our activity. Increased mental activity and stress increases the brains need for nutrients and oxygen.

During the experiment we provided such conditions to provoke the process of theoretical problem solving without making increased physical effort (only looking at the computer screen and answering). This allowed us to observe an increase in the frequency, amplitude changes in breathing, changes in temperature of the body, which can be considered as indicators of motivation, intellectual activity or stress.

Figure 05 shows the tool of respiration measurement.

Fig. 05. Monitoring the amplitude and frequency of breathing.

Face-tracking

Today, eye-tracking systems equipped with high resolution cameras in conjunction with "emotion recognition" software operate in real time, providing a digital analysis of the changes in facial expressions to create a description of emotions. Such programs are also becoming more common in commercial studies such as the analysis of audience reactions to presented advertising. Figure 6 shows the window of one of these programs, working with the camera and provides an example of how the FaceReaderTM "emotion recognition" software by Noldus Information Technology B. V. is used.

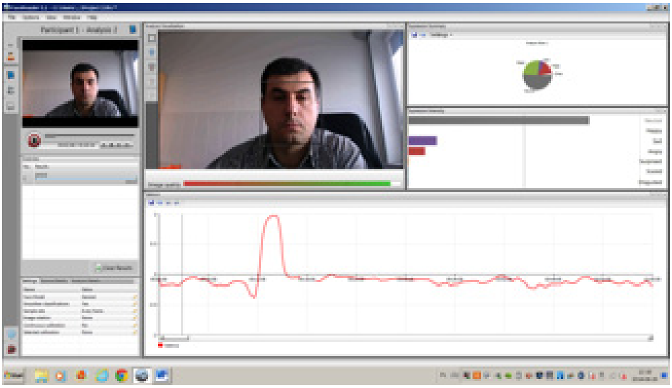

Fig. 06. The main window of FaceReaderTM software.

Electromyography (EMG)

Electromyography (EMG) allows recording of the electrical activity of muscles. In most cases the muscles activity monitored and recorded includes the muscles of the face, neck and arm. In the literature, the testing of the activity of facial muscles is referred to as F-EMG, where 'F' is understood as the facial nerve, corresponding to the facial muscles [Sosnowski, 1993]. Electromyography facilitates registration of electrical activity associated with facial expressions, and therefore, is helpful in attempts to scientifically register emotive responses. A characteristic feature of the test is its high sensitivity which provides the ability to measure electrical activity of muscles, despite of the lack of their visible physical movement. However, compared with EEG, it requires the usage of high sensitivity equipment, because of the very low signal amplitudes involved. The typical problems associated with using F-EMG are: filtering a signal and its proper processing, elimination of artifacts and correct interpretation of the recorded signals.

Fig. 07. Method of fixing F-EMG electrodes

Oculography – eye-tracking and pupilometry

There are many methods for testing the activity of the eye. The most popular are video-based combined pupil/corneal reflection methods [Duchowski, 2002, 2007]. Modern systems for analysis of eye movement are often called eye-trackers, and are characterized by excellent performance and accuracy.

From the didactics of science point of view, the recording of eye tracking activity while analyzing and solving tasks presents a very important extension of the current research methods. It gives us the ability to analyze solving strategies and to search for common errors and patterns of analysis. Psychological studies also associate the change in pupil diameter with a subjective evaluation of task difficulty [Kahneman & Beatty, 1966] cognitive load and emotions.

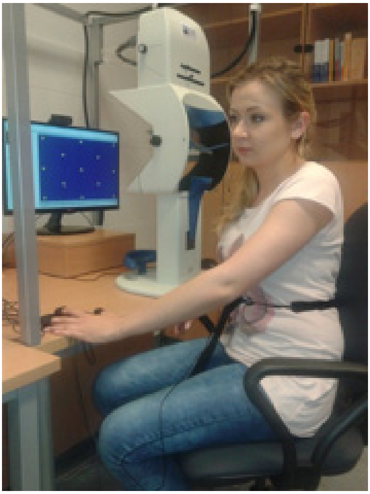

Fig. 08. Eye-tracker™ Hi-Speed 1250, iView X™ in our laboratory.

Eye-Tracking Research In Science Education

Review on the use of eye-tracking for exploration of learning

In 2013, Lai M.L., Tsai M.-J., Yang F.Y., Hsu C-Y, Liu T.-C., Lee S.W.-Y., Lee M.-H., Chiou G.-L., Liang J.-C., and Tai C.-C. [2013] published an article in the Educational Research Review. The authors revised the way of using of eye-tracking technology for the analysis of learning process. They took into consideration 81 papers on that matter from 2000 to 2012 containing data from 113 studies carried out and described in articles from the Social Science Citation Index. They concluded that the use of eye-tracking technology for the analysis of learning process in recent years was focused on the following fields:

1. patterns of information processing,
2. effects of instructional design,
3. reexamination of existing theories,
4. individual differences,
5. effects of learning strategies,
6. patterns of decision making,
7. conceptual development.

In this article we present selected methods of data analysis, being used by our Interdisciplinary Research Group of Cognitive Didactics, and concerning the work of an examined eye. Our studies referred to the fields outlined above as numbers 1 and 3-6 in the context of the didactics of science.

Overview of the experiment

The study included 103 participants with different levels of subject matter knowledge and experience in mathematics and physics:

- 4 experts: professor in physics, three scientists with PhD degree: in physics, mathematics and computer science;
- 9 PhD students in physics (1^{st} and 2^{nd} year),
- 75 university students of physics (3^{rd} year), biology (3^{rd} year), computer science (2^{nd} and 3^{rd} year) and mathematics (3^{rd} year)
- 24 the 2^{nd} grade secondary school students (17-18 years old).

The research theoretical tools were 12 problems on the topics of physics, mathematics and computer science. Most of them were multiple choice problems with only one correct answer. Here, we will use Problem 1 (see Figure 9) as an example. The formulation of the task is the following:

"The motion graph illustrates the changes of the velocity (v) in time (t) for two vehicles (I, II). Which of the following statements is incorrect?

A. The vehicle (II) caught the vehicle (I) after 10 minutes.

B. In the timespan of 0-10 min the greater distance was driven by the vehicle (I).

C. The speed of both vehicles was the same for t = 10 minutes.

D. The vehicle (II) moved with greater acceleration.

E. The distance driven by the vehicle (I) is twice as long as the distance driven by the vehicle (II)."

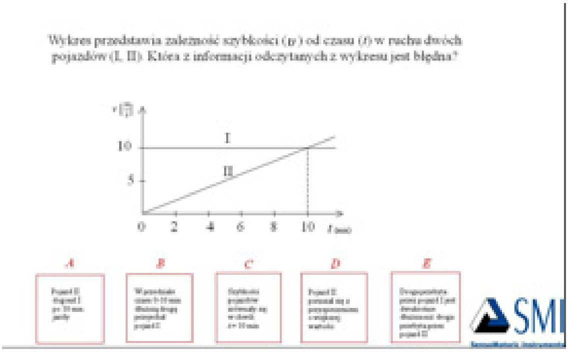

Fig. 09. The formulation of Problem 1.

Advantages of eye-tracking methods over conventional tests on the basis of scan paths

The first examples are dedicated to the analysis of looking paths, named scan paths, utilizing BeGaze™ Eye Tracking Analysis Software by SensoMotoric Instruments (SMI). BeGaze™ presents clear graphic interpretation of data showing the successive fixations (that is stopping of the eyeball at a certain point of a screen) and saccades (paths of displacement between two consecutive fixations), both in real time in the form of video files and in the form of a picture showing the whole record of saccades and fixations during the subject's work. Apart from the scan paths SMI BeGaze™ 2.4 provides also another kinds of gaze plots such us bee swarm or gaze replay.

We illustrate the usefulness of the data visualization, exploring what kind of question is actually being answered by students. Problem 1 is formulated in constricted form with respondents being asked to indicate the incorrect statement. Additionally, the key formulation, which is the phrase "is incorrect", is written at the end of the text, at the end of the line. The analysis of scan paths provides the additional data which allows us to examine in detail whether the selection of the correct answer is a symptom of strong subject matter knowledge of an examined person.

We have found that among people who identified and selected the statement “A” properly (as the only incorrect), are those who even did not read at all the content of the task - see Figure 10. The analysis of the scan path leads to the conclusion that the person chose the correct answer completely by chance.

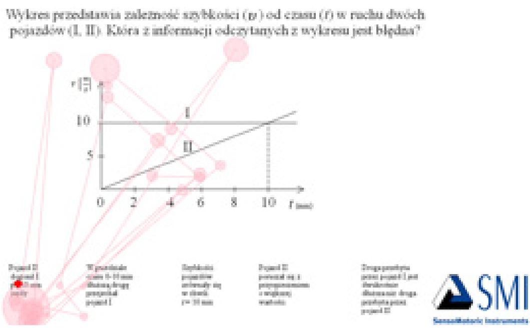

Fig. 10. Scan path - participant no. P77.

It also transpired that some respondents did not read the most essential phrase: “is incorrect”. They responded to another question, trying to indicate the correct statement. Thus, in this case, the choice of the correct answer to the problem proved their faulty subject matter knowledge. The scan path in the Figure 11 shows the way of looking at the problem by the student of computer science no. P 27.

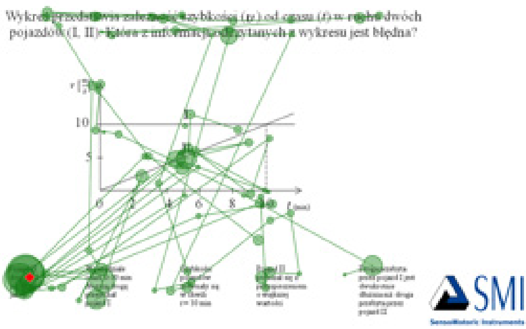

Fig. 11. Scan path (P27) – not looking at the phrase „is incorrect”.

Similarly, examining the responses, we find that the choice of answer „A” can be a symptom of:
- a strong subject matter knowledge and skills,
- an incomplete one,
- an defective one,
- or do not give any information on subject matter knowledge and skills.

All of this depends on what question respondents answered and in what order they looked at the statements, knowing that there is the only one correct answer.

Scan paths provided researchers with a lot of information. Using the real-time recording, we can also explore strategies of problem solving; mistakes in the analysis of tasks content and the level of difficulty of the problem for a participant. In addition, scan paths can be used for improvement to the problems’ formulation.

Key Performance Indicators

Researchers can define areas of the screen to analyze data in various ways, depending on what is the research question. Such an area is called the Area of Interest (AOI). We can also define which data has to be delivered by the program for AOIs. The automatic settings of the program take into consideration the following data:
- Time of fixation (ms, %),
- Fixation count (number of fixations within an AOI),
- Entry time (average duration from start of the trial to the first hit of an AOI),
- Dwell time (ms, %, all fixations and all saccades within an AOI),
- Hit ratio (how many subjects out of the selected subjects looked at least one time into an AOI),
- Revisits,
- Sequence.

All of this metrics can be obtained for either an individual participant or the whole group (or sub-group) being tested. In the last case, the averaged data is taken into consideration. Below we present two different ways of defining AOIs. In the first one, we obtained averaged data for all the 103 study participants (see Fig. 12), and in the second, we obtained individual data for the previously mentioned student no. P 27 (see Fig. 13).

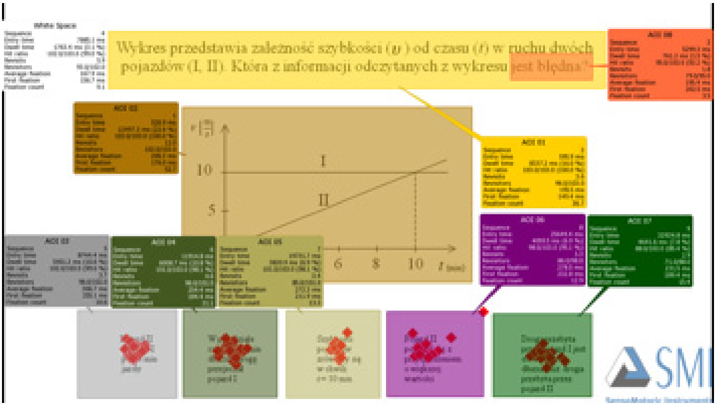

Fig. 12. AOI for all study participants (103 people).

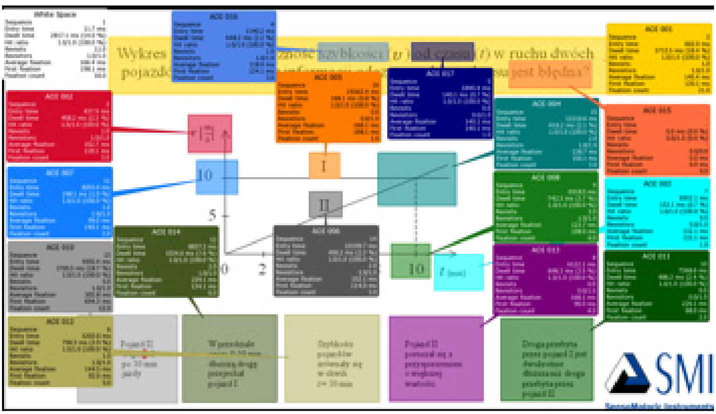

Fig. 13. AOI for the student no. P27.

Thorough analysis of this data might be a subject for further investigation, and the Figures 12 and 13 demonstrate the depth of available information. Let us note, for example, only that there is the uniform distribution of answers, that only 95 people out of 103 hit the phrase meaning "is incorrect" (AOI 015). Individual analysis leads to the precise conclusion in what order the person looked at the task (sequence); that they did not hit the AOI 015 at all, we can indicate how long they analyzed clearly defined areas (such as a description of the axis, or the intersection point of the graphs) and many other areas, that we regard as important, depending on the defined research problem.

AOI sequence charts which is another way of examining the precise strategy

The BeGaze™ program also provides a graphic representation on how long and in what order the analysis of each AOI proceeded. The AOI Sequence Chart shows the temporal order at which AOIs were hit by a particular subject. The program begins with the presentation of data from this AOI, which was looked at first by a respondent (see Figure 14, the AOI 02). The abscissa axis is the time axis, and the ordinate is the individual defined AOI. These charts allow us to find a task-solving strategy. For example, respondent P64 began with a careful reading of the text and graphical formulation of the task, then started analyzing the statements from "A" (that is AOI 03), then successively every statement and finally returned to statement "A". Each time, the statement's analysis was interspersed by going back to the graph (AOI 02). Among the analyzed statements (AOI 03 - 07), the subject devoted most of the time, to statement "E" (AOI 07), which was analyzed simultaneously with the graphs and the correct answer "A". We can observe a consistent proceeding and thorough analysis of each statement. Moreover, statement "A" was probably immediately selected as the correct answer. We can also find statement "E" to be the most difficult to verify for the participant. This person's subject knowledge is in-depth and strong and he used a consistent strategy. Respondent P64 indeed was an expert and the record of his work, and the AOI Sequence Chart, confirms this.

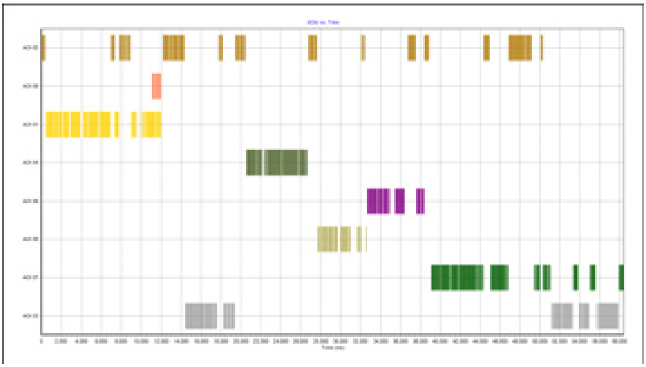

Fig. 14. AOI sequence chart (P64).

Analysis of selected parameters in the AOI

Findings can be also generated from selected data when the detailed analysis of AOIs for an individual respondent is needed. For example, analyzing the field "statement is incorrect" (AOI 015) among people who have chosen answers A - E as correct ones (abscissa axis), we obtain data for all 103 participants. In this case the interesting parameters for us were: number of revisits, fixation count, fixation time [%] and dwell time [%]. It is interesting to find a noticeable trend in the data. Specifically, for those who have chosen the answer "B" as a correct response for this task, all the values for the analyzed data were at maximum. It appears that the field explored the longest is "statement is incorrect". It is also the field that is most frequently returned to, and the one that received the maximum number of fixation and dwell time compared to other examinees.

The findings can be interpreted as a fact proving the difficulty associated with negation, because there was a need to indicate an incorrect statement. Note that answer B was the first correct statement.

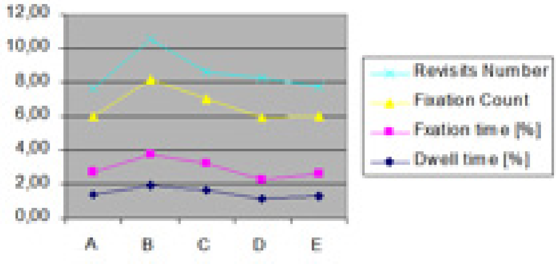

Fig. 15. Chosen data of all participants for the AOI “is incorrect”.

Heat maps and focus maps

Heat maps and focus maps provide another useful way of presenting data. They show in colors (heat map) or monochromatically (focus map) dwell time or fixation time, depending on how we define the parameters needed for a chosen participant. In Figure 16, we present the heat map for a student of physics (P10). Depending on the length of fixation time the screen shows different colors – from blue (lack of fixations) through green, yellow, orange to red - representing the longest time of fixation, with the warmer colors (red, orange, yellow) indicating longer time of fixation at a point on the screen. Similar maps can be generated for chosen groups of participants or even for all participants, based on the averaged data.

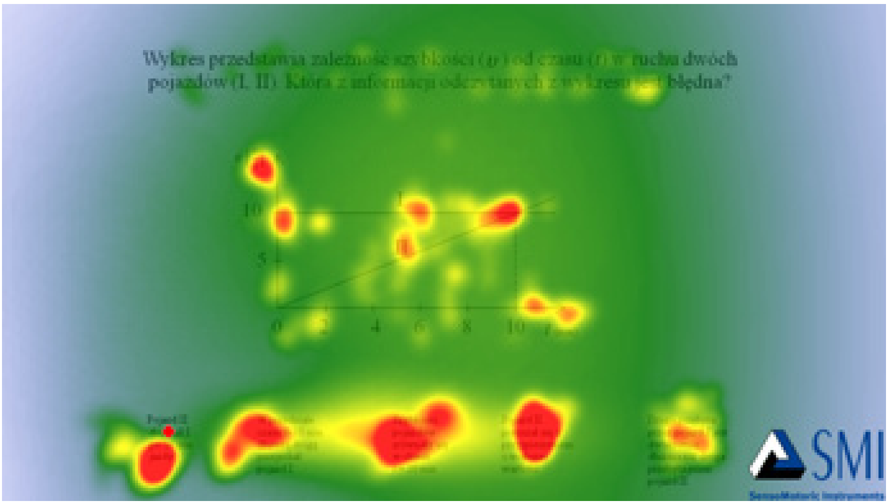

Fig. 16. Heat map – respondent no. P10.

Relative changes of pupil diameter as an indicator of the level of task difficulty

Neural efficiency hypothesis assumes that more intelligent individuals process information and solve problems in a more efficient way, without incurring large mental effort than the less intelligent [Haier, Siegel, Tang Abel, & Buchsbaum, 1992; Hendrickson, 1982; Schafer, 1982]. This hypothesis is strengthened by psychophysiological research of the response of the pupil of the eye. The extension of the pupil of the person being tested while solving the problem of cognitive load is an indicator of psychophysiological analysis process and processing. The greater extension of the pupil diameter is, the greater the information processing and greater mental effort [Beatty, 1982; Beatty, & Lucero-Wagoner, 2000; Kahneman & Beatty, 1966].

Ahern and Beatty [1979] showed that there is a relationship between the pupil reactions and cognitive abilities of individuals. They proved that the changes of the pupil diameter recorded as the students were multiplying were negatively correlated with their cognitive abilities. Comparing pupil reactions with students' scores, they have found that the students underperforming in the test Scholastic Aptitude Test (SAT) showed higher dilate of the pupil during multiplication than students who achieved higher scores in this test. This result is consistent with the hypothesis of neural efficiency.

The aim of the our research is to try to identify whether the monitoring of changes of the pupil diameter during process of solving science problems can facilitate information on the subjective assessment of the degree of difficulty of tasks to be solved.

The changes in pupil size were measured using the Eye-Tracker™ Hi-Speed and iViewX™ software by SensoMotoric Instruments (SMI) assuming a sampling rate of 500 Hz.

Data analysis was later performed with BeGaze™ software. Before starting the procedure, 9-point calibration was done, with the assumed precision of less than 0.5 of a degree. Care was taken to ensure that the light intensity in the room was always the same. Before calibration, respondents spent a few minutes in the room to adapt to the lighting conditions. Due to the significant differences of individual values of pupil diameter, comparison of relative values was performed.

Figure 17 shows the relative changes of pupil diameter during familiarization with the task and making decision by the respondents. The graphs (Fig. 17, 18) show the average value of the relative changes of pupil diameter during the first and last 25 fixations.

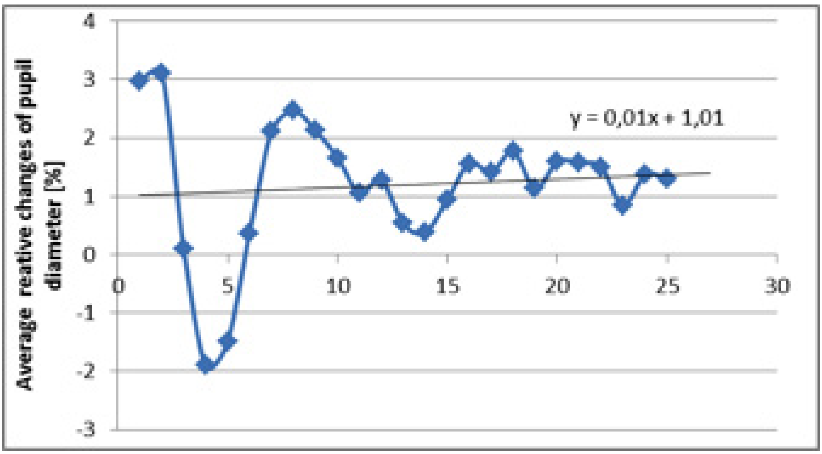

Fig. 17. Average value of the relative changes of the pupil diameter during the first 25 fixations.

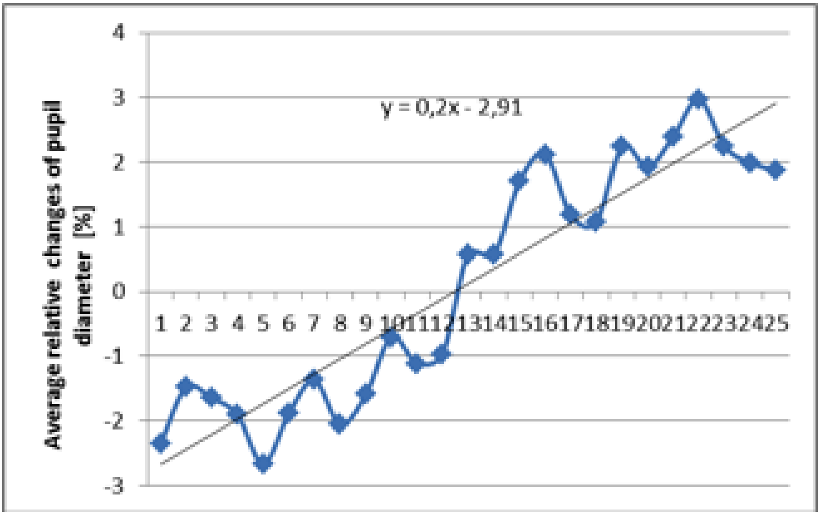

Fig. 18. Average value of the relative changes of the pupil diameter during the last 25 fixations.

The analysis of the data indicates that pupilometry can be also very useful as a method for research on science education, by providing complementary knowledge on students' motivation to undertake mental effort, subjective opinion on the difficulty of tasks and the level of stress related to the process of problem solving.

References

Acharya, U.R., Joseph, K.P., Kannathal, N., Lim, C.M., Suri, J.S. (2006). Heart rate variability: A review. Medical & Biological Engineering & Computing, 44, 1031–1051.

Ahern, S.K., Beatty, J. (1979). Physiological signals of information processing vary with intelligence. Science, 205, 1289-1292.

Allen, J., Armstrong, J., & Roddie, I. (1973). The regional distribution of emotional sweating in man. Journal of Physiology, 235, 749-759.

Beatty, J., & Lucero-Wagoner, B. (2000). The pupillary system. In J.T. Cacioppo, L.G. Tassinary, & G.G. Berntson (Eds.), Handbook of Psychophysiology (2nd. ed., pp. 142–162). New York: Cambridge University Press.

Beatty, J. (1982). Task – evoked pupillary responses, processing load and the structure of processing resources. Psychological Bulletin, 91, 276-292.

Duchowski, A. (2002). A Breadth-First Survey of Eye Tracking Applications. Behavior Research Methods, Instruments,& Computers, 34 (4), 455-470.

Duchowski, A. (2007). Eye tracking methodology. Theory and Practice (2nd. ed., pp. 142–162). London: Springer.

Haier, R.J., Siegel, B., Tang, C., Abel, L., Buchsbaum, M. S. (1992). Intelligence and changes in regional cerebral glucose metabolic rate following learning. Intelligence, 16, 415-426.

Hendrickson, D. E. (1982). The biological basis of intelligence, Part II: measurement. In: H.J., Eysenck (Ed.), A Model for Intelligence (pp. 197–228). New York: Springer.

Kahneman, D., & Beatty, J. (1966). Pupil Diameter and Load on Memory. Science, 154, 1583–1585.

Lai, M.L., Tsai, M.J., Yang, F.Y., Hsu, C.Y., Liu, T.C., Lee, S.W.Y., Lee, M.H., Chiou, G.L., Liang, J.C., & Tai, C. C. (2013). A review of using eye-tracking technology in exploring learning from 2000 to 2012. Educational Research Review, 10, 90-115.

Schafer, E. W. (1982). Neural adaptability: a biological determinant of behavioral intelligence. International Journal Neuroscience, 17 (3), 183-191.

Sosnowski, T. (Ed.). (1993). Metody psychofizjologiczne w badaniach psychologicznych. Warszawa: PWN.

VaezMousavi, S. M., Barry, R. J., Rushby, J. A., & Clarke, A. R. (2007). Arousal and activation effects on physiological and behavioral responding during a continuous performance task. Acta Neurobiologiae Experimentalis (Wars), 67, 461–470.

Verney, S.P., Granholm, E., Marshall, S. P. (2004). Pupillary responses on the visual backward masking task reflect general cognitive ability. International Journal of Psychophysiology, 52, 23-36.

Sosnowski, T. (2002). Zadania umyslowe a aktywnosc sercowo-naczyniowa, Sopot: Gdańskie Wydawnictwo Psychologiczne.

Roman Rosiek & Mirosława Ewa Sajka

Pedagogical University of Cracow, PL

roman.rosiek@gmail.com, msajka@gmail.com

Analysis of saccadic eye movements of experts and novices when solving text tasks

Anna Stolińska, Magdalena Andrzejewska, Władysław Błasiak, P. Peczkowski, Roman Rosiek, Bożena Rożek, Mirosława Sajka, Dariusz Wcislo

Introduction

Visual perception is the primary source of information about the surrounding world. It is a process of active search for interesting and relevant visual data, having a discrete character. Discontinuity of visual perception is associated by physiological visual process, during which the human eye makes from 3 to 5 moves per second, consisting of a saccade and fixation. A saccade is a rapid change of the orientation of attention, and a fixation is a short period of stable orientation. The duration of fixation indicates the processing of data currently in the visual field. A detailed visual information (a high resolution image, the so-called sharp vision) can be collected from the size of about 2 degrees [Duchowsky, 2007], hence the active looking requires a search of the field of perception, i.e. the movement of eyes (saccades). The purpose of this abrupt eye movement is positioning the axis of vision in both eyes on selected items of the viewing scene, to enable them to acquire as much data. It should be noted that during the eye movement occurs a phenomenon called saccadic suppression, which is associated with a decrease in perceptual awareness and a reduction in visual sensitivity before and during saccades [Ibbotson & Krekelberg, 2011].

The movement of the eye in the direction of the emerging stimulus in a field of view would seem a simple reflex, but a detailed saccadometric studies show that it is linked with the participation of cortical centres of decision-making, supervising the process of seeing [Ober, Dylak, Gryncewicz & Przedpełska-Ober, 2009]. The transfer of vision to an interesting piece of the environment, ie the saccade reaction, consists of two intervals: the time between stimulation and response (latency) and the duration of saccades - ie, eye movement until it is completely stopped. Nouraei and other researchers have shown that latency, or the time elapsed since the onset of the stimulus to the initiation of movement is approximately 200 ms [Nouraei, de Pennington, Jones & Carpenter, 2003]. Studies show, in turn, that the time needed to receive visual information and to generate arousal and to send it to the muscles controlling eye movement is 60 ms [van Beers, 2008]. The missing of about 120 ms is the time, which indicates that saccade refixation is not merely a reflex, even though we have no voluntary control over the duration and velocity of our saccadic eye movements. This time is designed to take into account the context of a situation requiring the implementation of saccades [Ober et al., 2009]. This means that the bottom-up processes and bottom-up attention, which involves the reflexes, and which manifests itself with involuntary response to the stimulus emerging in the field of vision, may be as important in the control of eye movements as top-down processes and a top-down attention, in which volitional movement of attention takes place [Tatler, Baddeley & Vincent, 2006]. It should be noted, however, that some researchers believe that different readers have different perceptual spans indicating areas of effective vision, and that new information is not acquired during saccades [Rayner, 1998].

The movement of the eye during the perception of a scene can indirectly track the decision-making processes that accompany the exploration of the world from one point of fixation to another. Thus, we learn how the process of selection of information happens, which is very important in the learning process.

In the seventies of the last century research was undertaken, that contributed to the development of the theory of “scan paths” [Noton & Stark, 1971], which is associated with a fixed, specific, recurring diagram of a person looking at a specific image. There was observed similarity of paths looking at the same picture in the learning phase and recognition. In later years, studies comparing the scheme of looking at paintings by experts and novices were undertaken, which allowed to conclude that knowledge shapes the way they view, that a bottom-up processes can be broken by top-down processes. It has been shown that the effect of bottom-up, resulting from the specific properties of the features of the object, directing gaze was apparently reduced when subjects viewed images from their field of expertise [Bałaj, 2011]. The fact that the bottom-up motivated scene search strategies are characteristic of novices is also confirmed by the study of American psychologists Geoffrey Underwood and Katherine Humphrey [Francuz, 2013].

While viewing static images, in which it is necessary, for example, to read the content commands of the given exercise and watching illustrations necessary for its solution, followed by a "task" processing of information - visual information are filtered taking into account the intentions, needs, beliefs or knowledge of the one watching the scene. It seems, therefore, that the dominant role, both for novices and experts, plays in this case the top-down processes, which can be traced to contribute to identify the schemes of problem solving. In particular, the saccadic eye movements and scanning behaviours are important in that they reveal the control of selective processes in visual perceptions including visual searching and reading [Liversedge & Findlay, 2000]. Saccade parameters of trajectory eye movements that researchers measure and analyze, among other things:

The amplitudes of saccade-is the angular distance the eye travels during the movement, usually measured in degrees or min. of arc. Saccade amplitude, that is, the distance between the two points of fixation depends on the visual scene viewing - the size and position of viewed objects. Most analyzed value is the average amplitude of the saccade, which is considered as a measure of the search strategies of visual scene [Francuz, 2013].

Speed Saccades - saccades are one of the fastest movements that the human body produces. Saccades velocity [°/s] increases proportionally (but non-linearly) to the amplitude and the relationship between the amplitude of its time and speed are relatively fixed and known as the standard saccades. Often the analyzed parameter is the average velocity and peak velocity (the highest velocity reached during the saccade Vmax).

Saccade duration –the time taken to complete the saccade. For normal subjects the relationship between saccade amplitude and duration is fairly linear. The duration of the saccade and the average velocity are really measures of the same parameter [Bahill, Clark & Stark, 1975].

Between the above-mentioned parameters of the saccade amplitude not exceeding 35° a relationship exists, which is expressed by the formula [Pavlidis, 1985]:

$$V_{max} \cdot T = c \cdot A$$

where:

V_{max} – maximum velocity of a saccade [°/s],

T – duration of saccade [s],

c – scaling factor, its value is 1.65,

A – saccades amplitude [°].

In the analysis of eye tracking data also taken into account are the frequency of regressive saccades or saccade gain - the amplitude of the first saccade made to the target divided by the target's distance from fixation and latency-expressed in milliseconds [ms], is defined as the time from target onset is the time of eye motion onset using velocity criteria.

Purpose of the paper

Research on the wider education process using equipment recording the eye movements as the experimental method are carried out for many years, but as shown by the figures presented by the researchers [Lai et al., 2013] there is a significant increase observed since 2009. Researchers found that among 113 analyzed the vast majority of research related two issues: measuring the effectiveness of teaching (26 works), and analysis of the patterns of information processing (53) during the learning process. The learning process is different for every individual, dependent upon how the method of processing information coming from the environment shaped during the life, which is also on experience. It affects targeting strategies and focusing attention on specific objects. In the discovery of this strategy the observation of what activates the attention is helpful, what incentives are needed to initiate work with the information, that is, finding the optimal (leading to fixing the problem) patterns of information processing.

In oculomotor studies, it is assumed that the gaze is directed to those elements of the visual scene, which are thought to have significance for the viewer, so the parameters of eye movements are interpreted as indicators of mental processes [Francuz, 2013]. An important indicator for the analysis of the process of solving the problem is not only the time spent on processing the data, but also the order in which its elements are analyzed.

The results of studies undertaken will answer the question:
whether there are differences in the saccadic movements while solving text tasks between experts and novices, and whether on the basis of these parameters it is possible to deduced about the different patterns of processing of the presented content?

Methods

The experiment was conducted in the neurodidactic laboratory at Pedagogical University in Cracow. For the study SensoMotoric Instruments Hi-Speed500/1250 iViewX ™ eye-tracker was used recording data stream with resolution of 500 Hz such as, for example, coordinates (i.e., x and y position coordinates of sight), pupil size (measured in relative and absolute), and the parameters of saccades and fixations. Spatial accuracy of the device is 0.01°, the delay calculation is less than 0.5 ms, the system delay is less than 2 ms. Interface design used in this system allows for keeping the head still, without limiting the field of view of the subject. Before each test was performed calibration and other activities aimed at the preparation of the subject, so the results can be considered as reliable and not biased. Among other the chin support position was corrected so that the test subject is in the most comfortable position while keeping the eye positioned centred relative to the centre of the screen. In addition, during the examination of all persons provided the same environmental conditions such as temperature, lighting and sound insulation. The results were based on the software SMI BeGaze™ 2.4.

Respondents were solving tasks in the field of science: mathematics, physics and computer science. For the purpose of considered research problem one task from each discipline was chosen, and because of the heterogeneity of subjects in each task has been split into groups of experts and novices. The students recognized as experts were ones representing various subjects, i.e. physics, mathematics, computer science and academics who gave the correct answer. In addition, for the task of physics graduate students representing this subject were also chosen. In groups of novices there were students who solved the indicated tasks incorrectly. Detailed information about the cardinality of each group are shown in Tab. 01.

Tab. 01. The division respondents for a group of experts and novices according to the field.

Subjects	Experts (n)	Novices (n)
Physics (Ph)	13	13
Mathematics (M)	10	17
Computer Science (CS)	14	19
Total	37	49

Each task required analysis of the content of the command and the illustration that for the task of physics (Task Ph) also contained a response (the task was to select the appropriate graph showing the dependence of the speed of time in elevation up), in the case of tasks in computer science (Task CS) algorithm presented in block diagram form (next to the same algorithm presented in the form of pseudo-code), whereas in the task of mathematics (Task M) allowed only to visualize the problem and possibly solving the problem using the operation of imaginary drawing and counting bullets. Respondents chose one of five answers by a mouse click.

Results

In order to discover regularities in the field of eye movement, in particular, the selected saccade parameters saccades, in the course of solving problems in various fields of science (mathematics, physics, computer science), an analysis of the length of the scan path was made (SCANPATH LENGTH), which is measured in pixels [px] and the total of all saccades amplitudes recorded during the solving of the task. The path length was directly related to the number of taken saccades (SACCADE COUNT) of all tasks within the correlation coefficient ($r = 0.918$, $p < 0.05$), evidencing a very strong positive relationship. Due to the different nature of the tasks, and thus a different visual scene, it seems obvious that the total length of the trajectory of the subjects' eye and the number of saccades in each task may be different. The question that the answers, concerned, therefore, whether in terms of these parameters, there are differences in the groups of experts and novices. For this purpose, the analysis was performed using t-test for independent samples, and the results are presented in Tab. 02.

Tab. 02. SCANPATH LENGTH [px] i SACCADE COUNT - t-test results for experts and novices with the division on the tasks.

		NOVICES (mean)	EXPERTS (mean)	T	Df	p
TASK Ph	SL	28,992.08	31,136.69	-0.361	24	0.721
	SC	127.23	148.07	-0.668		0.510
TASK M	SL	23,776.06	45,155.20	-2.771	25	0.010
	SC	125.06	219.60	-2.415		0.023
TASK CS	SL	38,089.79	39,385.93	-0.292	31	0.772
	SC	198.84	225.21	-1.189		0.243
ALL TASKS	SL	30,710.12	38,046.81	-2.043	84	0.044
	SC	154.24	196.59	-2.254		0.027

Comparing the length of the path of sight for studied groups, it is clear that the experts "went" a longer way solving tasks. This pattern applies to any type of task, and this difference is most evident in the case of a mathematical problem, where the average value of the parameter LENGTH SCANPATH in the group of novices is almost two times shorter (mean = 23, 776.06) from its value in the expert group (mean = 45,155.20). This difference is statistically significant, p = 0.010. Similar results can be seen in the case of the number of taken saccades.

The observed relationship are also shown in Fig. 01.

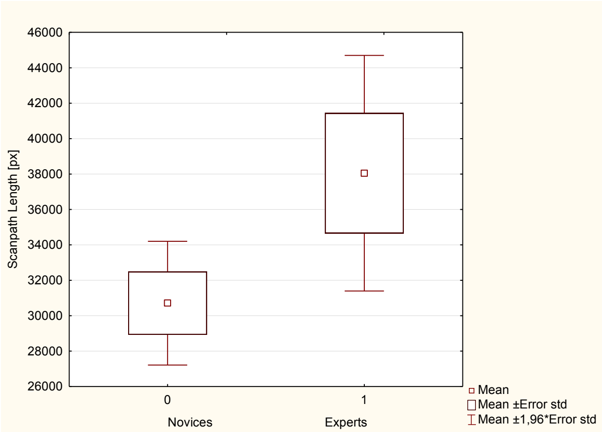

Fig. 01. The average total length of the saccades -differences in the groups of experts and novices.

The total length of the paths set by the eye movements of respondents varied within each task, as illustrated in Fig. 02., but as shown by analysis of variance (one-way ANOVA), the differences were not statistically significant.

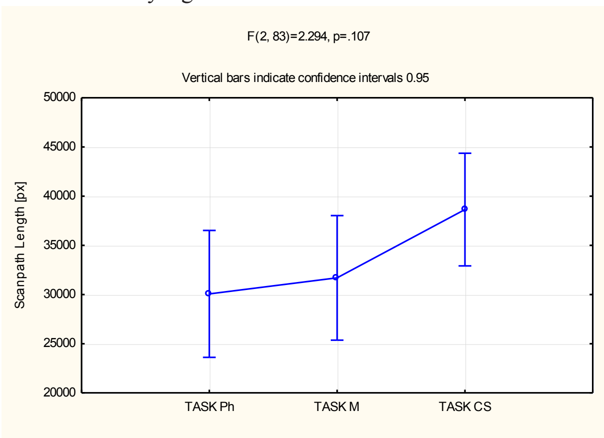

Fig. 02. The average total length of the saccades -differences within each task.

The longest path of the scan (mean = 38,639.67) was when the subjects performed the task in computer science (TASK CS), at the same time very similar average values of this parameter for the other two tasks (TASK M mean = 31,694.26 and TASK Ph mean = 30,064.38). This result is not surprising and confirms the specificity of algorithmic tasks whose solution required cyclic (repeated) analysis of selected areas, determined by the flow of control block diagram and within instruction pseudo code. An important parameter of saccades length based on their length is the average amplitude (SACCADE AMPLITUDE AVERAGE [°]), calculated as the ratio of the scan path and the number of saccade. As mentioned earlier, the average length of saccades is one of its most important characteristics and is considered as a measure of visual scene search strategy (Francuz, 2013). In the case of this indicator also the t-test was performed to detect differences in the groups of experts and novices within each task. The results are presented in Tab. 03.

Tab. 03. SACCADE AMPLITUDE AVERAGE [°] - t-test results for experts and novices with a breakdown for tasks.

	NOVICES (mean)	EXPERTS (mean)	t	df	P
TASK Ph	4.50	4.65	-0.402	24	0.691
TASK M	3.60	5.16	-2.906	25	0.007
TASK CS	3.57	3.61	-0.1496	31	0.882
ALL TASKS	3.83	4.38	-2.235	84	0.028

In relation to this indicator also revealed differences between the analyzed groups-in the expert group average length of saccades proved to be higher than in novices. The strongest relationship is experienced for a mathematical problem, for which it is statistically significant, p = 0.007. The obtained results across all types of tasks are shown in Fig. 03.

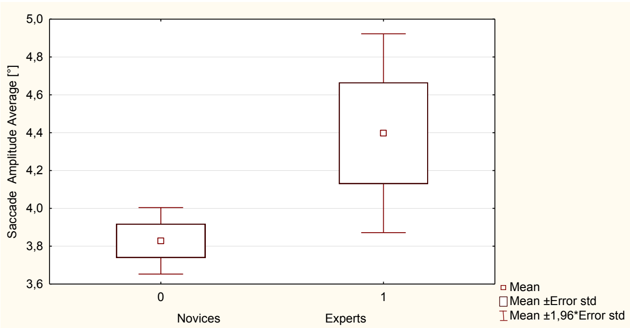

Fig. 03. The mean amplitude of the saccade-differences in the groups of experts and novices.

The applied analysis of variance revealed a statistically significant difference for this index within particular types of tasks [F (2,83) = 5.711, p = 0.005]. It should be noted that the average saccade amplitude, as shown in Fig. 04., for physical tasks (TASK Ph, mean = 4.58) was longer compared to the value of this parameter in the remaining tasks (TASK M mean = 4.18, TASK CS mean = 3.59) and for algorithmic tasks, this difference was statistically significant (Scheffe test, p = 0.006).

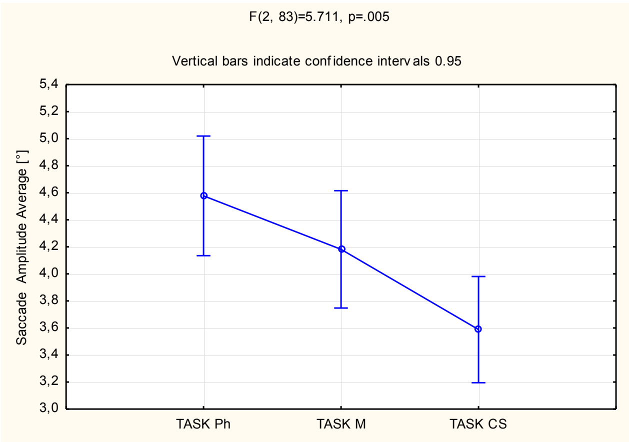

Fig. 04. The mean amplitude of the saccade-differences within each task.

Shorter saccades (eye fixation points located close) may indicate an increased concentration of attention on the area, and the long - on its larger dispersion. Therefore, the results obtained can again try to explain the specificity of computer science tasks that required attention in the two aforementioned key areas to achieve the result.

Another parameter associated with the saccade movement of the eye is average saccade velocity (SACCADE VELOCITY AVERAGE [°/s]).

Tab. 04.SACCADE VELOCITY AVERAGE [°/s]- t-test results for experts and novices with a breakdown on the tasks.

	NOVICES (mean)	EXPERTS (mean)	T	df	P
TASK Ph	94.21	101.64	-0.736	24	0.469
TASK M	85.07	105.06	-2.100	25	0.046
TASK CS	77.14	78.92	-0.302	31	0.764
ALL TASKS	84.42	93.97	-1.869	84	0.065

T-test results allow us to conclude that the average saccade velocity for experts and novices differed significantly in the case of a mathematical problem.

In addition, analysis of variance revealed that the average saccade velocity during the solution of particular types of tasks were significantly different [$F(2,83) = 6.422$, $p = 0.003$], and the Scheffe test used allowed to state that statistically significant differences exist between the task of algorithmic and other two, respectively, for TASK Ph $p = 0.004$, for TASK M $p = 0.048$.

The analysis revealed that the relationship between the individual tasks were the same as in the case of the mean amplitude of the saccade, allowing you to conclude a high correlation between these parameters. This is also confirmed by the correlation coefficient $r = 0.872$ (see Tab. 06.), whose value indicates a strong positive relationship medium speed and medium amplitudes saccadic eye movements.

Each saccade is performed within a certain time, hence a further consideration is the indicator of the average duration (SACCADE DURATION AVERAGE [ms]).

Tab. 05. SACCADE DURATION AVERAGE [ms]- the results of the t-test for experts and novices with a breakdown of the tasks.

	NOVICES (mean)	EXPERTS (mean)	T	df	P
TASK Ph	43.34	41.15	1.537	24	0.137
TASK M	37.73	41.16	-2.053	25	0.051
TASK CS	39.10	37.43	1.5337	31	0.135
ALL TASKS	39.75	39.74	0.0087	84	0.993

A comparison of average saccade durations in groups of experts and novices can say that in this case it is impossible to detect statistically significant differences.

In contrast, the average duration of saccades when solving different types of tasks was significantly different [$F(2,83) = 8.323$, $p < 0.001$], and Scheffe test used showed that statistically significant differences exist between the task from physics and the other two, respectively, for the TASK M $p = 0.009$, for TASK CS $p < 0.001$.

This result also highlights the importance of the task category. Each of the analyzed task was a text task and a test, it seems, then, that their difficulty level was affecting the measurement parameters of eye tracking.

Tab. 06. Pearson correlation coefficients for the selected saccade parameters (values are indicated significant p <0.050).

	Saccade Duration Total [ms]	Saccade Count	Saccade Duration Average [ms]	Saccade Amplitue Average [°]	Saccade Velocity Average [°/s]
Scanpath Length [px]	0.909	0.918	-0.053	0.300	0.319
Saccade Duration Total [ms]	-	0.981	0.047	0.207	0.209
Saccade Count	-	-	-0.125	0.146	0.202
Saccade Duration Average [ms]	-	-	-	0.308	-0.041
Saccade Amplitude Average [°]	-	-	-	-	0.872

Conclusions and implications

According to research on the perception of works of art [Francuz, 2013], saccades with long amplitudes are characteristic for experts and most commonly associated with top-down processes. The results obtained in this experiment confirm that this regularity applies not only to the process of viewing, but also problem solving-it was observed for all three types of tasks analyzed. It can therefore be concluded that in the case of solving, the experts implement global strategies analyzing tasks, while novices - local.

Studies have shown that the analysis of parameters of saccade brings important information not only about the differences of behaviour (methods of exploration of visual scenes) within the study groups, but also allows for conclusions regarding the characteristics of the same tasks. Guided by this observation the problem was formulated, which is the subject of subsequent experimental studies on differences in the pattern of eye movements during task solving, classified in terms of difficult and easy. This assumes that the studies are compiled from declarations of the respondents and the results obtained by them. Promising predictors appearing in the problem, in addition to the parameters already analyzed, are the so-called return saccades analyzed in relation to defined areas of interest (AOI) and maximum (peak) value of saccade velocity (PEAK VELOCITY), which is an indicator, as the researchers found [Di Stasi, Marchitto, Antolí, Baccino & Cañas, 2010], sensitive to changes of cognitive load.

References

Bahill A.T., Clark M.R., Stark, L. (1975) The main sequence, a tool for studying human eye movements. Mathematical Biosciences (24), pages 191-204.

Bałaj B. (2011) Analysis and interpretation of eye movements in scanning imaginary. W K.-W.B. (red. Gorbaniuk O.), Studia z Psychologii w KUL (pages 169-188). Lublin: KUL.

Di Stasi L., Marchitto M., Antoli A., Baccino T. i Cañas J. (2010) Approximation of on-line mental workload index in ATC simulated multitasks. Journal of Air Transport Management 16(6), pages 330–333 (DOI: 10.1016/j.jairtraman.2010.02.004).

Duchowsky A. T. (2007) Eye tracking methodology: theory and practice, Springer - Verlag,London.

Francuz P. (2013) Imagia. W kierunku neurokognitywnej teorii obrazu.Lublin: Publisher KUL.

Ibbotson M., Krekelberg B. (2011) Visual perception and saccadic eye movements. Current Opinion in Neurobiology (21), pages 1–6.

Lai M., Tsai M., Yang F., Hsu C., Liu T., Lee S. (2013) A review using eye-tracking technology in exploring learning from 2000 to 2012. Educational Research Review (10), pages 90 -115.

Liversedge S.P., Findlay J. M. (2000) Saccadic eye movements and cognition. Trends in Cognitive Sciences 4 (1), pages 6-14.

Noton D., Stark L. W. (1971) Scan paths in eye movements during pattern perception (171). Science, pages 308-311.

Nouraei S.A., de Pennington N., Jones J. G. and Carpenter R. H. (2003) Dose-related effect of sevo¯urane sedation on higher control of eye movements and decision making. British Journal of Anaesthesia 91 (2), pages 175-183 (DOI: 10.1093/bja/aeg158).

Ober, J., Dylak J., Gryncewicz W., Przedpelska-Ober E. (2009) Saccadometry - new possibilities for assessment of the functional state of the central nervous system. Nauka 4/9, pages 109-135.

Pavlidis G. (1985) Eye movements differences between dyslexics, normals and retarded readers while sequentially fixating digits. American Journal of Optometry and Physiological Optics (62), pages 820-832.

Rayner K. (1998) Eye movement in reading and information processing: 20 years of research. Psychological Bulletins, 124 (3), pages 372–422.

Tatler B.W., Baddeley R. J., Vincent B. (2006) The long and the short of it: Spatial statistics at fixation vary with saccade amplitude and task. Vision Research (46), pages 1857-1862.

Van Beers R. (2008, April 30) Saccadic eye movements minimize the consequences of motor noise.Accessed May 25, 2014 from PLoS ONE: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0002070

Appendix

The tasks analyzed in the article.

The physics task (TASK Ph).

The mathematics task (TASK M).

The computer science task (TASK CS).

Anna Stolińska

Pedagogical University of Cracow, PL

anna.stolinska@up.krakow.pl

M-technology in Chemistry Education

Stárková Dagmar, Rusek Martin

Introduction

Information and communication technology (ICT) has penetrated all spheres of human life. With its development the devices have been shrinking into their users' day bags or even pockets. As the prices drop, almost everybody owns their own device (smartphone/iPhone, tablet, notebook/ultrabook). Mobile devices and applications they are able to run are an indispensable part of everyday life. This does not apply only for adults but more and more for children. Researches show annual escalation of percentage of children who possess a mobile device. Also, age limit of first phone ownership is decreasing [Fielden & Malcolm, 2007; Madden et al., 2013]. Mobile device ownership is common also among Czech students [Rusek, 2012] therefore it is important to work in this field.

It naturally brings new options into the educational process. Lately, some new approaches arose and the world has adapted them. These approaches are for example: flipped classroom, adaptive learning, virtual classroom, MOOC, self-directed learning, LMS, gamification or mlearning. The authors of this paper focus on m-learning, an educational approach based on mobile device which meditates learning [Rusek, 2011; Svoboda, 2009; Thornton & Houser, 2004]. Since 2005, m-learning is also one of fixed stars in the Horizon Report, annually published reports within the Horizon Project. Mobile devices, connectivity, and application are identified as a contemporary trend [NMC, 2014].

Contemporary students start using technologies in early age, but the purpose is mostly communication and/or fun. Students often do not realize it is possible to use their devices for something else. Therefore, this is a teacher's job to show them. Nowadays there are lots of options how to do so, as demonstrated by several projects (Acer-Europian Schoolnet Tablet Pilot, Tablets for Schools, Tablette Elève Nomade apod.). The goal is to use mobile applications (apps) demanding and also offering more than just an information search. Further in the text, Chemistry education apps are introduced. Their evaluation is needed in order to provide teachers with sufficient background since teachers without thorough training, inspiration and motivation to use mobile devices still with the superiority of frontal education limiting true potential of the devices in doing so [Neumajer, 2013].

Methods

Research question

The research question stems from the introductory part. It is necessary to subject the apps to thorough analysis. The research question was following: *What are overall functions of available apps designed for chemistry education?*

As the research question is descriptive, hypothesis was not worded.

Apps selection

The apps destined for further evaluation were selected based on these criteria:

- topic - designed for chemistry education,
- operation system - Android,
- user rating - three of five stars or more,
- costs - free of charge,
- language - English.

Apps evaluation

The selected apps were cross sectioned into the following categories according to the content of each apps [Libman & Huang, 2013]:
- Research and Reference/Study Guide,
- Periodic Table,
- Games and Quizzes,
- Calculations and Balancing Chemical Equations,
- Molecular Viewing,
- Chemical Structure Drawing,
- Complex apps.

Particular apps were afterwards evaluated with the respect to cognitive operations they require from a learner. For this purpose, the revised Bloom's taxonomy was used.

Results

For better transparency, the results will be in the above mentioned categories.

1. Research and reference/study guide

This group contains a large group of apps. A user is just a passive receiver of information. These apps are just e-books or access points to database, therefore cannot be considered very different from school text books.

2. Periodic table

Again, this group of apps is very numerous. There are apps only depicting the periodic table of elements, there are also interactive apps enabling a user to find more information about an element they tapped on. Especially the possibility of finding more about an element puts these apps ahead of the classic school periodic table poster.

3. Games and quizzes

This category contains a wide range of apps from very simple to quite complex tasks. There are lots of fill-in-information games, as well as multiple choice games available. The topics are for example: nomenclature of the compounds, composition, elements, reactions, functional groups, etc. As it is easily accessible, these may become a very popular tool in chemistry classroom. There is also a possibility to let students share the results as the games usually keep score.

4. Calculating and balancing chemical equations

Although the competence to count and balance chemical equation belongs to general chemistry knowledge, there are plenty of apps available. However, these may help as a control to students who are not sure with their result.

In this category, it is possible to find apps that help with a reaction products etc. These may also help as a control for example after students do their homework.

5. Molecular viewing

These apps also belong among popular. In the classroom they can help visualize structures which would be unpresentable to students. As these apps have a lot in common with the next group, more detailed description will follow.

6. Chemical structure drawing

The benefit of these apps is also their interactivity, so a user can not only create formulas, but also project them in 3D or 2D and rotate them on the display of their device.

More advanced apps enable naming created compounds and also looking for their features in databases. A user thus gets more thorough information which may serve well for faster or more interested students. With these possibilities, school exercises can move to a state where students work alone from the very beginning being simply guided by teacher's instruction.

The following table shows blending of the created categorization of mobile apps with the revised Bloom's taxonomy. It expresses the possibilities of developing and achieving educational objectives that apps themselves offer.

Tab. 01. Apps and Revised Bloom´s Taxonomy.

	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Research and Reference/ Study Guide	Terminology, Theories, Models Structures, Properties	Interpreting, Summarizing, Classifying, Inferring, Comparing…				
Periodic Table	Elements, Structure, Properties and Rules	Interpreting, Categorization, Comparing, Distinction, Explaining		Organizing		
Games and Quizzess	Recognizing of Chemical Structure, Name, Compound…	Classifying, Summarizing, Inferring, Comparing	Executing			
Calculations and Balancing Chemical Equations	Terminology, System of units, Chemical Equations	Classifying, Inferring, Comparing, Interpreting				
Molecular Viewing	Identification of a Model (Compound, Structure)	Classifying, Comparing, Interpreting, Recognition		Attributing, Organizing		
Chemical Structure Drawing	Identification of a Model (Compound, Structure)	Classifying, Comparing, Interpreting, Recognition	The use of a known process for a new assignment	Attributing, Organizing		

Most applications develop user‘s lower cognitive abilities. To achieve higher, teacher´s guidance is necessary. For a teacher (student), it's important to know the educational potential of an app which may be connect it with educational objectives.

Conclusion

Mobile information and communication technologies are without doubt a phenomenon of last several years. There is no way to avoid them in both personal and working life. Not to keep falling back, schools cannot rigidly stay based on a blackboard, a chalk and a textbook. However, utilization of mTech needs to be done with a respect to particular topics. The "cool" effect of using the technology in education vanishes in several lessons and the tool loses its magic. Therefore there needs to be more behind this teacher's step.

A lot of mobile apps are possible to be used both in school (classroom) and out of school. A teacher can use the motivational effect of novelty of this approach as well as the fact lots of results of educational games may be shared online keeping a healthy competition for example among homework solvers. On the other hand, apps have not reached their potential yet (see the Tab. 01.). Considering the reality where every owner of a smartphone uses several apps simultaneously, purely educational apps build on the distance learning premises are rare. Teacher's assistance is still necessary, although it diminishes the unique of distance learning whenever and wherever a learner feels like learning.

Last but not least, the mTech inclusion in education will surely lead students to a true understanding of the potential of the devices they use. The common experience shows youngsters use them mostly for chats, social networking, listening music and playing games. The authors of this paper are further going to work in this field in order to offer teachers (and their students) effective ways of using mTech in education also as an instrument of leading students to the path where they understand they are responsible for their own learning and that ICT may considerably help them.

References

Fielden K., Malcolm P. (2007) Cell phones in New Zealand secondary schools: boon, banned or biased? In D. Parsons & H. Ryu (Ed.), Mobile Learning Technologies and Applications.

Libman D., Huang L. (2013) Chemistry on the Go: Review of Chemistry Apps on Smartphones. Journal of Chemical Education, 90(3), 320-325. doi: 10.1021/ed300329e.

Madden M., et al. (2013) Teens and Technology (pp. 19).

Neumajer O. (2013) Počítačové tablety ve škole bez dalších podpůrných aktivit selhávají. Česká škola. Retrieved from http://www.ceskaskola.cz/2013/11/ondrej-neumajer-pocitacove-tablety-ve.html.

NMC (2014) Horizon Report 2014 (pp. 52). Retrieved from http://www.nmc.org/pdf/2014-nmc-horizon-report-he-EN.pdf.

Rusek M. (2011) Mobilní technologie : rozšíření kompetencí současného učitele chemie. Media4u, 8(X3), 116-121. Retrieved from http://www.media4u.cz/mmx32011.pdf.

Rusek M. (2012) Možnosti a omezení zařazení mobilních technologií do výuky. In V. Ježková (Ed.), Kvalita ve vzdělávání, (pp. 152). Praha, UK PedF.

Svoboda P. (2009) M-learning a příklady využití mobilních technologií se vztahem k výuce technických předmětů. Media4u(X1), 119-122.

Thornton P., Houser C. (2004) Using mobile phones in education.

Stárková Dagmar[1], Rusek Martin[2]

[1] *Department of Teaching and Didactics of Chemistry, Charles University in Prague, Faculty of Science, Prague, CZ*

[2] *Department of Chemistry and Chemistry Education, Charles University in Prague, Faculty of Education, Prague, CZ*

dadecek@gmail.com, martin.rusek@pedf.cuni.cz

Fostering digital competence with computer-supported real laboratory

Andrej Šorgo

Introduction

The recognition, that the content and nature of needs, (not to mention their future needs) and that students who have completed their studies are still not prepared to enter the world the knowledge provided by the formal educational system often fails to reflect actual students' of labour, is not new [Šorgo & Kocijančič, 2004; Šorgo & Ploj Virtič, 2014]. In addition, even when their knowledge, at the moment of grading, is up to date in the school context, there is a discrepancy between school equipment and procedures and the professional equipment and protocols that they will encounter during their careers. In the quest for strategies that will align education, recent needs and future perspectives, words like 'literacy' (literacies) and 'competence' (competenc(i)es) have become part of the educational vocabulary. It is not the aim of this paper to review all these concepts, but for reasons of clarity, the word 'competence' is understood in the broad sense provided by the EU framework of lifelong learning (Recommendation 2006/962/EC) as "a combination of knowledge, skills and attitudes appropriate to the context". Scientific literacy is understood (OECD-PISA) as "the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity". Skills are defined as "the ability to do something that comes from training, experience, or practice" (Merriam – Webster). 'Skills', in the context of this paper, is recognized as a synonym for generic competences extending beyond and between school subjects and connecting the world of school with the outer space of real life. There can be differences among the priorities and competences-literacies lists provided by various authors and organizations [Svetlik, 2006], but some common skills (generic competences) are identified by almost all lists. Framework for 21st Century Learning, for example, divides them into the following categories: i) Life and career skills; ii) Learning and innovation skills that include critical thinking and problem solving; communication, collaboration; creativity and innovation, and iii) Information, media and technology skills (literacies).

While it is easy, at least at the conceptual level, to accept the idea that education needs change, the hard part is in transferring ideas into real school practice. The reasons are many, ranging from teacher attitudes to shortage of equipment or available school time. The important question in attempts to improve education is, whether something recognized as beneficial in one environment will have equal impact in other environments. The educational literature is overpopulated with success articles showing that Method One is superior to Method Two and (rarely) Three. However, in practice follow up experiments or quasi experiments often show unexpected side effects or even the recognition that things simply do not work.

Computers and the accompanying technologies have become an integral part of our lives, as both visible and invisible technologies [Carr, 2003]. Information and Communication Technologies (ICT) provide an example of such technologies which have fundamentally changed education, [Mishra & Koehler, 2006], with the recognition that buying computers is the easiest task in introducing them into education [Hepp et al., 2004]. In science education, computers have found their way into instruction in line with other school subjects as a source of information, as a typewriter, or for multimedia and, in a specialized way, as a universal measurement (data acquisition) system. This give teachers of science a unique position in a school. If they decide not to teach students how to write an essay or prepare a presentation, somebody else will do it, but if they do not use data acquisition systems as part of computer-supported real laboratory (CSRL), there is nobody to do this instead of them.

Digital competence (literacy), as one of the European competences for lifelong learning [Recoomendations, 2006], is recognized mainly as a number of internet-based skills. It is defined as follows: “Digital competence involves the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet.”

Digital competence is only an idea without the operationalization and application of its contexts, methods and strategies in science education. For the purpose of operationalization, a list of key competences provided by Meyer’s report (1992) were found suitable to connect the science laboratory with the broader concept of digital competence.

Methods

The paper is based on first-hand experience with the introduction and development of and reflective practice in the use of data-loggers at elementary, secondary general and vocational schools, and in higher vocational and university education in Slovenia. Various different data acquisition systems and software were tested in both real (CMC-S1, CMC-S2, CMC-S3 (http://www.pef.uni-lj.si/eprolab/comlab/soft/eprolab-si.htm); and LabPro, LabQuest (http://www.vernier.com/) and virtual worlds [Puhek, et al., 2013]. Over a timespan of almost 15 years, a number of journal and conference papers were published. A list of references is available on the author’s personal web page (http://splet02.izum.si/cobiss/bibliography?code=13962).

Results

From recent and past experiences, it has been recognized that computer-supported laboratory could influence and even widen digital competence (literacy). However it is not technology that works for itself, but the conceptual framework and the methods and strategies for its use. Inquiry- and problem-based laboratory work is superior in comparison to the expository (“cook book”) approach [Šorgo, 2010; 2011]. The list of generic competences influencing digital competence, following Meyer’s key competences, is as follows:

Collecting, analysing and organising information

Through work with CSRL, student learn how to collect, organize, and analyse primary data. Teachers should emphasize and lead them towards the recognition that data on the Internet is there because someone has collected it and made it accessible. They should distinguish between raw, primary data and results and conclusions based on selected and statistically manipulated data. Because experimental data is visible in time on a screen as tables and graphs, this can be recognized as both bad and good: as good, because there is no need for students to lose time in data collection, and students can concentrate on an experiment and comment on it. Given the number of sensors and the combinations among them, it is possible to prepare experiments previously not imaginable in elementary or high school. However, in reality the dominant practice in CSRL is experimental work performed in a plug- and play- fashion, with the student’s only task being to stick sensors into something and at the end to embed graphs into a report. Because students are not involved in the planning, they have poor understanding of the units, axes, outliers, smoothing of noise, calibration, etc. [Šorgo & Kocijančič, 2004]. To extract the best from CSRL, expository exercises should be replaced by inquiry- and problem-based styles as often as possible.

Communicating ideas and information

The benefit of CSRL correlate with the teacher’s demands. If the expected results of a laboratory activity are filling in gaps or sticking a graph in a worksheet, then the contribution of CSRL to these competences will be minimal or even non-existent. If students must prepare their own reports as individual or group work, based on involvement in planning, realization and post-laboratory debate, then the added value is much higher [Šorgo, 2010].

Planning and organising activities

Planning and organizing activities not only form part of digital competence but also contribute to a “sense of initiative and entrepreneurship”. Students should be involved in the early stages of preparatory activities. Giving them everything on a tray with the task of following the manual blindly can help in illustrating a process; however, as recognized already in the paragraph about data collection, they often do not realize what they are doing. Planning of laboratories should not be a one-time experience but should be a continuous practice, helping students to get early experience in project work.

Working with others and in teams

Students should be proficient in individual and team work, and CSRL allows both styles. Because of the scarcity of laboratory equipment at many schools, even students who prefer individual work must learn how to cooperate. The best results were achieved with the use of sequential work as a combination of well-defined individual and group tasks.

Using mathematical ideas and techniques

With a number of sensors and combinations among them CSRL allowed the quantification of many observations (e. g., ion selective electrodes). Students can quantify very short, very long or even unexpected observations [Šorgo & Kocijančič, 2004; 2012]. Some of the computer programs have statistical tools already embedded in them, but even if they do not, all of them allow the export of raw data to some of the statistical programmes. In this way the connections with mathematics can be strengthened [Šorgo, 2010].

Problem solving

Problem solving is a high priority on the competence lists and can be connected by digital competence, because students should learn how to solve problems in both real and virtual worlds. First-hand experience can help in understanding the processes of scientific reasoning. The issue with problem solving is that teachers very rarely use this strategy in regular science classes. Regular laboratory work is replete with expository exercises but lacking in inquiry- and problem-based activities. Even short demonstrations can be performed as problem-based activities, a fact that remains unrecognized by most teachers [Šorgo, 2011].

Using technologies

Technologies have become part of our everyday experience and without them one cannot find a book in a library or buy a plane ticket. It is impossible to teach students how to manipulate every technology with which come into contact over lifetimes. It is more important to teach them procedures as transferable skills. Even if they do not use these technologies, they will be able to understand some important issues such as measurement errors, calibration, and the limits of technology, to prepare them for make better decisions concerning safety or environmental conservation.

Conclusions

Computer-supported real laboratory (CSRL) has great potential, not only as a tool in clarifying science concepts, but as a tool for strengthening other important skills and competences, as well. The method is two-directional because many of the principles learned in the use of such laboratory work can be transferred, e.g.into digital competence. CSRL will not work by itself for every laboratory style used. Inquiry- and problem-based styles are superior to the traditional expository style that dominates school laboratories.

References

Carr N.G. (2003) IT doesn't matter. Harvard Business Review, 81, 5, 5-12.

Framework for 21st century learning. http://www.p21.org/storage/documents/P21_Framework_Definitions.pdf [Accessed on 9th July 2014].

Hawkins R.J. (2002) Ten Lessons for ICT and Education in the Developing World. In: eds. Kirkman, G., Cornelius, P.K., Sachs, J.D., Schwab K. The Global Information Technology Report 2001-2002: Readiness for the Networked World. World Economic Forum. Oxford University Press. pp. 38-43.

Hepp P.K., Hinostroza E.S., Laval E.M., Rehbein L.F. (2004) Technology in Schools: Education, ICT and the Knowledge Society. World Bank.

http://www1.worldbank.org/education/pdf/ICT_report_oct04a.pdf [Accessed on 3rd November 2005].

Merriam Webster. http://www.merriam-webster.com/dictionary/skill [Accessed on 9th July 2014].

Meyer E. (1992) Key competencies. Report of the Committee to advise the Australian Education Council and Ministers of Vocational Education, Employment and Training on employment-related Key Competencies for postcompulsory education and training. Australian Education Council and Ministers of Vocational Education, Employment and Training.

Mishra P., Koehler M.J. (2006)Technological pedagogical content knowledge: A framework for teacher knowledge.Teachers College Record 108, 6: 1017-1054.

OECD-PISA. http://www.oecd.org/pisa/keyfindings/pisa-2012-results.htm.

Puhek M., Perše M., Vršnik Perše T., Šorgo A. (2013) Perceived usability of information and communication technology and acceptance of virtual field trips by lower secondary students, undergraduate students and in-service teachers. Journal of Baltic Science Education, 2, 6, 803-812.

Recommendation 2006/962/EC of the European Parliament and of the Council of 18 December 2006 on key competences for lifelong learning [Official Journal L 394 of 30.12.2006].

Svetlik I. (2006) O kompetencah. Vzgoja in izobraževanje 37,1: 4-12.

Šorgo A. (2010) Apacer: a six-step model for the introduction of computer-supported laboratory exercises in biology teaching. Problems of Education in the 21st Century, 24, 130-138.

Šorgo A. (2010) Connecting biology and mathematics : first prepare the teachers. CBE Life Sciences Education, 9, 3, 196-200.

Šorgo A. (2011) In search of good science teaching with hands-on and minds-on computer-supported activities = Hledání efektivní výuky s praktickými i intelektuálními počítačem podporovanými aktivitami. In: BÍLEK, Martin (ed.). Technologicko-didaktická znalost obsahu v chemii: autorské články z mezinárodni vědecké konference. Praha: Oddělení didaktiky chemie Katedry chemie Přírodovědecké fakulty, 2011, 11-16.

Šorgo A., Kocijančič S. (2004) Teaching basic engineering and technology principles to pre-university students through a computerised laboratory. World Transactions on Engineering and Technology Education, 3, 2, 239-242.

Šorgo A., Kocijančič S. (2012) False reality or hidden messages: reading graphs obtained in computerized biological experiments. Eurasia, 8, 2, 129-137.

Šorgo A., Ploj Virtič M. (2014) Can we expect to recruit future engineers among pupils who have never repaired a toy?. In: 2nd International Scientific Conference on Philosophy of Mind and Cognitive Modelling in Education, May 26-28, 2014, Maribor, Slovenia. ABERŠEK, Boris (ed.).PCE 2014 : Conference Abstract Proceedings. Maribor: Faculty of Natural Sciences and Mathematics, 96-97.

Andrej Šorgo

University of Maribor/ Faculty of Natural Sciences and Mathematics/ Faculty of Electrical Engineering and Computer Sciences, Maribor, Si

andrej.sorgo@uni-mb.si

LEVEL OF ELEMENTARY PHYSICAL KNOWLEDGE IN HEALTH-CARE PROFESSIONALS MAY BE THE REASON FOR INNOVATIVE TEACHING OF (BIO) PHYSICS

Zuzana Balázsiová

The context and purpose of framework

This article presents a part of analysis of didactic test results of part-time students of Nursing. Target of test was to determinate the level of basic physical knowledge [Kráľová & Kukurová, 2008]. We found, that permanent acquisition of physical knowledge by students is insufficient.

The aim of study is determination of elementary physical knowledge retention level of nurses – part-time students of Nursing.

Methods

The research sample included 266 nurses – part-time students of the 1st – 2nd year of the study program Nursing at three Slovak universities. They were (30.8±7.96) years old in average. The youngest student was 23 and the oldest one was 57.

Data collection was obtained by original didactic test, which contained 11 biophysically oriented tasks aimed to solve the problems concerning the nursing practice and 9 tasks aimed on elementary knowledge of physics. This test was used for physical literacy research of nurses [Balázsiova, 2012]. We analysed in our article only physical part of this test (last 9 tasks). The focus of questions in the test is in the Tab. 01. The accepted limit was established as 60% of correct answers. Results of the test were processed using descriptive statistics. We determined the coefficient of difficulty Q for each task. Its normal value is from 30 to 70.

Tab. 01. Physical topics of questions in the test.

Question number	Topic of task
1.	surface tension
2.	pressure, Pascal law
3.	osmosis
4.	frequency
5.	sound
6.	center of gravity
7.	conversion of physical units
8.	gravity force
9.	melting, freezing

Results

Respondents answered correctly (4.21 ± 1.76) tasks i.e. (46.77 ± 19.55) %. 6 respondents obtained the lowest result 0 points. Two respondents gained maximal number of points. Majority of the respondents received 5 points, median equal 4 (Mo = 5, Me = 4). Coefficient of variation was Cv = 0.419. It shows statistical difference of physical knowledge among students.

The question number 7 was the most difficult (Tab. 02.), coefficient of difficulty Q = 80.08:

1 liter equals: a) 1000 dm^3, b)10 dm^3 , c) 1dm^3

The question number 9 was the easiest (table 2), Q = 13.16:

The differences between boiling and the solidification temperatures of water is: a) 0^oC, b) 100^oC , c) 273 K.

Tab. 02. Properties of physical part of didactic test.

	Number of task								
	1	2	3	4	5	6	7	8	9
n_c	86	180	79	174	107	91	53	120	231
n_{ic}	180	86	187	92	159	175	213	146	35
p	0.32	0.68	0.30	0.65	0.40	0.34	0.20	0.45	0.87
q	0.68	0.32	0.70	0.35	0.60	0.66	0.80	0.55	0.13
Q	67.67	32.33	70.30	34.59	59.77	65.79	80.08	54.89	

Legend: n_c – number of correct answers, n_{ic} – number of incorrect or missing answers, p – the proportion of students who solved the task correctly in the test, q – the proportion of students who solved the task incorrectly or missing answers, Q – coefficient of difficulty.

Conclusion and implications

We consider that the poor results, i.e. (46.77 ± 19.55) % correct answers relate with negative relationship of nurses to the (bio)physics as well as to the absence of physical base at high schools. [Kukurová et al., 2007] If students have deficiency of high school knowledge, it is unlikely that their new knowledge, abilities and skills acquired at university will be permanent. In this case, distortion or forgetting of learned information comes very soon. We consider, that classical methods used for teaching of physics in secondary and high school in the past are insufficient for permanent obtaining of knowledge by students. In the future, this knowledge is often missing in practice. Due to intensive forgetting, students cannot recover the basic concepts of the learned topics even by solving of a nursing problem. Poor elementary physical knowledge may indicate an inadequate technical, physical and computer skills of nurses and thus reduced ability to utilize in the fullest extent of innovative teaching methods as e.g. ICT in nursing practice. [Kráľová & Pekníková, 2013].

Statistically significant heterogeneity of physical knowledge (Cv=0.419) could be caused by lower number of questions in the test, different methods of physics teaching at secondary schools and diversity of qualitative relation to physics, which was created at primary school.

We believe, using ICT in physics teaching in all education levels, strengthen the ability of nurses to solve problems, improve the process of learning and self-learning, students understanding the practical importance of physics and improve their ability to communicate [Kalaš, 2000]. Combination of direct teaching in small groups of students and e-learning is advised for better results of students learning. [Dadgostarnia & Vafamehr, 2010] Also the problem based learning in nursing study leads to higher efficiency of work in practice finally. [Fesharaki, et al., 2010]

Acknowledgments: Contribution was supported by GP KEGA Ministry of Education, Science, Research and Sport of the Slovak Republic № 052UK-4/2013.

References

Balázsiová Z. (2012) Koncepcia výučby biofyziky v študijnom programe ošetrovateľstvo. [Conception of biophysics in bachelor nursing degree program] Dissertation thesis. Martin: JLFUK, Slovak Republic, 180 p.

Dadgostarnia M., Vafamehr V. (2010) Comparing the Effectiveness of Two Educational Approaches of "Electronic Learning and Training in Small Groups" and "Training Only in Small Groups" in Teaching Physical Examination. Iranian Journal of Medical Education [online]. 2010, vol. 10, No. 1, p. 11–18 [Accessed 2011-02-21] At <http://www.ijme.ir/browse.php?a_code=A-10-725-3&slc_lang=en&sid=1>. ISSN 1735-8892

Fesharaki M. et al. (2010) The Effect of Lecture in comparison with Lecture and Problem Based Learning on Nursing Students Self-Efficacy in Najafabad Islamic Azad University. Iranian Journal of Medical Education [online]. 2010, vol. 10, No. 3, p. 262–268 [Accessed 2011-02-21] At <http://www.ijme.ir/browse.php?a_code=A-10-143-5&slc_lang=en&sid=1>. ISSN 1735-8892.

Kalaš I. (2000) Čo ponúkajú informačné a komunikačné technológie iným predmetom. [What offer ICT for other subject?] Proceedings of the Conference Infovek. 2000. [online] [Accessed 2014-05-02] At http://www.infovek.sk/archivwebu/konferencia/2000/zbornik.html

Kráľová E., Kukurová E. (2008) Use the questionnaire to receive feedback information on the teaching process. In: Research in Didactic of the Sciences. Krakow: Uniwersytet Pedagogiczny im. Komisji Edukacji Narodowej, 2008, p. 219-222. ISBN 978-83-7271-519-7.

Kráľová E., Pekníková M. (2013) Digitálna kompetencia & využívanie informačnej podpory v medicínskom štúdiu. [Digital competence & using of information support in medical stuty] In: Formy a prostriedky vzdelávania na podporu prevencie chorôb v podmienkach eHealth. [Forms and means of education to promote disease prevention in condition of eHealth]. Praha : Evropská asociace pro fototerapii, 2013, p. 88-91. ISBN 978-80-87961-02-8.

Kukurová E. et al. 2007. Retrospektívna analýza žiackych fyzikálnych vedomostí a (ne)schopnosti ich rozvíjať v podmienkach zdravotníckych študijných programoch a čo ďalej. [Retrospective analysis of pupils´ knowledge and physical (in)ability to develop them in conditions of medical curricula and what to do next.] Proceedings of the Conference DIDFYZ, 2006, Nitra: Univerzita Konštantína Filozofa, SR, p. 2-5.

Zuzana Balazsiova

Institute of Medical Physics, Biophysics, Informatics and Telemedicine

Comenius University,

Faculty of Medicine, Bratislava, SK

zuzana.balazsiova@fmed.uniba.sk

Chemical Experiment in the actual centre ICT

Jiří Rychtera, Roman Hásek

Motto:

"But here, alas, is needed to break the school experimentation in chemistry from the deep crisis caused among other things by introducing structural model of chemistry at secondary school. As a result of this dismal situation there is a lack of new and original experiments, new experimental methodologies, tools for pupils and teachers' experimentation, collections of experiments, but also the decline of experimental skills of teachers of chemistry". [Holada, 1996]

Introduction

Currently, a lot of teachers tend to use videos of chemical experiments in teaching chemistry. The reasons for this are for example the price of feedstock and equipment for experimentation, the safety of pupils, a lack of space and time expenditure. Most of these videos are intended to complement the theoretical foundations and interpretation of the subject matter, to explain some regularity of chemical processes and also increase motivation and students' interest in chemistry. To understand the principle of chemical reactions a more comprehensive insight into the course of the analysis is needed. To implement the "intellectual insight" an interpretation of the real experiment with verbal accompaniment of the demonstrator is used. However, if the experiment has extremely fast or explosive progress, a student primarily depend on information obtained from the speech of the demonstrator. It is well known fact that the efficiency of learning grows proportionally if you replace data obtained verbally with data obtained in a visual way. Support of the intellectual insight by visual data should therefore be, in terms of the process of cognition, more efficient.

Choosing an appropriate experiment with extremely rapid or even explosive course, its classic recording by high-speed video camera or camcorder and subsequent analysis of the individual images, allows operators to support visual insight. For this purpose we have chosen an experiment presenting the chemical part of combustion engine. Through this experiment it is possible to prove the expected effectiveness of experimental and also cognitive activities. The whole methodological procedure is described later. The basis is the traditional performance of the experiment, followed by improvement of equipment, description of selected recorded images that enhance the efficiency of intellectual insight. Realized methodology corresponds to the objectives of Bloom's taxonomy.

The selected experiment is significant in terms of usability. After the described improvements we can obtain not only effective intellectual insight into the principles connected with function of petrol engines, but also we can think about some important processes, for example related to fuel treatment (use of additives) or an ecological side of the modeled processes (function of catalyst) .

Bloom's taxonomy of objectives

School chemistry experiment as a means of teaching is an important part of basic organizational forms of teaching in chemistry. We define it as a planned and systematic activity implemented by teachers in collaboration with students, the content of which is the study of natural phenomena under known conditions. Its aim is to acquire knowledge which leads to a deeper and general chemical knowledge. Inclusion of a chemical experiment in teaching contributes to fulfillment of a number of teaching and educational objectives. The vast majority of the chemical experiments described in textbooks is not time- consuming, quality-oriented, bringing mainly knowledge to students. Acquiring knowledge brings specific information to the student and subsequent reproduction is usually considered sufficient condition for implementation of effective teaching in the current school. Pupils in reality mainly repeat concepts, definitions and reproduce them. In terms of cognitive processes these can be assigned to the lowest category of Bloom's taxonomy of objectives. The school therefore begins to be less attractive, because the mere acquisition of knowledge is for pupils 'painful', acquired knowledge is forgotten and they can easily also "Google it", which leads to the syndrome of apparent doom and uselessness of school organized practices.

A change of this methodology, which our schools want for a long time, is related to modifications of target categories. According to mentioned Bloom's taxonomy of educational objectives it is necessary to organize the teaching process in terms of sustained support of intellectual assumptions, which are the prerequisite for operational processes with acquired knowledge. Students should be able to penetrate into the principles of presented events, explain them, formulate conclusions in their own words, give examples of connections, generalize, sort gained knowledge, etc. These processes also applies in the interpretation of the knowledge, since a pupil is forced to explain, compare, explore connections, model and abstract. The logical culmination of these processes is prerequisite to apply knowledge into the practice, not only in terms of understanding how the phenomenon is used, but also in terms of designing new applications. These are however only theoretical assumptions. In fact, according to the motto "There is a lack of new and original experiments, new experimental methodologies, tools for pupils and teachers' experimentation, collections of experiments, but also the decline of experimental skills of teachers of chemistry." [Holada, 1996] In this article we outline some of our ideas, which appear to us as a solution to the problems described above. For this purpose we chose an experiment that can demonstrate the chemical principles of combustion of gasoline vapor, which happens in the cylinders of gasoline engines.

The explosion of fuel mixture

The following experiment is described in publication [Los, Hejsková & Klečková, 1997] under the title The explosion of fuel mixture. "Make a cylindrical cardboard container of about 750 cm^3 and cover it with a lid. About 1.5 cm from the bottom cut a hole with a diameter of 0.5 cm. Put a few pieces of cork into a cardboard container and instill about 5 cm^3 of gasoline using dropper. Cover the container with the lid and shake vigorously. This creates a mixture of air and gasoline droplets. Place the container on a table and light the hole at the bottom. WARNING! The hole for the ignition or the lid must not be directed to the area where students or other people are! "

Fig. 01. Explosion of the fuel mixture [Los, Hejsková & Klečková, 1997].

The described experiment is very simple, it is realized without any problems and the move of the lid after ignition of the mixture clearly demonstrates the role of gasoline vapor in spark-ignition engines. We call it “working” function. Although the students can clearly see the movement of the lid, the actual burning of gasoline vapor is what remains hidden from them. It is hidden behind the opaque cardboard cylindrical container. The described apparatus shows the effect of so called Black Box (the effect of black boxes) where students are forced to use an intellectual insight into the observed experiment. This intellectual insight may not be adequate, it depends on the age and previous experience of the students. However, we can modify the experimental apparatus so that also visual insight would be applied.

Adapted apparatus

Experimental support for visual insight into the course of the story required a slight modification of the experimental apparatus. Instead of an opaque cylindrical container made of cardboard we used transparent PET bottle where we cut off the top part. The experiment is described in detail in [Bilek & Rychtera, 2000] and is schematically illustrated in the Fig. 02. The picture for support of intellectual insight is enhanced by comparison with the scheme of combustion engine (see Fig. 02.).

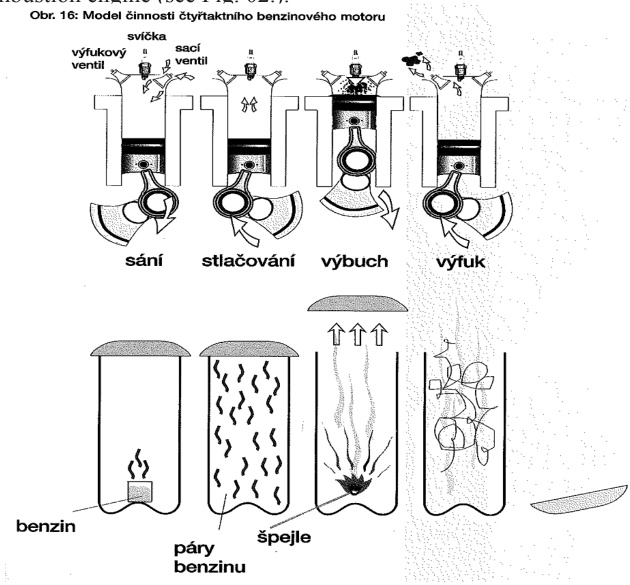

Fig. 02. Model of combustion engine [Bilek & Rychtera, 2000].

Since the shape of the apparatus changed after the burning of gasoline vapor, we replaced PET bottle with a thick-walled cylindrical vessel of polymethylmethacrylate (Plexiglas). Its resistance to high temperature is due to wall thickness satisfactory so it can be used almost without any limitation. We believe that due to the limited availability of this material teachers could use cylindrical glass containers, where the only problem would be drilling the hole to ignite gasoline vapors.

In order to present the gasoline engine in the best possible way a skewer used for ignition was later replaced by a spark plug and an induction coil so that it resembles the real engine (see Fig. 03.).

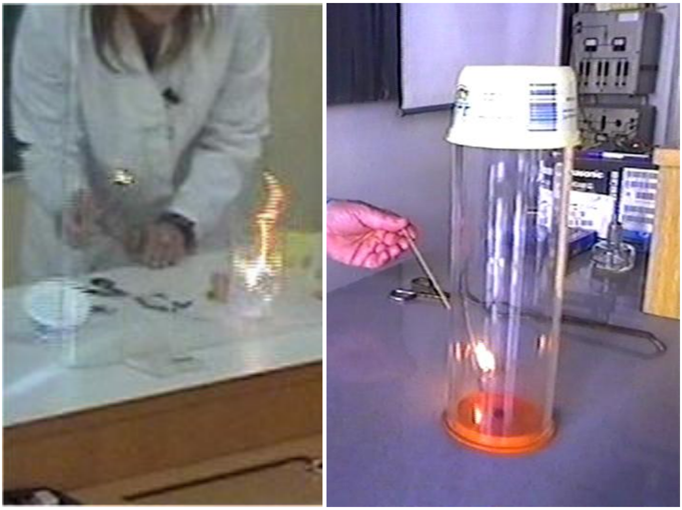

Fig. 03. Processed apparatus with spark plug.

Video and chemical experiment

Minor technical adjustments made the historical apparatus closer to reality. These minor chances did not aim to make the experiment the most effective but they were supposed to be the way how to improve effectiveness. The most significant aspect is visual insight during combustion. Replacement of the opaque cardboard container by Plexiglas not only allows observation of ignition, but also the observation of very rapid combustion process. “Very fast” means 0.3 seconds. Such a short time does not produce much effect for a normal human eye. To obtain the necessary amount of information we realized video recording of the experiment and then analyzed images with the support of appropriate software. This can be for example freeware Virtual Dub, etc. This method basically replaces expensive analysis conducted with high-speed camera which is necessary only in cases of extremely fast processes. As an example we choose a sequence of 8 consecutive frames, which represent above mentioned 0.3 seconds process (see Fig. 04.).

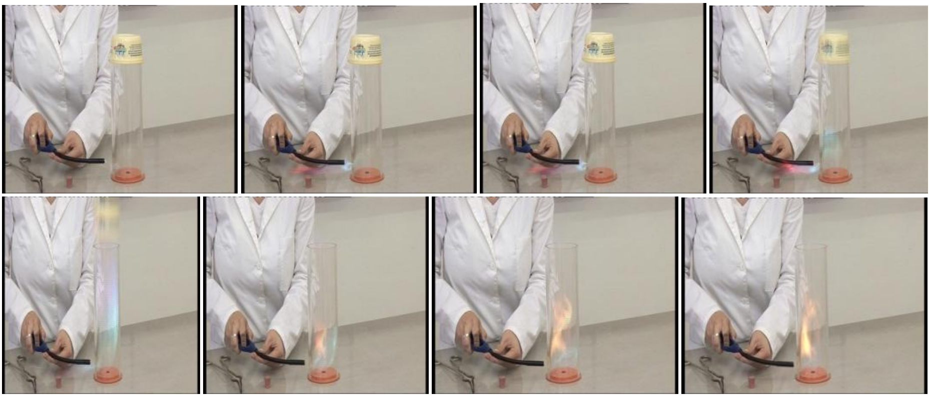

Fig. 04. Example of the sequence of 8 images presenting the time of around 0.3 seconds, allowing visual insight into the burning process.

An attentive observer who has the ability to analyze the movie will notice two colors of the flame. The initial stage is characterized by a blue color typical for the perfect combustion. Lower hydrocarbons from the gasoline pool are perfectly burned and consume an adequate amount of oxygen. Schematically, this process can be expressed by the equation:

$$2C_8H_{18} + 25O_2 \rightarrow 18H_2O + 16CO_2$$

Subsequently, heavier components of gasoline fractions are burned which probably do not have a required amount of oxygen and thus the flame is orange and glowing. “Visibility” is due to the unburned carbon particles as it can be observed in candle flame or acetylene. Schematically, we can demonstrate these findings in the following equations:

$$2C_8H_{18} + 9O_2 \rightarrow 18H_2O + 16C$$

$$2C_8H_{18} + 17O_2 \rightarrow 18H_2O + 16CO$$

In terms of learning, above mentioned analysis allowed us to carry out visual insight into the course of the story and afterwards intellectual insight, which can be considered as understanding of the principle of the action. Understanding of the principle of the process, as we mentioned in the second subsection, is characterized by higher level of educational objectives according to Bloom’s taxonomy and can also lead to the third level of the mentioned taxonomy, which is the recognition of examined applications. These applications can be for example catalysts in cars used mainly for environmental reasons as well as use of additives in motor fuels, the use of oxygen to support combustion of acetylene at autogenous welding, etc.

Conclusions

There are two levels increasing efficiency of the chemical experiment in the article. The first level corresponds to the technical improvement of equipment for realization of the experiment. Sequence: a) apparatus from a paper carton, b) apparatus from Plexiglas, c) apparatus from Plexiglas with spark plug – these lead not only to more effective intellectual insight by enabling visual insight, but also experiment resembles reality. However, higher effectiveness we can see in the second level improvement of the process of video analysis during the experiment. Using the appropriate software enabling processing of the recorded video, which means obtaining a smooth frame rate or image, the viewer can look into during fast processes with the help of classic video equipment and computers. The analysis of such situations may subsequently bring new knowledge to the discipline as well as to the education. Basically it is a contribution to ICT methodology for chemical experimentation.

References

Bílek M. (2011) a kol. K virtualizaci školních experimentálních činností: reálný a virtuální experiment – možnosti a meze jejich kombinace v počáteční přírodovědné výuce. M&V Hradec Králové

Bílek M., Rychtera J. (2000) Chemie na každém kroku, MOBY DICK, Praha, s.31, ISBN 80-86237-05-2

Holada K. (1996) Tendence přírodovědného vzdělávání a přípravy učitelů. In: Pešková J., Lipertová P. (eds.): Hledání učitele. PdF UK, Praha, s. 169. ISBN 80-96039-09-9

Janík T., Miková M. (2006) Videostudie (Výzkum výuky založený na analýze videozáznamu); Brno, Paido

Los P., Hejsková J., Klečková M. (1997) Chemie se nebojíme (2.díl chemie pro základní školu); Scientia Praha, 1. vydání, 89 s. ISBN 80-7183-027-5

Prokša M., Held L.(2008) a kol. Metodológia pedagogického výskumu a jeho aplikácia v didaktikách prírodných vied; Bratislava: UK,

Revize Bloomovy taxonomie edukačních cílů. [online] [cit. 2014-06-14] Dostupné z: http://aplikace.msmt.cz/DOC/NHRevizeBloomovytaxonomieedukace.doc

Acknowledgement

This article was supported by the project VeNaDo UHK reg.no. CZ.1.07/2.3.00/45.0014

Jiří Rychtera[1], Roman Hásek[2]

[1] *Univerzita Hradec Králové, Přírodovědecká fakulta, Hradec Králové,CZ*

[2] *Vyšší odborná škola zdravotnická a Střední zdravotnická škola Trutnov, CZ*

jiri.rychtera@uhk.cz, hasek@szstrutnov

EFFECTIVENESS OF EDUCATIONAL SOFTWARE IN SCIENCE EDUCATION WITH FOCUS ON CHEMISTRY – FROM THE RESULTS OF RESEARCH PROJECTS

Kateřina Chroustová, Martin Bílek

Introduction

Information and communication technologies influence the way of our live, and especially our perception, memorizing and evaluation of information, thus our learning itself. The biggest influence is evident in the new generation, the so-called "Generation Z", which is also named by technology, "Net Generation, Nintendo Generation, Digital Natives" etc. [Trnová, 2011]. This generation grew up surrounded by computers, laptops, tablets, mobile phones constantly connected to the internet, which affects the learning style of today's students. Lindgren (2010) states that students have mostly visual learning style in recent time, which means they learn best from the information provided to them in the form of pictures, schemes, animations, diagrams, videos and simulations. According to D. and J. L. Oblinger [2005] they are able to process information from multiple sources, have an intuitive ability to understand visual images, have better visual-spatial vision and learn better through discovery than mere communication of knowledge. They quickly transfer their attention from one activity to another, especially if they lose interest in performed activity; they respond quickly, but also expect a quick response, therefore for example they prefer to search on the Internet than in libraries. These facts are reflected in their education, and therefore we should include new technologies into lessons more often and find out ways of their most effective usage.

Educational software

One of the ways how to support visualization in science education is the usage of appropriate educational software. It transmits education in an environment that is familiar and attractive to students, it facilitates immediate feedback and in the case of chemistry also enables immediate display of complex internal structures of the compounds in 3D, without which student/pupils understand the structure and reactivity of chemical substances with difficulties. According to Cheng et al. (2010) education is supported by multimedia more effectively than education with traditional printed materials because a dynamic and interactive environment is more impressive for students/pupils when presenting abstract concepts and it can stimulate their creative thinking and engagement in the lesson. To sum up, interactive multimedia content can improve the effectiveness of education because it improves user satisfaction and engagement.

In the references, there are two approaches to the question of what is educational software. The first approach presents e.g. Dostál [2011], who terms as an educational software any computer software which is designated for educational purpose and can fulfil at least some of the didactic functions: motivation, exposition of subject matter, fixation acquired knowledge and skills and control their gained level. The second approach may be concept of Freire et al. [2012], who in their article term as educational software anything that can be used in the education or for education. They also mention requirements that educational software should fulfil:
- to develop creativity and interactivity as well as to enable student´s active attitude,
- to encourage curiosity and support cooperation and interdisciplinary work,
- to arouse reflection, reasoning and understanding of concepts and ideas ,
- to emphasize the importance of the process more than the outcomes,
- to correspond to the aspects of language (e.g. the age range, environment of use),
- to correspond to the socio-cultural, ethical, educational, ecological aspects, etc.

The advantages of usage of a computer and its potential in compare with other methods of education are indicated by Şerban and Savii [2011] in almost all studies:
- reduction of the time of study;
- facilitation of a positive change towards the complex attitudes;
- usage of computers is more efficient in teaching and learning than usage of any other method;
- computer-assisted instruction is more effective as an alternative form of education than alternative methods;
- students who learn slowly and who stayed behind have better results than the best students.

Possibilities of educational software in science education with a focus on chemistry

During science education and especially chemistry, which often belongs among student's unpopular subjects, we can engage pupils/student e.g. according Kupatadze [2013], when we keep three basic principles: "obviousness", "availability" and "scientific character". The principle of "obviousness" can be accomplished by the usage of experiments. However, as the author states in the schools in her home Georgia teachers contend with a lack of laboratories, lack of time to prepare lessons, plenty of subject matter and not enough hours, but also the problem with observance of work safety. Therefore, experiments are used in classical lessons only rarely. A similar situation is unfortunately also in the Czech Republic and probably also in other countries. Absence of experiments, namely, that is real, virtual or videos of them, complicates understanding of the issues by students, because static images never fully replace their function in science education. Kupatadze [2013] states that to fulfil the principles of "availability" and "scientific nature" should be used motivation of pupils/students through interesting stories and curiosities from chemistry, and based on them through discussion of the topic at the scientific level. E.g. about "sinking of Titanic" mention the impact of hydrogen bonds and discuss their nature. As one of the most effective ways to implement the three principles at the same time, the usage of educational software is exactly the thing to be considered.

In their article Tatli and Ayas [2013] arrived at similar conclusion. They point to the results of previous studies (all claims are substantiated by other references) dealing with the state of knowledge and understanding of pupils of ninth grade of primary school chemistry, but also a source of misunderstanding or misconception. Although pupils understand the physical and chemical changes, it is difficult for them to understand at a micro level and they cannot explain the chemical changes in the context of chemical bonds. Also, when they construct the concept of "chemical change", they have significant difficulties. The causes of these defects are by the mentioned authors often attributed to the lack of laboratory practice for several different reasons such as concerns about safety, lack of self-confidence and excessive amount of time and required effort to perform accurate experiments. These conclusions are based on the studies of various authors, e.g. Elton [1983]; Bryant and Edmunt [1987]; Hofstein and Lunetta [2004]; Mirzalar, Kabapinar and Adik [2005]; Ozmen [2005]; Yang and Heh [2007]; Durmus and Bayraktar, [2010]. However, also denote to the fact that it can be replace by one of the alternatives to laboratory exercises based on technologies.

There are several ways to include educational software in the science education: you can use it during exposition of subject matter, in fixation (exercises) of subject matter, for testing of the acquisition of subject matter, educational software exist also in the form of a simulation program [Machková & Bílek, 2013], educational computer games [Hanzalová & Chroustová, 2013], electronic textbooks [Chesser, 2011], electronic encyclopedia or programs for the control experimental work or more precisely laboratory [Chroustová & Bílek, 2014].

Examples of concrete educational software

Development of educational software is made by not only commercial firms but very often also by universities all over the world. We can name a few institutions on whose production we find good inspiration, e.g. the University Politehnica Timisoara in Romania [Şerban& Savii, 2011;

Şerban & Strugariu, 2011], the Ilia state University in Georgia [Kupatadze, 2013], the Charles University in Czech Republic [Sloup, 2011; Roštejnská, Klímová, Kučerová & Steinbauerová, 2009], the Hacettepe University and the Karadeniz Technical University and Bilkent University in Turkey [Kunduz & Seçken, 2013; Tatli & Ayas, 2013], the Loughborough University in United Kingdom [Abdulwahed & Nagy, 2011] etc. The disadvantage of local-language educational software, with the exception of the English language, is their language barrier that impedes their expansion into the international context. The study by Boot, Merriënboer, Veerman (2007) brings the comparison of software with a higher didactical quality between developers with high production experience and those with low production experience.

Virtual Chemistry

The educational software “Virtual Chemistry” [Kupatadze, 2013] includes topics from Inorganic and Organic chemistry. There are topics from Inorganic chemistry for example: “Chemistry and Matter”, “Substance and its Properties”, “Chemical Reaction”, “Laboratory Ware”, “Chemical Element, Symbol, Chemical Formula”, “Atomic Structure”, “Electrolytic Dissociation” and many others and from Organic chemistry: “Hydrocarbones”, “Alcohols”, “Aldehydes and Ketones”, “Organic Acids – Carboxylic Acids”, “Esters and Fats”, “Nitrogen – containing organic compounds”, “Proteins” and “Carbohydrates”. This program was created in Adobe Flash by Kupatadze and it includes all types of animations to connect organic chemistry with other sciences. This software is available from internet website: http://cvl.iliauni.edu.ge/start.html and also we can find demonstration and description of this software on youtube (e.g. http://www.youtube.com/watch?v=JiXSb4Qlaag) performed by author. Language of this program is English.

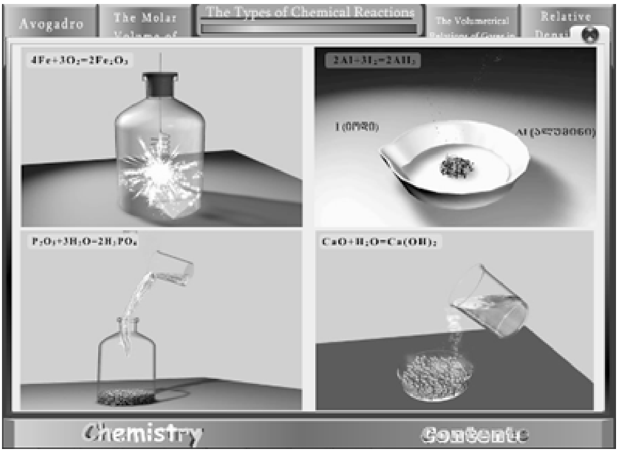

Fig. 01. Screen of Virtual Chemistry software (The types of Chemical Reactions).

Precipitation titrations software

The educational software “Precipitation titrations” [Kunduz & Seçken, 2013] was developed based on the 7E learning model (Excite, Explore, Explain, Elaborate, Extend, Exchange and Evaluate). It includes the topic of “Mohr and Volhard methods”, but also there is the toolbar of the software which includes parts like: “Not pad”, “Calculator”, “Periodic table”, “Materials to be used in experiments”, “Chemicals to be used in experiments”, “Rules to be followed in lab”, “Security signs”, “R-sentences”, “S-sentences”, “Major error sources in quantificational analysis”. This software is available from internet website: http://yunus.hacettepe.edu.tr/~tufan08/portfolyo/nazankunduz2/. Unfortunately the language of this software is only Turkish.

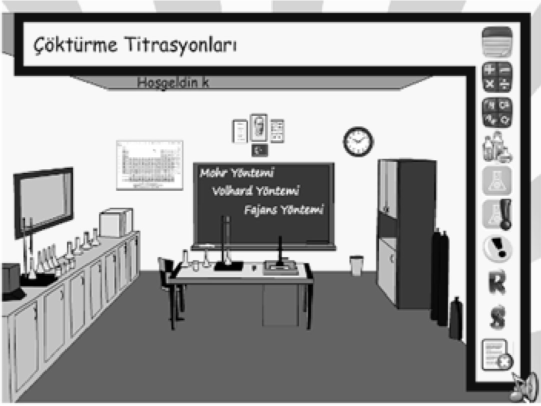

Fig. 02. The opening screen of Precipitation titrations software.

Virtual Chemistry Laboratory

Software "Virtual Chemistry Laboratory" is representing a virtual chemistry laboratory described by Tatli, Ayas (2013) has positive influence on students' results, eliminates the undesirable effects of virtual laboratories, increases student participation, visualizes the macro, micro and symbolical dimension of the experiment at the same time, provides a strategy to follow the process based on constructivist learning theory and strategies Predict-observe-explain (POE). Within the software, students are introduced to the experimental rules, laboratory equipment and materials for the user; provides pupils/students with information on the relationships between experiment and real life. The user has the flexibility in a wide range of applications and parameters; the software also allows you to record preliminary information about the user for the comparison with the final results.

Fig. 03. Screens from the virtual chemistry laboratory software (Tatli, Ayas, 2013).

ChimUniv

The “ChimUniv” [Şerban & Strugariu, 2011] is program for chemical bonds that demonstrates “metallic bonding”, “covalent bonding”, “ionic bonding” and “polar bonding”. This program offers a number of advantages: interferes with ordinary misconceptions and can support deeper understanding for chemical bonding and related topics such as reaction, ionization and chemical stability.

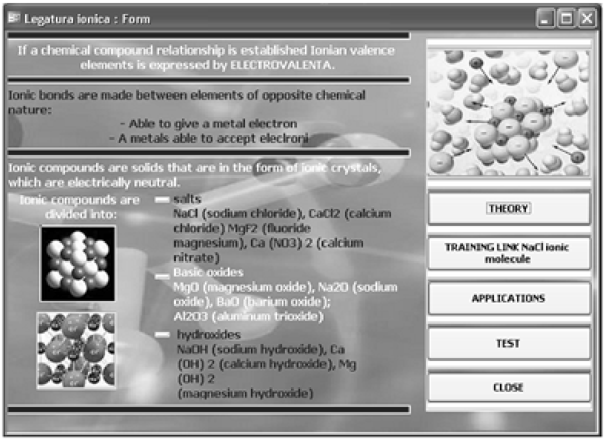

Fig. 04. Screen of ChimUniv software: Ionic Bonding [Şerban & Strugariu, 2011].

Chemical University

The software “Chemical University” [Şerban & Savii, 2011] is designed for secondary school students and first- and second-year college students in solving some of the calculations and determination of the chemical composition and molecular weight chemicals. It includes 3 parts: “Molecular weight” calculates molecular weight of substances, “Percentage composition” determines the chemical formula of a substance, if we know the percentage quantities of elements constituting the substance, and “Weight percentage” determines the chemical formula of a substance, if we know the mass ratio of elements constituting the substance.

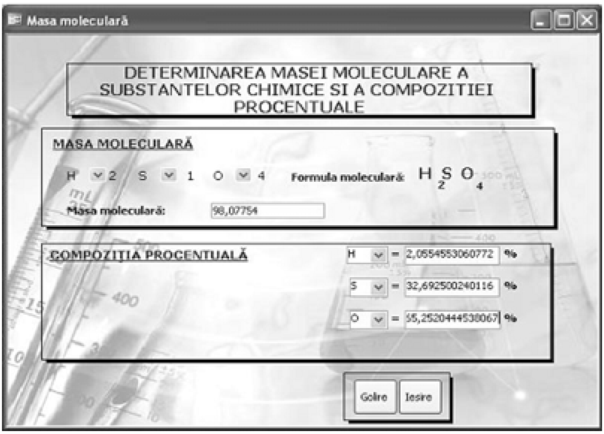

Fig. 05. Screen of Chemical University software: Molecular weight [Şerban & Savii, 2011].

Virtual field trip: The Natural Trail on Maribor Island

The "Virtual field trip" [Puhek, Perše & Šorgo, 2012] was based on previous real field trip in the Natural Trail on Maribor Island and can be used in the fields of biology and ecology.

This real Natural Trail was digitalized and published on the website

(http://e-ucenje.sinergise.com/). There we can find 6 checkpoints with exercises: "The Maribor Island preservation area", "Biodiversity", "How old is a tree?", "Deciduous trees", "Is it true that moss only grows on the north side of a tree?", "Coniferous trees", "Measuring pH-values of the soil under the trees" and "Animal adaptations". Web site of virtual field trip is in the Slovenian language.

Fig. 06. Virtual field trip: the Natural Trail on Maribor Island (Position of moss on a tree).

Educational software and new digital technologies

Additional dimension of usage of educational software provides for example Natural user interfaces which records hand gestures and movements so we can control software by hands. If we use it in virtual laboratory, it makes it more real and interactive [Wolski & Jagodziński, 2014]. Other possibilities is usage of iPads or other tablets in real laboratory as paperless laboratory course and with app Chemist it makes possible to record real experiment and create a virtual lab to share experiments with high school students [Hesser & Schwartz, 2013]. Usage of so called TriLab: Hands-on, virtual and remote lab all together [Abdulwahed & Nagy, 2011] also puts educational software to a new position. Nowadays we can make an molecular compounds structure in 3D, for example in open-source software CH5M3D (available at: http://sourceforge.net/projects/ch5m3d/) which combines HTML5 with the JavaScript code and provides information about the structure (bond lengths, bond angles, and dihedral angles), atoms and bonds can be added or deleted, and rotation about bonds is allowed [Earley, 2013]. And of course there is boom of digital textbooks available for computers, tablets or mobile devices too.

Design and course of research

It is unquestionable, that the usage of educational software in education brings a number of benefits and simplicity, but whether is education with this usage in it truly more effective, that is a question which we tried to answer in the results of research projects dealing with the impact of including educational software on education.

Kupakatze K. [2013] notes that educational software motivates students more and she demonstrates it even by the reactions of some students: a student of 7th grade: “When studying the classes of chemical compounds we use computer program. It is very interesting. Afterwards we ask the teacher and he carried out the experiment between sulphuric acid and sugar. It was identical to what we had seen in the program. It is nice, if it will continues in such a way, we shall become chemists. Such lesson is very interesting and we want more lessons”; “Show it again. We had understood it. I had remembered how to construct and represent chemical formula. The Georgian dance between Fe and S is bright. I am interested in what I had seen in computer.” and 8th grade: “I think such lessons must be held in every class. It is one of the ways to give knowledge to the child, which is not interested in chemistry. Even though the minimum from the whole information.”

Previous review and comprehensive studies

Several of the revision of studies dealing with the impact and effectiveness of educational software or computer assisted instruction (CAI) was published in the last 20 years. One of them is “A Meta-analysis of the Effectiveness of Computer-Assisted Instruction in Science Education” published by Bayraktrar [2002]. This meta-analysis explored effect size of computer-assisted instruction on student achievement in secondary and college science education in the United States between 1970 and 1999 in compare to traditional way. They used 42 studies which include 108 effect sizes to calculation of overall effect size of 0.273, which means that CAI has a small positive effect on student achievement. By authors it suggests that a typical student moved from the 50th percentile to the 62nd percentile in science when CAI was used. [Bayraktar, 2002].

Another one is e.g. review of research on technology-assisted school science laboratories by group of authors [Wang et al., 2014], which includes 42 studies published from 1990 to 2011 that are focused on technologies to support school science laboratories to be like simulations, microcomputer-based laboratories, virtual laboratories, remote laboratories, databases and other miscellaneous technologies. They point out that: “incorporation of technologies in school science laboratories has changed students’ learning experiences in terms of the phenomena to be explored, their interactions with the natural phenomena or materials, and approaches to handling and making sense of data.” [Wang et al., 2014]. So they suggest other topics for future research and discussion about technology-assisted laboratories.

From newest studies we note the article Revisit the Effect of Teaching and Learning with Technology [Yuan-Hsuan et al, 2013] which re-examined the effect of education with usage of technology on student´s cognitive and affective outcomes. They also used the meta-analytic technique and analysed 58 relevant studies published from 1997 to 2011 from an electric search of databases such as PsyInfo and ERIC. They detected effect sizes small to moderate across these cognitive and affective outcome measures. [Yuan-Hsuan et al, 2013]

Methods of recent analysed studies

Out of the research projects we selected for evaluation of studies those dealing with the effectiveness and attitude of pupils/students and teachers to usage of educational software in science education with the greatest emphasis on the chemistry education. They are national and international researches in areas such as in chemistry e.g. the usage and effectiveness of virtual laboratories [Tatli & Ayas, 2013; Kunduz & Seçken, 2013], in biology effectiveness and the acceptance of virtual field trip [Puhek, Perše & Šorgo, 2012; Puhek, Perše, Vršnik Perše & Šorgo, 2013] or computer-assisted instruction of science education [Lazarowitz, & Huppert, 1993; Kara, 2008; Lamanauskas, Šlekienė & Ragulienė, 2009]. We used a quantitative research and evaluation studies that have been published in specialized journals (see Tab. 01. and Tab. 02.) during the last 21 years (1993-2014), with special emphasis on the period after 2000.

Tab. 01. Overview of frequency of published years.

Year	1993	2002	2008	2009	2010	2011	2012	2013	2014
N	1	1	5	2	1	2	3	4	1

Tab. 02. Overview of used Journals.

Journal	*N*
Computers & Education	3
Education and Information Technologies	1
Electronic Journal Of Social Sciences	1
International Journal of Science and Mathematics Education	2
Journal Of Baltic Science Education	3
Journal Of Educational Technology & Society	2
Journal of Instructional Psychology	1
Journal of Research on Computing in Education	1
Journal of Science Education and Technology.	4
Problems of Education in the 21st Century	1

As we mentioned, those researches are usually quantitative, rarely accompanied by qualitative research. The studies focused on students' change of achievement uses quasi-experiment or experiment (N = 12), but there are used also some Likert-scale questionnaire to find out attitude of students, teachers or change of this attitude after using educational software (N = 6) and usage of fuzzy cognitive map (N = 1). Only one study was qualitative using interviews.

Tab. 03. Overview of subjects of studies and used research methods.

Subject	*N*	*Methods*	*N*
Biology	4	Experiment	6
Chemistry	7	quasi-experiment	6
Geology	1	Questionnaire	6
Physic	1	Interview	1
Sciences	7	fuzzy cognitive map	1

In experimental or quasi-experimental method we can find sampling large between 50 to 127 students (average about 80 participants) which includes one experimental and one control group [e.g. Akpınar, 2013; Osman & Lee, 2014], sometimes 2 control groups and 1 experimental are used [Tatli & Ayas, 2013] or 2 experimental groups and 1 control group [Ardac & Sezen, 2002; Kara & Yeşilyurt, 2008]or in case of repeating the experiment 2 control and 2 experimental groups [Abdulwahed & Nagy, 2011]. Analysis of obtained data is made by parametric t-test, ANOVA or some nonparametric test.

The results of analysed research studies from different vievs

Results of representative quantitative research projects can be presented in three categories: usage of concrete educational software in different science subjects, usage of alternative tools to real laboratory or real field trip and usage of computer-based or computer-assisted instruction point of view in science education in general.

Results of research projects related to usage of concrete educational software

The research by Kunduz and Seçken [2013] shows that after the usage of software "Precipitation titrations" in the teaching unit "precipitation titration" in the experimental group was statistically significant difference in favour of the experimental group between the test scores of experimental and control groups. This means that the work with educational software had positive influence on students. In the article the authors also refer to 21 other national and international studies which deal with the influence of computer-assisted instruction taking place in the period from 2000 to 2012 supporting the positive effect of multimedia in education and only 2 studies which detected no statistical difference between the experimental and control groups of students.

The effect of the usage of educational software in biology education was studied by three tests namely, that is cell division achievement test (CAT), the cell division concept test (CCT) and biology attitude scale (BAS). CAT includes 24 multiple choices type items based on the following categories: the purposes of mitosis, mitosis and the cell cycle, the stages of mitosis, the results of mitosis, the purposes of meiosis, meiosis and the sexual reproduction, the stages of meiosis, etc. CCT was designed to find out students' misconceptions about cell division and includes the set of questions to investigate the student's understanding of the processes, purposes, and products of cell division. BAS includes 15 sentences occurring in a five-point Likert-type scale to assess the sample's attitudes towards science lesson with emphasis to the biology lessons. These tests were used at the beginning and the end of the research. After the experiment, the achieved score of CAT increased in favour of the experimental groups. Another positive effect of educational software was observed in the student's understanding of the general functions of mitosis and meiosis. Unfortunately, even after the usage of the software some misconceptions still remained in students. An interesting fact is that there has been a significant change in student's attitudes towards biology only through the usage of edutainment software. [Kara & Yeşilyurt, 2008]

Other research project [Spyrtou, Hatzikraniotis & Kariotoglou, 2009] deals with educational software "Newton-3" focused into learning of Newton's Third Law by primary school and pre-school student-teachers who are not Physics majors in their lesson in the School of Education of our University. Results show that the usage of this education software was effective because the most of the teacher-students improved their knowledge related to the existence and representation of gravitational and electrostatic interactions.

Another study [Akpınar, 2013] explores the effects of usage of interactive computer animations based on predict–observe–explain (POE) as a presentation tool on primary school students' understanding of the static electricity concepts while the control group received traditional instruction. Data collection tools used in the study was static electricity concept test and open-ended questions before and after implementation and also 6 weeks after this implementation. Results showed that usage of interactive animations as presentation tools was more effective on the students' understanding of static electricity concepts in compare with traditional instruction.

Results of research projects related to usage of alternative tools to real laboratory or field trip

The impact of virtual laboratory on student's achievement was engaged by Tatli and Ayas (2013). The results show that there were statistically significant differences between the scores of the pre- and post-tests in each group in favour of the post-test. A more detailed investigation showed that the greatest improvement has been achieved in the experimental group. This means that education supported by software of virtual chemistry laboratory is at least as effective as the real laboratory. Similar result has also the recognizing laboratory equipment: it has been shown that software of virtual laboratory is at least as effective as laboratory material and equipment from real chemical laboratory in improving the ability to recognize laboratory equipment. Students can relate experiments with everyday life and have had the opportunity to examine the macroscopic, molecular and symbolic levels for each experiment at the same time. The authors suggest that virtual chemistry laboratory will be accepted in future as meaningful supplemental and support element of education. This will provide not only an effective learning environment, but will also minimize school expenses and time spent on this activity and will maximize safety of experiments at the highest possible level.

More positive results obtained authors of research study dealing with so called TriLab (virtual, hands-on and remote laboratory). They used the virtual component of the TriLab in a preparation session for undergraduate students, while the remote component was used to demonstrate theory applicability in postgraduate courses. The research shows the positive effect of usage of the TriLab components into education on students learning outcomes and motivation. [Abdulwahed &Nagy, 2011].

Research projects brought interesting results while comparing real field trip with virtual field trip [Puhek, Perše & Šorgo, 2012; Puhek, Perše, Vršnik Perše & Šorgo, 2013]. Students, who participated in real field trip, were slightly more successful, but effect size was between small and medium in both cases. Bigger difference was observed in different types of exercises: the "real-field-trip" students were more successful with exercises where they were able to see and observe real objects in nature, such as tree leaves stumps etc., but in exercises like understanding biodiversity were more successful "virtual-field-trip" participants because they were able to access the computer for detailed explanations and other additional data for those more complex or detailed processes.

Results of research projects related to computer-based or computer-assisted instruction

One of generally oriented studies compares the relative effectiveness of guided versus unguided computer-based instruction (CBI) with respect to traditional instruction in improving content knowledge and process skills. Results of this study show that the effectiveness of computer-based instruction increases when it is supported by teacher-directed guidance. And both of the CBI methods, which means with or without guidance, were found more effective than traditional instruction in improving process especially for student with better chemistry achievement. But in the point of view of knowledge of students who had traditional or guided computer-based instruction acquired significant achievement in knowledge, student with unguided CBI didn´t received expected content of knowledge. [Ardac & Sezen, 2002].

Another study research the effect of a computer-assisted instruction (CAI) on student attitude toward chemistry and their understanding of alternative conceptions for chemical bonding. Results shows to a positive effect of the CAI on student achievement and attitude toward chemistry and suggest that education of concepts related to chemical bonding can be improved by using CAI. This fact requires development of suitable educational software for different chemistry topics so as to encourage students' visualization skills and understanding. As author mentioned, the CAI has some limitations so it can´t be only one component in influencing students' attitudes, achievement and knowledge. It is a reason why CAI needs to be integrated with other teaching methods to be the most effective way in increasing of student knowledge and understanding of chemistry concepts. [Özmen, 2008].

Important results brought the study focused on the effect on retention of CAI in Science education [Kara, 2008]. It discovered that CAI is more effective than traditional instruction on students' academic achievement. By author educational program is the most effective component of CAI in increasing of retention level and author consider simulation as one of the most effective and the most interesting CAI programs. The most important fact is that the results of retention test (administered 5 months after application of CAI) shows that experiment group students have lost less knowledge than control group student according to post-test results, so CAI establish retention effect. Although change was small for both groups, retention scores of CAI are better than retention scores after traditional instruction. This result proves that CAI is more effective in lasting achievement.

Conclusion

Results of recent studies confirm usefulness of educational software in science education, we can see that usage of educational software has the positive impact on motivation and students´ attitude toward different subject from science (including chemistry); it provides higher understanding in problematic, abstract and complex topics as chemic bolding. Educational software can serve as valuable alternative to traditional real laboratory. Generally computer-assisted instruction (CAI) is more effective than traditional methods especially in lasting achievement. These results correspond with our research study [Chroustová & Bílek, 2014], in which we dealt with the effectiveness of educational software used in chemistry with focus to nomenclature of inorganic compounds. The results shows that the achievement in post-test was in both group similar, but when we focus only for traditional algorithmic tasks, experimental group received better results, it indicate to higher effect of educational software and we also recorded stronger fixation of knowledge immediately after the ICT-supported instruction. Sum up, we can tell that usage of educational software can improve effectiveness of education, if we used appropriate high-quality software with suitable method, and this usage has also effect on attitude of students. Of course there is space for many other research studies for the purpose of discovering the most effective way of implementation of educational software into education.

References

Abdulwahed M., Nagy Z.K. (2011) The TriLab, a novel ICT based triple access mode laboratory education model. Computers & Education, Vol. 56, Issue 1, January 2011, p. 262-274.

Akpınar E. (2013) The Use of Interactive Computer Animations Based on POE as a Presentation Tool in Primary Science Teaching. Journal of Science Education and Technology. December 2013. p. 1-11.

Ardac D., Sezen A.H. (2002) Effectiveness of Computer-Based Chemistry Instruction in Enhancing the Learning of Content and Variable Control Under Guided versus Unguided Conditions. Journal of Science Education and Technology. March 2002, Vol. 11, Issue 1, p. 39-48.

Bayraktar S. (2002) A Meta-analysis of the Effectiveness of Computer-Assisted Instruction in Science Education. Journal of Research on Technology in Education (International Society for Technology in Education). Winter2001/2002, Vol. 34, Issue 2, p. 173-188.

Boot E., Merriënboer J., Veerman A. (2007) Novice and experienced instructional software developers: effects on materials created with instructional software templates. Educational Technology Research & Development. Dec2007, Vol. 55, Issue 6, p. 647-666.

Cheng I., Safont L.V., Basu A., Goebel R. (2010) Multimedia in education: adaptive learning and testing. World Scientific.

Chesser W. D. (2011) Chapter 5: The E-textbook Revolution. Library Technology Reports. Vol. 47, Issue 8, p. 28-40.

Chroustová K., Bílek M. (2014) Efektivita využívání didaktického softwaru ve výuce chemie se zaměřením na názvosloví anorganických sloučenin. Media4u Magazine. Vol. 11, Issue 1, p. 58-64. ISSN 1214 9187.

Dostál J. (2011) Výukové programy. Olomouc: Univerzita Palackého v Olomouci. ISBN 978 80 244 2782 9.

Earley C.W. (2013) CH5M3D: an HTML5 program for creating 3D molecular structures. Journal Of Cheminformatics, Vol. 5, Issue 1, p. 1-13.

Efe R. (2011) Science Student Teachers and Educational Technology: Experience, Intentions, and Value. Educational Technology & Society, Vol. 14, Issue 1, p. 228–240.

Freire L., Padovani S., Jacobs K., Soares M. M., London M. (2012) A children, teachers and designers as evaluators of usability of educational software. Work, Vol. 41, p. 1032-1037.

Hanzalová P., Chroustová K. (2013) Instructional software with focus on instructional games in mathematics and chemistry education. In Gallová, M., Gunčaga, J, Chanasová, Z., Moldovcová Chovancová M. (Eds.), New Challenges in Education (p. 40–69). Ružomberok, Slovakia: VERBUM - vydavateľstvo KU. ISBN 978-80-561-0065-3.

Hesser T.L., Schwartz P.M. (2013) iPads in the Science Laboratory: Experience in Designing and Implementing a Paperless Chemistry Laboratory Course. Journal of STEM Education: Innovations & Research. Apr-Jun 2013, Vol. 14, Issue 2, p. 5-9.

Hossain S., Brooks L. (2008) Fuzzy cognitive map modelling educational software adoption. Computers & Education. December 2008, Vol. 51, Issue 4, p. 1569-1588.

Kara I. (2008) The Effect on Retention of Computer Assisted Instruction in Science Education. Journal of Instructional Psychology. Dec2008, Vol. 35, Issue 4, p. 357-364.

Kara Y., Yeşilyurt S. (2008) Comparing the Impacts of Tutorial and Edutainment Software Programs on Students' Achievements, Misconceptions, and Attitudes towards Biology. Journal of Science Education and Technology. February 2008, Vol. 17, Issue 1, p. 32-41.

Koleza E., Pappas J. (2008) The effect of motion analysis activities in a video-based laboratory in students' understanding of position, velocity and frames of reference. International Journal Of Mathematical Education In Science & Technology, Vol. 39, Issue 6, p. 701-723.

Kunduz N., Seçken N. (2013) Development and Application of 7E Learning Model Based Computer-Assisted Teaching Materials on Precipitation Titrations. Journal Of Baltic Science Education, Vol. 12, Issue 6, p. 784-792.

Kupakadze K. (2013) How to Make Lessons of Chemistry More Understanding and Easy (On an Examle of Concrete Program). Periódico Tchê Química, Vol. 10, Issue 19, p. 24-29.

Lamanauskas V., Šlekienė V., Ragulienė L. (2009) Computer-Based Technologies in the Process of Teaching/Learning Sciences in Comprehensive School: Socio-Educational Aspects. Problems of Education in the 21st Century. Vol. 16, p. 66-73.

Lazarowitz R., Huppert J. (1993) Science process skills of 10th-grade biology students in a computer-assisted learning setting. Journal of Research on Computing in Education. Spring93, Vol. 25, Issue 3, p. 367-385.

Lin L-F., Hsu Y-S., Yeh. Y-F. (2012) The Role of Computer Simulation in an Inquiry-Based Learning Environment: Reconstructing Geological Events as Geologists. Journal of Science Education and Technology. June 2012, Vol. 21, Issue 3, p. 370-383.

Lindgren E. (2010) A Reaserch paper. Bemidji State University, Bemidji, Minnesota, USA.

Machková V., Bílek M. (2013) Didactic Analysis of the Web Acid-Base Titration Simulations Applied in Pre-Graduate Chemistry Teachers Education. Journal of Baltic science education. Vol. 12, Issue 6, p. 829-839.

Nalatambi S. (2012) "Chem Twist" for Secondary/Tertiary level Education. In International Conference "The Future of Education: 2nd edition". ISBN 978-88-7647-808-6. Available at: http://conference.pixel-online.net/edu_future2012/common/download/Paper_pdf/

122-LG03-FP-Nalatambi-FOE2012.pdf

Oblinger D., Oblinger J. L. (2005) Educating the net generation. EDUCAUSE, c2005. ISBN 0-9672853-2-1. Available electronically at: „www.educause.edu/educatingthenetgen/"

Osman K., Lee T. T. (2014) Impact of Interactive Multimedia Module with Pedagogical Agents on Students' Understanding and Motivation in the Learning of Electrochemistry. International Journal of Science and Mathematics Education. April 2014, Vol. 12, Issue 2, p. 395-421.

Özmen H. (2008) The Influence of Computer-Assisted Instruction on Students' Conceptual Understanding of Chemical Bonding and Attitude toward Chemistry: A Case for Turkey. Computers & Education. Vol. 51, Issue 1, p. 423–438.

Puhek M., Perše M., Šorgo A. (2012) Comparison Between a Real Field Trip and a Virtual Field Trip in a Nature Preserve: Knowledge Gained in Biology and Ecology. Journal of Baltic Science Education. 2012, Vol. 11 Issue 2, p. 164-174.

Puhek M., Perše M., Vršnik Perše T., Šorgo A. (2013) Perceived Usability of Information and Communication Technology and Acceptance of Virtual Field Trips by Lower Secondary Students, Undergraduate Students and In-service Teachers. Journal of Baltic Science Education, Vol. 12, Issue 6, p. 803-812.

Roštejnská M., Klímová H., Kučerová O., Steinbauerová A. (2009) Animační program Adobe Flash a jeho význam ve výuce chemie. In: Research, Theory and Practice in Chemistry Didactics: 2nd Part: Overview

Studies and Short Information. Hradec Králové, IX – 2009. p. 372-376.

Şerban S., Savii G. (2011) About an Educational Software Used in the Chemistry for Determining the Chemical Composition and Molecular Weight Chemicals. Annals Of The Faculty Of Engineering Hunedoara - International Journal Of Engineering, Vol. 9, Issue 4, p. 191-194.

Şerban S., Strugariu L. (2011) Educational Software "ChimUniv" for Chemical Bonds. Annals Of The Faculty Of Engineering Hunedoara - International Journal Of Engineering, Vol. 9, Issue 3, p. 485-488.

Sloup R. (2011) Interaktivní flexibilní programy a interaktivní učebnice pro výuku chemie. In: Nové technologie ve vzdělávání: vzdělávací software a interaktivní tabule. 1. vyd. Olomouc: Univerzita Palackého v Olomouci, p. 120-122. ISBN 978-80-244-2941-0. Available at: http://www.ntvv.upol.cz/files/articles/radovan-sloup/radovan-sloup.pdf

Spyrtou A., Hatzikraniotis E., Kariotoglou P. (2009) Educational software for improving learning aspects of Newton's Third Law for student teachers. Education and Information Technologies. June 2009, Vol. 14, Issue 2, p. 163-187

Tatli Z.; Ayas A. (2013) Effect of a Virtual Chemistry Laboratory on Students' Achievement. Journal Of Educational Technology & Society, Vol. 16, Issue 1, p. 159-170.

Trnová E. (2011) Vliv informačních a komunikačních technologií na chemické vzdělávání. Media4u Magazine, Praha: Ing. Jan Chromý, Ph.D., 2011, Vol. 8., X3/2011, p. 112-115. ISSN 1214-9187.

Wang C.-Y., Wu H.-K., Lee S W.-Y., Hwang F.-K., Chang H.-Y., Wu Y.-T., Chiou G.-L., Chen S., Liang J.-C., Lin J.-W., Lo H.-C., Tsai C.-C. (2014) A review of research on technology-assisted school science laboratories. Educational Technology & Society, Vol. 17, Issue 2, p. 307–320.

Wolski P., Jagodziński R. (2014) Use of Natural User Interfaces in the Simulation of Chemistry Experiment. The 6th International conference Research in Didactics of the Sciences: Book of Abstracts. Pedagogical University of Kraków, Kraków, 2014 June 25th-27th, p. 55.

Yuan-Hsuan L., Waxman H., Jiun-Yu W., Michko G., Lin G. (2013) Revisit the Effect of Teaching and Learning with Technology. Journal Of Educational Technology & Society, Vol. 16, Issue 1, p. 133-146.

Yucel A., Cevik E. (2010) Teachers' Opinion's on Computer-assisted Chemistry Teaching. Electronic Journal Of Social Sciences, Vol. 9, Issue 31, p. 88-102.

Acknowledgement

This paper is published thanks to the financial support of the project of Specific Research of Faculty of Science University of Hradec Králové Nr. 2108/2014

Kateřina Chroustová, Martin Bílek

University of Hradec Kralove, CZ

katerina.chroustova@uhk.cz, martin.bilek@uhk.cz

THE INFLUENCE OF E-LEARNING ON METHODS OF KNOWLEDGE ACQUISITION ILLUSTRATED BY THE EXAMPLE OF SCIENCE FACULTY STUDENTS WHO LEARN REDOX REACTIONS BY MEANS OF MOODLE PLATFORM

Anna Michniewska, Paweł Cieśla

The context and purpose of the framework

In the late '90s there was a significant breakthrough in teaching and learning. People started to use the Internet as a teaching tool and the first e-learning platforms date back to this time too (The development of e-learning platforms, including Moodle platform, has been possible because of the special software to support teaching and learning on-line so-called LMS (Learning Management System) [Bednarek & Lubina, 2008]. All e-learning platforms combine all the functions needed for teachers and students i.e. posting homework, links, notes and other resources and to facilitating communication and discussion in the network [Wagner, 2011].

The e-learning is commonly applied in teaching, including at university level [Pospíšilová, 2013], Around the world, there are being created various courses whose aim is to improve learning outcomes. However, we have to reflect if all lesson topics can be taught by aid of the e-learning.

At the Pedagogical University National Education Commission in Krakow, teaching oxidation and reduction to students has proved to be very difficult in recent years. The oxidation and reduction reactions are very important for naturalists. The understanding of these reactions is very important e.g. while discussing the process of photosynthesis and cellular respiration.

Currently, there are several studies on the use of e-learning and e-learning platforms (Voithans, 2008). The research conducted by Jancarz-Łanczkowska and Potyrała indicates that teaching by means of the Moodle platform may give a wide range of learning opportunities, also in the natural sciences [Jancarz-Łanczkowska & Potyrała, 2010].

The Objectives

The objectives of the paper are divided into: theoretical, practical and cognitive objectives.

The theoretical objectives concern learning psychological and pedagogical aspects of teaching and learning, particularly the distance learning. The practical objectives included development, test and verification of the copyright chemistry course in oxidation and reduction and prepared right for students of natural sciences.

The cognitive objectives consisted in examining the cognitive impact of the e-learning on the ways of knowledge acquisition, namely oxidation and reduction reactions by the students of natural science and by means of the Moodle platform. Moreover the cognitive objectives focused on investigating the causes of students' failure while learning the oxidation and reduction reactions [Michniewska, 2013].

Research hypotheses

The basic hypothesis:

Power traditional teaching methods, E-learning improves significantly teaching.

Hypothesis: Partial

Moodle is a good tool to support teaching of oxidation and reduction reactions among students of natural science.

The study was based on the content of the natural sciences to create a course on the Moodle platform and the knowledge of the social sciences i.e. general didactics and present. The study included also the methodology and research tools of educational research.

The methods

The methods and techniques of research tools applied in this study are as follows:

Methods: a pedagogical experiment, analysis of documents (analysis of the literature curriculum for teaching), a diagnostic survey.

Techniques: survey, analysis of documents.

Research tools: a questionnaire survey.

The research

The research was conducted in the academic year 2013/2014 in the summer semester. The study group consisted of 36 first year students who study environmental protection at the Pedagogical University National Education Commission in Krakow. At the beginning of the summer semester, students were given the task to create an account on the e-learning platform.

In the month of May, only 31 people signed up for the course which demonstrates the attitude of other students to the subject and to the e-learning.

The Part of the course on e-learning platform related to the oxidation and reduction reactions consisted of a few lessons. The beginning of the course provides general information on redox reactions as well as the information that it has been prepared on the basis of the prof. John Raymond Pasko's script: "Chemical Calculations: script for students of biology". In addition, the course verbal comment and its graphic design aim to facilitate the analysis of different stages of coefficient agreement in redox reactions as well as the task analysis to be performed by students.

Fig. 01. Some lesson on platform.

Fig. 02. Testing part.

At the end of the course, students were given the hind send redox reactions.

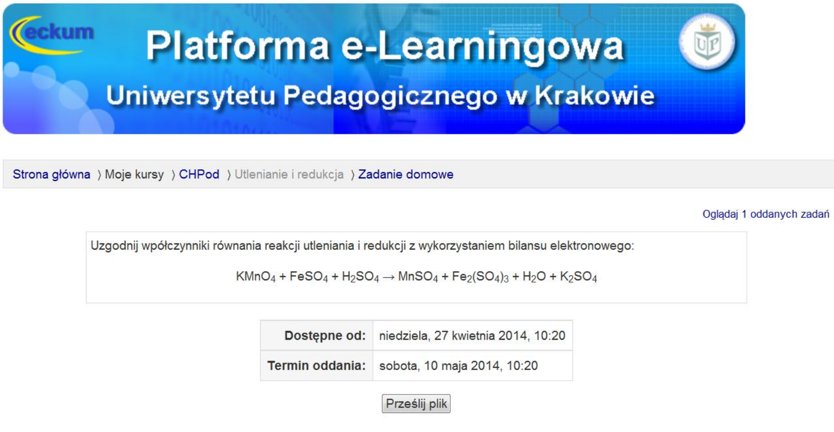

Fig. 03. Student's homework task.

Results

While analyzing the students' activity on the Moodle platform course, it stands out that only few students followed every class and the time spent on that was very short.

Data on students' activity on the platform leaves a lot to be desired. A very small percentage of students solved all the lesson exercises. Comparatively, the active students' results are between 10% to 26% and thus demonstrate that the teaching of oxidation and reduction reactions by means of the e-learning is not appealing to them. The whole course was done only by 3 students, but if we analyze the time they spent on familiarizing themselves with various lessons, we can draw a conclusion that some lessons were opened and immediately closed. Learning one lesson in several seconds is impossible and thus this indicates that students have not even reached the Lesson number 3 and Lesson number 4.

This task was accomplished only by 14 people. 8 people or 57% of the submitted work contains a valid entry in the equation coefficients agree redox reaction. In contrast, 6 people or 43% of the submitted work contains an incorrect entry, taking into account only the oxidation states of individual elements without the oxidation and reduction reactions is the ion.

Tab. 01. The activity of students on platform.

Topics	Number of students	The average time	The longest time	The shortest time
Definition	8	10 min. 33 sek.	29 min. 19 sek.	1 sek
Introduction	6	7 min. 47 sek.	11 min. 30 sek.	2 min. 1 sek
Complex ions	6	9 min. 8 sek.	32 min. 52 sek.	41 sek.
Lesson number 1	5	4 min. 36 sek.	10 min. 47 sek.	37 sek.
Lesson number 2	3	1 min 21 sek.	3 min. 7 sek.	26 sek.
Lesson number 3	3	48 sek.	1 min 42 sek.	13 sek.
Lesson number 4	3	41 sek.	1 min 22 sek.	18 sek.
Introduction	6	7 min. 47 sek.	11 min. 30 sek.	2 min. 1 sek

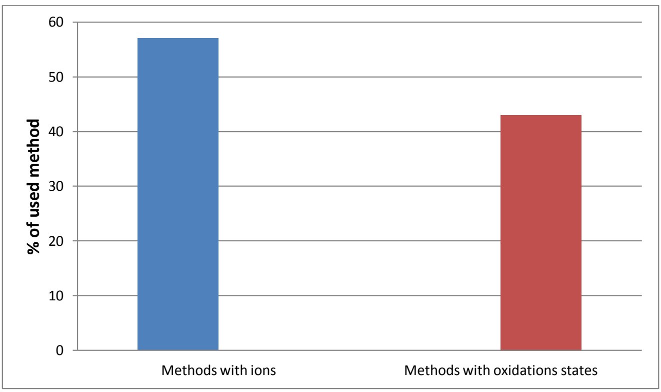

Fig. 04. Results of students homework.

Some students answer for their homework :

The first method:

$2KMnO_4 + 2FeSO_4 + 3H_2SO_4 \rightarrow 2MnSO_4 + Fe_2(SO_4)_3 + 3H_2O + K_2SO_4$

$2K^0Mn^{+4}O_4^{-2} + 2Fe^{-2}S^{+2}O_4^{-2} + 3H_2^{+1}S^{+2}O_4^{-2} \rightarrow 2Mn^{+2}S^{-2}O_4^{-2} + Fe_2^{+2}(S^{-2}O_4^{-2})_3 + 3H_2^{+1}O^{-2} + K_2^{+1}S^{-2}O_4^{-2}$

The second method:

$KMnO_4 + FeSO_4 + H_2SO_4 = K_2SO_4 + MnSO_4 + Fe_2(SO_4)_3 + H_2O$

$Mn^{+VII} + 5e \rightarrow Mn^{+II}$

$Fe^{+II} - 1e \rightarrow Fe^{+III}$

$2Mn^{+VII} + 10e \rightarrow 2Mn^{+II}$

$10Fe^{+II} - 10e \rightarrow 10Fe^{+III}$

$2KMnO_4 + 10FeSO_4 + 8H_2SO_4 = K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$

The study shows that only 86% of the first year students enrolled in the Environmental Chemistry Basics course, out of whom only 64% received homework. These figures demonstrate the students' approach to the subject and to the course final exam.

Conclusions

The Data on their activity on the platform is not satisfactory. A very small percentage of students accomplished all courses. The results demonstrate, i.e. from 10% to 26% of students' activity, that the teaching of oxidation and reduction using e-learning is not attractive to them. All courses were accomplished only by 3 people, but by analyzing the time to familiarize yourself with the different classes one may draw the conclusion that some lessons were only opened and immediately closed. It is impossible to dedicate several seconds for one lesson, thus this indicates that the students did not even familiarize with Example 3 and Example 4 (Tab. 01)

Students spent the most time on accomplishing the task which consisted in providing the definition of oxidation and reduction, and another one related to the complex ions. The method of coefficients agreement is very important to understand the equations oxidation and reduction, thus the average student's time or 9 min 8 sec. does not seem to be enough to learn this. The Statistics of the students' activities (Tab. 02) indicate that the preparation of more than 3 lesson does not make sense because the students do not show interest in following other lessons.

Students did not take advantage of learning the use of e-learning platform. According to Górniak, teaching the redox reaction "requires the direct contact with the student". The blended learning allows to obtain the desired teacher's results. Plichta notes the e-learning course should guarantee the achievement of the objectives otherwise is not effective. These objectives should be formulated in accordance with the five demands SMART (Simple, Measurable, Achievable, Relevant, Timely) in order to motivate the student to benefit from this form of education (Plichta, 2012). The motivation plays a very important role and the present research reveals that the students of the Environement from the Pedagogical University. National Education Commission showed no inner desire to acquire and expand their knowledge. The study had a pilot character and next time should be conducted on a larger research group, namely include other students of natural science in order to fully verify the partial thesis.

References

Bednarek, J.; Lubina, E. (2008) Kształcenie na odległość. Podstawy Dydaktyki, Wydawnictwo Naukowe PWN SA, Warszawa, str. 185-200.

Górniak, L. (2012) Czynniki specyficzne i niespecyficzne w ocenianiu skuteczności kształcenia z wykorzystaniem tutoringu i e-learningu [w:] Człowiek. Media. Edukacja., red. Janusz Morbitzer, Emilia Musiał, Kraków, str. 140-151.

Jancarz-Łanczkowska, B.; Potyrała, K. (2010) Wykorzystanie platform zdalnego nauczania w edukacji przyrodniczej i biologicznej [w:] Research in Didactics of the Sciences, red. Małgorzata Nodzyńska, Jan Rajmund Paśko, Kraków str. 171-175.

Michniewska, A. (2013) Wpływ e-learningu na sposoby przyswajania wiedzy przez studentów kierunków przyrodniczych na przykładzie reakcji utleniania i redukcji z wykorzystaniem platformy Moodle [w:] Sborník příspěvků z konference a soutěže eLearning 2013, Gaudeamus, Hradec Králové, str. 126-129.

Paśko, J. R. (1997) Obliczenie chemiczne. Skrypt dla studentów kierunku biologia, Wydawnictwo Naukowe Akademii Pedagogicznej, Kraków, str. 25-46.

Pospíšilová, L. (2013) Spojení Moodle a Mahary v kurzu Angličtina pro polygrafii. [w:] Sborník příspěvků z konference a soutěže eLearning 2013, Gaudeamus, Hradec Králové, str. 27-32.

Voithans, A. (2008) Using Moodle at the University of Latvia- New Possibilities in e-Physics Education [w:] Research in Didactics of the Sciences, Kraków.

Wagner, J. (2011) Kształcenie na odległość wspomagane komputerowo jako element procesu edukacji pedagogów, Toruń.

Anna Michniewska, Paweł Cieśla

Pedagogical University of Cracow

Faculty of Geography and Biology, Institute of Biology

Krakow, PL

anna.michniewska@gmail.com

pawel.ciesla.33@gmail.com

THE IMPACT OF E-LEARNING ON THE INTEREST IN NATURE AMONG STUDENTS OF THE UNIVERSITY OF CHILDREN AND PARENTS AT THE PEDAGOGICAL UNIVERSITY OF KRAKÓW

Kamila Moskal, Małgorzata Nodzyńska

Introduction

Since the 20s of the twentieth century there is the development of distance learning. Constantly changing world as well as technological innovations led to the development of e-learning, based on the work of the computer connected to the Internet, as one of the newer methods of teaching.

Acquiring knowledge in this way has its advantages and disadvantages. The ability to access the course from any place, and at any time of the day or night, meant that science can reach everyone. The use of the Internet for distance learning also allows individualization of teaching, unmatched by other methods. Such a form of individualisation in teaching has also pluses and minuses. On one hand, it lets pupils learn at their own pace, but on the other hand, it limits contact with the teacher and other participants of the course, and in consequence can reduce the motivation of the student to study.

Courses that are currently on the market are directed primarily to children in primary schools, lower secondary schools, secondary schools, graduate students and the elderly people. So far, noone has created any course for much younger people, namely pre-school children and early school children. This paper describes the results of the research on a group of preschool children enrolled in the University of Children and Parents at the Pedagogical University in Cracow, Poland.

Theory / base

The history of distance education.

The year 1728 is considered as the beginning of distance learning. That year, on March 20, “The Boston Gazette” placed the advertisement of Phillip Caleb who advertised himself as a teacher of stenography – he was sending learning materials to his students by mail. A significant impact on the development of correspondence courses had Pitman brothers who in the years 1837-1856 conducted regular correspondence courses of stenography.

In 1858, University of London created the first extramural courses. In 1873 Ann Eliot Ticknor founded the Society for the Promotion of Science in the House, which taught thousands of women in the United States. Foundress, is considered the mother of the American system of correspondence courses.

Wesleyan University in Illinois was the first university that offered graduate distance education leading to obtain vocational education. However, in 1906, the university authorities have not agreed to the further development of remote university courses.

In the course of the development of distance learning, the year 1883 seems to be important, in which the state authorities for the first time recognized the validity of the finishing of extramural courses issued by Chautauqua College of Liberal Arts in the State of New York [Wagner, 2011]

The turn of the nineteenth and twentieth centuries was full of Open Universities, which allowed to obtain the academic title through correspondence courses. In 1906, at the University of Wisconsin the distance learning department was established [Verduin, 1991]. With advances in technology, which was the development of the movie production, the first catalog of instructional videos was issued. [Wegner, 2011].

Distance education quickly assimilated new technologies in order to make the transmission of learning materials more attractive to the student. In the twenties of the XX century, in the United States, “educational radio” began the activity, also popularly used in sparsely populated areas of Australia from the 30s of XX century. The next medium, which began to be used to teach at a distance, was television. Pioneering country in the use of telecommunication for educational purposes was the United States. [Wagner, 2011].

In 1920, a professor at Ohio State University has developed a learning machine, which allowed the creation of questions and exercises with multiple choice questions [Wegner, 2011]. Thirty years later, at the University of Illinois the first high-speed computer named ILLIAC was built . It was used to solve scientific inaccuracies [Wagner, 2011].

“The development of technical means of communication, such as telephone, radio, television, made the ways and means of transferring knowledge to the distance more attractive and caused great acceleration of the knowledge transfer. Another breakthrough is brought in the nineties of the twentieth century with a new medium - the multimedia computer. “[Wagner, 2011, p. 11]. The origins of the e-learning is dated to the year 1965, when at this time has its origins the first distance-learning system for use on a computer, so-called. PLATO [Wagner, 2008].

Internet, for the needs of science and scientists, was used in the late 80s and 90s. One of the first was the system of MOO, applied to the virtual service for research and training, which was created in the Weizmann Institute in Israel. He had to meet the following objectives [Sanson, 2008]:
• “Enabling of sending and leaving messages for users;
• collection of archival materials of the most important virtual meetings, which were held in the framework of this project;
• establishing and running clubs of users and authors of papers published in specific scientific journals;
• organizing and conducting seminars, poster sessions, and even entire scientific conferences;
• meetings with scientists from around the world representing a wide variety of specialties;
• the creation of a resource center of public scientific information;
• assembly tools for preparing the electronic version of presentations, demonstrations and training materials;
• providing a rich assortment of materials for the preparation and implementation of a unified learning process for teachers and learners located in different parts of the world;
• meetings with experienced programmers involved in the development of tools to conduct virtual training courses, workshops and conferences;
• development of an automatic archiving system for meetings and conferences;
• allow the continuation of the discussion after the conference for those interested in real time, in a specially generated for this purpose “meeting rooms”;
• sharing existing materials and resources for other network systems (outside of projects BioMOO) in order to promote the achievements and lessons accumulated in global publicity of archives” [Wagner, 2011, p. 17-18].

The term e-learning for the first time appears at the end of the twentieth century, and in subsequent years its development follows.

Also in the Polish education phenomenon of distance education is not a new achievement. In Poland, since the eighteenth century, there were attempts to give lectures for those who were not covered by the studies at universities. The first classes were of the nature of correspondence courses for craftsmen. This kind of education had been held at the Jagiellonian University since 1776.

The twenties of the XXth century abounded in the development of radio - all kinds of talks have been broadcasted. There were many famous persons engaged in this activity, especially scientists. Among them was Janusz Korczak, who in the years 1935-1936 broadcasted program entitled “Talks of old doctor”, which were mainly concerned with the problems of philosophy and history of Poland [Miszczak, 1972].

“Created in the 20s of the twentieth century. “Wszechnica Radiowa” was teaching Polish history, literature as well as knowledge about the world. Since 1949, the lessons were broadcasted on three levels: low (Polish language, mathematics, geography, science), medium (literature, history and science), and high (mainly the ideology for the party activists) “[Wagner, 2011, p. 21] .

In Poland, since 1938, educational programs on television are published. Prepared programs were designed to reach out to people of all ages:

- the youngest, were brought up by the “Dobranocka” (bedtime cartoons)
- for older people there were programs - guides, of which the most famous was the “Zrób to sam” (Do it yourself), led by Adam Słodowy.

Since 1960 there were broadcasts of educational programs led for young learners by brilliant researchers. Initially, these programs were assumed to be part of the lesson, in order to enhance its attractiveness and assimilation of knowledge. However, due to the problems of synchronization of classes in about 900 schools participating in the project the main recipients of these programs have become adults and seniors. No possibility of recording of the courses emitted on TV hampered further work on the development of distance education via television in Poland [Wagner, 2011].

Next years were fruitful in the development of educational programs for children and youth. Due to the success of some cycles, there have been introduced special programs for the elderly, among others, lessons of foreign language.

“In November 1973 the Ministry of Education and the Committee on Radio and Television established Radio and Television Teachers’ University (NURT - Nauczycielski Uniwersytet Radiowo-Telewizyjny). It was an educational institution in the years 1974-1991 working in cooperation with radio and television.

The target group were mainly teachers wishing to improve their professional skills and enrich general knowledge. (...) This program was of humanistic nature. It integrated and bonded contents, methods, forms of education with the functions and tasks of the teacher, that he should fulfil to society, to the world, as well as to himself. The program included in its scope many areas of science and the practice of the teacher’s profession “[Wagner, 2011, p. 23-24].

Another success in distance education in Poland was the foundation of the Educational Satellite Television - Edusat (9th November 2002), under a license issued by the National Broadcasting Council. It was the first educational satellite TV in Poland. It was linked with the “Wyższa szkoła Społeczno-Ekonomiczna” in Warsaw.

Edusat was designed to help students in the “distance learning”, through the issuance of lectures, classes in the social sciences and economics, which were given by eminent specialists. Edusat is a non-commercial project. Initially it have been working two days a week, but at the present time TV broadcasts programs seven days a week, not only emitting the lectures from the university, but also programs addressed to a wider group of people, offering a wide selection of recordings [http://edusat.pl/].

Years 1999-2002 are the creation time of “Teleuniwersytet”. This was a pioneering educational system with the use of television, however, limited by the use of a special decoder. This platform allowed the recipient asking questions while watching the lecture. There was possible contact with the lecturer through decoder or a special telephone line. This “Teleuniversytet” was available to every Polish university which obtained permission from the Ministry of Education and Sports.

A recent major achievement is the establishment of the Academic Science Television (ATVN). This is a free channel, having a scientific nature, which is transmitted through the Internet. The purpose of this television is to promote science in Poland by targeting to a wide range of people. Scientific proposition of this program is the large variety of thematic threads, which can be selected by the recipient. [Wagner, 2011].

Twenty-first century is a further development of distance education. E-learning is widely used in higher education.

E-learning

As a result of transformation resulting from changes in the processes of teaching and learning at a distance, i.e. learning by corespondence, television, radio, which bring together the details of text, audio, and video, as well as the use of information technologies that connect to the Internet network, led to the creation of multimedia systems that offer courses and training - e-learning platforms [Wagner, 2011].

“E-learning platform is a comprehensive tool for facilitating the administration of training, reporting and statistics, the creation of teaching materials and education management, providing procedures for communication between its participants” [Wagner, 2011].

E-learning is a phenomenon associated with providing of new information and communication technologies, which resulted not only in a change in the structure of the economy or society, but also in the functions and forms of education. “E-learning involves the use of the Internet in providing a wide range of solutions that enhance knowledge and improve the effectiveness of education” [Rosenberg, 2003, p. 1].

The word E-learning comes from the English.

There is no single definition of e-learning, which would be used commonly, scientific publications on this subject focus on teaching by distance, via the Internet, and on spreading the knowledge through CD / DVD or finally in the form of printed training materials. All definitions, however, has common characteristics, which can include:
• The method of transferring knowledge
• The method used in distance education
• The method, which is based on data communications technology
• The method, which involves the transfer of knowledge, process of control and evaluation of the effectiveness.

Criteria relating to ICT, force two consequences. First, the sender and receiver must have access to the Internet and the computer. Second, the sender and receiver need to be familiar with operating the ICT measures.

By using a computer and the Internet recipient can acquire new information from anywhere, he also decides the time of using that measures. Compared to the traditional method of training, e-learning does not require the presence of the participants in one place and at the same time. [Czarkowski, 2012].

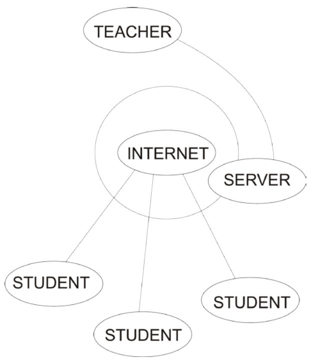

Fig. 01. E-learning - graphic diagram [Czarkowski, 2012].

The e-learning method requires the teacher and the participant of a course logging in to e-learning platform via the Internet. After logging students can learn, exchange experiences, analyze problems, ask questions both to the teacher and other participants, as well as answer questions. If participants and teachers are logged in symultanously they can chat. This is the example of a synchronous communication. In contrast, asynchronous communication takes place when teachers and students work in different time and with various time intervals.

The literature lists the following advantages of e-learning from the point of view of participants:
• A small fee for participation.
• The variety of possible forms and ways of acquiring knowledge.
• The ability of choosing the place of learning.
• The ability of choosing the time of learning.
• The ability of choosing the own pace of acquiring knowledge.
• Adjusting the course to suit participant's needs.

Moreover, the advantages of e-learning from the point of view of the organizers of the course are:
• Economy of costs.
• Monitoring the effects of assimilation of knowledge.
• Lack of limit of course participants.

To the most important advantages of the platform, we can include the possibility of a systematic improvement of the training program. The E-learning course can be regulary updated. That allows the customization of the platform to the current needs of the participants and include their insights into the resources and work of the platform. This makes it possible to adapt to the ever changing market. [Czarkowski, 2012].

The disadvantages of e-learning use are as follows:
• High initial costs
• Skills of using the Internet and computer operating.
• No direct contact with the teacher
• Motivation barrier
• Barrier of individualism in assessment
• Limited contact with other participants of the course

Since e-learning is commonly used as a teaching method it was decided to check whether this method is as effective in teaching younger people (children in preschool and early school) participants of the University of Children and Parents at Pedagogical University of Cracow. As the students of this university always take part in activities in science (biology, chemistry, physics or geography) with engagement, it was decided to prepare for them (and their parents) a remote course - allowing them to execute their own experiences and learning.

In the available literature, there is no mention of the creation of on-line e-learning course for children. Therefore, the course 'Chemistry for Kids' is the first Polish attempt to create such a course of basic chemistry for children of preschool age and early school.

Methodology of the research

The study was conducted from February to May 2014. The research was carried out on a group of 75 children with their parents, students at the University Children and Parents at the Pedagogical University, in age from 5 to 10 years. Classes were implemented on the E-learning Moodle platform of Pedagogical University. KEN in Krakow in frames of the course Chemistry for Children.

The main goal of the research was to verify whether the creation of remote courses for young recipients makes sense, moreover to verify if the students would be interested in them and whether they will be able to use the information included therein.

Main hypothesis assumed that, since preschoolers were interested in nature and the changes taking place in the environment, thus the remote course at this subject will be equally interesting for them.

Description of the course at the e-learning Moodle platform.

Fig. 02. E-learning course at the platform (the text for children is written with capital letters in blue; text for adults (parents, carers) in black).

Despite the authors' extensive experience with both laboratory work with such young children as well as the creation of educational e-learning courses [Nodzyńska, 2005; Nodzyńska M. Pasko JR 2007; 2012] - the on-line course for such a young (and not always independent) recipients was created for the first time. Work on the platform assumed immediate help of parents or carers in the implementation of experiences. Before the start of the course, parents / carers were asked to complete the questionnaire on use of technical equipment, including computer. Moreover they were asked if children work alone or with help. Their task was also to determine the degree of use of the Internet and participation in the e-learning educational courses.

Experiments that were prepared for the e-learning education based on safe substances available in grocery stores or pharmacies. Young students with their parents had also the possibility to become familiar with safety regulations. In the course there are videos of NAPO, showing a negative impact of various substances on human health and how it should be handled with the substances. Clips were prepared as animations, which allow young people easier assimilation the knowledge.

Fig. 03. Screenshot from the video to learn safety rules. [http://media.osha.europa.eu/napofilm/napo-003-scratch-and-sniff-episode-003-irritant.webm]

Young students after watching movies and reading the safety rules, had to do a short test to check their knowledge of safety. Also, parents, carers, who worked with children had to complete a questionnaire, enabling to check if their children understand the danger of working with certain substances.

Another topic on the e-learning course “Chemistry for Kids”, was to check the degree of knowledge about the sugar (it was the main subject of a series of lessons). Students participated in a virtual “lesson”. Their task was to complement subsequent elements of classes. they were asked questions such as:

- Is sugar composed of crystals?
- Is sugar soluble in water?
- What factors determine the solubility of sugar in water?
- Does sugar dissolve faster in hot water or in cold one?
- In which solution did the sugar dissolve faster: mixed or left alone?
- Which sugar dissolves faster: powdered sugar, crystal sugar, sugar cubes?
- Is the taste of vanilla sugar the same as the taste of vanilla sugar and cinnamon?

With each question, students have the appropriate drawing or animation. After the incorrect answers children were guided to the correct answer through additional explanatory information, or by subsequent experiments.

Fig. 04. Fragment of lesson “Check what you already know about sugar?”

Another part of the course contained 5 experiences that the students were asked to perform independently under the supervision of parents or carers. The experiments were based on substances generally available in homes, grocery stores or pharmacies. Their main task was to check whether the change of used substance will change the results of the experience.

List of chemical experiments, which were available on the e-learning course:

- „the foam for suction”
- „sweet foam”
- „sugar decorations”
- „glass from the sugar”
- „explosive candy”.

Recipes how to perform the experiments were illustrated by drawings so that the children who cannot read were able to actively participate in the execution of the experiment.

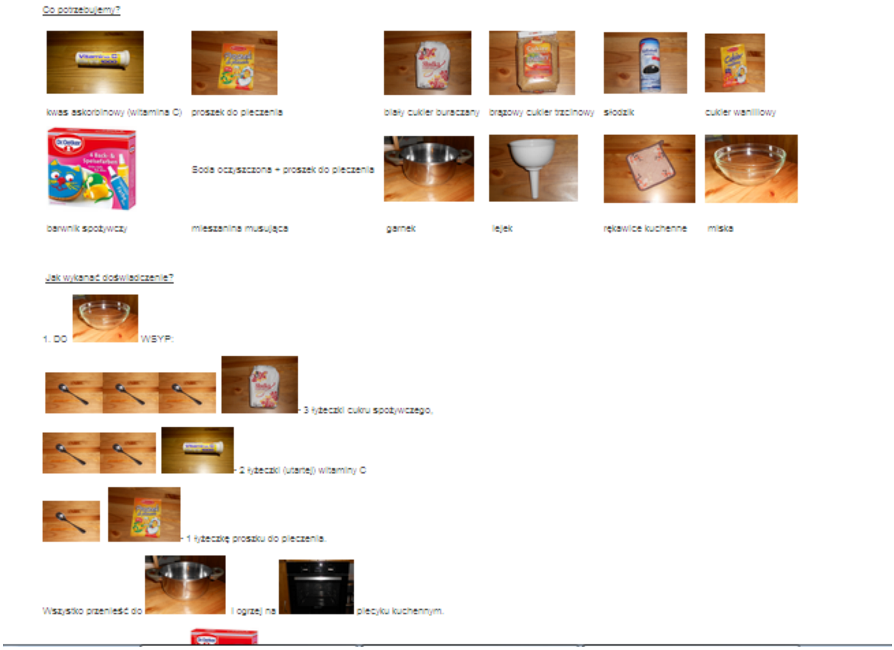

Fig. 05. Graphic recipe for “the foam for suction”.

Posted experiences were adapted to the needs of young students due to the fact that some of them could not even read properly.

Therefore, on the Internet course, photos of experiment components and the subsequent steps of adding the appropriate substrates dominated in the description of the experiment. Verbal part of experiments was addressed to parents or carers, so that they could better understand the experiment (and possibly, to answer children’s questions). The experiences has been selected for the young students in order to turn learning into a fun. The opportunity to try products of the experiments accounted for an additional attraction of studying.

After the experiments, students were given a short test, which was designed to check their knowledge about sugar which they obtained during the execution of experiments. The test contained 7 questions that concerned the whole course. The questions that were included in the test are listed below:

- What is the graphical symbol of a toxic substance and a substance harmful to the environment?
- Is sugar composed of crystals?
- Is sugar soluble in water?
- When does sugar dissolve faster?
- Are the brown cane sugar, white beet sugar and sweetener of the same taste?
- Does the change of sugar caused the change of taste of the ”sweet foam”?
- Did the change of the kind of sugar caused a change in the color of sugar mixture used for preparing decorations?

The participants also were asked to complete a survey in which they were to select their favorite experiments at the platform.

Results

There were 75 persons enrolled to the e-learning course in the field of natural sciences, chemistry, for children, the students of the University of Children and Parents at the Pedagogical University of Cracow. The research group of students was in the age of preschool and early childhood education. They were actively participating in the classes organized within the activities of the University. Unfortunately, only a few children completed the tests at the platform to check their knowledge and skills ("What do you know about health and safety", "Find out what you have learned about sugars", "Let's see what we have already learned"). Students who have completed the tests reached 100%.

Unfortunately, only seven parents of the course participants completed the included questionaires - this is less than 10% of students of the University of Children and Parents. It could be said that even though it seems that computers and the Internet are widely used at homes, however, they are not used for small children education.

The results of the survey for parents:

Preliminary survey for parents, that examined the level of computerization of the child's family consisted of 11 questions: six multiple choice questions, two questions using a Likert scale, two questions YES / NO, one open question. Answers to each question are summarized in the tables.

Tab. 01. Question - What devices are used at your home?

Participant	What devices are used at your home?
1	Computer – more than one, notebook, tablet, camcorder / digital camera
2	Computer, tablet, camcorder / digital camera
3	Computer
4	Computer, notebook - more than one, camcorder / digital camera, smartphone
5	Notebook, notebook - more than one, Tablet, camcorder / digital camera - more than one
6	Computer, notebook, tablet, camcorder / digital camera
7	Computer, notebook - more than one, camcorder / digital camera

Respondents answered that they have a computer or laptop at home, sometimes both devices. In most homes there is also a digital camera or camcorder. The vast majority of users underlined that they have more than 2 electronic devices.

Tab. 02. Question - My child uses on his own

Participant	My child uses on his own
1	Computer, notebook, tablet
2	Computer, tablet
3	Computer
4	Computer, camcorder / digital camera, smartphone
5	Computer, notebook, tablet, camcorder / digital camera
6	Computer, notebook, tablet, camcorder / digital camera
7	Computer, camcorder / digital camera

Parents, carers indicated that children use all the electronic devices available at their homes.

Tab. 03 Question - My child has his own

Participant	My child has his own:
1	Tablet
2	Tablet
3	The child has not his own devices, however devices at home are at his disposal
4	Camcorder / digital camera
5	Tablet, camcorder / digital camera
6	Notebook, camcorder / digital camera
7	The child has not his own devices

Two parents of seven indicated that their child does not have its own electronic devices; however the kid makes use of appliances available at home. The other answers have indicated that the child has its own notebook, tablet, or camera / camcorder - this indicates that children know how to operate that equipment.

Tab. 04. Question – Where do you use the internet?

Participant	I use the internet
1	at home, at work
2	at home, at work
3	at home,
4	at home, at work
5	at home, at work
6	at home, at work
7	at home,

Most parents use the internet both at home and at work, so you can say that it is a tool well known to them.

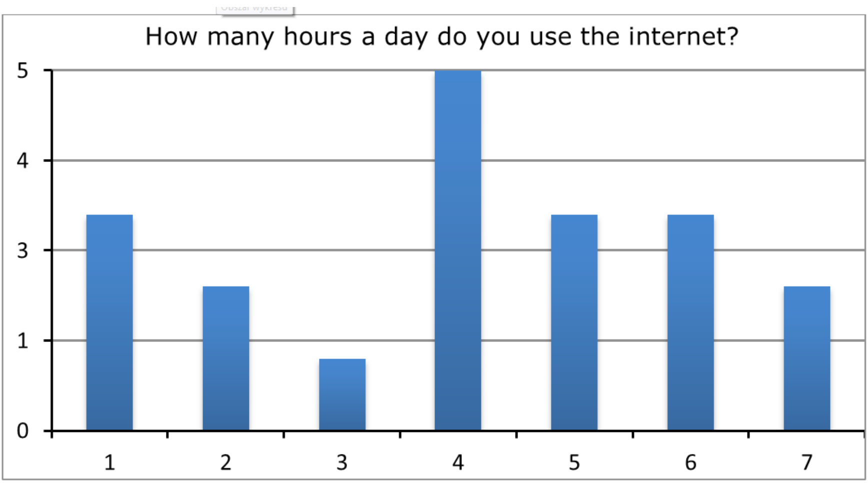

Fig. 06. Question - How many hours a day do you use the Internet?

Parents use the Internet every day for a few hours (from 1 hour to 5 hours), average 2,7h.

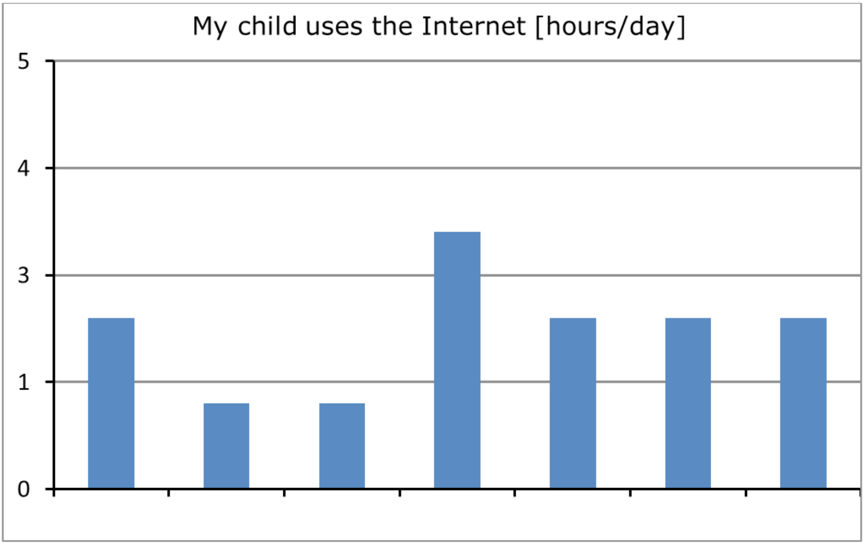

Fig. 07. Question – How many hours a day does your child use the Internet?

Children's online activity is much lower than their parents (from 1 hour to 3 hours; average incomplete 2h), but the shape of the graph is similar to the graph of the parents activity. This proves that parents who often use the Internet, allow their children for equal frequency in using the internet.

Tab. 05. Question – I use the Internet for

Participant	**I use the Internet for**
1	browsing pages with information and news, portals, videos, use of e-mail, creating on the Internet (I write a blog, upload videos, ...)
2	use of e-mail
3	browsing pages with information and news, portals, videos, use of e-mail
4	browsing pages with information and news, portals, videos, use of e-mail, listening to the music
5	browsing pages with information and news, portals, videos, use of e-mail, downloading programs, music, movies.
6	browsing pages with information and news, portals, videos, use of e-mail
7	browsing pages with information and news, portals, videos, use of e-mail

All respondents answered that they use the Internet to check email. For 6 people The Internet is also a source of information about the world around them as well as a source of entertainment (watching movies). Only one person is actively involved in the creation of the Internet - by writing a blog.

Tab. 06. Question - My child uses the Internet for...

Participant	My child uses the Internet for
1	watching cartoons online, playing educational programs online, playing games online
2	playing educational programs online
3	watching cartoons online
4	watching cartoons online, playing educational programs online, playing games online
5	watching cartoons online, playing educational programs online, playing games online
6	watching cartoons online, playing games online
7	watching cartoons online, playing educational programs online

Five respondents have indicated that their children enjoy educational programs on-line. The Internet is also used by children to play, especially online games. As well as to watch cartoons.

Tab. 07. Question - Have you ever took part in the training on educational platform?

Participant	Have you ever took part in the training on educational platform?
1	NO
2	NO
3	NO
4	YES
5	YES
6	NO
7	YES

Most respondents did not participate in training on educational platform.

Tab. 08. Answers to the question: Do you think that the course for preschool and younger school children on educational platform makes sense?

Participant	Do you think that the course for preschool and younger school children on educational platform makes sense?
1	YES
2	YES
3	YES
4	YES
5	YES
6	YES
7	YES

All respondents consider that the course on educational platform for children in preschool age makes sense.

Tab. 09. Question - What do you expect on the online course “Chemistry for Kids”?

Participants	**What do you expect on the online course “Chemistry for Kids”?**
1	Interesting experiments
2	I would like that through play: was interested in science, he wanted to learn new things, develop logical thinking and drawing conclusions.
3	The child’s curiosity, inspiration
4	I imagine that for a child at this level the most appropriate will be something intriguing and something that will interest him. Experiments, that can be repeated at home.
5	Transfer of chemical knowledge in a funny and accessible way
6	Education
7	Interest in the subject of nature

There are various expectations of parents and carers, but most want to interest the child in nature and chemical experiments.

Other questionnaires and votings were filled out only by a few persons, thus it is difficult to draw any conclusions from the answers given by the respondents. However, despite the fact that children have not filled the questionnaires, they were relatively active on the platform. Results of checking activity (logins) of participants in each course element are presented in the table below.

Table 10. Activity of participants

Experiments with sugar	
Check what you already know about sugar?	86
Dissolution of the sugar cubes in water	-
„The foam for suction”	
How to do it?	50
„Sweet foam”	
Try it yourself	17
„Sugar decorations”	
Find out how to make them, it's easy	17
„Glass from the sugar”	
Let’s play a glazier	17
Movie	4
Sugar ring	9
"Explosive sweet"	
Let's make some magic	23

The results allow us to conclude that the various elements of the course were interesting for children.

- „the foam for suction”
- „sweet foam”
- „sugar decorations”
- „glass from the sugar”
- „explosive candy”.

Conclusion

The study shows that children in preschool and early school age use the Internet, on average, 2 hours a day. This is done through their own electronical device, which is usually a notebook or a personal computer. They use these devices for play (eg. Playing online games or watching cartoons). They also work with educational programs on-line, however, due to the lack of participation in online courses by their parents and lack of knowledge on the specifics of such courses, activity of children (and their parents) in that course was lower than expected - they have not done all the exercises and questionnaires that were scheduled. Due to the very low activity in filling surveys, we assume that the interest in such a course, designed for small children, is not as big as expected.

Parents initially had high expectations for the course, but the lack of work with the child, which was necessary in the performance of experiments and filling out the survey, resulted in getting unsatisfactory results.

Although parents verbally declared interest in Poland's first online course for small children, they did not fully exploited the resources of the data that they received. It seems that the parents would like to see the course that did not require working with the child.

References

Czarkowski J.J. (2012) E-learning dla dorosłych, wyd. Difin, Warszawa.

Nodzyńska M. (2005) Rola doświadczeń chemicznych jako jednej z metod kształcenia. [in:] Acta Facultatis Paedagogicae Universitatis Tyrnaviensis – Seria D Vedy o Vychove a vzdelavani. Trnava.

Nodzyńska M., Paśko J.R. (2007) Interaktywne komputerowe doświadczenia w nauczaniu chemii. [in:] Materiały XVII Ogólnopolskiego Sympozjum Naukowego-Komputer w Edukacji. AP, Kraków.

Nodzyńska M, Paśko J.R. (2012) Projektowanie doświadczeń wspomaganych komputerowo jako jeden z elementów kształcenia nauczycieli chemii oraz wpływ tego typu doświadczeń na wyobrażenia uczniów o strukturze materii [w:] Człowiek, media, edukacja ed. Janusz Morbitzer & Emilia Musiał. - Kraków: Katedra Technologii i Mediów Edukacyjnych, Uniwersytet Pedagogiczny im. KEN.

Rosenberg M.J. (2003) E-learning, Strategies for Delivering Knowledge in the Digital Age, Mc.Graw-Hill, London.

Sansom C. (2011) BioMOO: Teaching biology in virtual reality.

Wagner J. (2008) Technologie informacyjno-komunikacyjne w kształceniu zdalnym, [in:] Technologie informacyjne w warsztacie pracy nauczyciela, red. M. Furmanek, Zielona Góra.

Wagner J. (2011) Kształcenie na odległość wspomagane komputerowo jako element edukacji pedagogicznej, Adam Marszałek, Toruń.

www.edusat.pl.

Kamila Moskal, Małgorzata Nodzyńska

Pedagogical University of Cracow, PL

malgorzata.nodzynska@gmail.com

Analysis of technological abilities of teachers

Małgorzata Nodzyńska, Paweł Cieśla

Speaking about the use of IT in teaching and the benefits that students can achieve with the use of that technologies in their teaching, first of the skills of teachers on the application of ICT should be taken into account.

Research

In March 2014 the research among teachers, participants of one innovative project for teaching natural sciences, in a form of questionaire, was carried out. One of the aims of the project is application of IT in teaching nature subject in a high school. The project involves transfer of knowledge in an interdisciplinary and integrated way, among others with the use of blended learning realised with use of Moodle platform. Teachers and students use ICT, and they perform tasks and experiments. Since participation in the project was voluntary, teachers knew the objectives of the project before, it could be assumed that the knowledge and application of information technology in these teachers was greater than the average.

The aim of the study was to examine areas of IT skills and the application of IT in the classroom by science teachers of secondary schools;

- the ability of using the following equipment:
  a printer,
  a photocopier,
  a mulitmedia projector,
  a scanner,
  a digital camera
  an interactive whiteboard
  a tablet,
  an overhaed projector
  a microphone
- the ability of using computer programs in education:
  for word processing,
  for image processing,
  for calculations (a spreadsheet),
  for presentations (eg. PowerPoint, Prezi)
  for modeling (eg. models of chemical compounds),
  CDs adds in textbooks,
  for creating interactive content
- the use of TI for communication between the theacher and student's parents:
an electronic mail (e-mail)
  communicators with voice and video (eg. Skype),
  chat,
  a discussion forum
  a mobile phone.

In addition, theoretical knowledge of teachers was checked and verified. Teachers were asked to define the following terms:

- bleneded lerning
-distance learning.

Moreover, teachers were asked whether the electronic gradebook and (or) e-learning platform is used in a school.

Results of the research

In the first question, teachers were asked about the devices that they are able to use without any troubles.

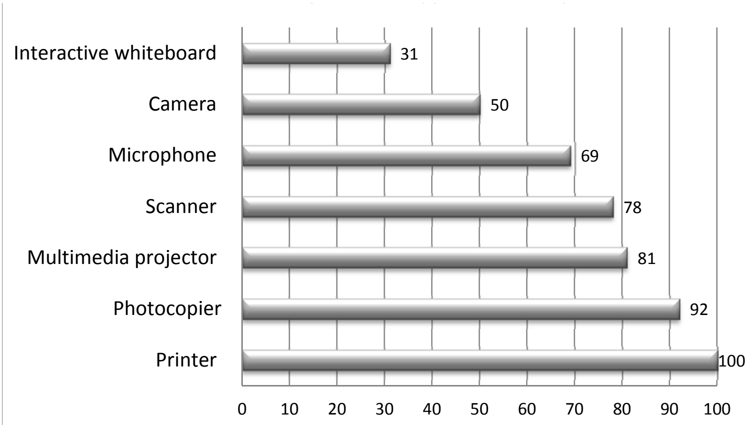

Fig. 01 Percent of teachers' answers to the first question, concerning electronic teaching aids that they can use without problems.

As can be seen from the chart above (figure 01), all asked teachers were able to use the printer, the vast majority of them used efficiently photocopier, multimedia projector and scanner. However, only 31% of teachers were able to use the interactive whiteboard. It can therefore be assumed that teachers gladly learned to handle those devices, which could help them at their work and not necesserily those that would make lessons more attractive to students.

The next questions were related to the problem of frequency of using various IT teaching aids.

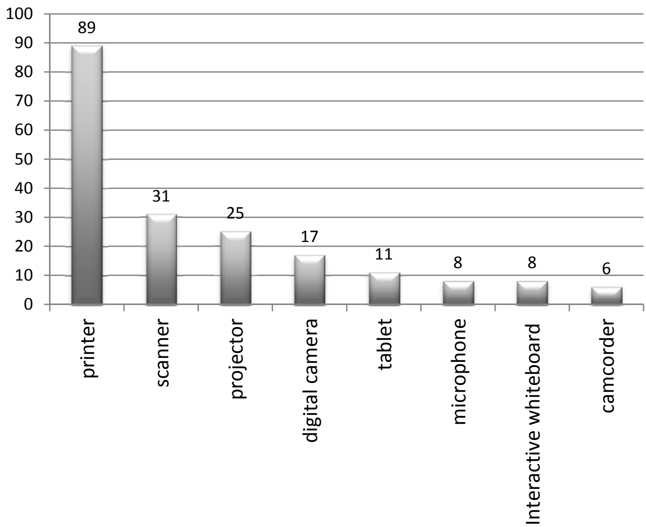

Fig. 02. Percentage of teachers using the presented teaching aid regularly in the educational process

The most common commonly and regulary used device at school practice was a printer (regulary used by 89% of teachers), in contrast to the camcorder, which was regulary used only by 6% of teachers. The percentage of regular use of other devices, which were generally chosen by less than 30% of teachers, is presented at figure 02.

The figure 03 presents the percentage of teachers who never used the presented device in a school practice.

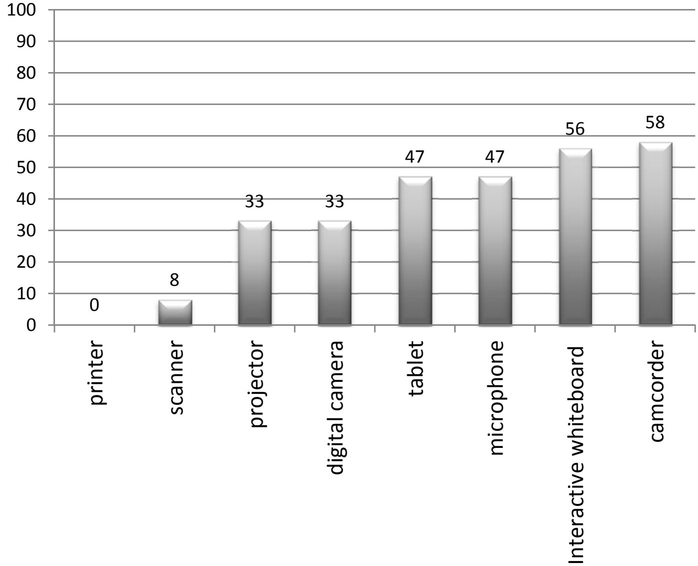

Fig. 03. Percentage of teachers who have never used the presented teaching aid in the educational process.

More than half of teachers never benefited from a camcorder in the classroom and interactive whiteboard as well. Almost half (47% of teacherrs) have never used the tablet and microphone. Finally, one-third of teacheres have never used the multimedia projector and the digital camera.

These global results must raise understandable anxiety – modern tools were not used in the teaching of the sciences, even by teachers involved in the innovation process of teaching natural sciences. Let's look more thoroughly at the frequency of the use of various tools mentioned above. The teachers were asked by Likert scale, which was understood as follows:

1 – I do not use the tool at all.

2 – I use the tool from time to time.

3 – I use the tool quite often

4 – I often use the tool

5 – I use the tool regulary

The printer (fig. 04.)

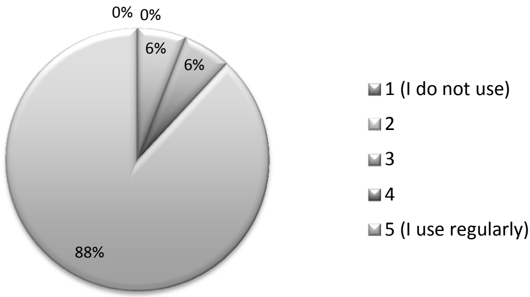

Fig. 04. Percentage of teachers' responses to the question: How often have you used a printer in your teaching process?

The printer can be handled by all surveyed teachers and is the most widely used tool in education process. 89% use it regularly and another 12% of teachers often do it. None of the interviewed teachers chose the option 'occasionally' and 'never'. Average frequency of use of the printer on a five-point Likert scale is 4.8. It can be concluded that the printer is the most useful device in Polish schools, however, if we consider the aplications of the printer (print of documents, tests, teaching aids for individual student's work etc.) the question arises whether this printer is not a factor that causes that pupils work all the time in the same way, what, in consequence, decreases pupil's motivation for learning. Thus a printer is helful for the teacher, however decreases teacher's creativity and attractiveness of the lesson.

It should also be noted, that the printing proces is often limited to uploading the paper into the printer and pressing the "print" button. Therefore, it is difficult to say how far skilled teachers are when it comes to use additional functions of the printer (eg. Two-sided printing, resize, print on multiple pages, printing quality, colour management). It should also be taken into account that the prices of small printers are relatively low, thus a lot of people have their own printer (in 2006. 42.3% of employed had a printer at home [Budgets, 2007, p. 135].)

Scanner

Another device of frequent use by teachers is the scanner (Fig. 05).

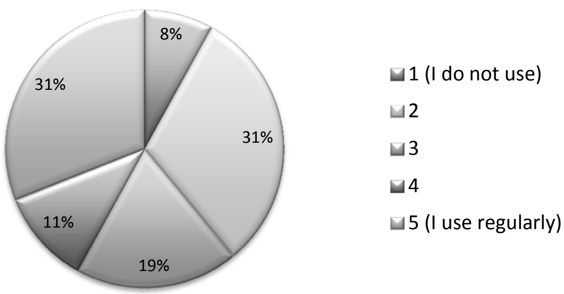

Fig. 05. Percentage of teachers' responses to the question: How often have you used a scanner in your work?

In total, 50% of teachers used a scanner 'always' or' often '- it can be stated that the device is slowly entering schools as a permanent element of the educational process. The average result of frequency of using the scanner in a five-point Likert scale is 3.3.

Similarly to the usefulness of a printer, the question arises whether the scanner is a device that only facilitates the work of teachers or maybe makes educational process more attractive and affects pupils become more motivated. Teachers usually scan texts, images from various books and other printed material in order to prepare other works to be used either in a form of Power Point presentation or in a printed form in a new layout (i.e. tests, worksheets, etc.). Possible application of the effects of scanning in non-printed teaching aids can in consequence make the lesson more diverse and more interesting. Relatively frequent use of the scanner by teachers is associated with recently increasingly popular all-in-one workstations (printer, scanner, photocopier and fax integrated in one device).

Multimedia projector

The third device used by teachers is multimedia projector.

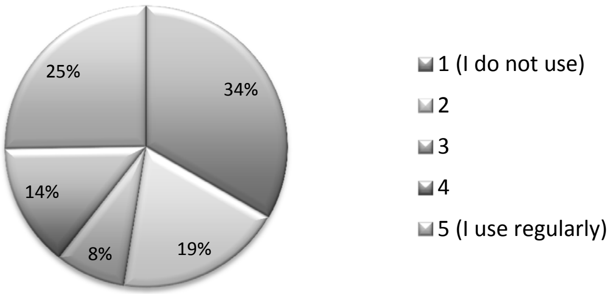

Fig. 06. Percentage of teachers' answers to the question: How often have you used multimedia projector in educational process?

53% of respondents used the projector 'always' or 'often', however as many as 39% did not use it at all or used occasionally. It can be concluded that almost half of the students at science lessons were deprived of the opportunity of watching any presentations, videos, animations, photos, ... or even CDs and DVDs attached to the textbooks. In the case of the sciences, which largely rely on visualization of the teaching content [Nodzyńska 2012] it appears to be a serious misunderstanding. It is very remarkable especially that computers with multimedia projector can be found in every school. Moreover, in many schools, there are classrooms equipped with the projector connected to the computer and there are no major problems for any teacher who would like to use that teaching aid.

The average result of the frequency of the use of multimedia projector, in the five-point Likert scale, is 2.8.

The camera is used relatively frequently to the projector.

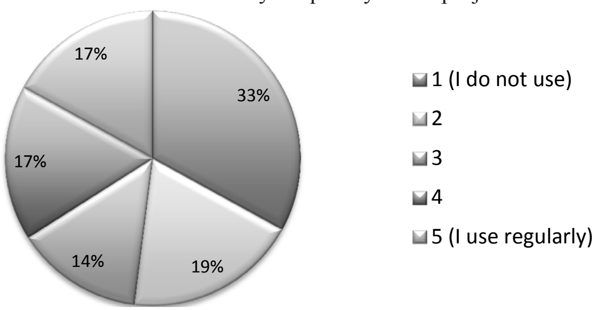

Fig. 07. Percentage of teachers' responses to the question: How often have you used a photo camera in the education process.

52% of teachers used it ‘always’ or’ often ‘in the classroom, but as many as 34% have not used it at all or used it occasionally. The average result of the frequency of using the camera on a five-point Likert scale is 2.6.

The use of digital cameras in the classroom in science education seems obvious. The cameras are very useful in documenting the results of the experiments. Nowadays, when schools are able to take part in various projects and grants, which often require photographic documentation, non-using of digital camera by 17% of the surveyed teachers is a failure. Moreover, at present almost every cell phone has built-in digital camera and almost averyone has a cellphone (mobile phones in Poland in 2006, 93% of employed have mobile phone [Budgets, 2007, p. 135]) .

Tablet

Tablets in everyday life have begun to replace laptops, the same way as the portable computers partialy replaced desktop PCs a few years ago.

Today, tablet slowly enters into education as a device supporting the learning process. The spectrum of possibilities of application of a tablet, makes it a convenient tool for teachers that can affect both the quality and the effectiveness of a teaching and learning process.

This device is very convenient in use and in transport. It is small and powerful. It can be easily packed in every bag, in stead of tons of paper sheets.

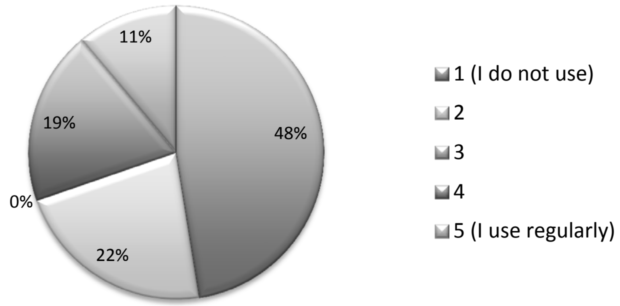

Fig. 08. Percentage of teachers’ responses to the question: How often have you used tablet in your work?

The average result of frequency of using the tablet in a five-point Likert scale is 2.3. Despite the obvious advantages, tablet is not widely used in the educational process. Only 30% of teachers use it ‘always’ or ‘often’ in the classroom and as many as 70% do not use it at all or do it only sporadically. This is probably associated with the fact, that the majority of schools are not equipped with tablets. The teacher who wants to use this tool in the classroom must use his own one and unfortunatelly many teachers cannot afford that.

The microphone (fig. 09)

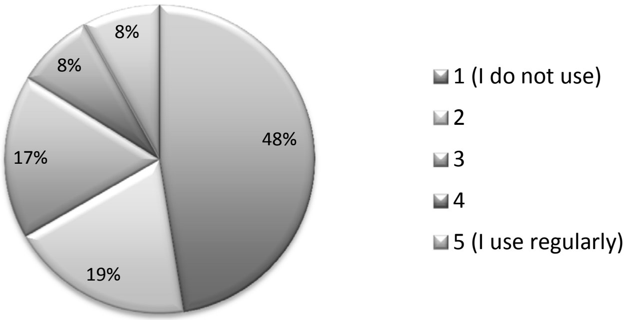

Fig. 09. Percentage of teachers' responses to the question: How often have you used a microphone in your work?

The microphone is quite specific tool. It can be applied to record the birds' voice and other sound effects. Moreover, it can be applied in preparing presentations with voice and finally for communication purposes. That is why only 16% of teachers use the microphone 'always' or 'often' in the classroom and as many as 67% do not use it at all or only sporadically. The average result of the frequency of using of the microphone in a five-point Likert scale is 2.1.

Camcorder (Fig. 10)

At science lessons, there should be many more applications of the camcorder comparing to the microphone. It can be used to record the effects of the chemical experiments, and then the experiments can be displayed once more in a slow motion to explain every part of the occuring process. Moreover it can be used to record the educational trips, shows and other situations. In the classrom it can be used in order to prepare educational movie or to do interviews. Its applications can be multiplied.

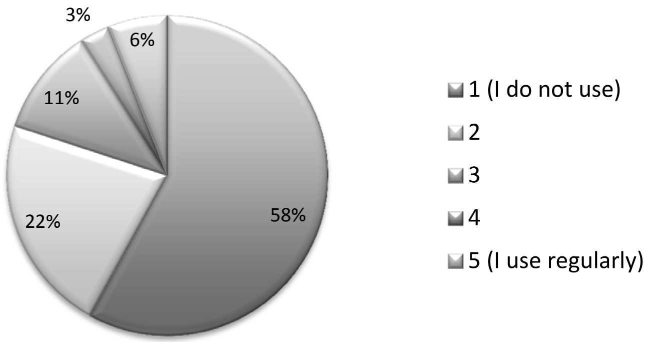

Fig. 10. Percentage of teachers' responses to the question: How often have you useda camcorder at your work?

Unfortunately, the average result of frequency of using the camcorder in the classrom in a five-point Likert scale is 1.8. It means, that only 9% of teachers used the camera 'always' or' often' in a classroom, but 70% of examined teachers hav never used it or used the camcorder very rarely. It is true that the camera is not standard and not required equipment at home, however, at present most of cell phones, tablets and digital cameras can record video even in HD quality. Therefore, teachers should be able to use this tool at their work in the classroom.

Interactive whiteboard (Fig. 11)

Today in Poland in many schools there are interactive whiteboards, however they are not very popular. They often are playing a role of a screen displaying the presentations, however their basic role is enabling interactions of pupils with computer in the classroom. The possibility of operating it by a touch of a finger or a special pen allows to fully use the power of the software on a PC. The software designed to work with interactive whiteboard also allows pupils to practice by solving various tasks and to save effects of their work in the computer's hard drive, that can be useful in further contacts with parents.

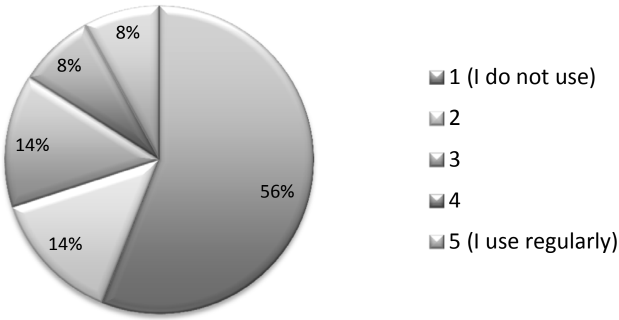

Fig. 11. Percentage of the responses to the question: How often have you used Interactive whiteboard at your work?

Despite its universal use interactive whiteboards are not very popular in Polish schools. However, there are usually a few ones in a great majority of schools. Therefore, it is up to the teachers whether and how often it is used. Unfortunately 56% of asked teachers have never used the interactive whiteboard in the teaching process. It can be understood that more than a half of teachers did not want to use it and did not want to get to know new media and its use in teaching. Only 16% of teachers have used the tool in their work. It is very little.

Summary of the use of electronic devices

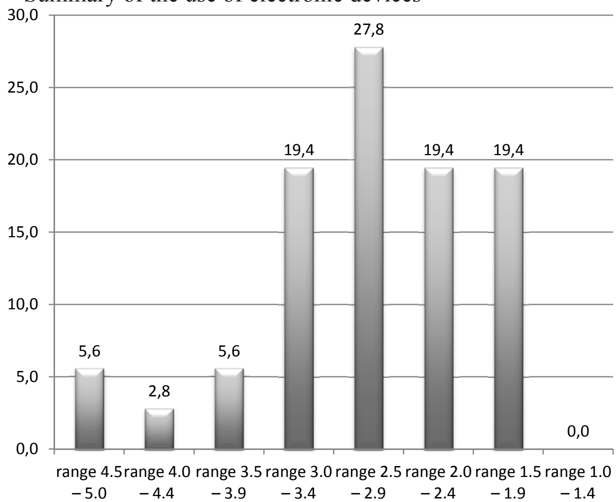

Fig. 12. Percentage of teachers in various ranges of a Likert scale of average use of electronic device at the teaching process.

The average result of the frequency of application of the above 6 tools, in a five-point Likert scale, is 2.7 (below ‘3’ which meant ‘often’). Thus, in general, teachers rather prefer not to use the electronic devices supporting the teaching process.

In the figure 12 it can be seen that only 34% of teachers use various devices quite often, often or regulary, and 28% of teaches use the equipment from time to time, however, unfortunately almost 20% of teachers use that measures very rarely. If, however, we ignore in this analysis the use of the printer - the results are even lower (Fig. 13).

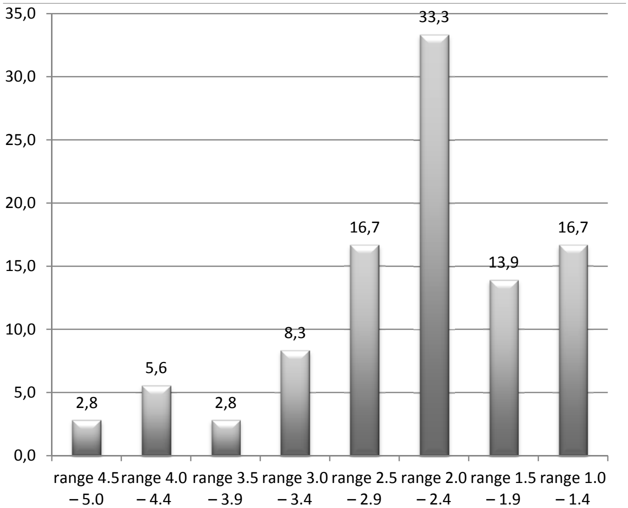

Fig. 13. Percentage of teachers in various ranges of a Likert scale of average use of electronic devices, excluding the printer, at the teaching process.

It can be seen that only 20% of teachers use various electronic devices (excluding printer) quite often, often or regulary. The most frequent range of average use of the tools is 2 – 2.5, that means that one third of teachers uses the devices occasionally. Almost 30% of teachers use the examined electronic devices very rarely or never.

A detailed analysis of responses from individual teachers to the questions about the use of eight devices discussed above shows that as many as 14% of the teachers in their responses selected “I never use it” five or more times. Aproximately 40% of teachers use one or two devices from time to time and the rest very rarely or at all.

It can therefore be said that among the respondents, there is a small group of teachers who use modern technology every day in the educational process (about 11% of teachers). They use regulary or very often minimum five of eight devices. There is also a large group of (14%) teachers who, almost never use IT tools for teaching. The group placed between these two extremes is very diverse. In this group there are teachers using some of the tools very often while others rarely or not at all, as well as people who seldom use all the tools.

Discussion of the use of the computer programs

The use of software there have also been studied: word processors, spreadsheets, applications for creating and editing graphical objects, presentations, software for modeling and finally programs for creating interactive tasks.

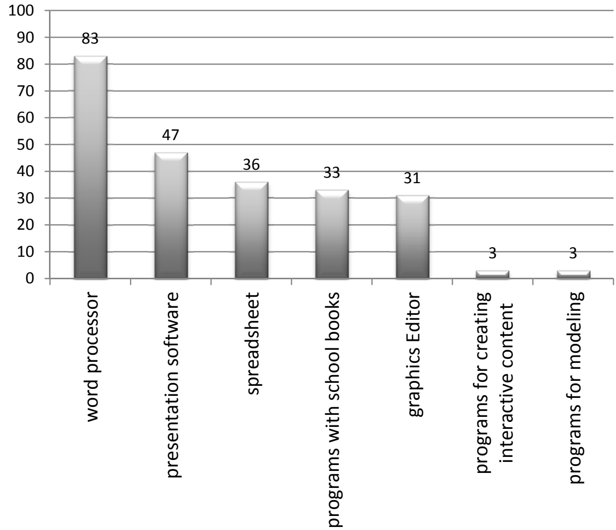

Fig. 14. Percentage of teachers using regulary various computer programs in the educational process.

Almost all respondents (83%) used a text editor for their work. This result is coherent with the frequency of use of the printer by teachers (88%). Much less frequently teachers used other software. Only 47% of teachers use software for creating presentations (such as PowerPoint, Prezi, etc.). These data are also consistent with the data on the use of multimedia projector (53% of teachers used it very often in their work).

Spreadsheets, graphics editors and programs included to textbooks are used regulary by about one third of teachers. In contrast, only 3% of the teachers regulary used programs for modeling and for creating interactive content.

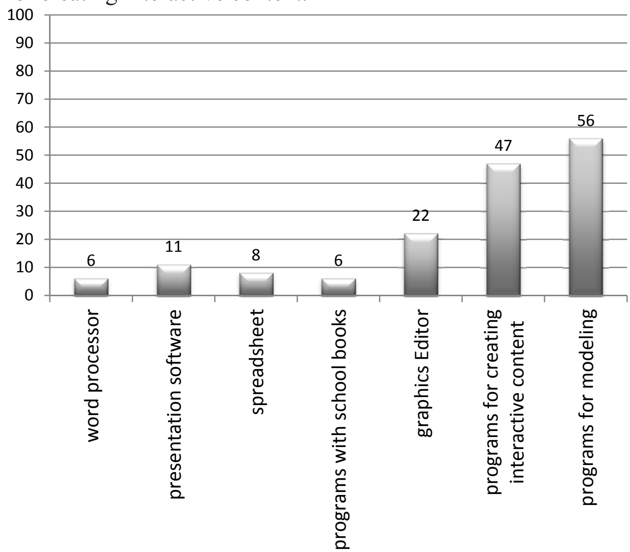

Fig. 15. Percentage of teachers who did not use various computer programs in the educational process.

It is very interesting that about 10% of teachers never uses word processing programs, programs for preparing presentations. It is amazing that even easy to use software designed for textbooks was not used, especially in the era of so strong developement of information technology.

Teachers Text editors are most commonly used to create lesson plans, tests, all tests, work cards.

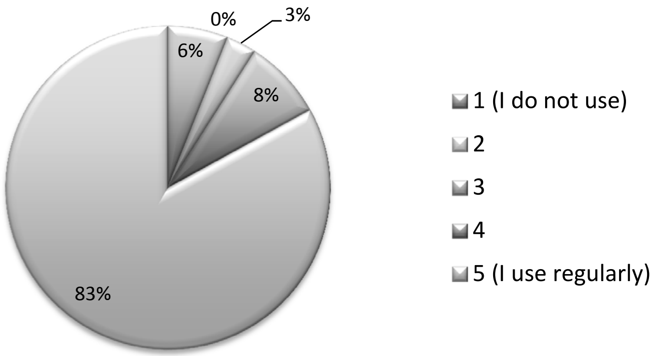

Fig. 16. Percentage of teachers' responses to the question: How often have you used the text editor at your work?

Text processors

It would seem that so popular tool as word processor is commonly used. In fact 89% of the teachers used text editors regulary or often in the education process, however, 6% of teachers did not use it at all - the question arises how do these teachers prepare their handouts, tests and quizzes for students? Text processors, such as MS Word, allow also for use a merge tool, which enable teachers to prepare personalised materials for pupils and individualisation of a teaching process [Nodzyńska, Cieśla, Paśko, 2011].

Presentations

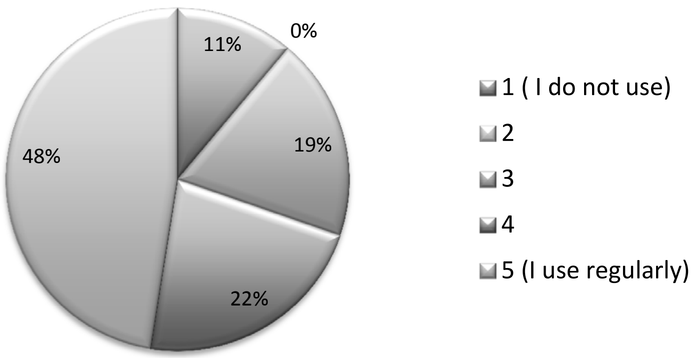

Fig. 17. Percentage of teachers' responses to the question: How often have you used programs for creating presentation, such as PowerPoint, Prezi?

PowerPoint presentations are one of the most frequently used IT tools in the classroom.

It is a matter of a debate whether presentations are a necessary element of the lesson, however undoubtedly increase its attractiveness.

In total, 60% of teachers use presentations regulary or often. It can be considered that it is sufficient amount, but the lack of any presentation in the classroom (11% of teachers) must raise concerns about the attractiveness of these lessons. Especially, as the ability to use the PowerPoint is a basic skill of IT competences.

The spreadsheet

The spreadsheet is most commonly used by the teachers for creating various calculations and graphs. In a school practice it is a good tool that can be used for evaluation of pupils' work and teachers themselves. In the classroom it can be used for presentation and analysis the data obtained in experiments, for example with the use of electronic pH meter, termometer, spectrophotometer and other sensors.

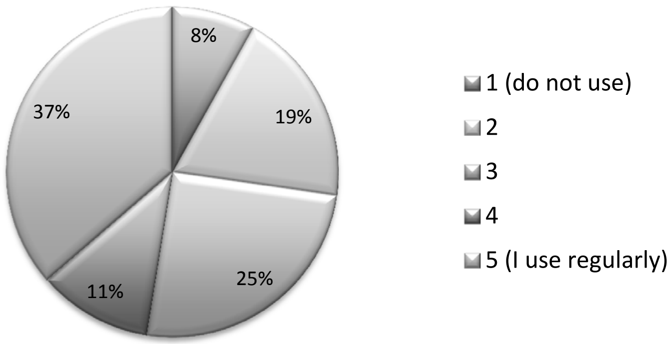

Fig. 18. Percentage of teachers' responses to the question: How often have you used spreadsheet in your their work?

48% of teachers used spreadsheets in teaching 'always' or 'often', however 27% of teachers did not use this tool at all or rarely.

Digital additives to textbooks

In Poland, many of school textbooks include educational programs on CDs that are compatible with the textbook and curriculum. It would seem, therefore, that most of the teachers should use these free programs in environmental education.

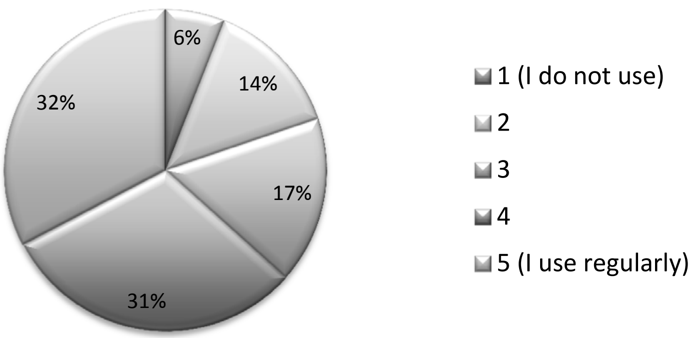

Fig. 19. Percentage of teachers' responses the question: How often have you used in your work the programs attached to textbooks?

As expected, as many as 63% of the teachers ‘always’ or ‘often’ use these materials, however there is a large group of teacheres (20%) who never or very rarely use such programs. Of course use of such programs is not obligatory, however it is frightening that one fifth of teachers do not use professional educational programs to enhance attractiveness of their lessons.

Graphical programs

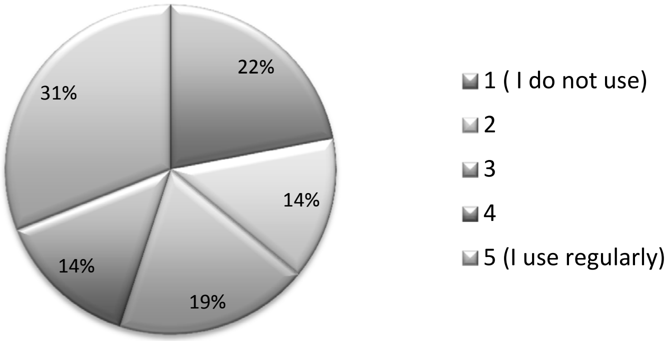

Fig. 20. Percentage of teachers responses to the question: How often have you used a graphics editor in your work?

Due to the necessary visualization [Nodzynska 2012] in science it appears that the graphic programs should be often used in teaching the sciences. However, the results are not optimistic. 45% of teachers regulary or almost regulary use graphic programs in teaching, but, as many as 34% do not do it at all or do it very rarely. Ability to use basic graphics software is the skill that every teacher should be familiar with.

Creation of interactive content

Creation of interactive content is not very popular, but there are educational portals where such a content is available to download and base on it, teachers can create their own modifications, that is much easier than creation from the beginning. At those portals teachers can also publish their own software. Although, at present there are many free programs (eg. HotPotatos, eXe) and websites (eg. Learning Apps Zondle) allowing for intuitive creation of interactive educational materials only 17% of teachers use these programs regulary and in contrast as many as 69% of educators do not do it.

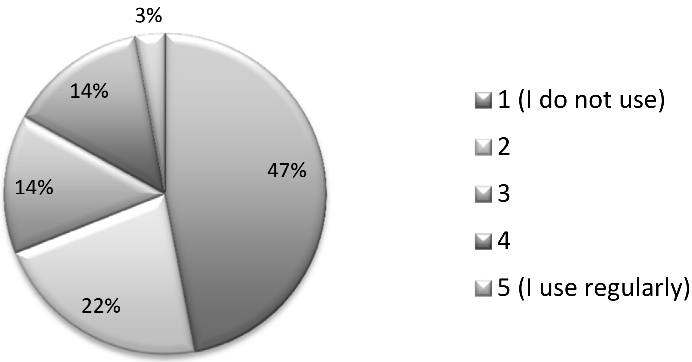

Fig. 21. Percentage of teachers’ responses to the question: How often have you used in your work programs for creating interactive content?

Unfortunately programs for modeling are not often used in environmental education. For example modeling of chemical compounds should be a compulsory element of chemistry and biology lessons (in the biochemical components). Only 9% of teachers use modeling programs in the teaching regulary. The vast majority of them (83%) do not use these programs. There are of course professional programs which use requires payment, but also there is a number of freely accesible programs when they are used non-commercialy. There are also websites of various universities where there are simulations and laboratories on-line.

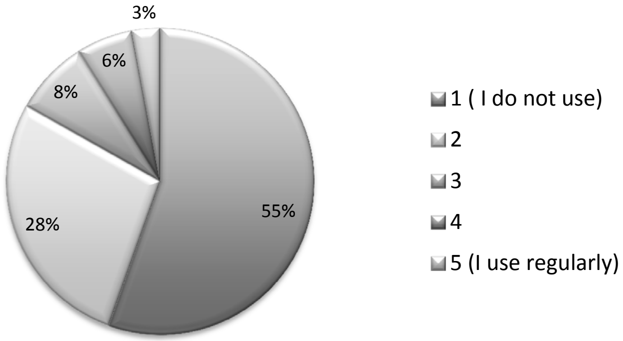

Fig. 22. Percentage of teachers' responses to the question: How often have you used programs for modeling?

A summary of the use of the software

The average result of the application of the above 7 types of programs in the five-point Likert scale is 3.2 (slightly above the '3' which meant 'often'), which means, that results are optimistic.

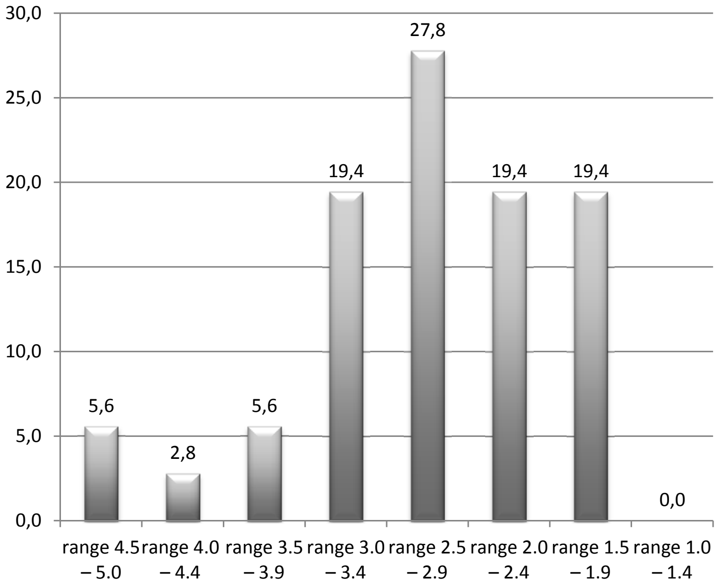

Fig. 23. Percentage of teachers in various ranges of a Likert scale of average use of various kinds of computer programs.

According to the above chart (Fig. 23) it can be concluded that teachers quite often use computer programs in education. The average result over ‘3’ was received by about 69.4% of the teachers. The average result is reduced by those teachers who never use any computer programs in teaching (they represent about 3% of the studied population), or use only one type of programs (they represent about 6% of the studied population).

As many as 31% of the teachers have never benefited or benefited very occasionally from more than 4 of 7 types of those programs. This means that even those teachers who often use computer programs in teaching, use only small number of programs. Only 3% of teachers use often or regulary all discussed kinds of programs and about 8% of teachers use more than five of 7 kinds programs.

Theory

The last two questions concerned the knowledge of notions “distatnt education” and “blended learning”. Analysis of tachers’ responses revealed that most of teachers has little idea about these ways of teaching.

The term distant learning.

38,9% of respondents just wrote a synonym of that notion that still was not its explanation.

19,4% teachers told that it is teaching with using the Internet

8,3% respondents answered that it’s the use of a computer,

5,6% of asked told that it is teaching through the platforms,

finally 2,8% teachers told it is a synonim of e-learning.

The term blended learning was understood variously and mainly incorectly. Only about twenty percent of answers were correct.

Conclusions

The research revealed that in XXI century teachers are not qualified enough in terms of using IT. The world has changed and most of pupils can use IT devices and software. Thus teachers should not be worse. The teacher should be the master for their students and this research show the oposite situation that in many cases the student surpassed the master. Teachers should always grow up with the developement of the world in order to be always the master. However, it does not mean that every lesson should be prepared with the use of IT. The traditional ways of teaching are very good, but pupils are used to use IT. This is their language thus teachers should be more flexible and open to new technologies.

References

Budżety gospodarstw domowych w 2006 r. (2007) Informaacje i opracowania ststystyczne GUS Warszawa

Nodzyńska, M; Cieśla, P., Paśko, J.R. (2011) Zastosowanie ‘korespondencji seryjnej’ w monitorowaniu indywidualnych osiągnięć uczniów - Media4u Magazine ISSN 1214 - 9187 Čtvrtletní časopis pro podporu vzdělávání The Quarterly Journal for Education * Квартальный журнал для образования S. 2011 s 58 - 62.

Nodzyńska M. (2012) Wizualizacja w chemii i w nauczaniu chemii Kraków.

Wyniki badań Megapanelu PBI/Gemiusa (http://web.archive.org/web/20121215034830/http://www.press.pl/~wwwadd/pliki_pdf/Wyniki_Megapanel_PBI_Gemius_maj_2008.pdf).

Małgorzata Nodzyńska, Paweł Cieśla

Pedagogical University of Cracow, Kraków, Poland

malgorzata.nodzynska@gmail.com, pawel.ciesla.33@gmail.com

Contents