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DIGITAL SUPPORT IN THE IMPLEMENTATION OF CHEMISTRY LABORATORY CLASSES

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Abstract: *The article attempts to analyze contemporary problems related to supporting the chemistry teaching process, in particular the integration of materials prepared on e-learning platforms in chemistry laboratory classes. For this purpose, the article discusses the experiences of the "Laboratory for Chemistry Teaching and Contacts with the Social Environment" – the project "Chemist as a detective" and the student project "Anvil." The primary aim of these projects was to provide students with an improvement in the quality of education as part of the third mission of the university, as well as interest in natural sciences. For this purpose, educational materials were created on the Google Classroom and Wakelet.com educational platforms. Prior to participating in the workshops and familiarizing themselves with the teaching materials, each of the 166 participants completed a brief survey or pre-test. They also took a test after completing the classes. The collected data were used to analyze progress in knowledge and progress in laboratory skills through observations. Individual conversations with students provided insights into their motivation to learn. On this basis, an attempt will be made to develop a modern didactic model combining laboratory classes, student activity with materials made available on the e-learning platform.*

Keywords: individual learning, chemistry, laboratory, educational platform, Google Classroom, Wakelet

INTRODUCTION

In schools teachers and students are increasingly utilizing new teaching resources and methods in chemical education, often relying on Google, one of the world's largest companies in the IT industry. As part of its mission, Google offers uses free educational applications designed to modernize and improve the educational process. Google Classroom, the educational platform developed by Google, using advanced technological resources, presents an important market alternative to commonly known Learning Management System (LMS) solutions used in both school and academic education (Szlach, 2019).

The Faculty of Chemistry at Adam Mickiewicz University is actively engaged in various educational initiatives as part of the university's third mission, with the aim of raising awareness about the significance of natural sciences in the modern world, in the daily lives of individuals, and their impact on the environment (Faculty of Chemistry AMU, 2023).

Academic teachers often conduct classes that incorporate practical teaching resources, aiming to not only acquire knowledge but also to motivate students to learn. This approach, in addition to its educational value, adds an element of enjoyment and should encourage participants to expand their (Bartoszewicz & Krzyśko, 2016; Bartoszewicz & Krzyśko, 2021).

During laboratory classes, students acquire manual skills are acquired through chemical experiments, making it essential to expand their subject knowledge. Previous research indicates that students who engage in self-education and online learning using Google Classroom exhibit higher levels of problem solving and critical thinking skills compared to those in traditional classroom settings without technological support (Khezel et al., 2023).

Therefore, it was hypothesized that the inclusion of materials supporting teaching using the anticipatory teaching method would increase the level of students' knowledge.

1. DIGITAL SUPPORT IN THE IMPLEMENTATION OF LABORATORY CLASSES

1.1. Project "Chemist as a detective"

At the Faculty of Chemistry at Adam Mickiewicz University, academic teachers conducted an implementation program for primary school students aimed at popularizing chemical issues in forensics through the project "Chemist as a detective". The project employed various methods to achieve its goals and research tasks:

- theoretical methods included the analysis, synthesis, comparison, systematization, and generalization of source materials in the field of flipped classroom
- empirical methods involved the observation of students during the "Detective Chemist" classes and surveys (questionnaires) to collect information about students' perception of the work of an analytical chemist in a forensic laboratory and its portrayal in crime series.

The research took place in the academic year 2021/2022 at the Chemistry Didactics Laboratory of the Faculty of Chemistry of Adam Mickiewicz University. 92 students from grades 7–8 took part in the research. The diagnostic tool of the study was a survey for teenagers called "The Chemist and Crime Series".

The aim of the classes was to familiarize students with the actual work of an analytical chemist in a forensic laboratory because many researchers point out that the image of a scientist in a forensic laboratory created in crime series is quite different from real work (Bergslien, 2006).
An initial survey conducted among students confirmed their interest in crime series. More than half of the respondents (54.3%) indicated that they sometimes watch such films and only 20% expressing no interest in this type of films.

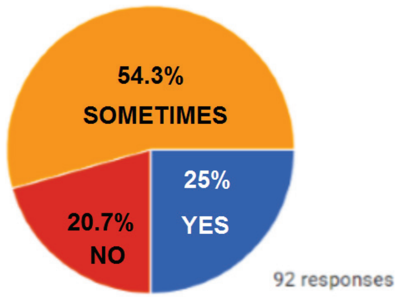


Figure 1. Students' answers to the question: Do I watch crime series? Yes 25%, No 20.7%, Sometimes 54.3

Source: Own work.

Two rounds of classes, lasting two and a half hours, were held in the Chemistry Teaching Laboratory, involving 92 primary school students in the seventh and eighth grades.
The "Chemist as a Detective" classes followed an anticipatory teaching strategy covering four stages (with the first two taking place before the planned lesson):

- ACTIVATION – students must activate their prior knowledge to acquire new knowledge at their own pace. They were encouraged to be actively engaged in learning new content, think creatively and critically.
- PROCESSING – students were assigned reading materials to be reviewed at home (approx. 45 mins), communicate with each other or learn together in groups, with the teacher available to offer guidance. At this stage, students acquired new knowledge themselves, building on their prior knowledge.
- SYSTEMATIZATION – this stage allowed students to further supplement and systematize their new knowledge. It took place during workshops or lessons, where the teacher answered questions, provided additional information, and summarized students' work. This stage also served to evaluate students' understanding of the material.
- ASSESSMENT AND EVALUATION – at this stage, the teacher evaluated students' work and achievements according to previously established criteria. Students might take tests or complete surveys, e.g., self-evaluations, using the elearning platform.

According to the assumptions of this teaching method, students prepare theoretically and practically before the classes, following instructions from the teacher. These preparations included the activation and message processing stages. Then, students were encouraged to ask questions and explore contemporary issues related to the class topic. The information and tasks provided before the lesson are intended to direct thinking on a new topic and motivate students to ask questions. It was expected that the lesson would organize and expand the knowledge acquired in the earlier stages. The systematization stage involved discussing the topic in a problematic and multi-contextual manner with the support of the teacher during in-person classes. The project was also subject to assessment and evaluation after the completion of the classes (Bartoszewicz & Zahorska, 2018).

For the needs of this project, materials were developed for students to read before and during the classes. These materials also included surveys for evaluation purposes. Google Classroom was used as a tool for creating and organizing tasks for students and facilitating communication. The materials were categorized according to the stages of anticipatory teaching implementation:

I. ACTIVATION folder, where the following are available:

- A brief survey
- A presentation with a link to articles: "Crime series from the perspective of a forensic scientist" and an article on food fraud.

Students were expected to read the provided texts without the need to learn them, the purpose was to draw attention to the following key points:

- crime series simplify the analytical processes,
- additional substances are sometimes added to food besides the desired minerals.

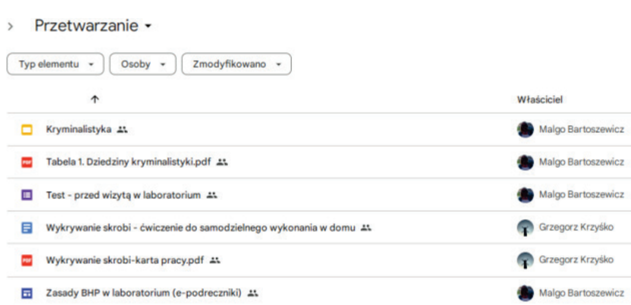
II. PROCESSING folder, where students had access to the following materials:

- A brief presentation about forensics
- An experiment that students could conduct at home (the iodine test) – students were encouraged to attach photos to the worksheet.

Students were expected to read these materials without the need to memorize them.

III. Systematization – classes at the Faculty of Chemistry of Adam Mickiewicz University – no materials were provided on the platform

IV. Short test



F i g u r e 2. A collection of materials for the "Processing" stage available to students for completing the classes

S o u r c e: Own work.

Google Classroom is a free educational platform that facilitates communication between teachers and students, the exchange of additional materials, and skills assessment.
Introduced to the market in 2014, it is designed to support teaching processes and serves as an alternative to well-known e-learning platforms. This service is free for non-profit institutions and individual users.
Google Classroom is also complemented by external solutions, such as:

- Science Buddies − provides many resources for teachers, parents, and students, including ideas for science projects, curricula for teachers aligned with selected learning standards.
- Ptable – an interactive platform that allows students can explore elemental properties, orbits, isotopes, and compounds through a dynamic interface.
- cK12 – contains modules for self-study, learning through games and activities, including chemical and physical simulations. The modular structure allows the use of quiz texts or videos (Szalach, 2019).

To begin using Google Classroom. the first step is to create classes and invite students by providing them with a “class code” generated by Google Classroom, or sending an invitation via the app. After joining the class, students gain access to a tool resembling a social network, allowing them to share necessary files, communicate with their peers, and exchange information.
To read the provided materials, students had to complete the following steps:

- receive the code for teaching activities from the teacher
- visit the Google Classroom platform website (www.classroom.google.com):

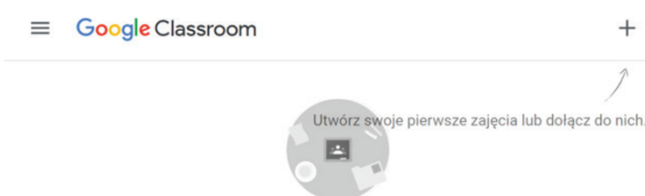


Figure 3. Screenshot of Google Classroom – login location

Source: Own work.

- click “+”, then enter the given class code and join the selected class group:

Figure 4. Google Classroom screenshot – student login location

Source: Own work.

Research in the field of chemistry teaching indicates that online learning via Google Classroom effectively improves students’ critical thinking skills in solving chemistry problems and improves academic performance (Khezel et al., 2023; Paristiowati et al., 2020).

On the dedicated class website, the teacher provided students with teaching materials related to forensics, preparing them for laboratory classes.
These materials covered various aspects, including:

- Introduction to forensic science
- Fields of forensics
- A pre-laboratory visit test
- Detecting starch – a self-conducted experiment task
- A starch detection worksheet
- Health and safety rules in the laboratory (see Figure 5).

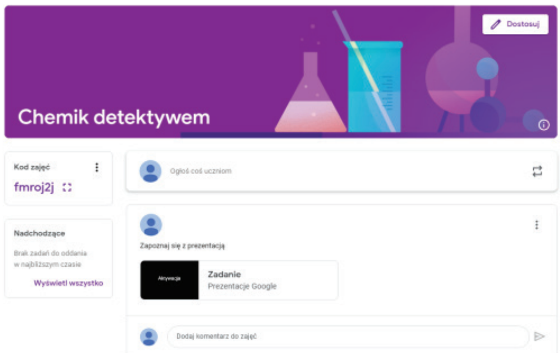


Figure 5. Screenshot of the Google Classroom course – "Chemist as is a Detective"

Source: Own work.

The practical laboratory classes followed the screening of a film that illustrated a story based on which chemical experiments were developed to solve the detective puzzle "Who killed Mr. Flower?" based on chemical and physical analyses commonly used in forensics.
After the film screening, students received folders with the history of Mr. Flower's work and death and a description of the experiments to be performed, which included:

- The story of Mr. Flower.
- Fingerprints − collecting fingerprints using fingerprint powders.
- Chemical analysis – does cream contain starch?
- Poisonous substances − copper salts in water,
- Forensic anthropology − determining the height of a suspect.

At the end of the class, students presented the results of their work and tried to answer the question posed earlier: "Who killed Mr. Flower?" After completing the classes, students were given the opportunity to complete a test and a survey at home to evaluate the classes.
Based on the implemented project and existing literature, several key benefits of Google Classroom can be identified:

- Easy setup – teachers can create classes and invite selected students.
- Ability to share various materials –tasks, announcements, and questions.

- Automatically saving materials in folders on Google Drive,
- Efficient communication and feedback provided by the teacher.
- Students can share materials and communicate through the class stream or via email.
- No advertising, and teachers' materials and student data are not used for advertising purposes.
- Mobile-friendly: easy to use on mobile devices (Doktorowicz, 2018; Iftakhar, 2016).

The survey results indicate that students are highly engaged and interested in chemical experiments (89.1%), especially those related to history and everyday life. The materials posted on the Google Classroom platform were rated equally highly. However, it is notable that only 43.1% of students indicated that the chemical knowledge discussed during lessons is useful in everyday life, while 32.6% are somewhat convinced of its practical relevance, therefore they indicated that they have no opinion, and 26.1% do not see the connection between what they learn in chemistry classes at school and everyday life (see Figure 6).

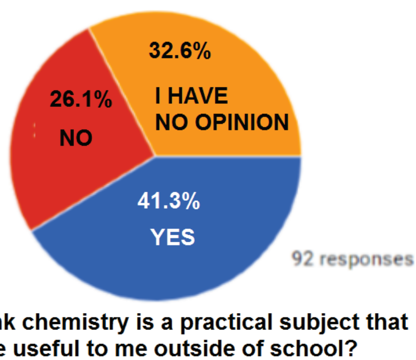


Figure 6. Students' answers to the question: Do I think chemistry is a practical subject that will be useful to me outside of school? Yes 41%, No 26.1%, I have no opinion 32.6%

Source: Own work.

When asked whether they would like to participate in future editions of the workshops, 98.9% answered affirmatively.

1.2. Project "LABirynt"

Since 2015, the Parliament of the Student Government of Adam Mickiewicz University has initiated a project supporting student activities, known as "Anvil." This project is open to students, PhD students, and employees of Adam Mickiewicz University who can apply for funding. In the academic year 2022/2023, co-financing was granted to the student project "LABirynt" focusing on teaching basic laboratory techniques. These classes were aimed at secondary school students and university students. A series of eight classes, each lasting three hours, were conducted, with 74 secondary school students registering for the workshops.

Drawing from past experiences (Bartoszewicz & Zahorska, 2018), it was decided to implement “LABirynt” classes in accordance with the anticipatory teaching strategy, specifically using the flipped classroom method. Materials for the workshops were prepared on the educational platform Wakelet (Wakelet, 2023).

Wakelet is a relatively new platform for creating and managing content in the form of collections that can contain links, photos, videos, articles, notes, and other elements. Wakelet allows users to create personalized content organized by topic, making it a valuable tool for storing, organizing, and sharing a variety of educational materials. Users can save important links (from blogs or websites), social media posts (from Facebook, Twitter, Instagram), YouTube videos and images, and then organize these elements into private or public collections. Users can also add notes to each item, ask questions and provide answers. It serves as a space for cooperation between teachers and students in various configurations. Wakelet can be used to improve student understanding through the presentation of digital learning resources as well as for collaboration. Wakelet is suitable for flipped classroom teaching or asynchronous learning. The results of research on the usability of Wakelet indicate that most respondents confirm its ease of use and highly evaluate its use as an interactive digital platform (Quah, 2023).

In summary, the tools provided by the wakelet.com platform are intuitive to use, and the resources located there are publicly available and free. For this reason, it was chosen to include materials in the LABirynt project.

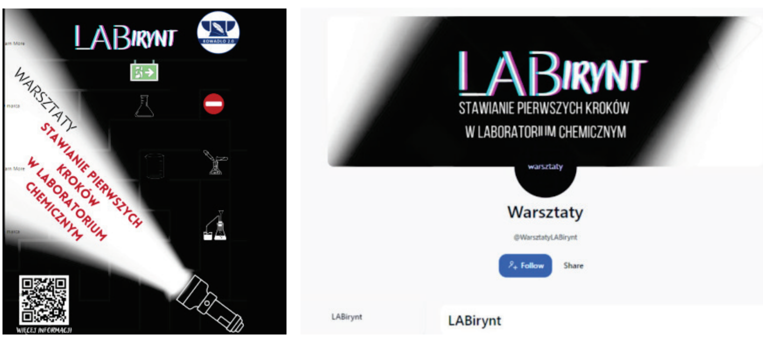


Figure 7. Poster design; Screenshot of the initial course on the Wakelet platform – “LABirynt”

Source: Own work.

Workshop participants familiarized themselves with the materials prepared on the Wakelet platform before the classes started. The materials https://wakelet.com/@WarsztatyLABirynt include:

- exercise descriptions,
- educational games,
- photos of laboratory equipment,
- safety data sheets for chemical reagents,
- infographics.

Figure 8. Screenshot of sample course materials on the Wakelet platform – "LABirynt"

Source: Own work.

Thanks to this approach, students came to classes already well-prepared, which is a key element of anticipatory education. The educational materials were categorized according to the stages of anticipatory teaching:

I. ACTIVATION

Pretest – available on the scheduled date on the Wakelet platform.

Materials available on the Wakelet platform:

- photos of laboratory equipment,
- safety data sheets for chemical reagents,

II. PROCESSING – materials available on the Wakelet platform:

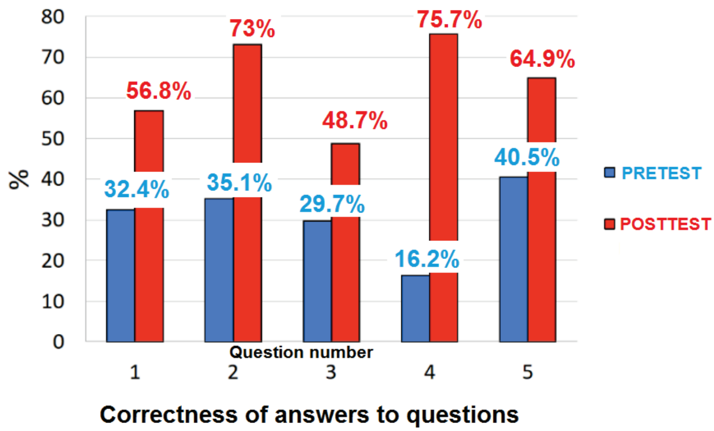
- exercise descriptions,
- educational games,
- infographics.

III SYSTEMATIZATION. Following the preparation stage, practical workshops were conducted at the Faculty of Chemistry of Adam Mickiewicz University. These workshops were divided into two parts. The first part concerned the preparation of copper(II) hydroxocarbonate, while the second part involved the titration analysis of acetic acid contained in vinegar. During these workshops project participants gained hands-on experience in fundamental laboratory techniques. They completed worksheets under the supervision of second-cycle students, and finally completed surveys.

IV. ASSESSMENT AND EVALUATION

Post-test – materials available on the Wakelet platform.

Each of the 74 participants completed a pre-test before attending the workshops and before reading the teaching materials. Subsequently, they completed a post-test after finishing the classes. The results are summarized in Figure 9.



F i g u r e 9. Pre- and post-test results. Correctness of answers to the questions asked

S o u r c e: Own work.

Based on the data collected, progress in knowledge and laboratory skills. Additionally, a survey conducted after the classes, which consisted survey question, which pertained to factors motivating individuals to learn chemistry, 82.4%of the participants indicated that grades were their primary motivator, followed closely by curiosity about the subject (74.3%). When it comes to chemistry, students showed the most engagement and interest in chemical experiments (74.3%). The materials posted on the Wakelet platform were equally highly rated. Students appreciated its intuitiveness and its compatibility with mobile devices, allowing them to access materials at any time and from any place. The biggest problem was accounting tasks. After the class, most students claimed that it was the best "chemistry lesson" they had ever taken part in. When asked whether they would like to participate in the next edition of the workshops in the future, an overwhelming 98.6% responded with an affirmative answer.

CONCLUSION

The use of Google Classroom tools and the Wakelet platform to support chemistry education in the laboratory has a positive impact on the quality and essence of teaching and learning among students. Google Classroom enhances students'knowledge acquisition, skill development, and competence building within the entire educational environment. This application enables students and teachers to function in a social network due to its mobility, saving time on distributing teaching materials before classes and motivating activates students to continue their work outside the traditional classroom setting. It was found that students develop their skills in teamwork, the use of mobile technologies in the learning and work processes. They also exhibit greater discipline and commitment. This kind of technology allows them to intertwine their study and free time.

The anticipatory learning strategy, also known as the flipped classroom method, allows for individual familiarization with the material at any time and place, both synchronously and asynchronously (before the workshop date).
This strategy also fosters the development of independent learning skills, information search and processing. However, it was noted that, in the absence of real-time contact in the virtual space, a decrease in motivation to prepare when students encountered any problems was observed (Dylak, 2013). Taking this observation into account, as part of the Study@Research competition of the ID-UB research project "TikTok as a tool supporting chemical education", an educational model will be introduced that combines laboratory classes, student engagement with shared materials on a free digital platform, and real-time meetings with lecturers before the workshops.

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