IT AS A MANNER OF DEVELOPING SCIENTIFIC THINKING

Hanna Gulińska
Faculty of Chemistry, Adam Mickiewicz University
Umultowska89b, 61-614 Poznań, Poland
gulinska@amu.edu.pl

Abstract: *In this paper, the course of research into different manners of preparing for chemistry classes and their effects of on the students' interest in this subject is described. The students' activity and self-study was considered the key aspect of the innovation referred to as "flip teaching". The study was conducted in the first years of secondary schools. Students participating in the study conducted small-scale experiments as recommended by their teachers, and then uploaded the results and their reflections on a dedicated platform in the form of descriptions, diagrams, videos of experiments and solutions to problem tasks suggested by the teacher.*

Keywords: flip teaching, flipped classroom, multimedia, platform, chemistry

INTRODUCTION

The essence of the flip teaching is changing the role of a teacher who not only teaches but also supports learning, not only presents the subject, but also explains it and changing the students' role from passive recipients to active constructors of their own knowledge. Lesson is also altered, it becomes the unit during which students are familiarised with a new content. It is aimed to strengthen their knowledge and solve problems. Environment is also changing – from lesson in a classroom to the Internet.

The fundamental idea in flip teaching is to introduce constructivist learning cycle: the search for references in existing knowledge (often colloquial, but also semantic) and external sources, through processing, to systematize, and finally (with the help of a teacher) to build students' categorical system (Cargill, Sanchez 2013).

Developed within the project Śniadeckich College, flipped classroom strategy (Dylak 2012), refers to the theory of constructivism and uses the achievements of science education, psychology, social science, as well as the potential of new information technology. It is an attempt to create an integrated strategy for teaching

and learning. Strategy, which will be a natural consequence of modern, teaching methods the student, appropriate for the digital age.

1. THE STAGES OF FLIPPED CLASSROOM STRATEGY

The essence of flip teaching is the active organization of information in the independent process of collecting information, and moreover, searching for references in their current knowledge. In order to understand the material, students using prior knowledge, search information in their memories and experiences that will enable them to understand new material and give it meaning.

The proposed flipped classroom strategy (Dylak, Duda 2011) assumes that the learning cycle consists of three phases: searching for references in students' existing knowledge and external sources, information processing, systematizing and building students' categorical system. Usually students independently collect data, organize it and create information, and then build a personal knowledge on a subject by solving tasks, in order to systematize students' knowledge (Dylak 2012).

Therefore flip teaching is a phased process. For each phase specific actions are assigned, to achieve the planned targets.

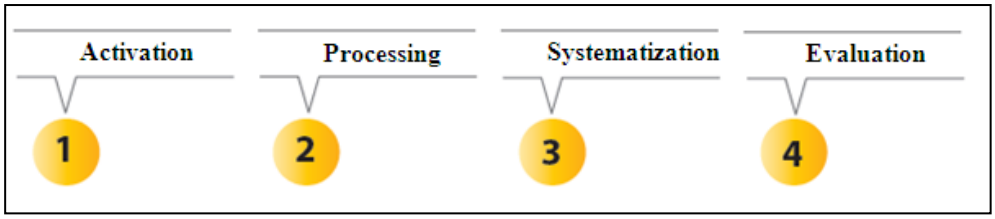

Figure 1. The stages of flipped classroom strategy

Source: author's materials

It should be noted that the vast majority of the time spent on the thematic issue is related to students' and teachers' performance on educational platform in the digital environment. Thus, apart from the obvious, planned effect – permanent personal knowledge building, it develops and improves skills related to the virtual environment.

Flip teaching was introduced to the Polish educational system in the Śniadeckich College project, as an innovative science curriculum. The project was started in 2010, and in the school year 2011/2012 a project's pilot was conducted at the Holy Mary Magdalene High School in Poznań and Juliusz Słowacki High School in Grodzisk Wielkopolski[1]. Conducted research and observations helped the contents

[1] The leader of the Project is the National Foundation for Computer Education (OFEK.pl). The project partner is the Adam Mickiewicz University(amu.edu.pl) with an interdisciplinary team headed by Professor Stanislaw Dylak

of the Science College educational platform on which they are embedded. All the teaching materials: e.g. scenarios, physics, biology, geography and math classes education guide entitled Methodology of flip teaching and 75 films and topics in biology, chemistry, physics, geography and math for the first year of high school classes (Dylak, Gulińska 2013).

After the test phase, a number of meetings were held, attended by head teachers, secondary schools' teachers (high schools and middle schools), representatives of local authorities responsible for education and education, representatives of the boards of education, the teaching staff working in educational institutions, representatives of educational institutions, foundations, individuals interested in education, educational experts and people interested in contemporary education and education in a broad sense. The speakers were those involved in the project.

1.1. Activation (Dylak, Wiśniewska, Leszkowicz 2013)

At this stage, the students, under the guidance of a teacher, choose from a list of interesting topics planned for implementation during the course. It is assumed that during this phase the knowledge possessed by students will be used (news, beliefs, colloquial terms, skills). The advantage of this approach is the use of the student's understanding in accordance with his or her personal knowledge and ideas. Moreover, it activates a personal, not forced from outside, critical reflection. At this stage it is important to identify not the intellectual capacity of students, but their cognitive preferences.

The activation step begins during the first lesson - as to the topics are assigned, and ends at the time specified by the teacher - but no later than a week after the first lesson. The teacher is present at this stage, especially when students summon him or her electronically.

1.2. Processing (Dylak, Wiśniewska, Leszkowicz 2013)

At this stage, students use the teaching materials which are indicated or prepared by the teacher. Constant communication between students and between students and a teacher is assumed. Students can, and even should ask the other students and teacher questions. Processing is carried out using the learning platform and should not exceed four days, during which students devote about 60 minutes to work on their own. At this stage, students work independently and/or in groups, in agreement with each other and with the teacher, they filter and organize the collected material. The leading role in the construction of educational resources, which are closely related to the processed issues, is played by students' cognitive- critical activities and teachers' critical-cognitive activities. Students' information, questions, proposed answers and assumptions should be the content base for resources associated with the issue – constantly supplemented and expanded.

To encourage students to be active inspiration from the teacher is needed. One way of inspiring students is to order them to create and constantly update individual Web sites and / or thematic notes in an e-portfolio. It is suggested that at this stage the

teacher uses such a tool as Web Quest, which helps organizing teacher's actions and students' reactions.

1.3. Systematization (Dylak, Wiśniewska, Leszkowicz 2013)

The third stage, like the first, is carried out in class, in the presence of a teacher. The essential part of systematization stage is preliminary test of knowledge, abilities, issues' understanding and scientific reasoning prepared by the teacher. Creating the test can be also one of the students' tasks to be performed by the students together and under the guidance of a teacher in the digital environment. It is suggested to take the test before the lesson, the teacher could be prepared to comment it and fill the gaps – in the knowledge, understanding, structuring, and interpretation. Thus, the lesson's starting point would be teacher's comments to the test results, as well as answers to students' questions.

At this stage, the students organize information gained during the activities undertaken whilst processing time. At the same time students also build their own cognitive schemes and place them in the system of the concepts they already knew, operations, assertions and beliefs, according to certain educational goals, selected by the teacher's in connection with established taxonomy purposes.

1.4. Evaluation (Dylak, Wiśniewska, Leszkowicz 2013)

During the evaluation stage students engage their knowledge as judges, critics and reviewers, making judgements about their work and achievements – such as what could be added or what sources have been forgotten, how to organize their work better in the future. What changed in students' knowledge during dealing with certain topic – for example, I knew that, now I know this, or now I know it differently ... Students practically use critical assessment skills acquired during a lesson in the classroom.

Assessment is measured based on criteria established in consultation with the students. Final rating issued by the teacher based on a students' participation in lessons and the content developed on their websites – is final. The evaluation is carried out on the educational platform and takes about 15 minutes.

2. FLIPPED CLASSROOM STATEGY DURING THE CHEMISTRY LESSONS

All scheduled in this way classes, including the chemistry course, in addition to typical mathematical, scientific and technical research skills are aimed to shape a number of other key competencies, such as communication in the mother tongue, digital competence, learning how to learn, social skills, initiative and entrepreneurship (Gulińska, Bartoszewicz 2011).

The activation step in the scenario of chemistry lessons conducted using the flip teaching includes student's objectives, detailed student's and teacher's actions and

activities as well as information on the student's work conditions including the timing and the form of communication with the teacher and other students.

The same stage in student's materials includes notes and tasks formulated by the teacher. Their goal is to inspire students to use multiple sources of knowledge, for example: own thoughts and judgements, colloquial opinions, other sources of popular science, textbooks, and encyclopaedias.

Materials for the teacher on the activation level are mostly the description of the activation presentation relating to individual modules' content.

Reviewer: *Units designed for teaching chemistry using flip teaching offer pupils a variety of activity opportunities, also in the digital environment. Students can work individually or in a group, they can communicate with each other and with the teacher. A variety of working environments and consistent teaching materials are conducive to the activity of the students, such as analysing, summarizing, checking and reasoning.*

For the purpose of these activities PowerPoint presentations and educational films corresponding to issues mentioned in the classroom were prepared. Especially educational films were proven valuable to raise students' activity working alone at home.

Figure 2. Frames from the film "You have to eat to live" which inspires students to take action

Source: The film "You have to eat to live, educational platform

Processing step in the scenario of lessons conducted using the flip teaching includes student objectives, detailed student activities and teacher activities, as well as additional guidance for teachers on compliance with health and safety regulations, and tips for performing and documenting the experiment by students in the "PHOTO" section. There are also tips on how to solve the problems associated the students' subsequent tasks. Again, the tasks for the students which the teacher can publish on educational platform were proposed.

Processing stage in the student's materials includes theoretical and experimental tasks' description. The results of these tasks the student shall publish on the platform in the form of so-called portfolio at the place and time specified by the teacher. It is suggested that the results of experimental work is illustrated by the self-taken photos or short films, which is particularly interesting and inspiring (even slightly weaker students) proposal. The student receives information about the possibilities of

developing their knowledge, for example, based on Internet resources (Böhmová, Šulcová 2007).

Figure 3. Sample student's photo placed on the platform

Source: Educational platform

Materials for the teacher on the processing stage refer to the materials in the scenario and materials for students. There are theirs supplementation and development. They contain valuable suggestions for teaching on the interpretation of certain phenomena, and above all include students' tasks solutions with additional methodological guidelines.

Reviewer: *Materials are in line with the current state of chemistry knowledge, and their layout and procedure promote the development of logical thinking and interest in chemistry and its practical applications. Materials are mainly addressed to the teachers involved in their work and will be an important part of education reform, which in the curriculum for the first year of high school establish new hours scheme for all subjects, and in addition quite revolutionary system of content when talking about chemistry.*

Bearing in mind the guidelines written in the new core curriculum as a starting point for the project in the field of chemistry student's experiment was established. It was assumed the work will be based on the activities in a home laboratory in a small scale CSS (Chemistry in the Small Scale). Each student receives a laboratory set which contains the elements needed to perform experiments recommended by the teacher in order to complete the activation phase. These experiments are performed according to its description, documented on a video or by taking photos which are later placed on the platform. Moreover students writes down his or hers observations on the worksheet.

Figure 4. In the small scale set's elements

Source: Educational platform

CSS technique allows to perform many classic experiments from various spheres of chemistry. Using simple equipment in a small size and very small quantities of substances increases the safety of the experiment, reduces the time during which it was carried out and allows to create a more detailed description. The main advantages of this experiment are: increasing the safety of the experiment, intuitiveness and ease of use of equipment, the ability to perform experiments at home, significantly reducing the amount of post-reaction waste, performing experiments impossible to perform in a standard scale, easiness and quickness of experiments' preparation, individual exercises, increasing student's motivation.

Reviewer: *Particularly noteworthy are experiments performed in the small-scale innovative technology and recorded independently by the student at home. They allow modern, activating and experimental approach to the teaching of chemistry. The proposed learning cycle includes over 30 interesting and easy to perform experiments that will contribute to sustainable consolidation of the content.*

To summarize student's research activities a package of interactive tasks was prepared. They are always in line with the presented issue, performed experiment and they show the attractiveness of the teaching process. Tasks appear on the platform only after the student carried out an experiment using CSS technique, what should be an additional incentive for students. The set of the interactive tasks prepared for each unit require student to identify the content of the tubes based on the observation of the experiment. Selecting the one of proposed samples is followed by mixing the contents of test tubes, so that the user has the opportunity to observe the reaction. Subsequent attempts allow students to carry out all the experiments and determine the substrates, which were used for the study.

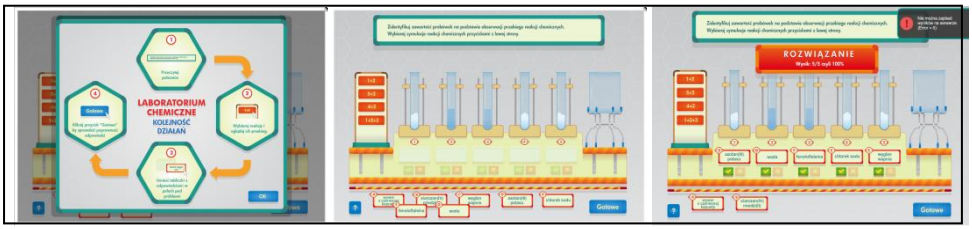

Figure 5. An example of a task in a virtual lab
Source: Educational platform

Reviewer: *These tasks can meet the following learning objectives:*

- *practice skills in the use of information technology;*
- *stimulating students to repeat information in an unconventional way;*
- *preparing to perform an experiment in a laboratory;*
- *preparing to conduct analytical studies;*
- *develop skills of logical reasoning;*

- *improvement of analysing the content of the command;*
- *preparation for media monitoring and evaluation;*
- *self-assessment of skills.*

Relying teaching on chemical experiment and making education similar to the a research process is one of the indisputable advantage of the reviewed materials.

The systematization phase in the scenario of a lessons conducted using flip teaching contains a lesson plan with standard stages such as organization part, repetitive part, relating part, progressive part and summary part. Planned teaching materials, which greatly facilitate the work of the future users are also described.

This stage in the materials for students contains tips on how to complete your notes in an e-portfolio and additional homework relating to the course (including the tasks for volunteers).

Materials for teachers at systematization stage refer to the materials in the scenario, and materials for students. This part of the materials for the teacher will be particularly valuable for him. They contain a detailed lesson plan for the classroom, especially information that searched by students at home, a description of the experiments that can be performed by a teacher, student's experiments, drawings proposal, diagrams, additional arithmetical tasks, crosswords, chemistry graphs, suggestions for homework.

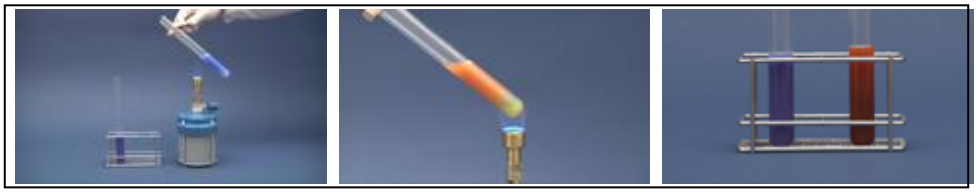

Figure 6. The proposal of the teacher's demonstration in the classroom

Source: Educational platform

Reviewer: *All experiments, both those performed and documented independently by the student at home (using a personal, dedicated, experimental project set), and the experiments carried out in the classroom with a teacher participation, are described both in the scenarios of lessons, as well as in the support materials for students and methodological materials for teachers. Simple and safe experiments shape students' research interests and directly influences on the increase of the students' interest in the subject.*

Evaluation stage closes the cycle of learning in the area of each of the 15 modules. Written lesson materials for students and teachers assume the participation of all students in project's summarizing and evaluation. Students are able to decide about their work and achievements. Teacher also asses, but only in consultation with the students and using the criteria developed jointly with them. The proposed evaluation forms are very diverse, they activate students, interact with their emotions and

trigger their engagement. The innovative forms of evaluation include: (*) after the class - establishing the forum thread - It made me curious ... (*) examining the quality of resources in the tab *Voting for the best materials*. Students' and teachers' actions planned as above will result in objective feedback and that can be used it in the future.

Reviewer: *The authors of each unit presented a description of the procedures for reaching goals. There is a variety of questions, tasks, theoretical experiments performed and recorded independently by students at home, experiments carried out with the participation of teachers in the classroom and interactive task. What should be noted is the fact that it show chemistry as an experimental science, especially in the area known by students from the everyday life. In the created by the authors of chemical experiments, there is whole set of experiments recommended at this stage of education.*

All units and additional materials are deposited on the platform, from where they can be downloaded suitably to ones needs.

CONCLUSION

Flip teaching is based on the prepared materials (scenarios for the student containing descriptions of all planned tasks, tests, scenarios for teachers containing descriptions of the solutions of tasks and tests) providing students with opportunities to complete various tasks, including using resources prepared by the students and the teacher in the digital environment. Students can work individually or in a group, can communicate with each other and with the teacher. A variety of work environment and consistent teaching materials are conducive to the students' activities, such as analysing, summarizing, checking and deduction (Barseghian 2010).

Students' comments:

- *Independent search of different information before the lesson makes it easier to understand the content presented in the classroom.*
- *It was interesting to use chat or forum to share experiences with the classmates and the teacher. You could upload the photos from the experiments and links to other web sites.*
- *Frequently we found information on the Internet, but sometimes it turned out that our responses were mistakes, which is why we chose websites with endings: edu, gov.*
- *Experiments carried out at home were mostly an interesting adventure, but for the moment we felt like scientists. Performing an experience made it easier to remember information. Photo story took a lot of time, but the result gave much satisfaction and positive effect on the final grade.*

- *During the discussion in the classroom about the tasks with whom we had trouble (done in preparation for classes in your home, complementing its portfolio) it was easy to understand where we made mistakes.*
- *Tasks in the virtual lab were great. This type of tasks allow you to test your knowledge in practice.*
- *Test mobilized us to work independently. However, the assumption that you had to be available on the platform the day before class at a certain time sometimes complicated my life.*
- *Using the platform, while solving the tasks sometimes consumed too much time. But thanks to the lessons we do not have to take notes and we were able to engage in a lecture.*
- *At the beginning of self-assessment was a difficult task, but with time it become quite easy.*

A teacher working in pre-school system: *Student while looking for answers independently, or thinking about the problem presented by the teacher develops creative thinking, is engaged in learning, and moreover he or she understands and remembers the content. Often before students answered the question on the platform, they consulted each other, discussed the problem – what improved their relationship and contributed to the integration of the class. By on dependently performing chemical experiments in the small scale, students had the opportunity to discover the nature of the researcher in themselves. These experiments gave students a lot of fun, increased interest in the subject, even though there were those who complained about cleaning up after the "home" laboratory classes it took them a long time. It turned out that this way of building their own knowledge, less gifted students new possibilities to demonstrate their initiative, as well as capacity utilization manual. Implementation of these activities resulted in their greater commitment to the lesson and, in consequence, in better grades.*

REFERENCES

Barseghian, T., 2010: *Students Learn in Class, Think and Discuss at Home,* KQED, November 19, 2010

Böhmová, H., Šulcová, R., 2007: *Chemistry Experiment in Distance Education* Problems of Education in the 21st Century PEC 2007, 2 (2)

Cargill, M., Sanchez, D.M., 2013: *Flipped School,* In: Informatics in Education, Toruń, pp. 23-25 [In Polish]

Dylak, S., Duda, L., 2011: *The implementation strategy of Collegium Sniadeckich,* Poznan

Dylak, S., 2012: *Methods of training in flip teaching strategy, collective work*, a text book co-funded by the European Union under the European Social Fund, Poznan

Dylak, S. Wiśniewska A., Leszkowicz M., 2013: *The strategy of pre-emptive education: the Teacher as the Architect of a Student's knowledge* In: Informatics in Education, Toruń, pp. 26-34 [In Polish]

Dylak, S., Gulińska H., 2013: Advance Learning Strategy: *the Teacher as the Architect of a Student's knowledge*, 10th IFIP World Conference on Computers in Education, Toruń, pp. 142-143

Gulinska, H., Bartoszewicz, M., Makles, G., Mischke, K., 2011: *Scenarios for Chemistry classes in line with flip teaching – Collegium Śniadeckich,* Department of Chemical Education, Poznan

Collegium Śniadeckich: *About the Project, 2012, Available at* www.kolegiumsniadeckich.pl and www.ofek.pl (Accessed on 10 February 2013)