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Eyetracking or a piece of paper in didactic research

Introduction

Problems of control and assessment is one of the most important fields of didactic knowledge as it is an immanent element of every single process of education. Responsible organization of teaching and learning is an obligation to become interested in effects, which means checking the knowledge and skills of students that would allow to state their progress and deficiencies and to make tools that would motivate students for further work.

Verification of knowledge

All methods that verify students' achievements should be used consciously by teachers. They can differ depending on the specifics of a subject taught, teacher's preferences, students' abilities, and limitation of space and time of the process of teaching. Teachers usually use traditional methods of verifying knowledge, which are oral, written, and practical tests. A written test may require the students to do the task, give answers to the questions or to complete a test. According to many didactics the didactic assessment which uses school-based tests is objective, accurate and reliable. This system of testing students' progress eliminates, to some extent, subjective feelings in a man-to-man relation. Nevertheless, the discussion if an objective grade can be set based on a test is still up-to-date and open. Professor Bogdan Śliwiński, a member of a Committee of Pedagogical Sciences of the Polish Academy of Sciences, states that tests do not measure the depth of knowledge and its range but only the superficial skills and competences. According to the professor, school does not teach skills connected with critical thinking, making analyses in a cause and effect categories or making conclusions anymore [http://wiadomosci.onet.pl/kraj/prof-boguslaw-sliwerski-zmierzamy-ku-edukacyjnej-katastrofie/7emqc].

It needs to be stated here that, despite the fact that using the above-mentioned methods is easy they are burdened with a high dose of subjectivism, being often "intuitive". Contrary to popular beliefs classical methods also have limited possibilities of making the assessment of school achievement. As Adolf Dygasiński stated in one of his works: "During all kinds of exams and tests teachers willing to understand the

level of intellectual developments of a student will not seek for what the student does not know, but they will base their assessment on what the student has really learnt" (Dygasiński, 1882).

Another approach to testing a student's knowledge – eyetracking

Means of verifying knowledge that were used so far checked only what the student could do and what one learnt and did not allow for tracking the student's way of thinking or attempts of solving the problem. Therefore they need to be constantly modernized, improved and adjusted not only to didactic requirements, but also to the requirements set by the environment, civilization and technology.

Due to dynamic development of electronics and IT tools new, non-invasive methods of monitoring psycho-physical parameters appeared, one of them being eyetracking which enables registering, measuring and analyzing data of position and movement of eyeballs. According to the assumption defined by the "mind-eye" hypothesis (Nielsen & Pernice, 2010) people usually think about things they are looking at and concentrate their attention on them. Since it is possible to recreate the path of a student's eyesight after they were asked questions in order to assign the answer out of a given set of answers, it is equivalent to the possibility of describing the cognitive process, studying the mechanism of this process as the eyes movement is a reflection of an operation that takes places in a student's mind.

In measuring devices that are used at present – eyetrackers – a camera detects the position of eyeballs, which are illuminated with an infra-red light invisible for a person. The infra-red rays reflected from the cornea can be seen as reflections (also known as Purkinje's reflections), and, among others, on this basis the 'x' and 'y' co-ordinates of the eye position are determined. At present there are two types of eyetrackers: mobile (headset or spectacle type) and stationary ones (that is a device integrated with a computer monitor, free-standing, whose location can be manipulated by the researcher, or a fully stationary system which also allows stabilization of a person that undergoes the analysis towards the measuring system). Mobile eyetrackers allow for conducting research in a natural environment of the object, for example in shops or objects of public services. Stationary eyetrackers are mainly used when it is sufficient to register the eyeballs movements while watching materials (visual scenes) presented on a computer screen (Stolińska, 2016).

Due to the development of computer technology, moderate price of eyetrackers which are compatible with free, open source Ogama software (http://www.ogama.net), studies using eyetrackers gained popularity and are used in a wide range of studies. Using eyetracking in educational studies is the latest trend among the existing usages, which is dynamically developing. At present eyetracking is seen as a precise reflection of interaction between the cognitive processes and outer visual stimulus. Some researchers claim that eyetracking is a kind of a window to one's mind, thoughts and feeling (Holm, 2007; Glimcher, 2003). While analyzing the eyes movement, it is possible to conclude the student's strategy of thinking while solving the problem. The results of verification of a student's knowledge that are seen on a piece of paper show a given range of knowledge that has been mastered by the student, yet rarely

do we learn about the total time needed to give the answer. Eyetracking enables to track the path of solving the task which allows a precise analysis of a way of reaching given results by the student.

Eyetracking research

In order to find an answer to the question of how students solve problem questions concerning natural sciences, research among students of a 6th grade of primary school was performed, using eyetracker – ET1000 – The Eye Tribe Tracker. The research was conducted in a classroom.

During the research, the students' task was to match in an adapted computer program created by Jan Rajmund Paśko and Andrzej Kamisiński (Paśko & Kamisiński, 2011), data presented as pictures, words or figures that were placed in a library situated above the panel, to proper charts. The data was collected by dragging them with the mouse from the library to the chosen field. The same data could be collected many times. The picture below presents the board of the task which required the students taking the test to match the model of the structure of water corresponding to a given state of matter (Fig. 1).

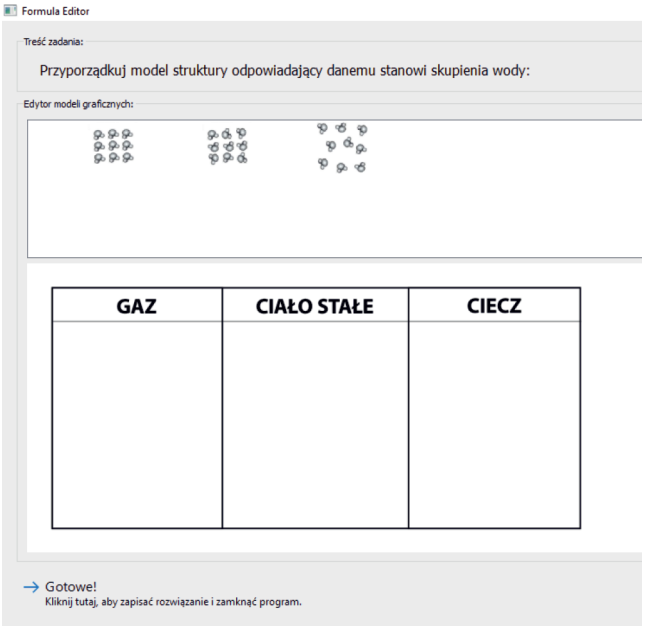

Fig. 1. The board of the task.

From registered in time of performing the eyetracking research we receive several dozen parameters. For example, it is possible to check thoroughly how the student's eyesight moved while doing the task. The easiest way is to review the animation and, at the same time, the movement of eyes which is recorded in a file with 'avi' extension. The blue color of the line illustrates the path of eyesight of the tested person (Fig. 2). The picture below shows that the respondent did not spend

even one second on reading the content of the task doing it completely intuitively. Red color of circles corresponds to the fixations – places of holding the eyesight. The size of the fixation point corresponds to the length of staying focused on a given element. The tested student was mainly focused on the model of the structure of water corresponding to the gas state of matter. The research of Renshaw and others (2004) indicates that the extension of the fixation time is an evidence of problems with assimilation of the information.

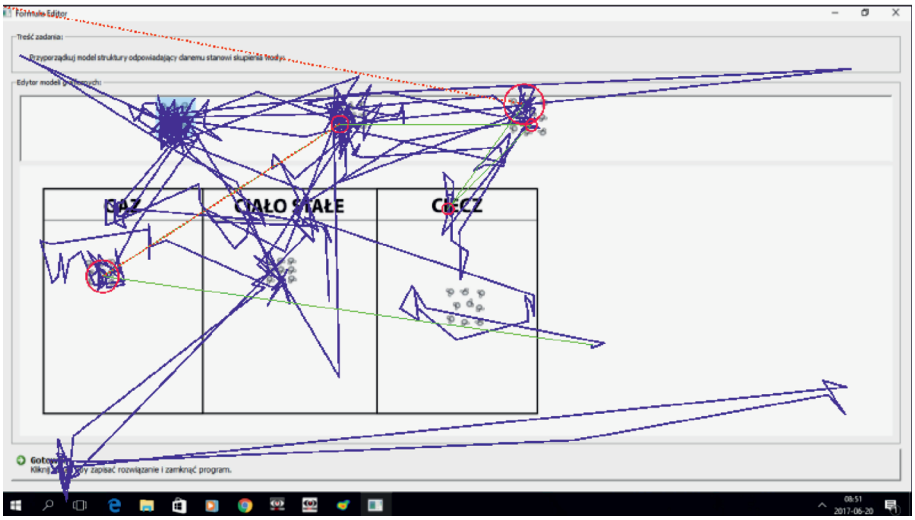

Fig. 2. The record of the results of study of the path of eyesight of the tested person.

There also exists a possibility of a number analysis of the fields. In order to do so the field of interest needs to be matched (Fig. 3) and then the exact comment of counting needs to be given.

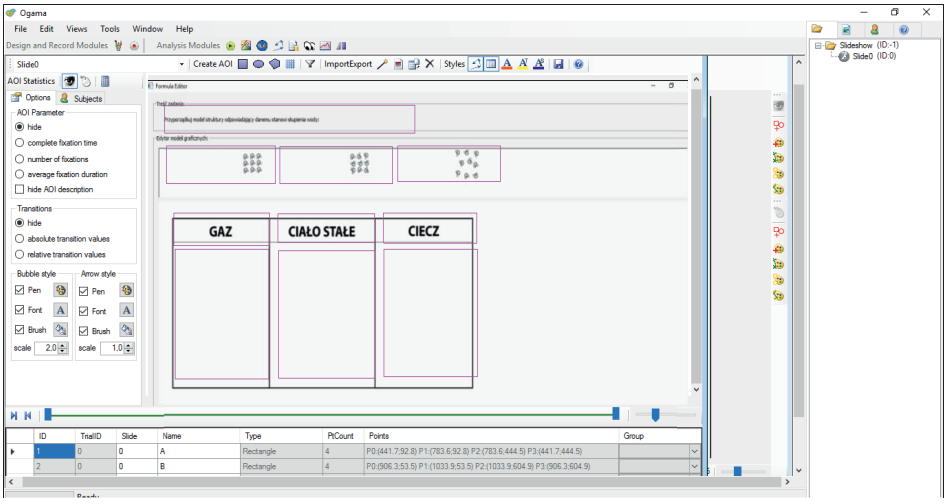

Fig. 3. A board of Ogama software.

For example, the order (Fig. 4) and the duration of specific fixations are of great help in defining the thought processes. The analyzed case shows that the student focused their eyesight on the wrongly matched model for the longest time, which is as much as 1017 ms (774 ms + 243 ms) (Fig. 5).

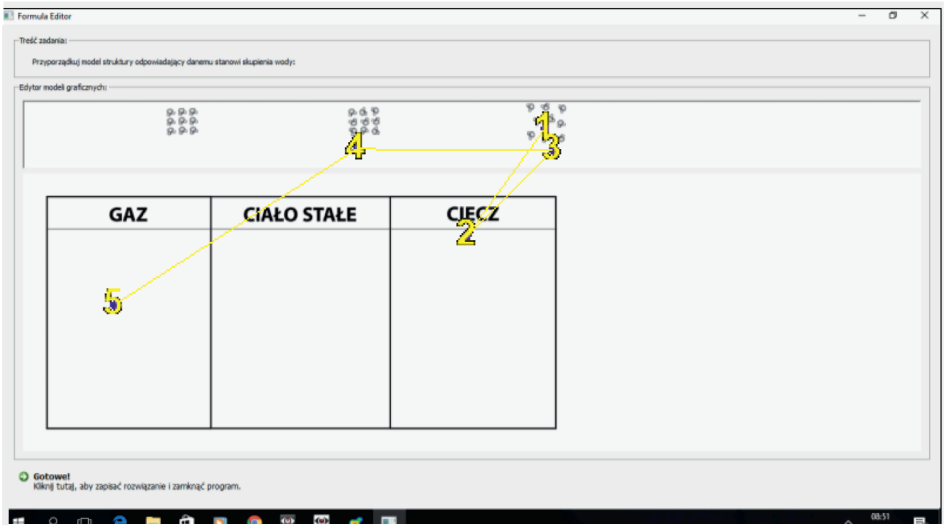

Fig. 4. The record of order of given fixations.

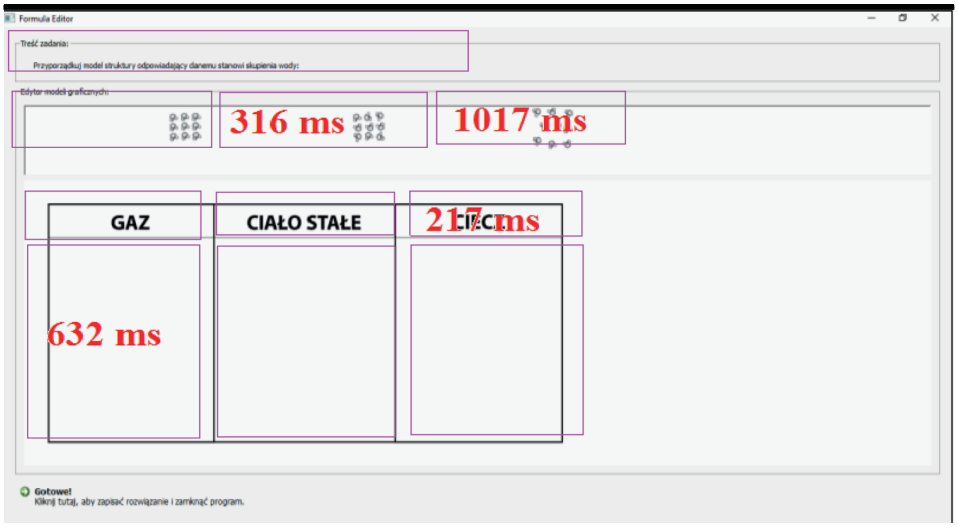

Fig. 5. The record of time of given fixations.

One can read the total time of solving given tasks with a mathematical precision. In the considered example the total time of solving the task was 19 s and 450 ms. Basing on the obtained data maps of eyes activities can be generated (so-called heat map) for the students. Blue color matches the shortest and red color matches the longest times of eyes concentration on a specific field of the monitor screen (Fig. 6).

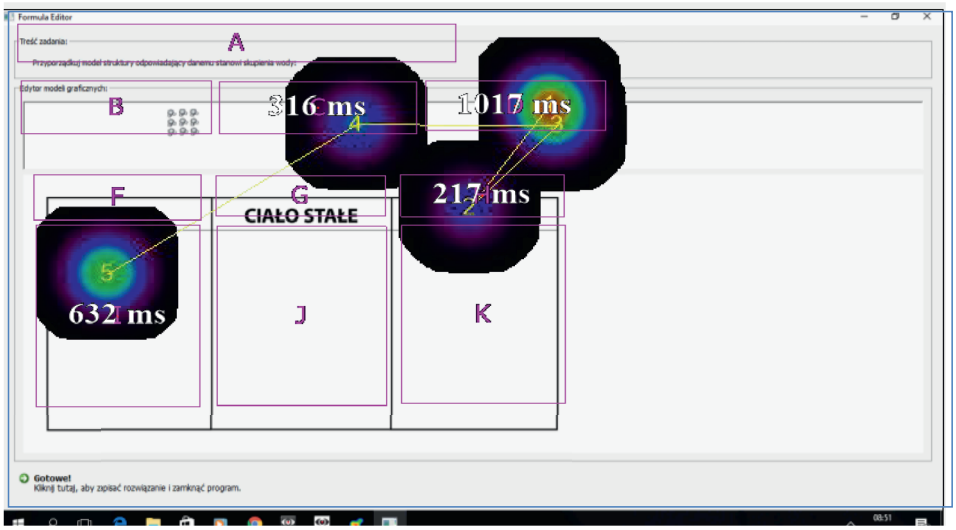

Fig. 6. The record of the research results – heat map.

Conclusion of the study

The above presented data may lead to a conclusion that the tested student has not read the description of the task as he immediately started assigning proper states of concentrations. He also did not return to the description while solving the task. Without a second thought he matched the model of the structure of water corresponding to the solid. He had no doubts concerning the correctness of the answer. It is possible to judge that he had serious "dilemmas" while matching the other two models of the structure of water. He pondered on one for a shorter time and longer on the other. Eventually the answers were wrongly matched. Hasten could be reason of a bad answer, which is backed by a very short period of solving the task (in comparison with other pupils). Furthermore, the student's final grade in science was "very good", as it was learnt during the study. The results of studies done with the eyetracker confirm that it is an ideal tool to use while positioning the way of solving of task, which is particularly interesting in the case of students whose result were unsatisfactory.

All the above mentioned information concerning students thinking while doing a specific task by a specific student cannot be obtained while using a traditional test (a short test or a class test) or even during an oral answer.

Conclusions

One of the mistakes of a present-day system of education is checking how well the knowledge was mastered by a student as the competences tests show. Their analysis gives information on the percentage of students who did a given task correctly. In the case of too few number of correct answers a teacher is obliged to prepare a recovery plan. However, the basis of the plan is not known as the teacher does not know why the students gave wrong answers (which the teacher does not even see). Yet, to prepare a recovery plan the reasons of a student's failure need to be known. According to Paśko and Rosiek (2004) one of the major mistakes of a present-day system of chemistry education is too great a focus on the importance of checking students' achievements. The difficulties which students face while doing a given task are too rarely taken into consideration. That is why the ways of students' thinking should be studied through tracking their eyesight while doing the task. Only eyetracking studies allow us to optimize the process of learning, especially the individualization of the process.

Ending

Eyetracking enables tracking and recording a way of analysis of tasks, diagrams, strategies of choosing answers while doing tasks and searching for typical mistakes made. Methods used so far only gave the possibility to state if the answer is correct and if the student did not exceed the given time limit which was set due to a key that was usually not very clear. This new technique of studying is very easy to perform and the results achieved satisfy even high expectations of the researchers. These measurements allow justifying the reason of a wrong analysis that takes place in a student's brain while doing a problematic task. They also give the possibility to set the time limit needed to solve a given task. Due to these studies it is possible to state how many times a student returns to the same place on a displayed board. Both the dynamic and the static images, as well as tasks in which a student needs to relocate given elements, can be the subject of the analysis.

However, to be able to use the opportunities of eyetracking to the full extent, special software needs to be prepared. One example can be a teaching-checking computer program of writing equations of chemical reactions (Paśko & Jyż, 2007).

Eyetracker is especially useful in didactic research concerning the natural sciences instead of a piece of paper. Therefore it can be stated that eyetracking is the future of didactic research especially in the field of natural sciences.

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Abstract

The topic of control and assessment is one of the most important fields of didactic knowledge. Teachers usually use traditional methods of verifying knowledge, which are oral, written, and practical tests. Despite the fact that using the above-mentioned methods is easy, they are burdened with a high dose of subjectivism, being often "intuitive". Contrary to popular beliefs classical methods also have limited possibilities of making the assessment of school achievement. Due to dynamic development of electronics and IT tools new, non-invasive methods of monitoring psycho-physical parameters appeared, that is eyetracking, which enables to track the path of solving the task which allows a precise analysis of a way of reaching given results by the student. The difficulties which students face while doing a given task are too rarely taken into consideration. That is why the ways of students' thinking should be studied through tracking their eyesight while doing the task. Only eyetracking studies allow us to optimize the process of learning, especially the individualization of the process.

Key words: eyetracking, instructing, verification of knowledge, didactic research

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