ICT AND INFOGRAPHICS OF ORGANIC CHEMISTRY TOPICS ON THE ELEMENTARY SCHOOL LEVEL, AS A METHOD OF INCREASING TEACHING EFFECTIVITY

Hanna Gulińska, Małgorzata Bartoszewicz, Wojciech Weiss
Adam Mickiewicz University in Poznań
Faculty of Chemistry, Department of Chemical Education
Umultowska 89b, 61-614 Poznań
gulinska@amu.edu.pl

Abstract: *the work is an analysis of contemporary problems related to chemistry teaching in a primary school. Problems, which result from the collision of dynamically developing digital and multimedia culture with the teaching trends that still prevail at schools. The dissertation presents three pillars on which modern education in the field of natural science can be based: scientific theory, experimental practice and graphic illustration of chemistry – a school subject, widely regarded as difficult and uninteresting. In order to support the efficient and effective implementation of the lesson topics the problem-based learning method using the traditional school textbook and the problem-based learning method supported by infographics and ICT was proposed. Both methods were aimed at students who have learning problems and also those who are gifted. The effectiveness of selected methods has been checked during chemistry lessons, and the conducted surveys have allowed to assess the level of understanding of knowledge and acquired skills.*

Keywords: teaching, problem-based method, infographics, ICT, work in the cloud

INTRODUCTION

The ICT (Information and Communication Technology) era presents contemporary teachers with different and new requirements profiled for continuous shaping and development of specific areas of information competence, outlining the directions of professional changes, including in the sphere of applying new technological trends to educational practice (Baron-Polańczyk, 2015). Teaching chemistry and other subjects in the field of science is a real challenge for modern teachers. These areas undergo a constant development. Modern researchers are constantly

improving the laws learned many years ago, which translates into frequent updates of the content taught at school. To pass this knowledge to the young people, who come into contact with purely chemical issues for the first time, is often difficult and meets with resistance resulting from the abstractness and intangibility of the discussed content. There is a stereotypical belief among students and even our society that chemistry is a difficult and incomprehensible science, and chemistry teachers are often associated with the worst memories from a school bench. This work aims to show the attractive aspects of chemistry – the school subject which is disliked by students, and to propose a key for understanding modern chemistry by a modern student.

1. PROBLEM-BASED TEACHING/ LEARNING

When talking about effective methods used in education, some theories developed by broadly understood pedagogy should be mentioned (Okoń, 2003). Analyzing the course of chemical education through this prism, we come to the conclusion that this subject is not much different from others. Why, then, learning science is so often disliked by students?

Chemistry is a science about the nature of matter, so it is a field describing everything that surrounds us. Apart from laws such as the law of definite proportion or Avogadro's law, it primarily helps the students to understand the regularity of the surrounding world. At the beginning of chemical education, students do not fully comprehend the surrounding environment, but are able to describe it thanks to their own observations, early school education, or responses to the surprising and often exhausting questions that parents are asked when kids are about 3-5 years old.

The 21st century offers new information channels such as the Internet. It can be described by concepts such as: mass-accessibility, multiplicity, quantity, speed, quality "(...) disturbing concepts introducing confusion to a world in which those mentioned above needs have so far been achieved in a much slower, calmer and less global manner. The technical possibilities and their easy availability give the impression that everything is extremely easy and simple. There is a belief that creating an information website or your own website on the Internet does not require a great knowledge. It is enough to know the basics of html or learn how to use platforms that support web development (joomla, wiki). Sometimes, to express your own thoughts, promote your work, one does not need to know anything, it is enough to sign up for discussion forums, create a blog, enter the Science Wiki, send a movie productions to YouTube, paste a presentation to SlideShare and become a full citizen of the world of information.

The Internet is full of service websites and new ones are being constantly created. All of them responding to already articulated needs, or even being ahead of them. As a result of this mass production, searching the Internet is getting more and more

difficult. The specialists in electronic information advise us: before you sit down to look for something on the Internet, train your eyes and fingers to use many techniques that will help you and train your intellect to have a critical approach to what you come across, because you will have to ask a lot of questions before you find trustworthy information and use it. Search wisely! (Barker, 2007). "Due to the nature of the Internet, publishing is becoming simpler and no one controls this process" (Bednarek-Michalska, 2007: 10). Therefore, unverified information should be approached with a great deal of caution.

Nevertheless, every child and every young person has the potential to become a scientist and on their own and formulate laws governing nature with just a little support. Such thinking has become the basis for the concept of problem-based learning at school (Okoń, 1975). Problem-based learning somehow reverses the order of the traditional system of passing the knowledge. The method is based on own attempts to come to a given solution, then checking whether things are the way you think they are, so in the first place – stating the thesis, and then approaching the essence of the problem, i.e. chemical law.

Let's ask ourselves once again – *Why is chemistry not liked by students*? And let us answer the question *because often the teaching method that favours students' memory does not work in this case.* A modern student who knows very well how to format a computer and set up a Smartphone, does not like to hear the phrase *because that is the way it is and that's all*. The theoretical teaching of the subject arouses aversion, destroys the natural need for searching and the youthful curiosity of the world. In contrast, problem-based learning focuses on creative and independent thinking and acting independently. It provides not only expert knowledge, but also shows the path to reach this content, helps to penetrate into the laws of nature and creatively interfere in the natural and social world. It often happens that the young people entering their adult lives feel embarrassed because of the abstract nature of the knowledge they acquired at school and lack of skills to apply it in everyday life. Modern education system, and chemistry teaching, should therefore put the students in a centre, so that even if they have no interest in the subject, which due to social diversity is completely normal, they know at least the method of reaching conclusions based on careful analysis and their own critical observation. The problem-based learning method is also open to those students who are particularly interested in the subject, supports them through creative action, and maximizes their potential.

It would seem that when applying the problem-based teaching method the teacher is not really needed, because the student's work consists in generating ideas, independent search for information, observation, self-reflection and, as a result, reaching conclusions. There could be nothing more wrong. In every educational method, the teacher is a team leader. The teacher is present when the work begins, when the thesis is formulated, he or she supervises students' work, stimulates the discovery of new sources of information, provokes further analytical questions, and above all, makes sure that at the end of the work, the student formulates the correct

conclusions, because despite the scientific nature of the work, at the end of the day, during school lessons the student must get to know the truth. Whatever method he or she intends to use to discover the law of mass conservation, it must at the end be properly and truly presented.

2. CHEMICAL EXPERIMENT VS THEORY

Two basic interrelated cognitive pillars are essential in the implementation of the problem-based teaching, or any method of supporting the transfer of knowledge in the field of natural sciences: these are theory and experiment. During the traditional learning process, the experiment is like an empirical support for strict rules, theories and laws characteristic of the branch of science; using problem-based teaching, we very often stress the experimental area because of the need to build a creative and practical approach to the task and to discover new contents. Neither theory nor experiment can act alone because "theoretical assumptions are used to discover a certain part of the world as interesting cognitively. They also set out measurement procedures and interpretation methods. However, the theoretical assumptions remain in close conjunction with experimental assumptions defining the practical and empirical meaning and applicability of some apparatus, and the principles of their combination and transformation (Sobczyńska, 1993). Teaching through an experiment is not only a way to illustrate difficult scientific issues in an attractive way, for a chemist teacher, it is a real remedy. In fact, the chemistry teacher is very lucky, because even with the most clumsy group of students, he or she is at least able to interest them. The experiment is primarily a substitute for scientific work, which is why it is strongly encouraged that the experimental methods are implemented as tasks that are not just a teacher's show, but which each student can do on their own. It is a kind of confrontation with the technique of performing experiments.

In February 2018, students of the Faculty of Chemistry at Adam Mickiewicz University, were observing a chemistry lesson taking place in the so-called "district class" in one of the Poznań peripheral primary schools. In the teaching environment there is such a term for a group of students from nearby families, often struggling with various educational problems, which unfortunately affect the quality of both learning and teaching. The topic of the lesson was - *solubility*. The students made experiments at their own benches for one hour. They prepared solutions, mixed, poured, even broke some test tubes, still amongst all this, one could sense a kind of commitment and concentration among these young people.

Has this lesson run out of theory? Of course not. The seventh-graders did not make any notes, they often did not even have notebooks, due to family material problems. The notes were taken on a work sheet, which contained clarification of theoretical issues – strictly in line with the core curriculum – as well as tasks for independent work. Despite the fact that the lesson was very unusual, it seemed to

be kind of filled to the last minute and "tailor-made". Of course, thanks to the merits of a sensitive teacher who realised the potential of the experimental method very well. Even if none of these pupils will ever have a chemical career or any "career" at all, during this lesson the accent fell on practical learning ... in fact learning about life. The fact that the child broke the test tube, that it had to deal with the stress associated with the responsibility for school equipment, the precision learnt during trivial activities, which consisted only in pouring, mixing, stirring, confirms multi-effectiveness of the problem-based teaching method.

3. VISUALISATION FOR TEACHING CONTENT

The implementation of problem-based teaching in the didactics of chemistry, the use of experimental methods supported by scientific theory are undoubtedly a diversification of the didactic process. Let's consider if there is another factor that would be an additional asset of the above system. As mentioned at the beginning of the dissertation, chemistry is a difficult, abstract science that generates stress in young people. An incomprehensible theory, can be explained or visualized by an experiment, and especially experienced personally by a student, but teachers are not always able to apply this method. Sometimes the problem is a lack of reagents or a properly equipped chemical laboratory, sometimes the content of the teaching excludes the use of the experiment, e.g. in the school environment we cannot show the experimental method of radioactive decay, fractional distillation of crude oil, etc. It may turn out that in such a situation another medium is needed, information technology comes in handy, in our case in the form of a presentation with infographics.

Illustrations in school textbooks have been used since the beginning of their history. What could not be easily explained by verbal language was translated by images, the more so because according to the assumptions of the "bible pauperum", it was easier to reach the illiterate using pictures. A significant part of people are visuals, so learning about the world through image, colour, shape or scheme is most effective for them. The 21st century sets new requirements for school textbook designers and teachers themselves. The power to focus attention through a graphic sign has been mastered by marketing and advertising. We see colourful, attractive images on posters, billboards, shops and restaurants.

Visual experiences are very important in education. One of the facts confirming this educational trend is the phenomenon of Web 2.0 and the creation of social networks on the Internet, based largely on visual interactions of users. If this is the case, the phenomenon at the centre of interest in, among others, pedagogy may undergo a partial change. As a result, learners and teachers must acquire new skills and new competences. "Education must be able to adapt to these changes and new ways to study the interests. This is connected with the development of broadly defined media competences (Strykowski, 2004) or, in a narrow segment, of visual competences (Rogowski, 2010)" for (Leszkowicz, 2011).

Another element that changed the principles of psychophysiology of vision and at the same time influenced the quality of teaching in a modern school is infographics. At the beginning there were newspapers and magazines with not so many illustrations. The entire 20th century is actually the development of television and film, which revolutionized the media and advertising market, and at the same time became a didactic tool. In the 90's and in the early years of the new millennium TV, VHS cassettes replaced traditional TV sets, projectors and transparencies, slides, although the teaching materials were prepared much earlier. It was a time when a teacher could use films showing the experiments that were difficult to carry out in the school studio, which was very attractive and gave good results. Nowadays, every child has the resources necessary to enrich the learning process at his/her hands (Gulińska, Bartoszewicz, 2016). For example, youtube.com contains hundreds of films, good both from the perspective of content and visual quality, such as films on the "Projects – IT + WLF" channel, as well as many amateur films and animations showing chemical experiments. The question is how to find a place for interesting, encouraging, transparent and substantive images in this dense tissue of audiovisual contents that are widely available? One of the solutions may become the inclusion of good and appropriate infographics.

The infographics has become an inseparable element of attractive transfer of information. Picture culture is extremely popular, because graphics can express more than words, and the human brain reacts much faster - thus it is easier to absorb the content with the image. It is nothing more than blending in the crowd of marketing and advertising specialists with the didactic processes. It sounds a bit disturbing, but we live in media times, and what is more, children live in these times and if modern education does not catch up with the cultural and social changes, it will not be able to reach the young people and thus to teach effectively. Through professional action and cooperation between didactics specialists and graphic designers, an effective didactic medium can be created, which in the science of chemistry can form a bridge between the theory and the experiment or be a substitute for an experiment.

The principle of creating infographics is much more complicated than the principle of creating illustrations, because in this case we strive to visualize the content, to compress the text and compose graphics, illustrations and words to present coherent information, which simultaneously reduces the time needed to acquire it, and also increases the efficiency of the teaching process. In connection with the abundance of publicly available content, teaching materials should be of the best quality so that they attract the "smart" pupils, and at the same time can be understood also by the so-called "weaker" students. Infographics are not made to measure, they are universal and have to hit everyone, but they should most of all support the work of students who have learning difficulties. A talented young person will be able to efficiently implement the problem method and obtain information even from widely available sources or simply enjoy watching them in a free time. A student who has hard time learning must be properly guided on the

theory - experiment path and this process should be supported by the infographic presentation of teaching content (Levine, 2006).

In connection with the development of media and the creation of e-books, the use of infographics is an excellent way to reach the student through modern multimedia devices, such as a tablet, a laptop or a Smartphone. The dynamic development of new media puts new demands on the infographics designers, namely: interactivity. Tasks that check pupils' knowledge as well as practical skills can be arranged in a well-thought-out, graphical layout. Interactive digital tasks can actually be simulations of chemical experiments, which is the next step to properly preparing students for independent experimentation and evoking their research sensitivity. An interactive computer and educational games can be a solution. Perhaps the next step in the development of new media will be AR or AI technology, and future generations will learn chemistry using 3D simulations and VR goggles. Modern technology already uses these elements. Today's teenagers spend their free time playing hyper-realistic computer games, designed on modern programming engines such as Unreal or Unity, so the requirements are huge, and the answer should be professional cooperation of educators and designers.

4. INFOGRAPHICS AND INTERACTIVE TASKS PROJECT

Based on the above assumptions, a series of infographics in the field of organic chemistry and interactive task projects were designed to be used on digital media such as a computer, a tablet and a Smartphone and placed in the Google cloud. The aim of these activities was first of all graphical visualization of organic chemistry issues at the level of the 8^{th} grade of primary school, and also the desire to test the effectiveness of teaching using modern teaching resources in the form of infographics and interactive tasks.

Two of the prepared chemistry lesson scenarios, are presented below.

- In the first one, a teaching method was to pass the information to the pupils, illustrations and photos included in the modern textbook and the traditional tasks were used as teaching aids.
- In the second one, a teaching method consisted in the use of coherently composed infographics and related interactive tasks.

The element that checked students' knowledge was the same for both scenarios, and it consisted in designing a different character of the chemical experience. The correctness of the performed task proved the efficiency of teaching with the given method. The scenarios were implemented during a chemistry lesson in grade 7^{th}, in which the students had not yet dealt with issues related to organic chemistry, which gave a clear view of the extent to which young people understood the new material.

5. LESSON SCENARIO – OPTION 1

(a lesson supported by working with a printed textbook (Gulińska, Smolińska, 2017).

Topic: Cellulose - compound sugar

The reference part

T: Today we are going to talk about compound sugars. Sugars are a group of compounds that belong to the Organic Chemistry department. All organic substances that made up tissues of animals, plants and other, are primarily built of carbon and so are sugars.

T: What kind of sugars are you familiar with? What did you hear about sugars? (white sugar, cane sugar, brown sugar, glucose, fructose, calories, sweets)

T: What kind of sugar is associated with cellular respiration or photosynthesis? (glucose)
T: Glucose is one of the basic types of saccharides. The structural formula of glucose looks as follows:

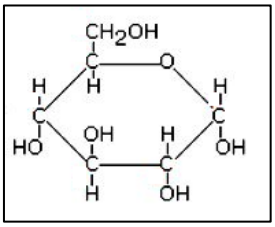


Figure 1. Drawing on the blackboard

Source: Own work

T: As you can see, glucose has a rather complicated structural formula, which we are not going to discuss in detail today.

T: We have established that glucose is a simple sugar, and today we are going to talk about cellulose, which is a what kind of sugar (*compound*).

The core content

Notes for the notebooks: Cellulose, also known as fiber, is a polysaccharide of 3,000 to even 14,000 glucose monomers (single glucose molecules) linked together by glycosidic bonds.

T: I am going to draw a piece of cellulose on the board, which shows how individual glucose molecules connect by means of glycosidic bonds:

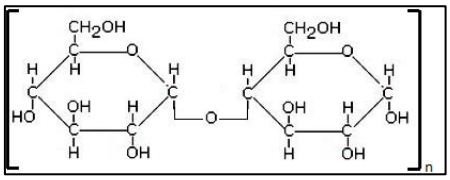


Figure 2. Drawing on the blackboard

Source: Own work

T: Who will come to show where the glycosidic bond is located?

Further note to the notebook: Cellulose is the basic substance that builds plant cell walls. Large amounts of cellulose are found in wood, stems and, moreover, in fruits and leaves.

T: What do you think: What do we use cellulose for? In what elements of everyday life can we find it? (paper, textiles, cotton wool, gunpowder, dressings).

Further note: Man and carnivorous animals do not digest cellulose, but it is an indispensable element of human diet, because it regulates the functioning of the intestines, preventing many diseases.

The presence of a glycosidic bond indicates that the sugar is compound. There is a reaction that proves that cellulose is a sugar, called the *Trommer Trial*, but for the reaction to take place in a proper manner, the cellulose should first be broken down into individual glucose molecules. Note the colour change of the substance in the test tubes before and after the reaction. After viewing the illustrations in the manual, we will make this experience together.

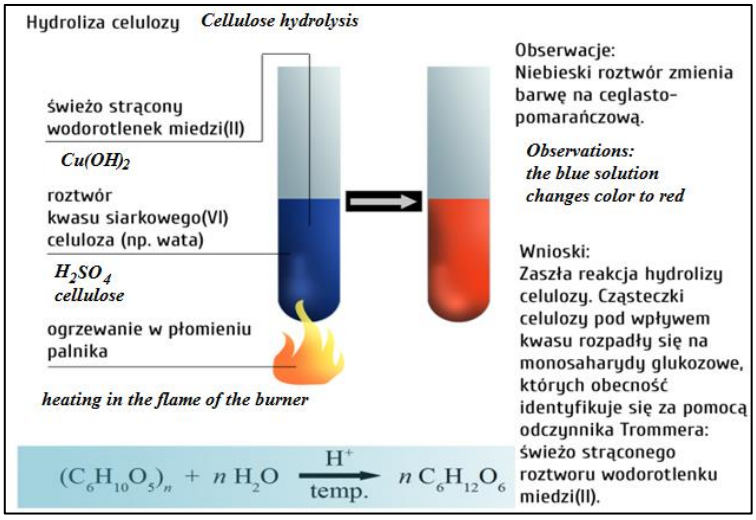


Figure 3. Drawing from the textbook – cellulose hydrolysis
Source: Own work

The summary

As a summary, each student repeats and independently performs tasks related to the lesson.

6. LESSON SCENARIO – OPTION 2

(a lesson supported by a presentation using an infographics and an interactive test).

Topic: Cellulose - compound sugar

The reference part

Today we are going to talk about compound sugars. Sugars are a group of compounds that belong to the Organic Chemistry department. All organic substances that made up tissues of animals, plants and other, are primarily built of carbon and so are sugars.

T: What kind of sugars are you familiar with? What did you hear about sugars? (white sugar, cane sugar, brown sugar, glucose, fructose, calories, sweets)

T: What kind of sugar is associated with cellular respiration or photosynthesis? (glucose)

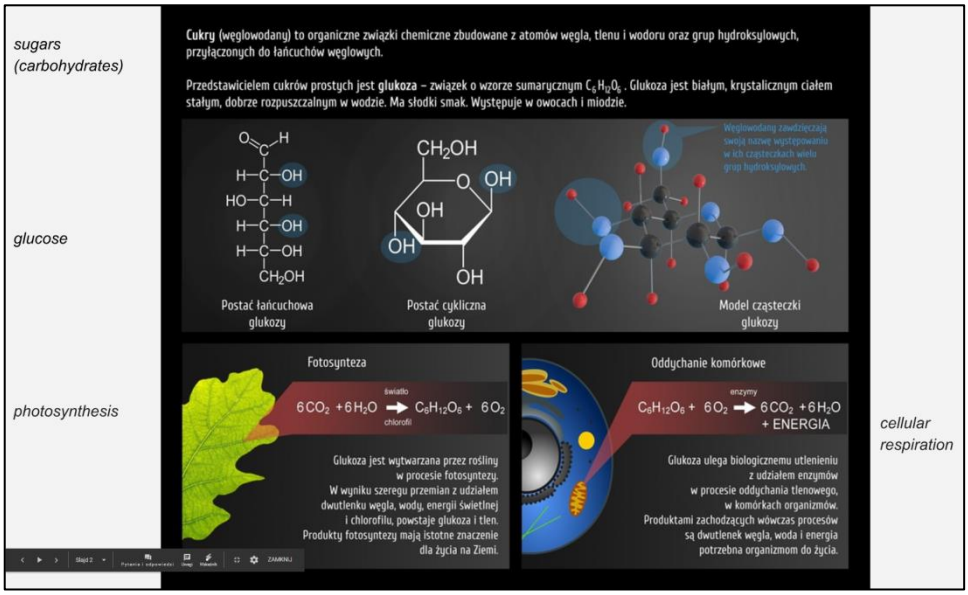


Figure 4. Fragment of presentation with infographics

Source: Own work

T: Try to graphically illustrate the process. Use your imagination and coloured pencils.

T: Glucose is one of the basic saccharides. Take a look at its structural formula (*it's complicated, it's hard to remember*)

T: Now, look again at the drawing and build a model of glucose molecule. Use sticks and modelling clay.

T: We have established that glucose is a simple sugar, and today we will talk about cellulose, which is a complex sugar. (*what does it mean?)*

T: It means that it is made of two molecules of glucose connected together. I will also give you a hint and tell you that oxygen takes part in this combination. Will you manage to propose such a construction yourself? Draw it please.

T: What raw materials are cellulose obtained from and what is it used for? (it is *obtained from wood, plant stalks, used for paper, fabric, cotton wool, materials for dressings, gunpowder*).

T: You remember what Trommer glucose test result was like for sucrose and starch. Please, design an experience that will allow us to determine if cellulose passes this test, and if so, under which conditions (*which reagents should we use*?)

T: If you do not know, analyze the records on the infographic.

The core content

In this part, students discuss the information on the cellulose infographics – occurrence, application, construction, and the Trommer test.

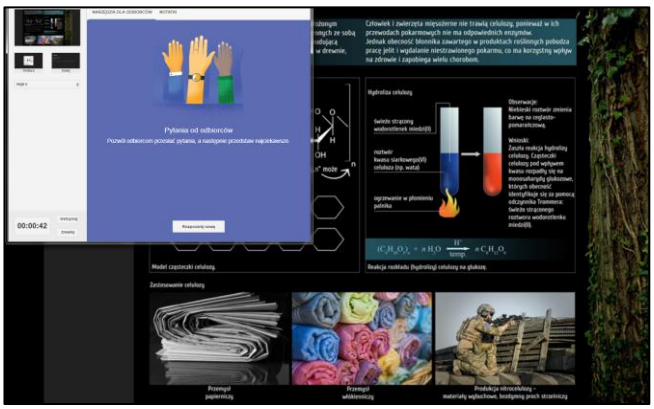


Figure 5. Fragment of presentation with infographics

Source: Own work

T: New words: glycosidic bond and monosaccharide. What is a monosaccharide?

T: Glycoside bond, is a bond connecting two molecules of glucose, who will point them?

The summary

As a summary, each student independently reviews the presentation and infographics posted by the teacher in the cloud, and then performs tasks related to the lesson on their smartphones.

7. CHECKING TASKS FOR BOTH CLASSES

At the end of the lesson, the students from both groups were solving tasks. They contained 16 elements requiring student action. Students participating in the first version of the lesson once again viewed the illustrations in the textbook and their notes and then proceeded to solve the tasks on specially prepared work sheets. Students participating in the second version of the lesson had a teacher's cloud folder with presentation and infographics made available by the teacher, and then they solved an interactive test.

Task 1. True / False. Evaluate the correctness of the sentences below by selecting TRUE or FALSE.

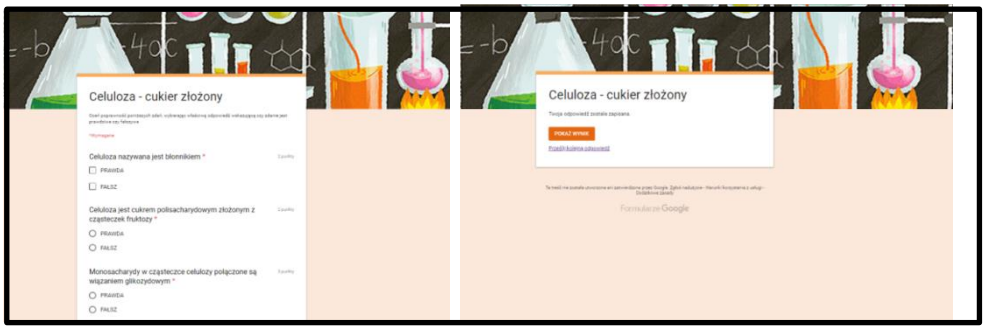


Figure 6. Interactive task

Source: Own work

Evaluate the correctness of the sentences below, highlighting the correct answer indicating if the sentence is true or false.

Celuloza nazywana jest także błonnikiem.	P	F
Celuloza jest cukrem polisacharydowym złożonym z cząsteczek fruktozy.	P	F
Monosacharydy w cząsteczce celulozy połączone są wiązaniem glikozydowym.	P	F

Figure 7. Tasks that were solved in the work sheet

Source: Own work

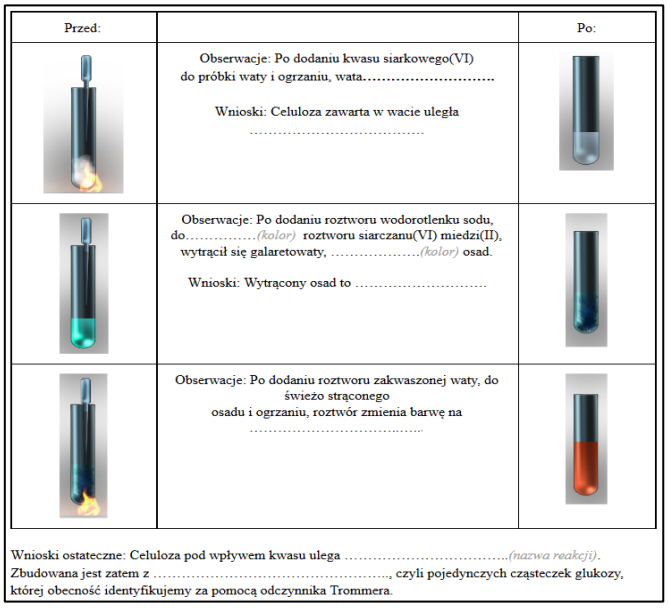
Task 2. Enter a short text: On the screen you will find individual stages of the experiment characteristic for sugars. In observations and conclusions, put the appropriate words in the gaps. Use the hints in brackets.

Figure 8. Interactive task

Source: Own work

While designing this task, the test option was used in a Google form, short answer options were selected and a few options for the correct answer were allowed. An analogous task placed in the work card is shown in Figure 9.

Insert the correct text: You have different stages of the experiment typical for sugars in front of you. In observations and conclusions, put the appropriate words in the gaps. Use the hints in brackets.



Przed:		Po:
	Obserwacje: Po dodaniu kwasu siarkowego(VI) do próbki waty i ogrzaniu, wata…… Wnioski: Celuloza zawarta w wacie uległa ……	
	Obserwacje: Po dodaniu roztworu wodorotlenku sodu, do……*(kolor)* roztworu siarczanu(VI) miedzi(II), wytrącił się galaretowaty, ……*(kolor)* osad. Wnioski: Wytrącony osad to ……	
	Obserwacje: Po dodaniu roztworu zakwaszonej waty, do świeżo strąconego osadu i ogrzaniu, roztwór zmienia barwę na ……	

Wnioski ostateczne: Celuloza pod wpływem kwasu ulega ……*(nazwa reakcji)*.
Zbudowana jest zatem z ……, czyli pojedynczych cząsteczek glukozy, której obecność identyfikujemy za pomocą odczynnika Trommera.

Figure 9. Tasks that were solved in the work sheet

Source: Own work

8. RESULTS OF DIDACTIC EXPERIMENTS

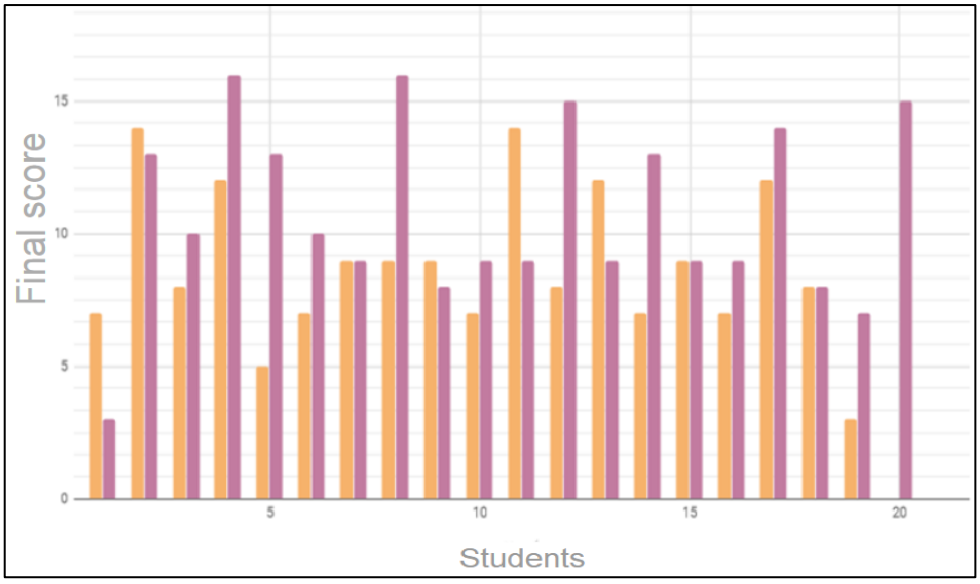


Figure 10. Comparison of the test results in the class taught according to the traditional scheme and class, in which the lesson was supported by the presentation with prepared infographics and interactive tasks.

Source: Own work

Both lessons were carried out in the 7th grade of primary school. One of the classes was 19 pupils, and the second one was 21 pupils. The material was prepared within 45 minutes, based on two lesson plans – 1) traditional with the use of teaching aids, such as a school board and textbook, and 2) with elements of a problem-based lesson with a multimedia presentation using infographics displayed during the lesson with a projector, and then during the summary made available to students in the cloud and interactive tests to be solved on Smartphones.

During the lesson there were no problems connected with pupils behaviour. The results of previous chemical education among students of both classes were comparable (insight into interim evaluations and proposals for assessments at the end of the year). In each class there was at least one student demonstrating the characteristics of an outstanding student and at least one student with both educational problems and difficulties in acquiring knowledge. The results of two tests are shown in column charts (Figure 10, Figure 11). Based on the statistical analysis of the results of the test, it can be concluded that the application of the problem-based method with the use of didactic means in the form of infographics contributed to the increased teaching efficiency in the tested group. The results of the true/false type task are proportionately higher.

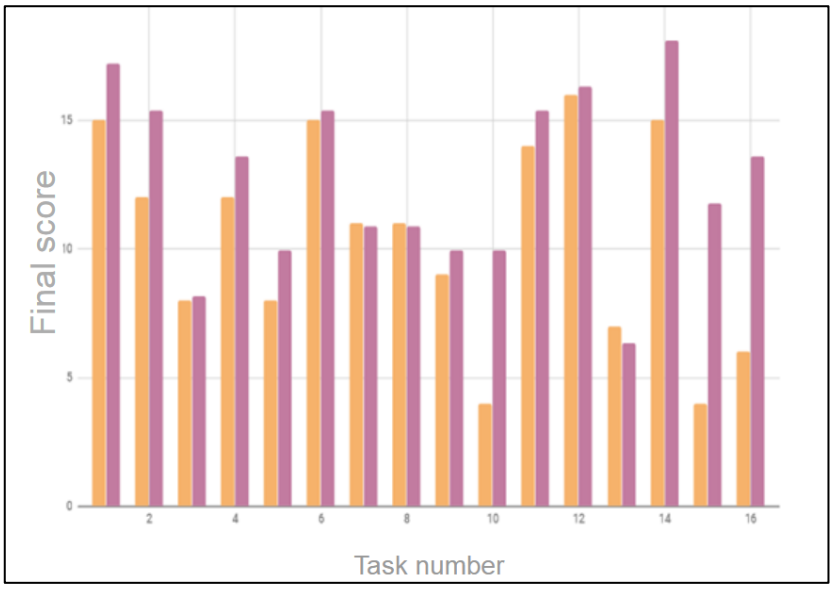


Figure 11. Comparison of the results from all tasks in the class taught according to the traditional scheme ■ and class, in which the lesson was supported by the presentation with prepared infographics and interactive tasks ■.

Source: Own work

No improvement was found in the efficiency of solving the true / false type task, which belonged to the tricky commands (instructions 4 and 5). However, a significant increase was noted in efficiency of solving the task of designing a chemical experiment. Particular improvement of the results can be seen in the final part of the task, where students had to formulate observations and conclusions. The results of the task in which pupils should give the name of the chemical compound are similar. This may be due to the current backlog or efficiency of teaching by the current teacher.

The conducted research allowed to confirm the hypothesis that the designed, visual didactic aids optimize the teaching/learning process because both groups have had visual help and increase its effectiveness, improving the results obtained by students and positively influencing the development of the learner. The results of the described research regarding the use of visual techniques confirm the research of other authors that the presence of visuals in teaching gives better results in the form of shortening the time of learning, streamlining the understanding of the material taught and reducing education costs resulting from the acceleration of the teaching process (Jagodzińska, 1991, Kozielska 2015).

CONCLUSION

The contemporary man communicates with the world around him with pictures and words. As much as 95% of knowledge is obtained on the basis of the reception of information by means of sight and hearing. However, it should be remembered that the role of eyesight is 7 times greater than hearing, which has a significant impact on the popularization of visual culture. "Visual means play an important role in shaping the consciousness and behaviour of a modern student. Contemporary periodical publications addressed to the mass audience are increasingly composed of illustrations for which the text is merely an addition. Thanks to visualization, we reach real, internal and subjective emotions, sensations and images." The dynamic development of information technology has a significant impact on changes in modern education. Teaching aids currently prepared for students are mostly audiovisual materials. They require a greater amount of work from the creator, and the creation process itself is more time-consuming than in the case of traditional educational materials. The materials used by teachers should illustrate and make learning more attractive. "The explosion of digital technology we are currently experiencing changes not only the way we live and communicate with each other but also our brains, which are undergoing a rapid and profound change" (Small&Vogan, 2011: p.14). Hypertexts can lead to disruptions in understanding the content (Zhu, 1999). The division of attention enforced by multimedia reduces the cognitive abilities of learners and, consequently, also the efficiency and level of understanding. "Didacticians pointed out that the transmission of information in many forms helps in understanding – illustrations in textbooks explain and reinforce the text message. They proved that presentations with visual explanations can increase the effectiveness of learning"? (Kozielska 2015: p.176).

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