GOOD PRACTICES GUIDE

on ICT implementation in transdisciplinary teaching and learning

EDITURA SITECH CRAIOVA

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Chapter 1

THE ROLE OF ICT IN TRAINING THE COMPETENCES OF THE 21ST CENTURY

The role of ICT in training The Competences of the 21st Century

Introduction

The growing influence of technology on all day-to-day activities led to Koyoma's use of the term "information society" for the first time in Japan in 1968, which was taken over by Masuda in 1972 in "The Plan for Information Society", a programmatic document on the transformation of the educational system.

Other authors (Martin and Norman, 1970; Rothman and Mosmann, 1972; Martin, 1978, Martin 1981) have used the terms "computerized society", "Information era", "wired society" or "telematic society", but with the end of 80s and with the explosive growth of information the term that was established was that of "information society". After 1990, once ideas and knowledge become simple traded "goods", a new concept takes shape, that of "Knowledge society", (Anderson, 2008). With the increase in the volume of information to be analyzed and interpreted, the need for tools and therefore skills completely different than a few decades ago. The pace of change is increasing, favoured mainly by new technologies, and young people need skills and abilities such as adaptation, communication, the ability to learn, to help them in a global economy, where labor mobility becomes a priority. Thus, the focus shifts from the level of knowledge of an employee at a given time, on lifelong learning, adaptability to change, collaboration, mediation communication, but also to use ICT.

Reich in 1992, states that as the degree of integration of new technologies in all branches of the economy increases, the structure and share of jobs will change in the coming years. Thus, jobs that include repetitive activities will disappear, the place of employees being taken by robots or automated machines, so that jobs such as symbolic analyst - "mind worker" will be increasingly sought after on the labour market.

In fact, the information society and the knowledge in which we live today could not exist without the huge potential introduced by the new discoveries in the field of information technology. It has come to be used in the most diverse fields of activity, in many cases in order to process, interpret and use the information in a very particular way. Education systems around the world face major challenges, to keep up with the demands and needs of the labour market, to prepare young people to be an active part of the knowledge society, for jobs that have not yet been invented and for challenges that have not yet been were anticipated. These new skills are known as the Competences of the 21st century and contain a series of knowledge, skills, attitudes, being considered as having a critical importance for the success of young people in the world of tomorrow.

In recent years, there has been increasing pressure on education systems, schools and teachers to revise the curriculum, in line with the new challenges in society knowledge. (OECD, European Commission). However, the results of the PISA international examinations, which correlate and analyze information on students' ability to use knowledge and skills in key subjects, to communicate, analyze, interpret and solve problems in different situations, related to learning motivation but also to other factors outside the school, showed that countries have adapted the curriculum in different proportions. This indicates that decision-makers in those countries did not understand the importance of curriculum review but also of the fact that education systems are strongly resistant to change.

Comparative analysis of the framework documents defining the competences of the 21st century

Although the concept of Competences for the 21st century is a relatively new one, the interest shown towards it has been approached by a large number of organizations, so Dede (2009) considers that it is rather an umbrella phrase, under which several concepts were brought together. He also believes that precisely these multiple approaches, lacking clarity and unity can lead to the problem of

the Tower of Babel, when researchers end up using the same words but with different meanings.

Thus, some international organizations refer to the 21st Century Competences as lifelong learning (EOCD, 2004), the European Commission uses the term key competences, competences that are interdisciplinary and covering all subjects and school activities, and in the US the term used is 21st Century skills.

Precisely this definition of the term Competences for the 21st century, in different ways, can lead to confusions and divergent interpretations. To these are added the widespread use, in order to refer to some skills associated with 21st century skills, of related terms - such as applied skills, intercurricular skills, interdisciplinary skills, transdisciplinary skills, transferable skills, transversal skills, non-cognitive skills. (Tilea and collaborators 2000)

There are currently several reference frameworks for the 21st Century Skills, the best known of which are:

-The Partnership for the 21st Century Skills Framework (2006) - developed in the USA, by a national organization P21, formed in 2001 with support from the US government and several private sector organizations. (Voogt, 2012)

- EnGauge, was developed in 2003 by the group Metiri and Learning Point Associates in order to promote the skills of the 21st century among students and teachers.

-Assessment and Teaching of the 21st Century Skills (ATCS), developed as part of an international project sponsored by Cisco, Intel and Microsoft. (Voogt, 2012)

- The 21st Century skills and competences for new millennium learners, an initiative of the Organization for Economic Co-operation and Development (OECD)

-Key competences for lifelong learning, a European reference framework, developed within the work program "Education and training 2010". (European Commission, 2018)

Digital skills

The world we live in is one unprecedentedly connected to a great diversity of equipment and software applications, in which, regardless of the time of day (home, work, school, leisure) we live various digital experiences. It has thus become a necessity to adapt to new technological developments, in order to meet the demands of the labor market but also the opportunities offered by the knowledge society. The novelty of digital skills, but also the huge potential of these technologies in acquiring other skills, made the school a major player in training these skills. This period began with the introduction and use in the school of computers, internet, laptops, tablets and continued with the integration in the teaching / learning / assessment activities of e-Readers, PDAs, smartphones and software applications (browsers, multimedia development tools, collaboration platforms for capitalizing on E-learning, social media applications).

The way in which teachers use ICT in teaching activities can enhance students 'learning experiences, and with the integration of technology began the transformation of the school space to facilitate students' learning and training in the process. Khlaisang and Mingsiritham (2016) show that students learn better when they get involved and are part of their own training process, especially if the learning process is one that also uses communication and collaboration platforms.

Dillon (2004) considers that ICT has been a problematic field from the beginning. Thus, it appeared quickly, not having time to establish a robust intellectual tradition, during the training period being strongly influenced by computer science and partially annexed by the field of educational technology. Also, the coexistence and regular emergence of different perspectives on the role, benefits and problems of using ICT in education, generates an almost permanent state of debate around these issues and does not leave enough time to establish arguments and produce ideas. fundamental. Hinostrosis (2008) appreciates that technology is evolving very fast and therefore, there are always "new technologies" that involve new promises about the impact of student learning, the renewal of expectations and possibilities. For example, multimedia educational software (1980) was replaced by

integrated learning systems (early 1990s), which were replaced by web systems (late 1990s),

which in turn have been replaced by learning objects (2002), which are now being replaced by applications for portable devices (2004) and applications in the classroom, such as smart cards (2005), portable technologies (2006), etc.

From the point of view of the results brought to the students, Underwood and Dillon (2004) wonder if the assessment methods are not erroneous, given the novelty of the field. Thus, very good results are obtained in the study of English in the primary cycle, in the study of sciences, in certain classes, with certain students and teachers, but also situations in which the results are not in line with expectations. Possible causes can be the lack of experience in choosing applications by teachers, the lack of training in the field of teachers, the huge number of applications but also their volatility, many being projects - open souce and freeware, the wrong way to quantify the level of appreciation of the degree of integration of ICT in teaching (Buzera, 2018)

Regarding the learning and enrichment of the school curriculum (Roschelle et al. 2000) and (Hinostrosis, 2008), IT is a good tool for studying real-world contexts, visualizing and analyzing problems, for feedback, reflection and review.

In terms of improving ICT skills, everyone agrees with the success of acquiring those hardware and software skills in accordance with the curriculum, but also with the benefits of using applications to acquire 21st century skills, such as the ability to collaborate with a diverse team - face to face or remotely - to accomplish a task, creating, sharing and mastering knowledge by filtering a large mass of quasi-accurate information, etc. (Hinostrosis, 2008)

Although the use of ICT brings a significant number of benefits, its implementation is not always easy, especially due to the complexity of ICT for teaching and learning due to the overwhelming number of available options resulting from combining four sets of elements: - different contexts in which IT can be used: cultural, social norms, educational policies, available IT infrastructure, etc .; - the variety of pedagogical approaches that can be used: depends on the teachers' experience; - activities that take place during a lesson; - the set of IT options. This last category includes general tools, teacher tools, classroom management communication resources, design and simulation. When choosing them, it is recommended to take into account that students learn better when they are directly involved, and have full control over ICT tools. Their choice must be made according to the skills concerned: communication, collaboration, knowledge building, real problem solving and innovation, etc. If in the case of the acquisition of certain competencies things are quite clear, for the acquisition of others certain aspects must be taken into account. The construction of knowledge takes place when students generate ideas and understand what is new to them, through interpretation, analysis, synthesis or evaluation, and ICT supports the construction of knowledge when students use directly or indirectly ICT for the construction of knowledge. Students are considered to become creators of ICT products when they create products that others use. Thus, when students act as designers, ICT tools help solve real problems and even innovate.

According to Hinostrosis (2008), the trend in the implementation of new technologies makes it possible to group them as follows: 1. Expanding learning opportunities (learn anywhere and anytime); 2. Creating new learning scenarios in traditional contexts (in schools) 3. Improving the teaching and learning process; Teaching has not always been considered an opportunity to use technology to improve the learning process; only recently have new initiatives focused on using digital technologies to improve the teaching-learning process.

Two of the most widely used technologies today are IWB and SVLE. Although IWBs are relatively old technologies, their high frequency of use, and the possibility that the software developed for use in the classroom can be extended to other resources, make these technologies still highly valued. Since 2003, the use of SVLE has steadily increased in all schools, but also among other lifelong education and training providers. The technology used was the Learning Management System mainly in the form of proprietary software and open source software. It has also been found that a number of innovative technologies are widely used in SVLE, including wireless and mobile technologies. SVLE in the three-dimensional virtual world has been widely used to promote social interaction when students actively participate in designated tasks and activities. Studies have shown that the main benefits of using IWB and SVLE for teaching and learning are: (Hinostroza, 2008, Khlaisang , 2016)

- versatility with applications for all ages; more opportunities for interaction and classroom discussions; increases the joy of lessons for students and teachers.
- allows teachers to integrate IT into lessons; encourages spontaneity and flexibility; allows teachers to share and reuse materials;
- increases the joy and motivation of students; offers more opportunities for participation and collaboration; reduces the need to note taking; students are able to deal with more complex concepts; different learning styles can be adapted;
- allows students to be more creative in presentations for their classmates;
- students learn more effectively through active-participatory methods
- the skills regarding communication, collaboration, problem solving are considerably improved, contributing considerably to the development of a critical and analytical thinking.

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Chapter 2

Technology integration models

THE SAMR MODEL

This is a model structured on four levels for the selection, use and evaluation of the technology that can be used in the teaching process (Puentedura, 2006). These levels of technology integration in teaching activities are: Substitution, Augmentation, Modification and Redefining. Their starting letters are the ones that also form the name of the model. The levels are grouped in the Enhancement area (the first two) and in the Transform area (the last two).

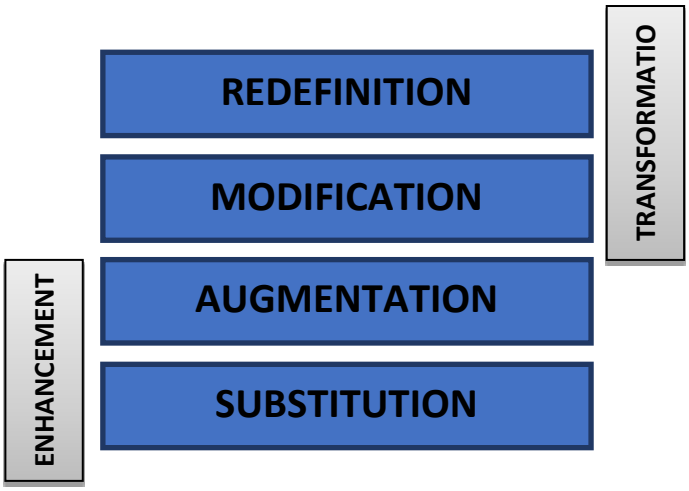

Figure 1. SAMR model (adapted Puentedura, 2006)

Substitution level - S - is where technology replaces a traditional tool, without changing the learning task, or making other functional improvements. Some classic examples of using technology at the S level are:
-replacing the taking of notes by students on notebooks with computer editing in Google Docs.
-scanning / converting worksheets by teachers and sharing them with students through the tools in the Classroom platform instead of distributing them in physical format.
-recording the lessons by the teachers and distributing them in the form of videos so that the students can watch them later.
Increase Level - A - is when technology replaces a classic tool, activity or resource, bringing functional improvements. At this level a technological improvement is offered for a learning task that could be completed without technology. Some classic examples of using technology at level A are:
-replacing the tests written on the sheet of paper with automatic tests performed with an application such as Google Form.
-replacing the classic tests with online tools (Kahoo, Socrative) that allow their gamification.
-supporting by students more complete and attractive oral presentations, accompanied by PowerPoint, Google Slide or Prezi presentations containing multimedia elements.
-students' use of the Internet and search engines to study a subject independently, as opposed to relying on the teacher's knowledge (Best J., 2015)
-creating by teachers of virtual boards or forums using an application such as Padlet, where students have the opportunity to post questions, links, images and other digital artifacts.
Modification Level - M - allows significant modification of a pre-existing task in a way that is not possible without technology. At this level, technology modifies the initial task or resource and is used to design interactive and dynamic tasks that go beyond the limits of a traditional class. This facilitates

collaboration and cooperation at the classroom level. Some classic examples of using technology at M level are:
-the use by teachers of a learning management system such as Google Classroom, Moodle, Schoology or Canvas for classroom management. (Christmas D. et al., 2021)
-creating by students an informative video presentation or even comics instead of a standard oral presentation to demonstrate the acquisition of knowledge.
-creating a digital brochure or a class magazine that incorporates multimedia elements.
Redefining Level - R - allows the creation of a completely new learning task, in a way unimaginable in its absence. Redefining learning has the potential to connect learning with the real world and produce authentic results. Some classic examples of using technology at the R level are:
-solving a learning task (perhaps from an Erasmus + project) using Google Docs by students from different countries, with support from international teachers and experts.
-making various virtual excursions (tours) in relation to the learning objectives.
-publishing by students the works, investigations on certain local / regional topics on different blogs, sites, inviting community members to evaluate them.

Conclusions

The SAMR model provides a means of examining each learning task to determine the depth and complexity of technological integration (Kirkland 2014). And Hilton (2016) considers it as a lens that allows teachers to analyze whether the technology meets the needs and objectives of learning, or what could be the directions for future improvement.

Even if it is a model that focuses mainly on technology, the key to using the SAMR model is not to think of it as a progression.

Effective use of technology means creating a rich type of learning tasks that redesign traditional ways of learning and create opportunities that do not exist without the use of technology. (Kirkland A., 2014)

THE RAT MODEL

The RAT model of Dr. Joan Hughes (2005), allows teachers to self-assess the level at which they manage to integrate technology in teaching. RAT is an abbreviation for **Replacement, Augmentation, Transformation** and proposes that the integration of technology in education can be analyzed taking into account the impact it has on educational activities and desired outcomes. (Kimmons, Hall, 2016). The RAT model allows the integration of technology to be used as a replacement, augmentation or transformation.

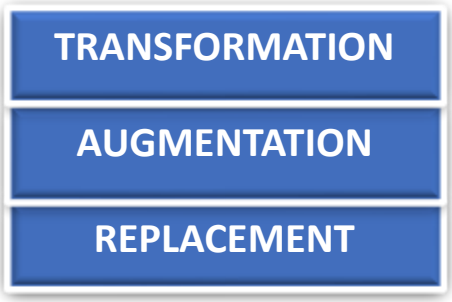

Figure 2. The RAT model (adapted by Hughes, 2006)

Technology as **replacement** does not change teaching activities but involves moving them to a new environment, replacing a traditional approach with new digital tools. In this case the technology serves the same instructive purpose.

Technology as **amplification** does not change the teaching activity, but makes it more efficient by bringing improvements to it.

Technology as **transformation** usually changes the teaching process in a way that would not be possible without technology.

Example:

-students replace writing an essay on a notebook with writing it on an online editor such as Google Docs (R)

-students use automatic tools to automatically correct the text or to replace certain words to improve the communication and therefore the material (A)

-the teacher checks and analyzes the essay shared by the students and introduces comments including in real time to provide feedback -. (T)

RAT and SAMR comparative analysis

Both models can introduce slight ambiguities in assessing the framing of technology at different levels. No distinct boundaries are set between the levels, leaving practitioners with great flexibility in setting these boundaries. Thus, in the RAT model it is considered that the boundary between augmentation A and transformation T is ambiguous, and in the SAMR model the boundary between substitution S and augmentation A is very close.

Both models are student-centered, but the ways in which students are involved are not always clear.

Both models are compatible with the teaching activity, being designed for this, which makes them easy to adopt by education participants.

Both models are in agreement with the theory developed by Seymour Papert (1990) - technocentric models and in agreement Hamilton (2016) both do not take into account the context.

THE PIC-RAT MODEL

It is a theoretical model for integrating technology in the classroom, student-oriented and pedagogy-oriented and easy to understand and implement by teachers (Kimmons, R., Graham, C. R., & West, R. E., 2020). As the creators of the model themselves claim, its construction starts from two questions: (Ottenbreit-Leftwich, A. & Kimmons, R., 2020).

-How do students use technology? (PIC)

-How does technology affect the pedagogical aspects of the content of a lesson? (RAT)

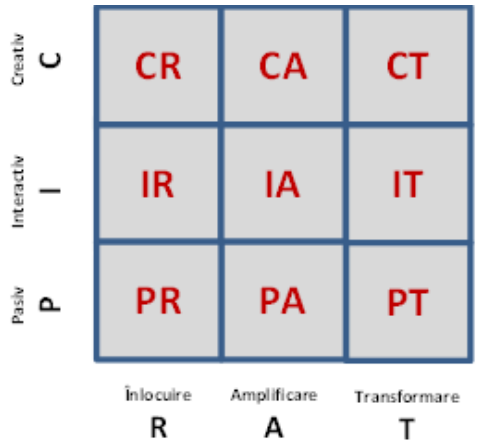

Figure 3. The PIC-RAT model (adapted after Kimmons and others, 2020)

Regarding the first question - in the case of the Plickers application the student uses technology in a passive way, even if the lesson is dynamic, engaging and fun.

Regarding the second question, it can be considered that technology improves the educational process by providing the assessment of all students simultaneously and provides the teacher in real time with a wide range of statistics and information.

From this reason we can consider that according to the PIC-RAT Model for assessing the degree of use of technology - the Plickers application will be in the PA position, the student uses the technology passively, and the technology brings an improvement of the instructional process.

Conclusions

The application offers a high autonomy to the teacher in relation to the technology. This can be very valuable when working with classes of young students or when students and the teacher have reduced digital skills.

Thus, according to Aljaloud A. and his collaborators (2015), one of the great fears of teachers when using SRS-type applications is overcome, namely the loss of time due to technical problems or incompatibilities. This autonomy is also useful when students come from disadvantaged backgrounds and the school cannot make up for their shortcomings. The fact that students can participate on an equal footing ensures equal opportunities, which technology by definition should bring to the education process.

The only shortcomings of the application are due to the limitations offered by the free version, but also due to the fact that in relation to the particularities of the application, with the response mode through QR code cards, there are few options for making items.

Also, the use of a single model to assess the degree of integration of an application in the instructional process can lead to erroneous results, especially if they do not take into account other information such as context, or are technocentric, focused on integrating technology for any purpose.

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EXAMPLE OF USING THE MODELS OF INTEGRATING AND CHOOSING THE TECHNOLOGY
(The International Conference, EUROPEAN CULTURE AND CIVILIZATION IN VIRTUAL DIMENSION)

INTEGRATING TECHNOLOGY IN THE CLASSROOM. PLICKERS APPLICATION

PhD Buzera Marius, Colegiul Tehnic „General Gheorghe Magheru”

Abstract: *In recent years, the number of SRS (student response system) applications used in education has grown exponentially, and many, although not specifically designed for education, have been quickly adopted by the school environment without too much study and research on their benefits. Under these conditions, the identification of models that assess the degree of integration of new technologies in education becomes mandatory.*
Cuvinte cheie: Students Response System, Plickers

Introduction

In recent years, technology has become a natural reality of educational systems in more and more countries, and the pandemic caused by the SARSCov2 virus has accelerated and intensified this process. Technology was not created to meet the needs of educational systems, but the creativity and imagination of teachers has contributed to the total transformation and redefinition of the educational act. The increasingly affordable price of technology and the fact that more and more schools are opening up and allowing students to use their own devices for educational purposes (smartphones, tablets, etc.) in classrooms have contributed to its proliferation in classrooms.

One of the technologies that has been imposed in recent years is SRS - Student’s Response System. In recent years this technology has received various names such as Classroom Response Systems (SRS), Electronic Student Response Systems (SERS), Classroom Performance Systems (CPS), Audience Response Systems (ARS), Response Systems personal (PRS), electronic response systems (ERS), Class response systems (CRS), voting systems or simply clickers. (Aljaloud A., Gromik N., Billingsley W., Kwan P., W., H., 2015).

The name clickers comes from their shape, similar to a small remote control, which the teacher distributes at the beginning of the class and collects them at the end. Students used these devices to answer by pressing their buttons in relation to the options of the questions that were designed with the help of video projectors. Although clickers appeared in the early 1950s, due to the high price they were mainly used only in the university environment, but with the development of data transmission technologies and the advent of smartphones they were "rediscovered". The main advantages introduced by SRS, which have contributed to their explosion in recent years are:

-transforms students from passive listeners into active participants, increasing the interactivity between students and teachers but also the collaboration between students (Lam, S. L., Wong, K., Mohan, J., Xu, D. & Lam, P., 2011).

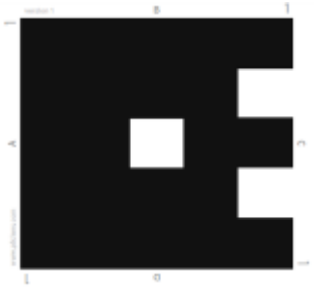
-motivates and engages students, especially the shy ones, changing their attitude towards involvement in class activities (Mula, Kavanagh, 2009).

-provides efficient and immediate feedback in the case of initial and formative evaluations where studies have shown that very good results are obtained. (Bradley, K. D., 2019)

Currently, SRS applications are found in a great diversity, from those that tend to give technology a central role, to those that tend to keep technology as far away from the classroom as is the case with the Plickers application.

Presentation of the Plickers application

The Plickers application is also called paper clicker (Bradley, KD, 2019), given that in this case, students will not use any type of electronic device to answer but a card with a QR code, which was assigned distinctly to each student. (Buzera, Luțaru, 2020)



Picture 1. Card no. 1 (source www.plickers.com)

The application is available in two variants: free and with subscription and can be accessed from www.plickers.com with any type of browser: Edge, Opera, Safari, Chrome, Mozilla, Internet Explorer, etc. In order to use the application, the teacher will initially have to create an account on the platform and then install it on the mobile phone using the same access data. The new versions allow both the manual creation of each class and the addition of each sequential student to the class, or the import of classes and associated students directly from the Google Classroom application, thus effectively contributing to significantly reducing the workload of the teacher.

Picture 2. Import students from Google Classroom

Creating tests with the Plickers application is relatively simple, as they are obtained as a combination of text and / or images. In order to apply such a test, it is necessary that the classroom has a minimum of equipment: a computer - which will be used to launch the test, a mobile phone - of the teacher, which will "scan" the students, a video projector to project the questions, an internet connection and the cards with the QR codes that will be distributed to the students at the beginning of the class. After launching the test, students will read the question on the projection screen and answer by raising the card to the position corresponding to the option they want.

a.

b.

Picture 3 (a,b) Scaning students answers with a mobile phone

After the students answer, the teacher can observe in real time the correctness of the answers through the color code associated with them, and in addition the application installed on the mobile phone provides short information and statistics related to the students' response. Subsequently, by accessing the platform the teacher has access to a wide variety of statistics and individual reports for each student, but also class-level statistics over different time intervals: weekly, monthly, or teacher-defined periods.

Picture 4. Statistics and individual reports in a class

Evaluation of the Plickers application

To analyze how the Plickers application was integrated into the classroom the SAMR model of Dr. Ruben Puentendura (2006) and the PIC-RAT model of Kimmons, Graham and West (2020) were considered.

The SAMR model

It is a relatively new model, but increasingly popular with pre-university teachers around the world. The model is developed by Dr. Puentedura (2006) being structured on four levels and is used to assess the degree of integration of technology in the teaching process.

Picture 5. The SAMR model (adapted after Puentedura, 2006)

Substitution Level -Plickers can be used to provide an initial or formative assessment to replace a paper and pencil assessment.

Augmentation Level (improvement) - Plickers automatically assesses the responses of all students and informs the teacher about their correctness, providing additional feedback options to the teacher and improving the educational process.

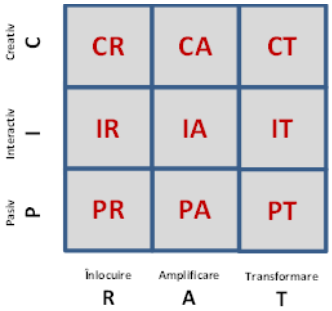
Although there are studies that claim that Plickers can also produce the modification of the teaching process and even its redefinition (Bradley, K. D., 2019), this can be considered as forced. The fact that the teacher uses an augmented reality application to scan students' answers cannot be considered a modification or transformation of the teaching process, because the application is used exclusively by the teacher.

The PIC-RAT model

It is a theoretical model for integrating technology in the classroom, student-oriented and pedagogy-oriented and easy to understand and implement by teachers (Kimmons, R., Graham, C. R., & West, R. E., 2020). As the creators of the model themselves claim, its construction starts from two questions: (Ottenbreit-Leftwich, A. & Kimmons, R., 2020).

-How do students use technology? (PIC)

-How does technology affect the pedagogical aspects of the content of a lesson? (RAT)



Picture 6. The PIC-RAT model (adapted after Kimmons and others, 2020)

Regarding the first question - in the case of the Plickers application the student uses technology in a passive way, even if the lesson is dynamic, engaging and fun.

Regarding the second question, it can be considered that technology improves the educational process by providing the assessment of all students simultaneously and provides the teacher in real time with a wide range of statistics and information.

From this reason we can consider that according to the PIC-RAT Model for assessing the degree of use of technology - the Plickers application will be in the PA position, the student uses the technology passively, and the technology brings an improvement of the instructional process.

Conclusions

The application offers a high autonomy to the teacher in relation to the technology. This can be very valuable when working with classes of young students or when students and the teacher have reduced digital skills.

Thus, according to Aljaloud A. and his collaborators (2015), one of the greatest fears of teachers when using SRS-type applications is overcome, namely the waste of time due to technical problems or incompatibilities. This autonomy is also useful when students come from disadvantaged backgrounds and the school can not make up for their shortcomings. The fact that students can participate on an equal footing ensures equal opportunities, which technology by definition should bring to the education process.

The only shortcomings of the application are due to the limitations offered by the free version, but also due to the fact that in relation to the particularities of the application, with the response mode through QR code cards, there are few options for making items.

Also, the use of a single model to assess the degree of integration of an application in the instructional process can lead to erroneous results, especially if they do not take into account other information such as context, or are technocentric, focused on integrating technology for any purpose.

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Chapter 3

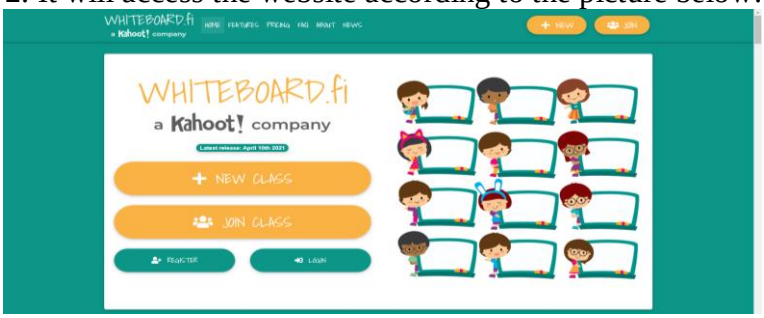
Applications and software solutions used in the teaching-learning-evaluation process

Whiteboard

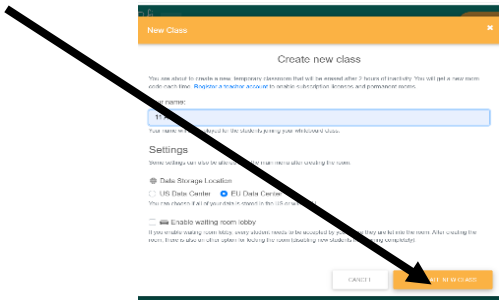
To write on "whiteboard", you can use the application "Electronic whiteboard" / smart whiteboard (https://whiteboard.fi/). To write easily, at a decent speed it is necessary to have an electronic tablet / pen, but you can also use the keyboard. In this sense, the following steps are followed:

TEACHER

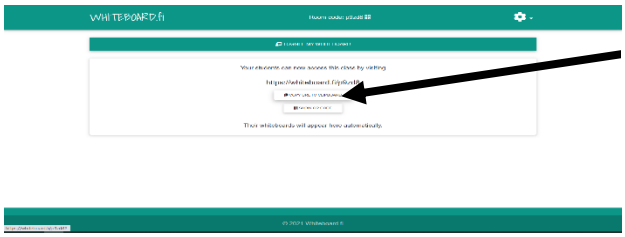
1. Types: https://whiteboard.fi.
2. It will access the website according to the picture below:



3. Click on **+NEW CLASS**
4. Fill in the name in the open window (it is not necessary to write your name, it is usually written the class), then click on **+CREATE NEW CLASS**:



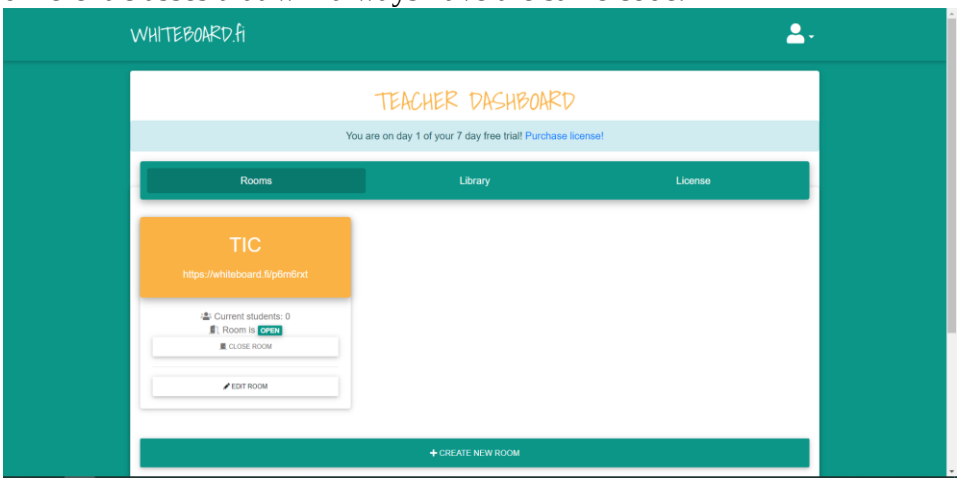
5. Create the class and copy the address, which will be pasted in the chat room for the students to be able to see the teacher's board but they will also have their own board.



copy link

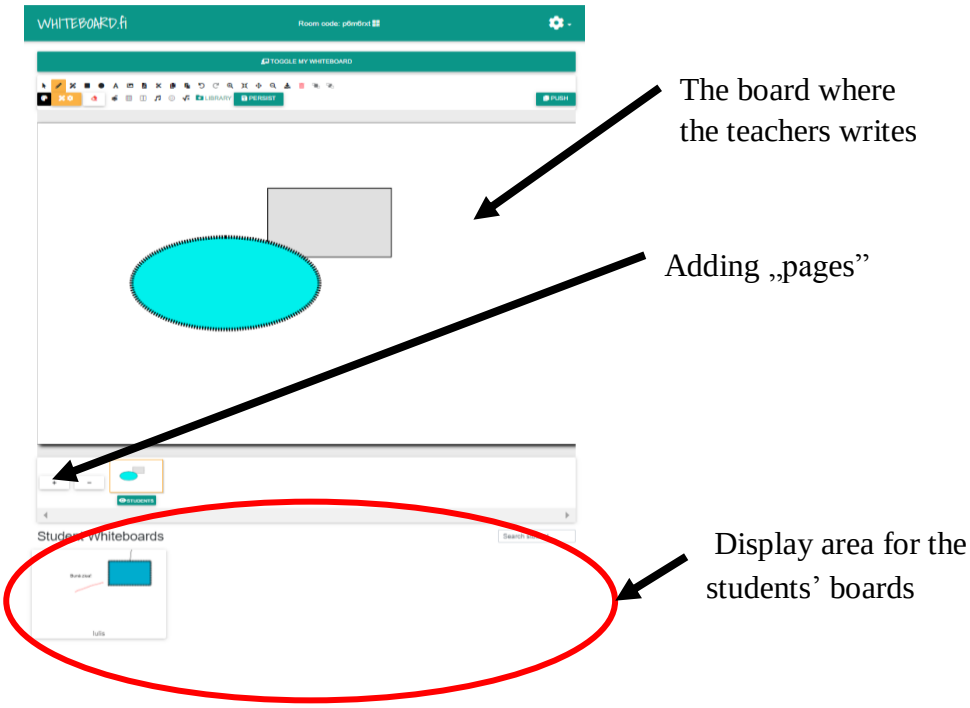
OBS.: A. The students see both their board and the teacher's board.

B. If the teacher uses a licensed version, he will be able to create different classes that will always have the same code.

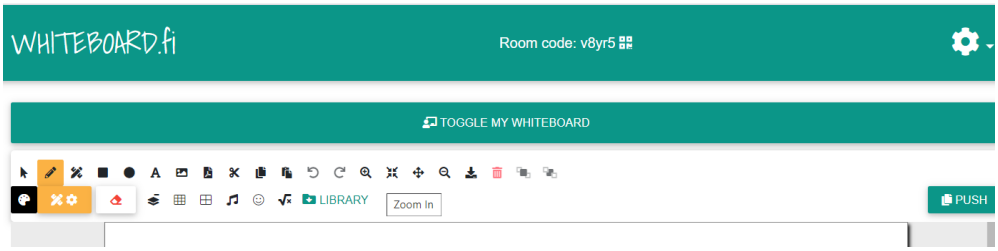


If you click on the class (TIC) the above picture is shown where the teacher will be able to activate its board with **TOOGLE MY WHITEBOARD**.

6. The teacher shows the board by clicking on **TOOGLE MY WHITEBOARD**.



7. Work tools:



First row, from left to right: selection, drawing (free writing), line, square, circle, text, inserting an image, inserting a pdf document, cropping, copying, pasting, undoing, redoing, zooming in, undo magnification / reduction, sheet metal movement tool, zoom out, unload, delete, bring to front, bring forward.

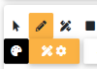
Second row: color change, tool settings, delete, the selected image is sent in the background, adding in background small grid, large grid background addition, insert music sheet, insert mathematical formulas.

OBS .: a) The student has the same tools to write on his board;

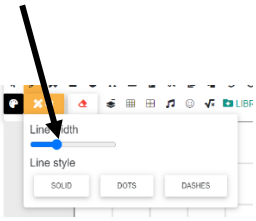
b) The teacher can activate the board of any student so that everyone can see what he is wrting.

A) 

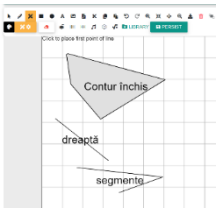
selecting an area;

B)  drawing, free writing;

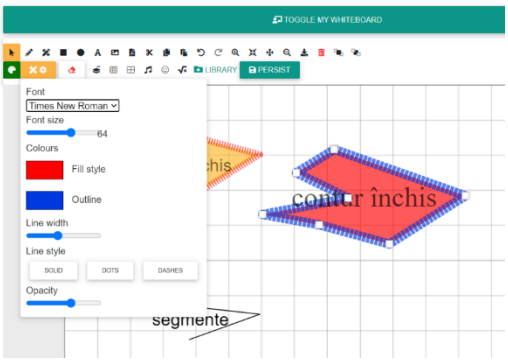
If drawing, free writing is selected, the possibility to change the writing thickness is displayed in the tool settings, and the color changes from the color palette.



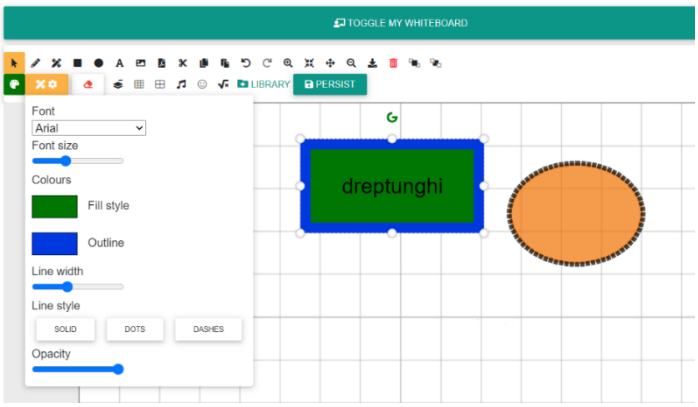
C) To draw a line, several connected lines (segments) or a closed outline, use the line tool.



Click for the first point, is shown then the lines will be drawn. By clicking on the drawn area, a text box is displayed where we can write what it represents.
In the tool settings we can change: font type, fill colour, font size, fill colour (if applicable), outline colour, thickness, line style, opacity.



D) Adding rectangle / square or ellipse / circle is done with the symbols square and circle.

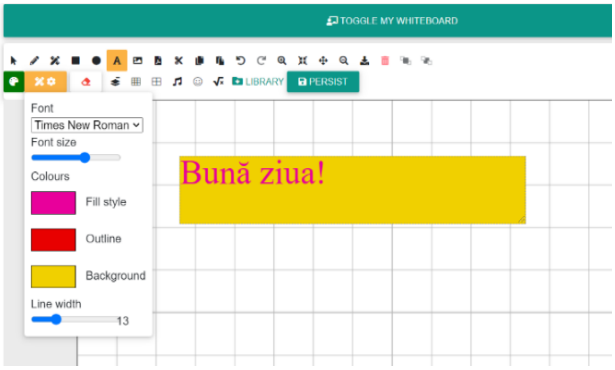


In the tool settings we can change the font type and size, the color of the shape fill, the color of the contour, the thickness of the contour, the type of contour and the opacity.

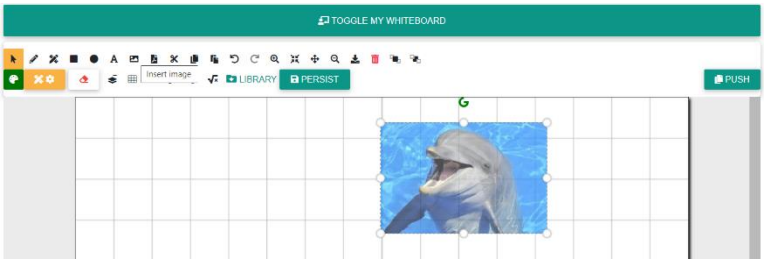
E) With the **A** button, add writing.

Steps: select **A**, click on the board where we want to write, a box is displayed where we can type the text.

In the tool settings we can change type, font size and color, text outline color, text box fill color.

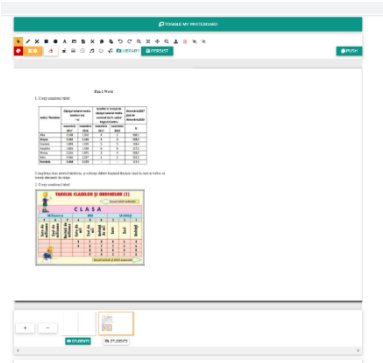


F) Insert image from computer. In the tool settings we can only change the opacity of the inserted image.

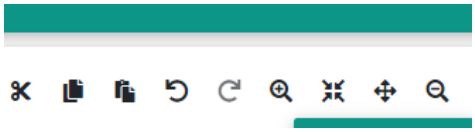


G) Insert **pdf** document can be used for testing.

When inserting, another board (another sheet) is displayed containing the pdf document.



H) The following 5 tools are cutting, copying, pasting, undoing, redoing, zooming in, undoing zoom in / out, whiteboard, zoom out, They have the same role as in any application.

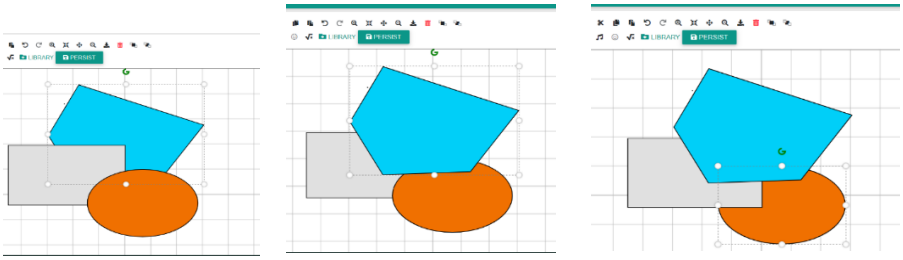


I) Download. 

It has the role of downloading the teacher's board (or the teacher can download his board) as files of the type: **PNG**, **JPG**, **SVG** or **PDF**,

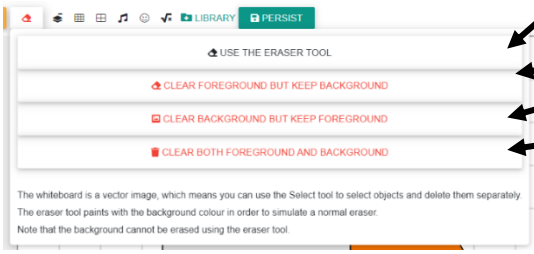
J) The delete tool can be used after we have activated (after clicking) on the object we want to delete. 

K) Tools: bring to front, bring forward. 



OBS: The last object (line, rectangle, text, etc.) is always in the nearest plane.

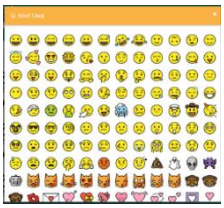
L) Eraser:



- it is used as a normal eraser
- erases everything on the board
- erases the board background
- erases both the content and the background of the board

M) Tool transforms everything on the board in background.
N) Different types of sheet lining can be done from:

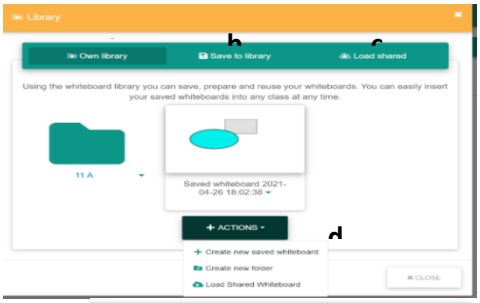
O) Inserting emoticons:



P) Equation editor:
When you click on the equation editor, a dialog box for editing the equation is displayed.

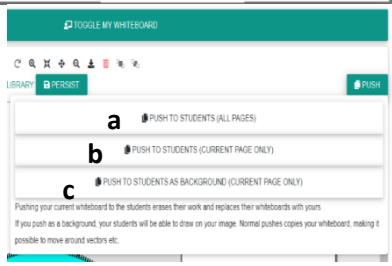
R) Library tools:

When clicking on **LIBRARY** the following window opens:



Where:
a - own library
b - rescue in the library
c - loading from the library
d - action button for creating new board and saving, creating new folder, loading saved board

S) By accessing the **PUSH** button we will have the options:
a - send all pages to students (boards)
b - send to students only the current page (board)



c - send to students only as current background pages

8. The teacher can activate the board of any student so as everyone in the class to see what the student did, by clicking on the respective board.

The student's board will be visible to the whole class, and the student can still write.

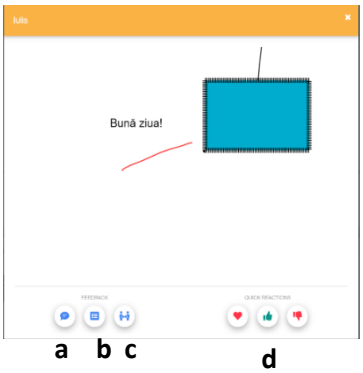
Where:

a - the teacher can add comments

b - viewing the feedback history

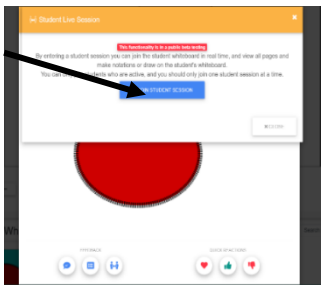
c - sharing the student's board (can write both the student owning the board and the teacher)

d - feedback in the form of **likes**, appreciations or not

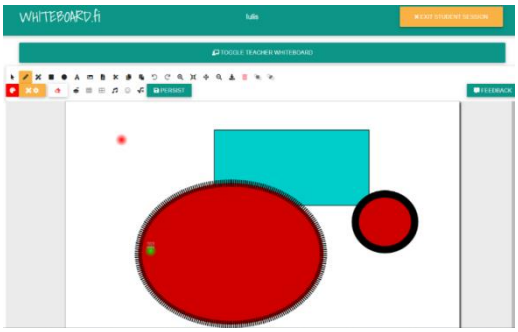


9. The teacher can share the board of the student so that he can answer and make corrections like on a normal board.

Clicking on the **"c"** sharing button brings up the dialog box, where the teacher activates the button **JOIN STUDENTSESSION**.

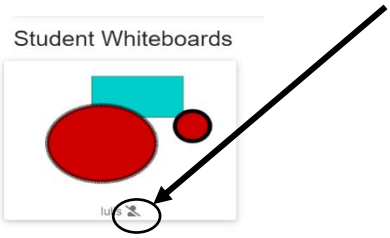


The student's board is displayed with the name, feedback button and exit button (button only for the teacher). The student's cursor is displayed in green, which also contains the name, and the teacher's cursor in red.

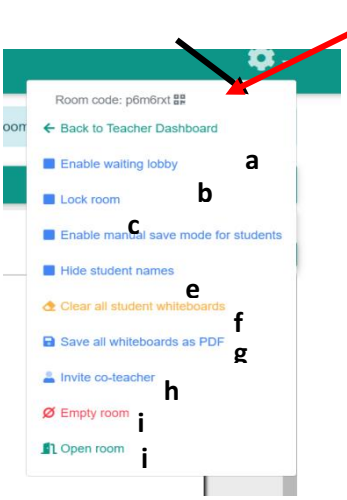


At the end of the session (the student's board) we return to the teacher's board.

10. If the student is no longer active (has run out of internet or has closed his board, the teacher will notice because the sign of **disconnection** is displayed:



11. From the settings of the application the teacher can perform the following operations: room code



a - back to the teacher's board
b - allows waiting
c - locker room (after the student has entered the code, the teacher must give acceptance from this virtual "locker room")
d - activating the manual save mode for students
e - hide the student's name
f - delete the board of all students
g - saving the students' board in pdf format and the possibility to check the teacher's board for saving
h - invites a co-teacher
i - empty the room (session)
j - open the camera

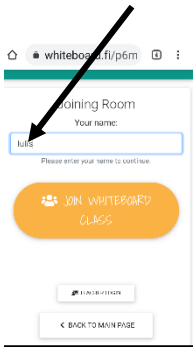
THE STUDENT

The student can use computer / laptop / tablet or even phone. You do not need to download any application.

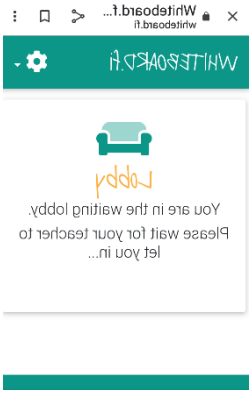
1. Type: https://whiteboard.fi.
2. Open the application and it will be displayed:

clicks on **JOIN CLASS** and types the code received from the teacher

3. A dialog box will be displayed on the student's screen where he will enter his name, after which he will click on **JOIN WHITEBOARD CLASS.**

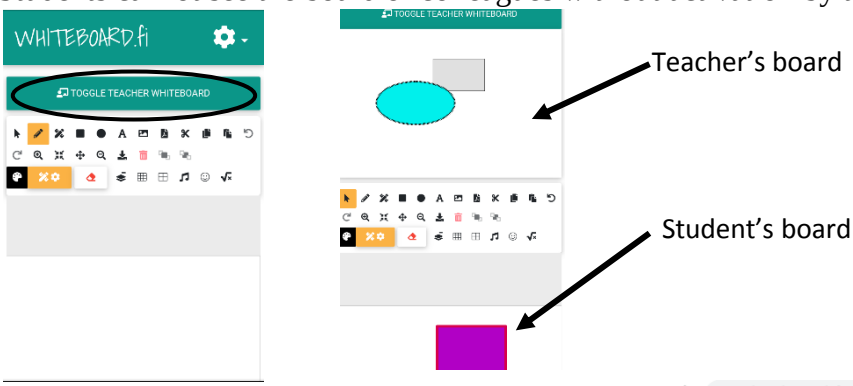


4. If the teacher has ticked in the settings **enable waiting lobby**, then the student will receive a "screen" waiting ("locker room"). The teacher will either accept it or uncheck the option **enable waiting lobby.**

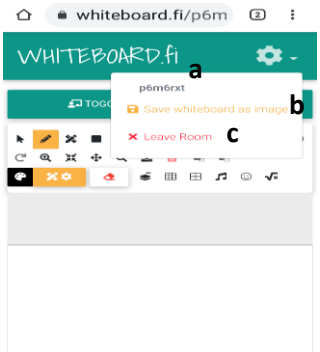


5. After acceptance, the student's own board will be displayed.

Clicking on **TOGGLE TEACHER WHITEBOARD** also opens the teacher's board, so the teacher's and student's board will be on the screen. Students cannot see the board of colleagues without activation by the teacher



6. The student has the same tools as the teacher.
7. The settings for students contain:
   a - the room code
   b - saving your own whiteboard as an image
   c - leave the room



Miro (mind map)

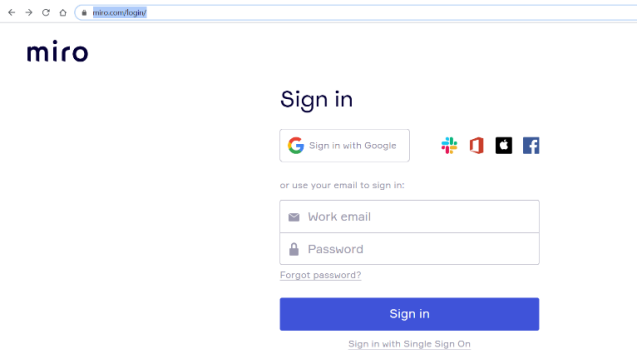
Mind maps or cognitive maps can be defined as the image of the way of thinking.

Different sites are used to make the concept maps, such as: https://miro.com/login/, http://popplet.com, https://bubbl.us, https://www.goconqr.com , etc.

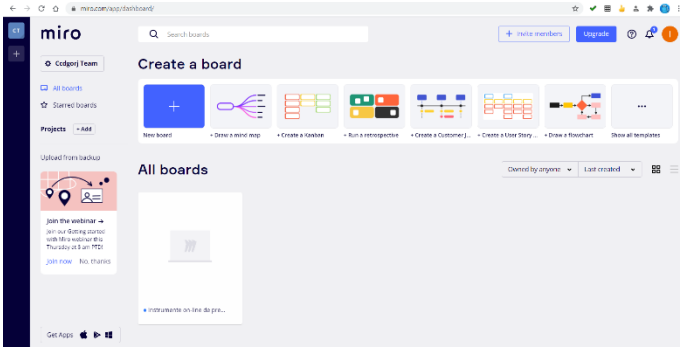
We present the creation of concept maps with the help of the site https://miro.com. To use miro.com, we need to create an account or we can use the accounts of Google, @ slack.com, Microsoft (@ hotmail.com), Appel, @ facebook.com.

To use miro.com follow the steps:

1. You access the site by typing in the address (URL) https://miro.com/login/ and you are logged in.

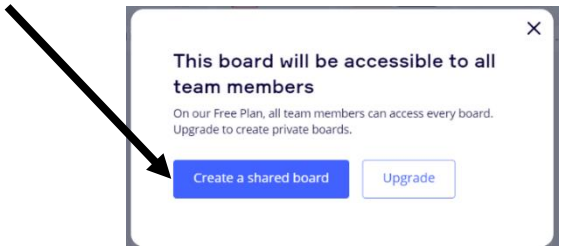


2. After logging in, the interface of the site http://miro.com is displayed.



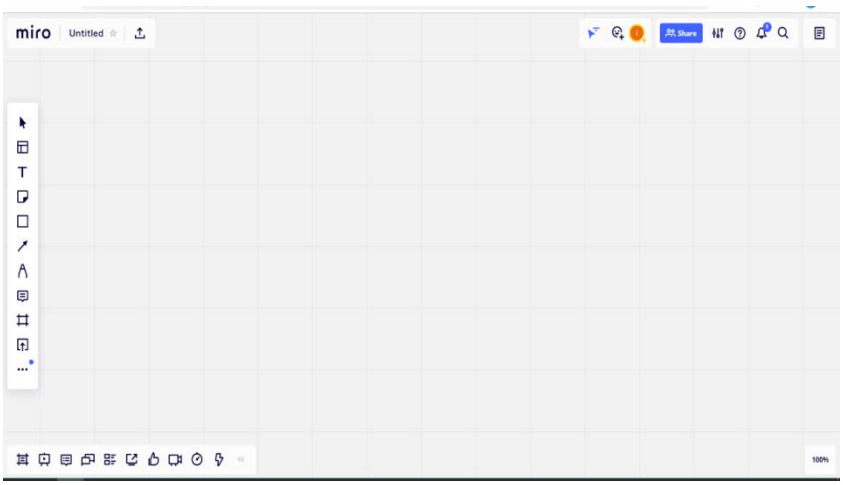
3. Choose from **Create a board** from the design templates or **New board**. Choosing the **New board** variant will be displayed:

and click on **Create a shared board**, and then the miro board and design templates will open.



If you choose between the design templates, the same dialog box is displayed with **Create a shared board**, the miro board opens with the template already chosen on the miro board, which can be modified (add, delete, format elements)

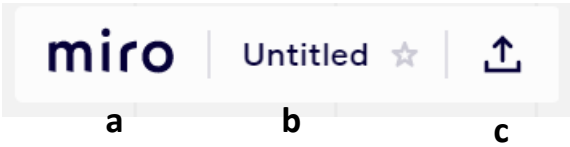
4. The miro board looks like in the picture below:



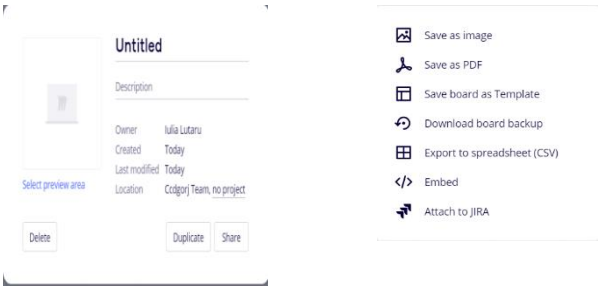
A.

a. Accessing **miro**, we get to the start board (the one in point 2).

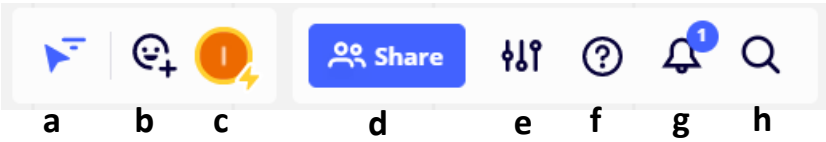
b. We can edit the board settings by filling in the required data (if you want) in the dialog box that is displayed.



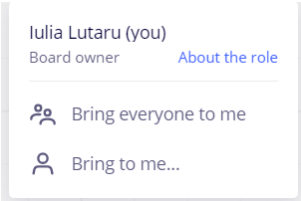
c. We can download the board in different forms.

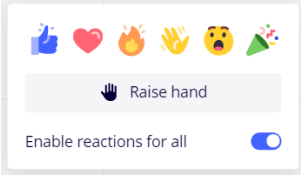


B.



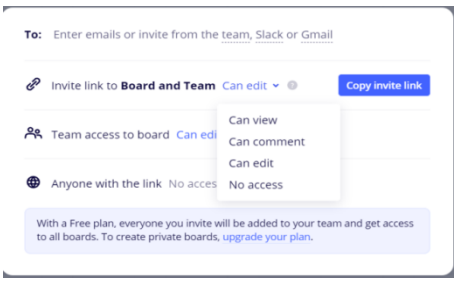
a. Show or hide the cursor of those who collaborate in editing the miro board.
b. Emoticons used for student reactions



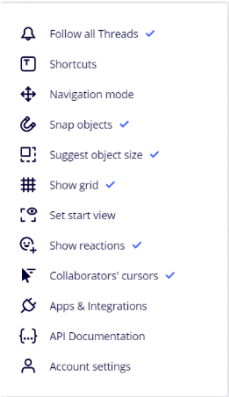


c. Activating it shows who is the initiator of the board (whose miro board is), showing of all those who have made changes to the board (collaborators).
d. Sharing the board.

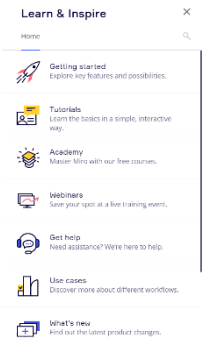
By clicking **Share**, a dialog box is displayed where we can obtain the collaborator invitation link and we can choose the type of collaboration (collaborators can view the board, comment, edit or without access), the collaborators' access to the board (collaborators can view the table, comment or edit).



e. Board settings.
By clicking on different settings options, the sign is displayed informing us that those settings have been activated.

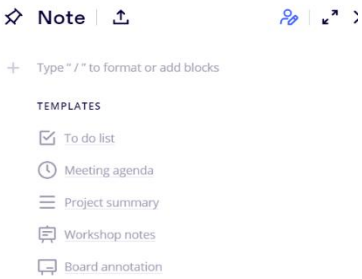


f. Guides, tutorials for different tools, format, ... for using all the elements in **miro**.



h. Search for characters, words in the active board.

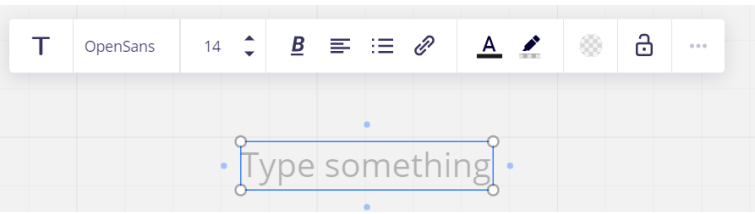
C. Notes



D. Work tools.

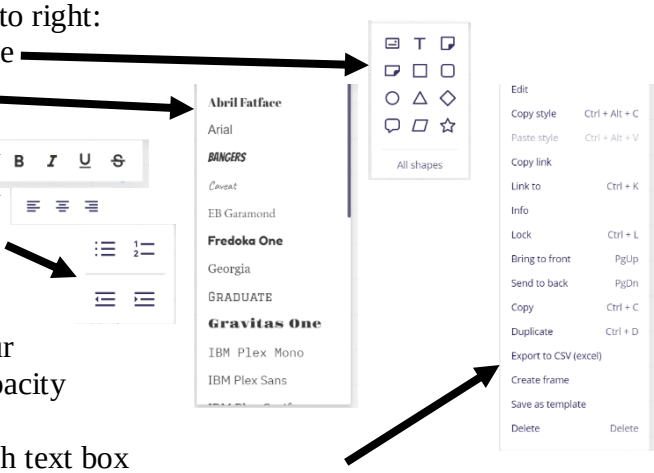
a - select
b - templates
c - text
d - sticky notes
e - forms
f - connecting lines
g - pen
h - comments
i - frame
j - upload
k - more applications and tools

a. With the help of the selector you can "move" the board.
b. We can choose different types of templates as needed. These templates can be modified by adding, removing formatting items.
c. Activating the button to add text, the cursor changes in a vertical line and clicks where we want to add text. An edit box and a formatting bar for the text box and content will be displayed.



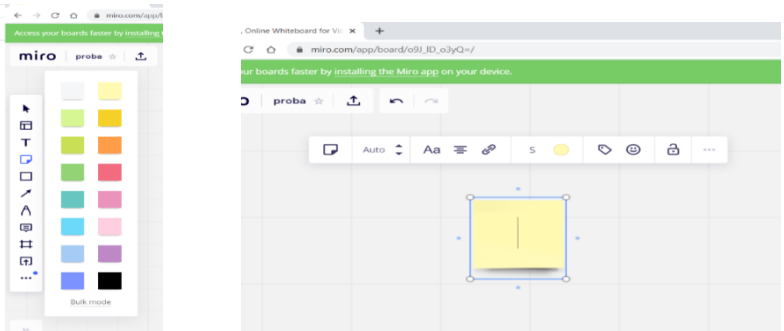
Text box

Formats from left to right:
- changing to shape
- font
- size
- effects
- allign
- add list
- insert link
- text colour
- highlighter colour
- set colour and opacity
- lock
- more options with text box

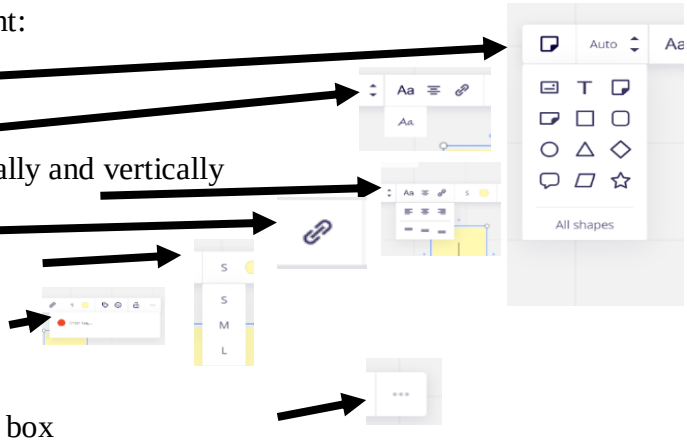


d. Sticky notes

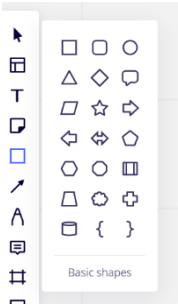
Activating the button, various coloured notes appear, and the mouse turns into a „sheet". Click where we want to have the note.

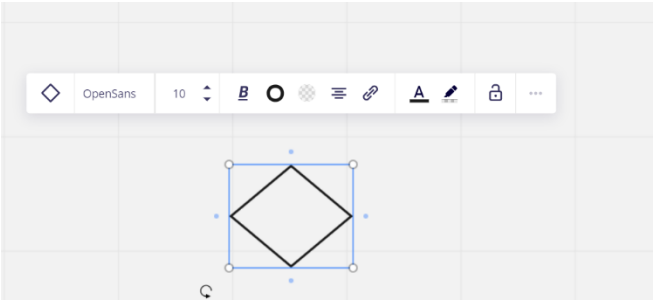


Formats from left to right:
- changing to shape
- font size
- font style
- text alligning horizontally and vertically
- add link
- sticker size
- sticker colour
- add tags
- add emoticons
- lock
- more options with text box



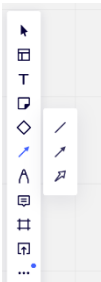
e. Shapes

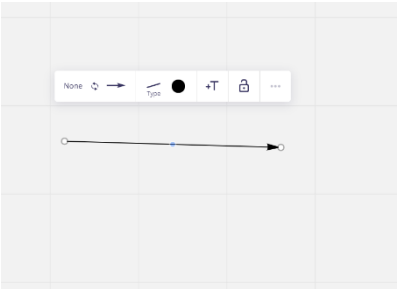




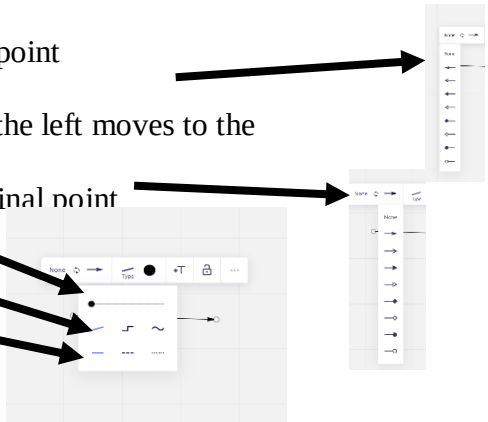
Formats from left to right:
- shape switching
- font (for text)
- character size
- font style (B, I, U, S)
- align the text both horizontally and vertically
- font color
- highlight color
- background color and opacity (transparency)
- lock
- more options for working with the text box

f. Connection line.

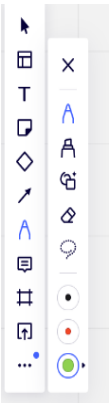




Formats from left to right:
- changes the type of „arrow” for start point (the right end in the example)
- changes (moves arrow, the arrow int the left moves to the right and the other way)
- changes the type of „arrow” for the final point
- line type (line width, straight / broken / curved line, line / dashed line / dotted line)
- line color
- add text by clicking + T formatting will also open text (position relative to line, color, size)
- lock
- more options for working with the text box



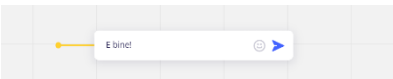
g. Pen.
On activating the pen more specific tools will open.



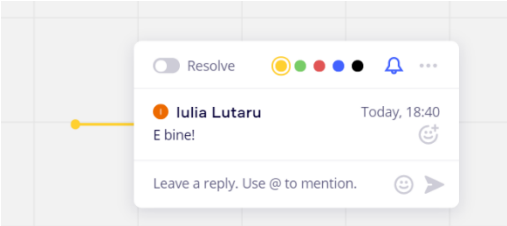
- pen
- highlighter
- intelligent drawing
- eraser
- lasso selection

- different colors for pen, highlighter, shapes (we can also change the thickness of the lines)

h. Comments
After activating, the mouse turns into a "sheet", click on the board where we want the comment to be displayed. Write the comment and click on send ("plane").

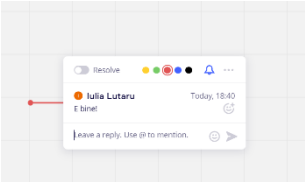


After sending, a window will be displayed where you can change certain features.

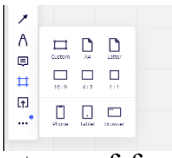


You can change the sign color for the comment:

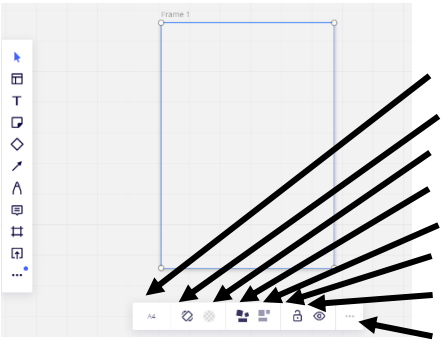
At more options  we can show the entire comment by pinning, adding link or erasing the comment. By checking pinning, the board will display:



and other comments or answers to comments can be added.

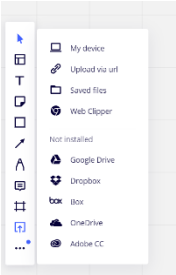
i. Frames 

The type of frames (sheet) is chosen, it helps to “scroll” on the board and when saving / printing the elements appear only from the frames



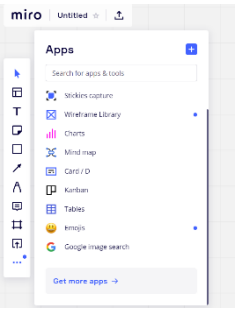
- change frame
- positioning
- frame colour
- free from
- grid
- lock
- preview
- more options

j. By activating you can upload different documents from different sources.

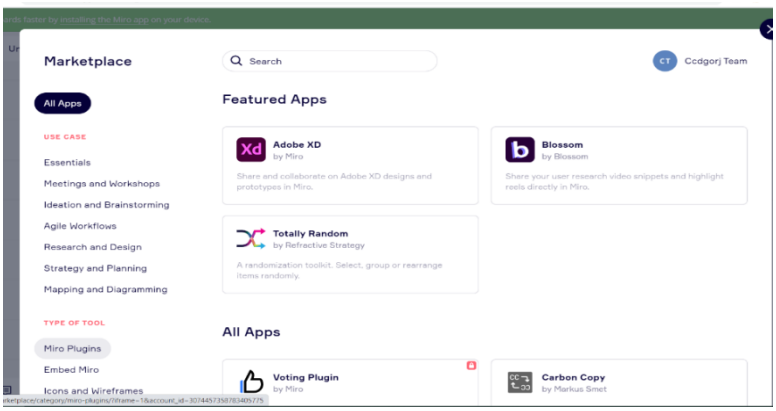


k. More applications.

With„drag end drop" we can move on **D** toolbar.



By clicking **Get more apps** more applications that can be opened are added.

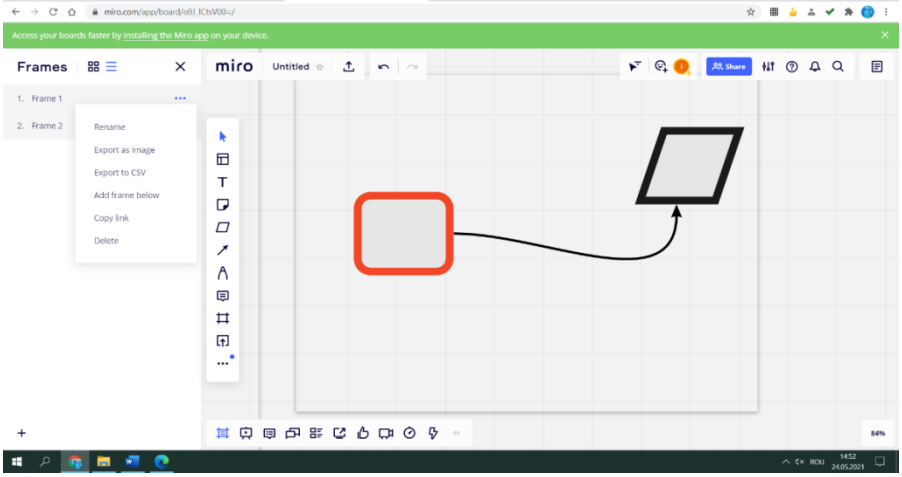


E.

a b c d e f g h i j k

a. Frames.

Activating will open a "table of contents" with frames on the left. Choosing the desired frame we are directed on the miro canvas at that frame.



Frames can be renamed, exported as image or CSV, added new frame (as shape with the selected one), copy or delete. A new frame of another format can be added from the "+" sign.

b. Type of presentation.

When the button is activated, the elements from **A, B, C, D** disappear in order to visualize a large area of the **miro** board.

c. Comments

Showing the comments grouped at the left.

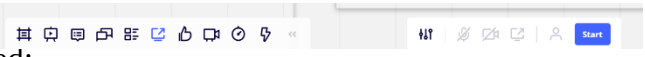
d. Chat.

Conversations with participants.

e. Cards.

f. Screen sharing

Activating will display:



After „**Start**” is displayed:

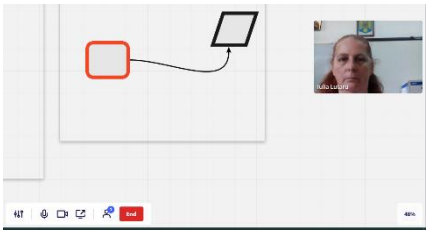
g. Vote.

This option is available for 14 days, then it requires payment.

h. Video conversations.

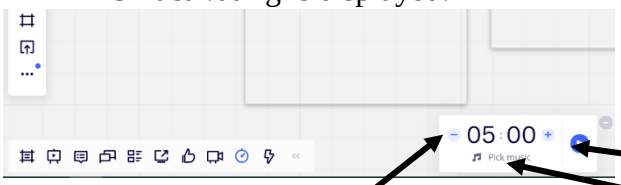
In this case the camera is activated.

After „**Start**” is displayed:



i. Timer.

On activating is displayed:



You can change the duration, you can choose the music and then play.

j. Activity.

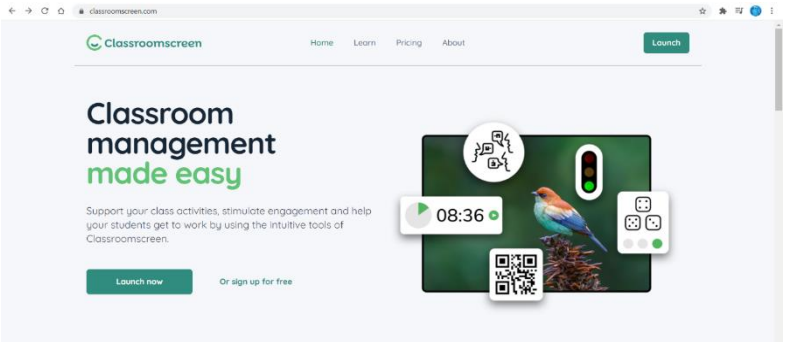
Clicking on **"activity"** opens to the left all the activities (changes) made on the **miro** board.

k. Action button to expand or collapse the **E** taskbar.

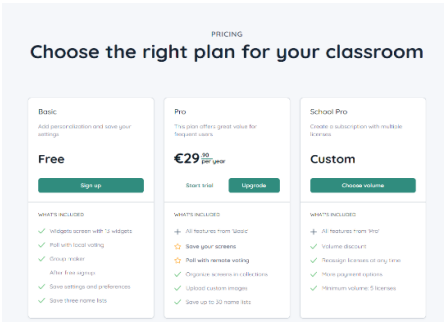
CLASSROOMSCREEN

Classroomscreen is an online tool for organizing and managing classes that can be used in the classroom, on a whiteboard or practically. Classroomscreen allows you to create a wallpaper with up to 14 widgets (stopwatch, drawing tool, random name selector, traffic light, text box, polls, and more) - you can keep the widgets of your choice and hide the others. The tool will also create student groups for you! The free version of this tool is a great way to organize your distance learning lessons.

The purpose of using the application is to manage content, behaviours, and procedures in the classroom. This tool is available on any device with a web browser, does not require any special software, The free account includes all 13 widgets, 3 checklists including up to 100 students on each list, polling options, creating workgroups ... and the possibility to save all personal settings. To access the application, type in the browser classroomscreen.com and it is displayed:

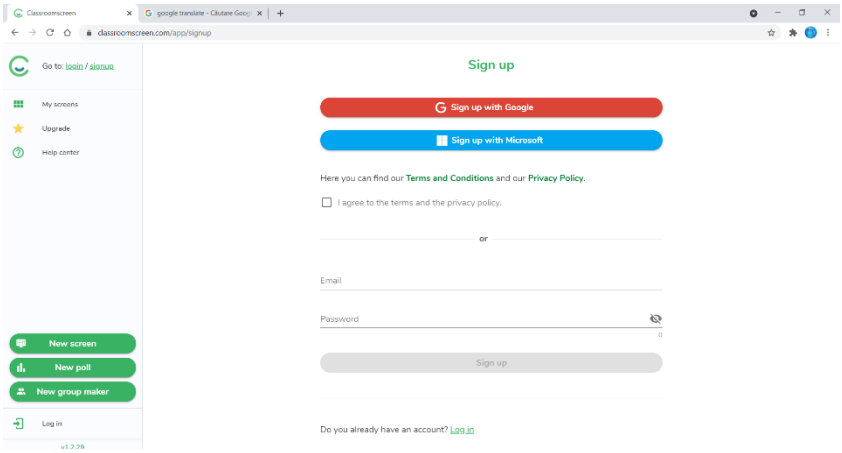


We can launch the application without creating an account by clicking on **Launch** or **Launch now** or by clicking on **Pricing**, we can choose the right plan.

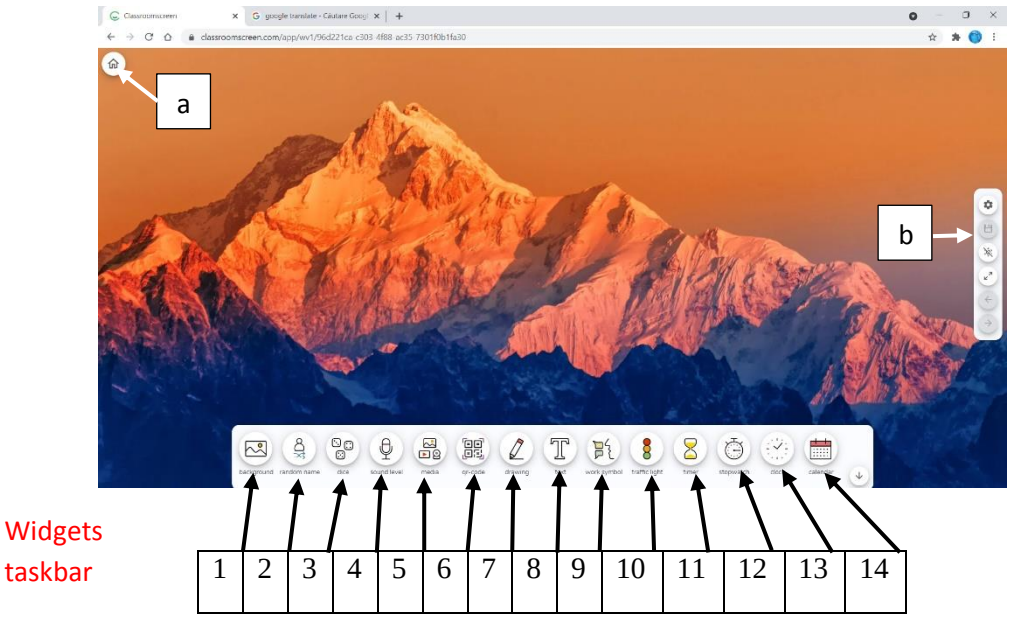


Obs.: We can use the application very well without an account, we just can't save the student lists and customize the settings.

To log in we can use a Google or Microsoft account.



After connecting a picture with all widgets will be displayed.

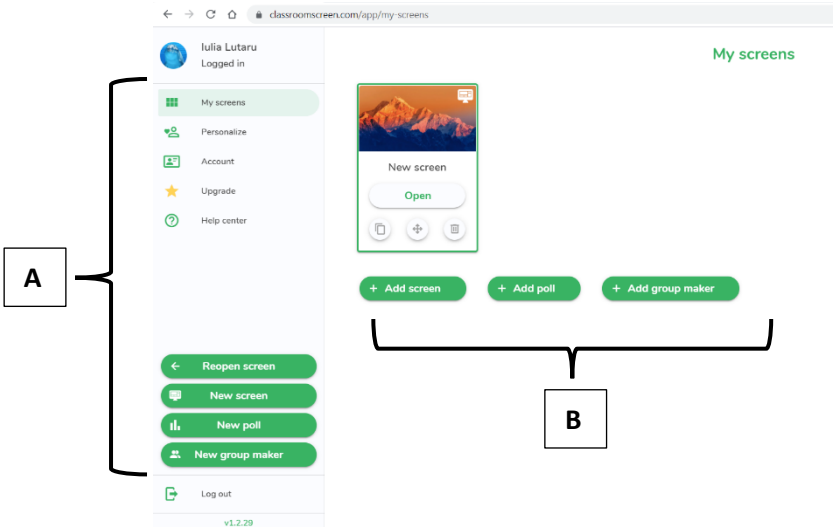


This image shows us all the options of the widget: background, random name selector, dice, sound level, media support (add images, videos and more), QR code generator, drawing tool, text box, working symbols (to show if

students should work with a partner or in a group), traffic light, stopwatch, clock and calendar.

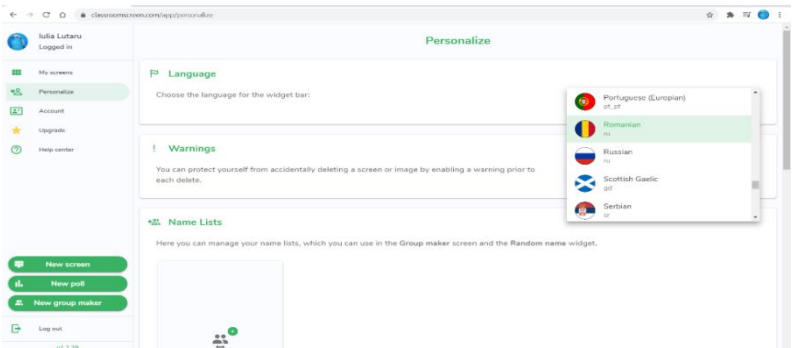
By clicking the right bottom arrow from widgets, we can hide them or not.

a - Home button

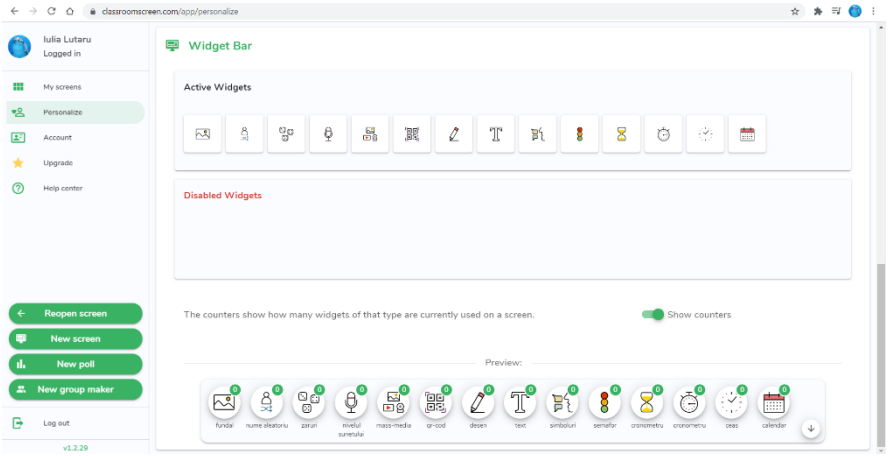


The buttons displayed in the ***A area***, are: **My screens**, **Personalize**, **Account**, **Upgrade**, **Help center**, **Reopen screen**, **New screen**, **New Poll**, **New group maker**

From **Personalize**, we can change the language for the 13 widgets of the application, create list of students.



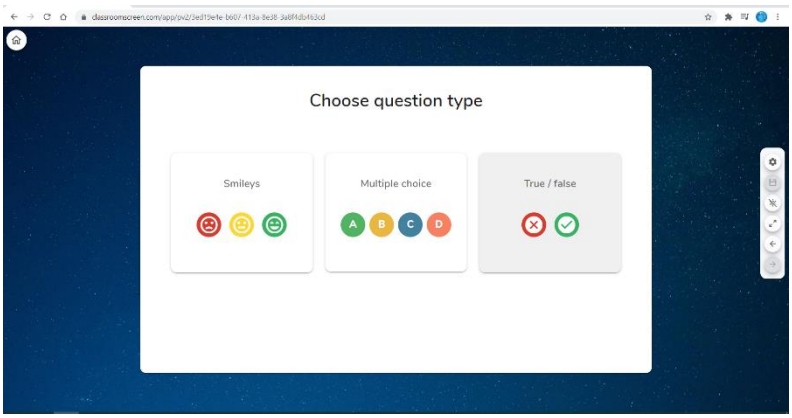
Also from **Personalize** we can disable widgets enable/disable any time a widget is opened on the screen.



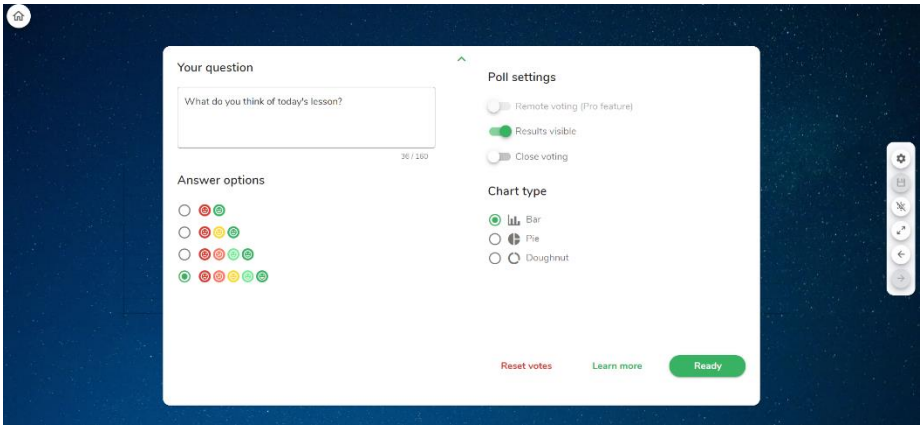
Activating the button **My screen**, will display the existing screens, or we can add new ones.

At **Account** we can customize our account, **Upgrade** can change to a new type of account (paid), **Help center** has explanations, descriptions of the application, **New screen** adds a new screen, **New poll** creates polls, **New group maker** creates groups of students for teamwork.

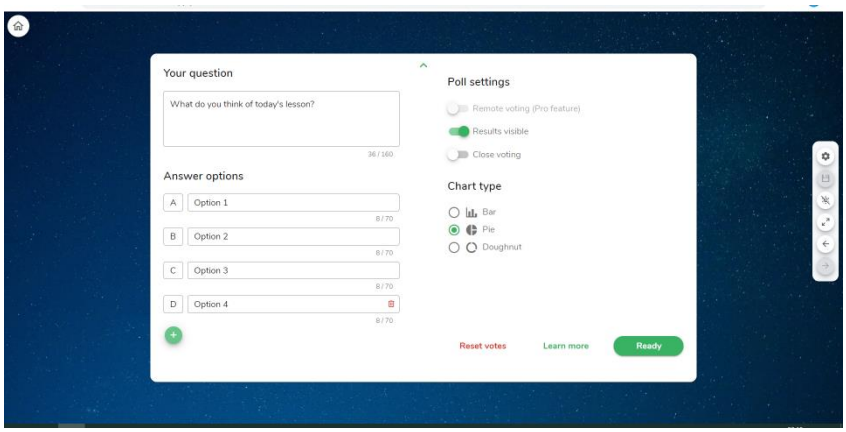
On activating **New poll** a new screen with the 3 types of polls with emoticons multiple choice and true / false is displayed.



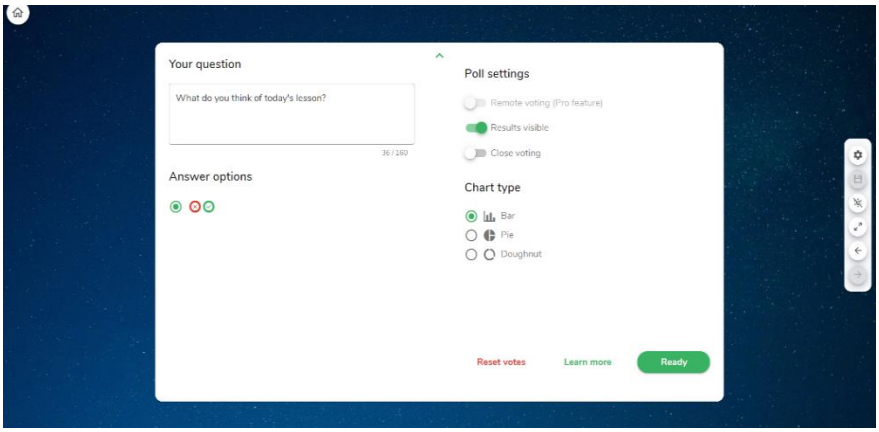
- **emoticons** -type the questions at **Your question**, answer options (from „sad" to „happy"), diagram type (bars, pies, doughnut) and we can activate the end of voting.



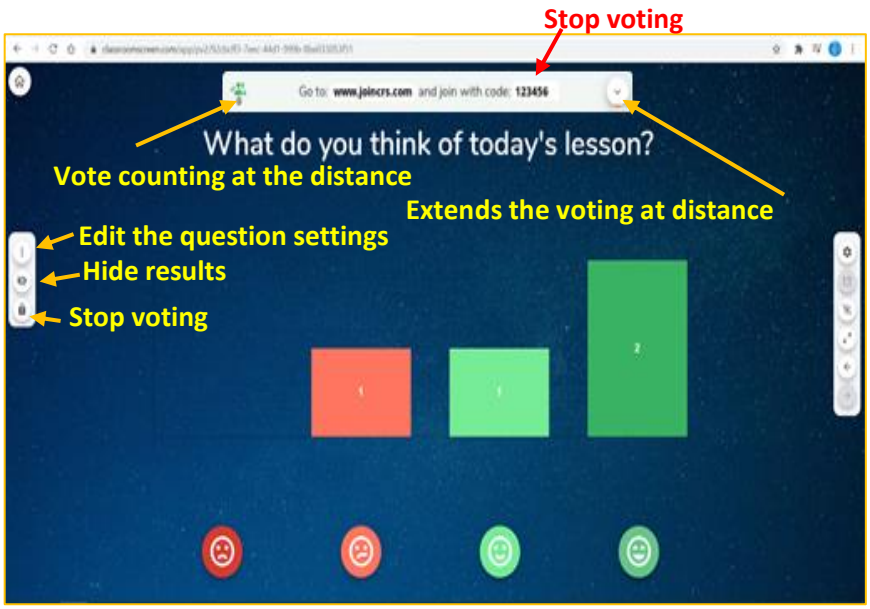
- **multiple choice** – on the answers options there are A, B, C, D variants, and at the + sign we can add more answers and we can delete, if we want, the last remaining answer. (E.g., we can delete answer D, being the last one, but if we still want to delete we can delete answer C which meanwhile became the last answer).



- **True / false** -the answer has as only true or false options.

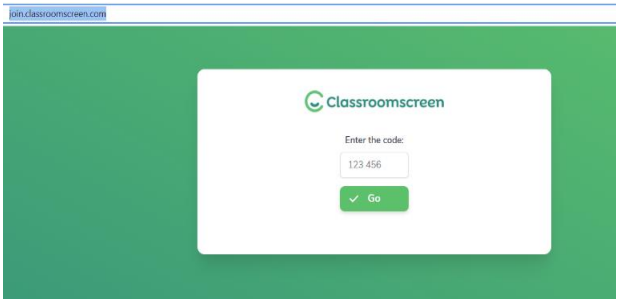


Regardless the type of poll we use, at the end click on **Ready** and the voting screen is displayed.



The students type in browser **https://joincrs.com/** (or **https://join.classroomscreen.com/**).

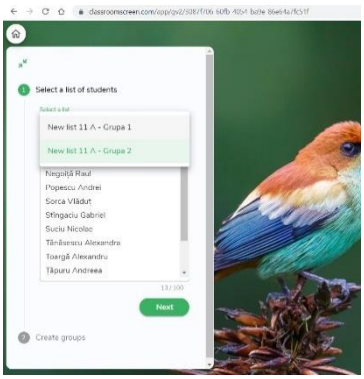
On their screen is displayed:



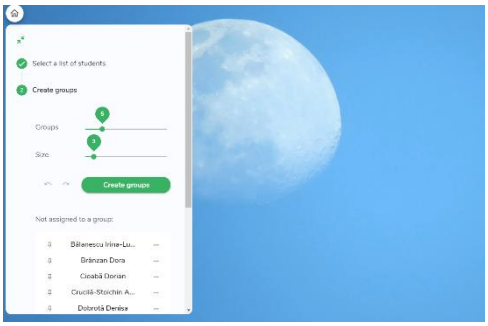
Students enter the code given by the teacher and then click on GO and answer the survey.

New group maker-teacher creates work groups from a list of students, specifying the number of groups and the number of students in a group.

- select the desired list



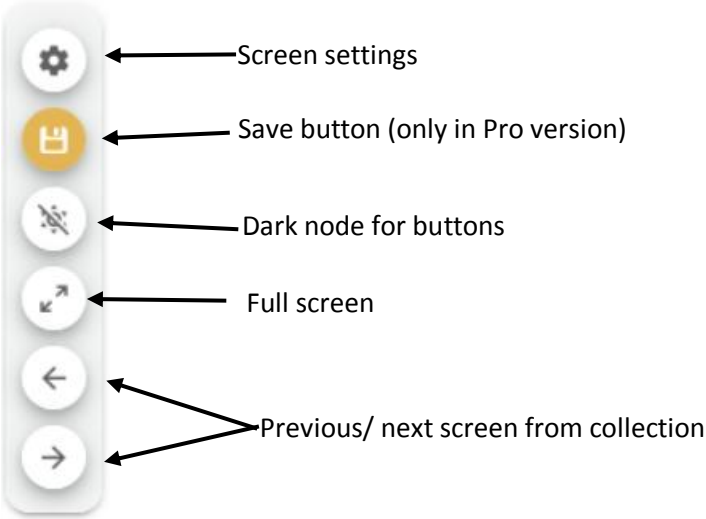
- click on **Create groups** or **Next**, the number of groups is chosen, and the number of students in a group is automatically calculated.



- press the button **Create groups**.

Area B – also called **My screen** we can add a new screen, new poll and create new groups.

Obs.: Only the **Pro** version allows saving the screens, polls and groups.



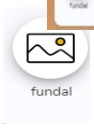
Screen settings:

- **Screen options**: we can give the screen name, description, download a background (png image) from the computer, take a screenshot.
- **Local background**: you can enable / disable image deletion and you can add any image from your computer as a background.
- **Wallpaper:** we can choose wallpaper from an image library.
- **Animated background:** we can choose an animated image from an animated library as a background.
- **Colored background:** we can choose for the background a color from the predefined ones.

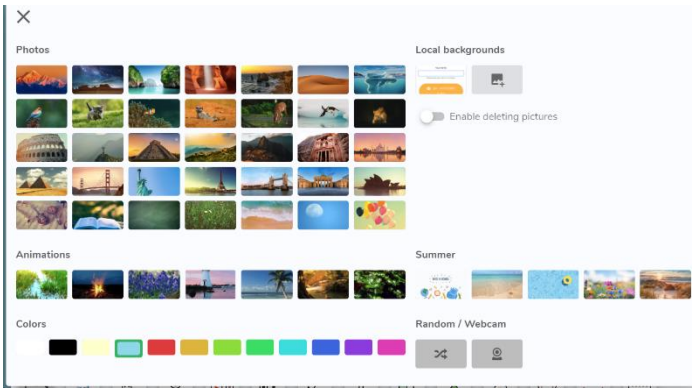
Widgets toolbar:

When a widget is active, you will see a green circle appearing at the edge of the button. The number in the green circle indicates how many of these widgets are active.

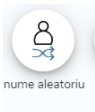
1. **Background**



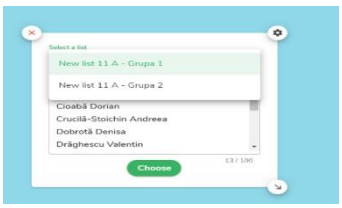
- Clicking on the **background** opens a dialog where we can change the wallpaper as in the **Screen settings**. After finishing the settings, the window closes from **X** in the upper left corner.

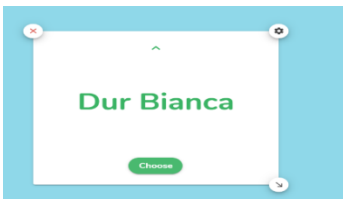


2. **Random name:** used to randomly choose the student who will answer.



- By activating **random names**, a window appears where we can select a list of students, if the list was created from **Personalize** or copy from a document the students of the class (where we have class) and paste in the list. In order for the application to select a random name from the list, click on the **Choose** button.





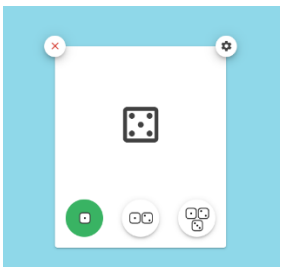
Obs .:

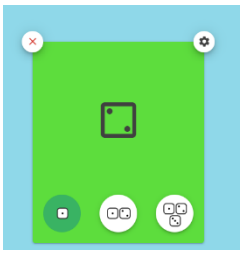
- By clicking **X** (upper left corner of the widget window) we can close it, ie it is no longer on the screen).
- From the arrow in the lower right corner, enlarge / reduce the window.
- From the settings, top right corner, we change the options of the widget (we can remember the extracted name so as not to accidentally appear at a later extraction, activation / deactivation of the animation, activation / deactivation of the sound.) And the background of the widget.

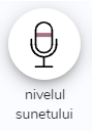
3. **Dice**: 

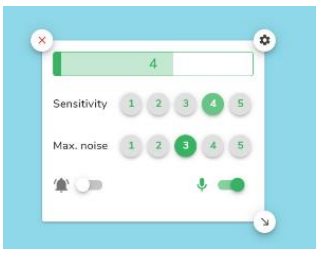
- is used as a game for choosing a number, which can represent the numbers in the mark register (order number of students) or to randomly choose the item from a set of questions.

As widget options we only have wallpaper and background setting where we can change the background.

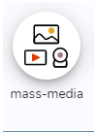




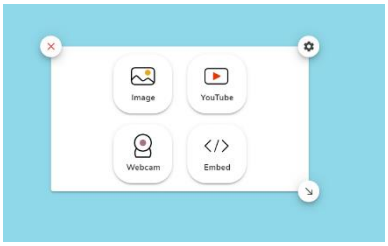
4. **Sound level**: 



- is used to change the sensitivity, sound or turn off the microphone, and from the settings we can change the color of the widget.

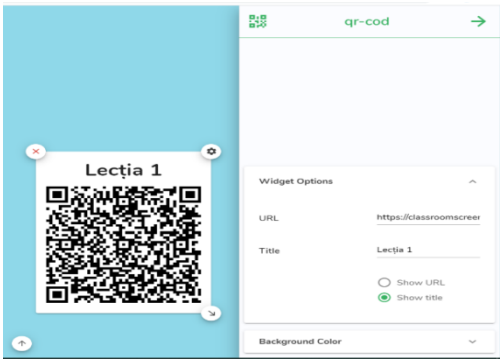
5. **Mass-media**: 

- is used to insert pictures and videos from youtube, webcam.



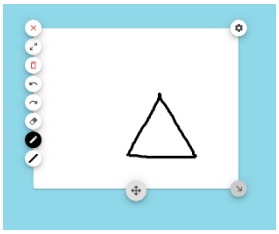
6. QR - code:

- The application generates a QR code for the screen in use. In the settings we can choose the display of the URLs of the screen or the title given by us, respectively the background color for the widget.

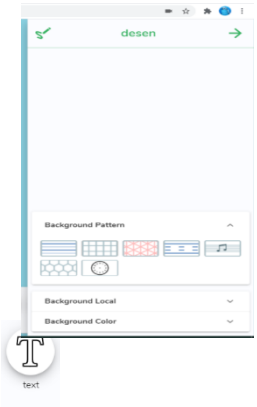


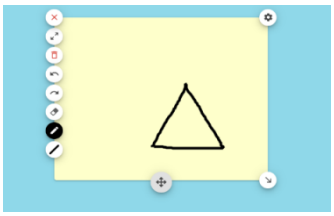
7. Draw:

- is a drawing sheet that has as tools: maximizing the window (full screen), basket, undo, redo, eraser, pencil color, pencil thickness.



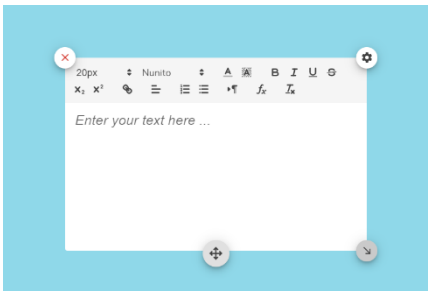
At the window settings we have options for the background pattern (math, music, type 1 background, type 2 background, etc.), local background, color background.





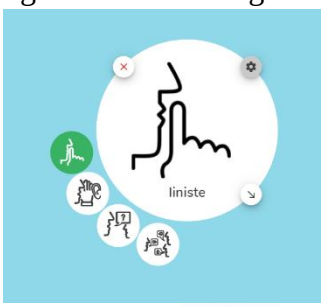
8. Text:

A box is displayed in which we can edit the desired text with different formats: font type, size, alignment, color, indexes, power, highlight, etc. In settings we can change the background color of the widget.



9. Symbols:

It is used to display symbols such as silence, whisper, asks the neighbor, work together during classes. In the settings we can change the background of the widget.

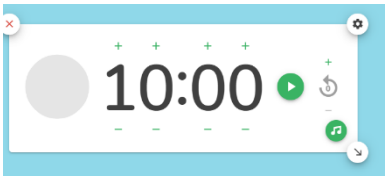


10. Traffic lights: 

This tool used to show the beginning or end of a stage of the lesson, assessment, etc. From the settings we can change the background of the widget.

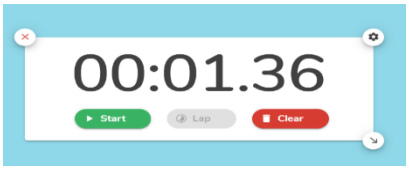
11. Timer: measures the time left 

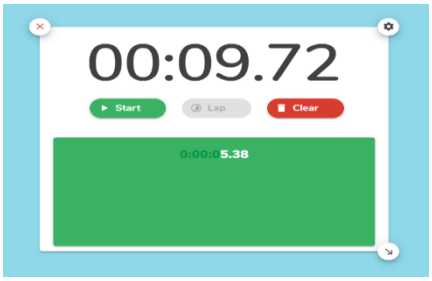
It can be used to measure the time of evaluations. We change the hour and minute from + and - to increase / decrease the minutes and seconds (the timer is initially set to 10:00). From the music sign we can change how it sounds at the end of time and in the settings we have the ability to change the background color of the widget.



12. Stopwatch: 

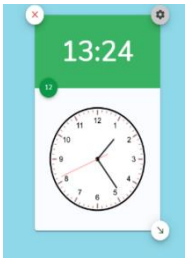
Measures the time starting from 00:00.00. There is **Start**/ **Pause**, **Lap** and **Clear** button**.**

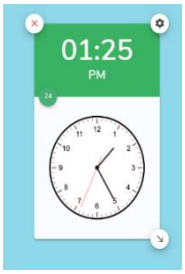




13. Watch: 

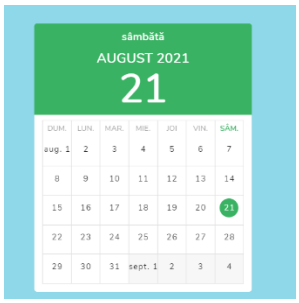
Shows the exact time and we can choose the display format 24-hour format or 12-hour AM/PM format.


13:24
17


01:25
PM
24

14. Calendar:


calendar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Kahoot

Generalities / History

The application was launched in 2013 by Johan Brand, Jamie Brooker and Morten Versvik in a joint project with the Norwegian University of Science and Technology (NTNU), which was joined by Professor Alf Inge Wang and entrepreneur Asmund Furuseth.

From the very beginning, the stated mission of the producers was to turn the learning process into a fantastic experience by combining interest in games and curiosity in a fun way.

Even if initially the application has gained notoriety in educational institutions, in recent years it is increasingly used in training and preparation processes in various fields of activity, but also in conferences, debates, etc. Starting in 2019, the platform also includes DragonBox applications for learning math, Poio for teaching children to read, Actimo for acquiring entrepreneurial skills and Drops for learning languages.

The popularity of this application in less than eight years since its launch among students and teachers is evidenced by the following indicators made public in early 2021:

-the application has been used in all countries of the world by about a billion players, of which 1.5 billion in the last year.

-Half of teachers and students in the US have used the application in the last year

Presentation

Kahoot is an online learning platform based on the game, in the form of tests and questionnaires generated by teachers, which can be accessed by students through a web browser or even through the application. Teachers can create their own tests or use existing ones, projecting them with a video projector if the lesson is a traditional one with a physical presence or distributing them with the computer screen during online lessons, while students can send the answers with the help of any smart device connected to the internet, without the need to have an account on the application or to download it, but only based on the PIN of the game provided by the teacher.

The application is available at https://kahoot.com and in order to be used it does not have to be downloaded to your computer or smartphone, but if you want to install it, you can download it for free from Google Play, App Store and Microsoft App Store.

The minimum installation requirements for the application are:
- Windows 10 operating system
- iOS 10.0 or iPadOS operating system
- Android 5.0 operating system
- Free space between 44MB and 109 MB, depending on the version of the operating system.

Kahoot version for edcucation

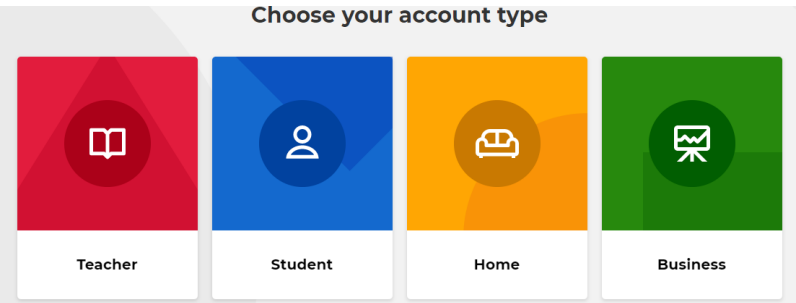
Kahoot offers users 3 versions: School, Work and Home.

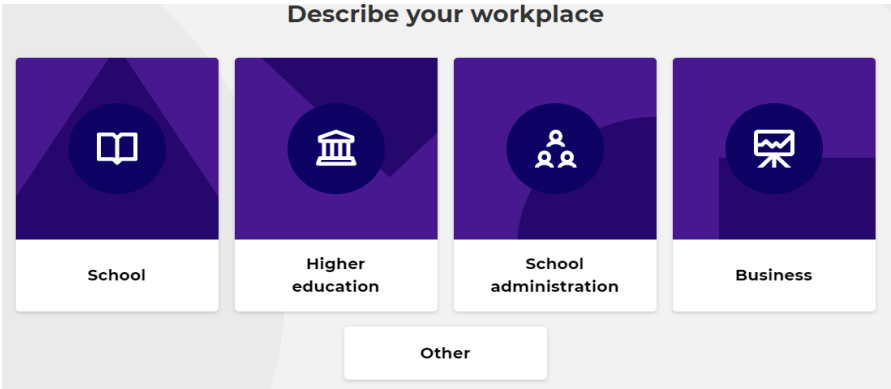
The School version provides users with 4 usage plans: Basic, Pro, Premium and Premium +. The Basic version is free and has only basic functions accessible, while the rest of the carials require the payment of a monthly or annual subscription.

The Pro, Premium and Premium + versions also have trial variants for 7 days.

To use the Kahoot application, we can structure and organize the necessary activities in 3 steps:
- Registration and creation of the teacher account;
- Creating tests;
- Launching and applying tests;

The registration and creation of the account by the teacher involves the following steps:
- access the application at https://kahoot.com/
- select the Sign Up button in the upper right corner of the site.
- the type of account is established, in this case the Teacher type is chosen





- the place of work is specified, in our case - School / School Administration.
- to create the account you need the email address, or you can choose to use Gmail or Microsoft accounts.
- specify the application variant you opt for: Basic, Pro, Premium, Premium +
- the username and name of the school are specified and the application is ready for use.

It is recommended that you check your personal details before use by selecting the Settings button at the top right.

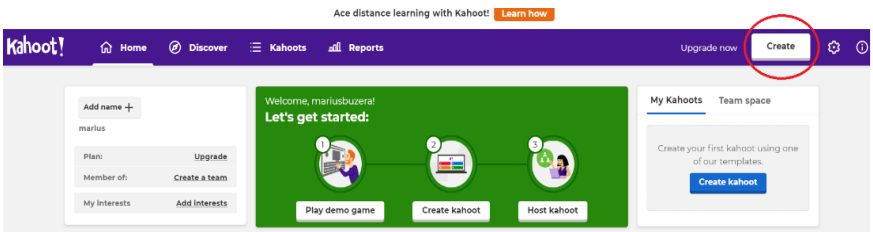
Attention - even if students do not need to create accounts to use the app in the classroom, they can create accounts and take private tests, but those under 13 cannot search for or share Kahoots tests.

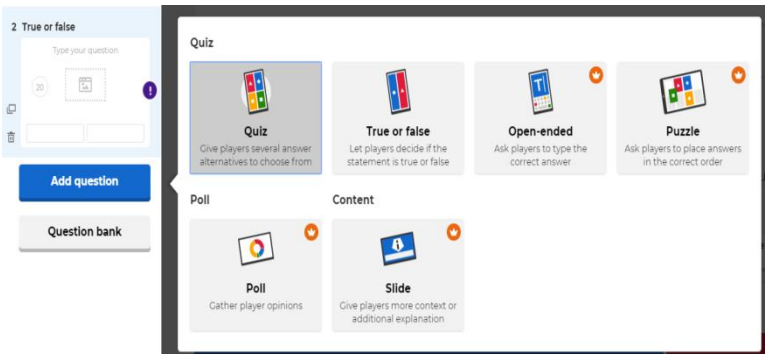
To create a Kahoot test the teacher will have to go through the steps:

-click on the Create button in the upper right corner of the screen.

-select one of the options: Create - New kahoot, Template - Kahoot! for formative assessment, Template - Get to know your teacher. To create a now kahoot test it is recommended to use the Create - New kahoot option.

-the test is created by establishing for each question its type, selecting the Add question button.



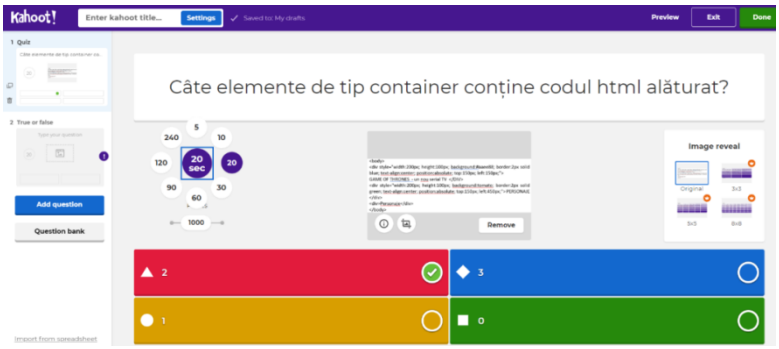


As can be seen from the image, only the Quiz and True and False versions are available for the Basic version. Quiz - allows you to create a multiple choice question and True and False - creates a question with a True or False answer.

For each question you can: set the solving time, associate images, movies, sound files. Images can be personal images from the teacher's computer, or images from the application library, and media files can be personal or uploaded from YouTube.

Questions are limited to 125 characters and can also be uploaded via a spreadsheet. After entering the answer options, click on the option that is the correct one. The application allows you to set one or even all variants to be correct. Once the questions are entered, they can be edited, moved or even deleted.

-after entering all the questions, click on the Enter Kahoot title button, where you enter: the title of the test, a description of it and who has the right to see the test (private - Only you or public - Everyone). At the end, select the Done button.



The test can be edited at any time to add or modify questions.

To run the Kahoot test, the teacher must go through the steps:
- select the Kahoots button at the top left of the main page;
- choose the way in which this test will be "played", selecting one of the two options Teach or Assign. In the first variant the teacher assists the students during the test, which takes place in the classroom, and in the second variant the test can be taken by students from other locations. Next, choose one of the two options: Classic (player vs. players) or team (team vs. team). The game will show the PIN code of the game, which the students will use to connect

- students will connect with the help of the mobile device to the address kahoot.it and will enter the PIN code of the game. To connect students can use the real name or a nickname.
- after the launch of the test by teachers, students will analyze the question and answer on the mobile device, choosing the correct option. At the end of each question, the application will display the ranking with the first five students in descending order of the scores obtained.

- at the end of the game, the results are centralized and can be analyzed later by to the teacher.

Kahoot allows the simultaneous application of several tests, without the need for students to log out and change their name / pseudonym.

To apply a Kahoot test, the teacher needs a computer connected to the Internet to launch the test, a video projector to project it, and students can use their own smartphones or other digital devices.

Unlike other applications of this type, in the Challenge function the teacher can assign tests as homework that students solve at home in the mobile application in the form of games.

Certification

For teachers, technology specialists, administrators and other categories, the application allows you to obtain certifications after taking courses offered for free. Currently, the training program consists of three levels: bronze (beginner), silver (intermediate) and gold (advanced). Going through them involves the study of a documentation provided and the completion of tasks at the end. The score required for promotion is 80%, ie at least 8 out of 10 questions must be answered correctly.

Conclusions

Even though it is a relatively new application, Kahoot has aroused the interest of academia, which has conducted several studies on its advantages and disadvantages. Thus, the Kahoot application helps to support students' learning, providing immediate feedback. Kahoot also offers the opportunity to assess not only students' conceptual understandings, but also to support the construction of new knowledge and understandings through additional explanations during or immediately after the completion of the game. Raymer (2013),

Applications like Kahoot are a great choice for teaching activities, given the wide access of students to mobile devices, wi-fi availability and their affinity for computer games. (Carolyn, LaRosa, 2017). These Elearning tools add positive energy to classes, which translates into better understanding and motivation. Perhaps most significantly, “gamification” of learning increases student involvement by appealing to all students, even the most introverted, combining a fast-paced cooperative learning environment and friendly competition (Kapp, 2012).

Other studies have shown that the Kahoot app has helped to create a learning experience that has been described as "relaxed", which has contributed to a useful dynamic of classroom involvement. This is considered very useful for the reflection of lectures and class discussion, especially in courses lasting more than 1 hour. (Licorish, Owen, Ben, Li, 2018)

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Note: *The material contains information made during the activities or dissemination of the products of the Erasmus + project "Integrating technology in the teaching process, path towards building 21st century skills". Part of the material was presented in the book Instrumente digitale pentru educație, Publishing House Revers, Craiova.*

OPTIONAL CURRICULUM

Chapter 4

MODERN METHODS OF ENVIRONMENTAL QUALITY ANALYSIS

Modern methods of environmental quality analysis

Introduction

Water is essential for life on our planet. To thrive, the planet's ecosystems, society and economy all need fresh and clean water in sufficient quantities. For many years, protecting the health of EU citizens through safe access to quality drinking water has been one of the elements of the EU policy.

Drinking water is intended for human consumption: water in its initial state or after treatment, intended for drinking, cooking, food preparation or other household purposes. It can be supplied at the tap, in a tank, in bottles or in containers.

Since 1975, the European Union has adopted a number of water laws aimed at protecting consumers and users of water from harmful effects.

In 1980, a directive on standards for water intended for human consumption, known as the "Drinking Water Directive", was adopted. It was subsequently revised in 1998 and is currently being revised.

A first directive on drinking water quality in the Member States was adopted in 1975. Subsequently, a new directive on standards for water intended for human consumption was adopted, namely the Drinking Water Directive. Its aim is to protect human health from the negative effects of any contamination of water intended for human consumption. Adopted in 1980, the directive was revised in 1998.

The Drinking Water Directive sets quality standards for drinking water in the EU for 48 parameters that need to be regularly monitored and analyzed by Member States. These parameters are classified into three categories:

• microbiological parameters (important for human health), which include in particular the parameters E. coli and enterococci;

• chemical parameters (important for human health), ranging from specific substances, such as various metals and organic compounds, to generic substances, such as pesticides and by-products of disinfection;

• indicator parameters, which provide information on water treatment processes and organoleptic qualities (such as the color, smell and texture of a substance) and the aesthetics of drinking water. This category consists of a combination of microbiological, chemical and radiological parameters. Failure to observe an indicator parameter is a signal that indicates a possible water supply problem. Such an issue needs to be examined, in particular from the perspective of possible risks to human health. As part of the requirements set by the Drinking Water Directive in relation to the assessment of drinking water quality, several million analyzes are carried out each year in the Member States. For example, in the 2011-2013 reporting period, 4.1 million analyzes were performed for microbiological parameters, 7.1 million for chemical parameters and 17.5 million for indicator parameters. If at least 99% of all analyzes carried out in a given year meet the established standard, the Member State shall be deemed to comply with the value parameter set out in the Drinking Water Directive.

In the case of indicator parameters, exceeding the standard does not necessarily mean a situation of non-compliance with the directive because, in most cases, there is no direct threat to human health. Even if most of the indicator parameters do not pose a direct threat to human health, they could have an indirect impact on the quality of water in appearance, taste or smell and could therefore influence the degree of acceptance by consumers. For example, the threshold set in the Drinking Water Directive for the iron parameter is 200 µg / l. If the iron concentration is 300 µg / l, the water has an obvious taste, becomes cloudy and stains. Such a result is not to the liking of consumers. From the point of view of human health, the permissible iron concentration is 2 000 µg /

l, thus far exceeding the level which is in fact acceptable to consumers. Indicator parameters can also compromise proper water treatment. For example, the presence of organic matter could result in improper disinfection.

In general, the quality of drinking water in the European Union is good.

There is a high availability of safe drinking water throughout the EU. However, there are still regions that do not provide citizens with access to water supply services. According to Eurostat17, the rate of population connected to the public water supply system differs significantly between Member States. This rate is the lowest in Romania, where only 62% of the population is connected to the public water supply network.

Collecting water sample and their storage

Sampling / sample collecting is the action of taking a piece of water considered representative in order to determine some well-defined characteristics.

In order to collect a sample of drinking water to be analyzed, we must take into account a number of factors, such as: water source, season, ambient temperature, utensils used, etc.

Collecting water samples for physical, chemical and microbiological analysis is a very important step, as the samples collected must be representative, as we must not make changes in the composition and quality of water due to poor sampling techniques or improper preparation conditions of the material used during sampling.

The water is collected for physical-chemical and microbiological analyzes in glass or polyethylene bottles with a ground or hermetically sealed stopper.

The collection vessels must be thoroughly washed to remove any traces of organic matter or impurities that could distort the composition of the sample. Washing the sample vessels will be done with a mixture of sulfochromic and detergent, followed by rinsing with tap water, then with distilled and double-distilled water, and finally drying.

Ideally, the samples should be collected in vessels made of colorless glass and resistant to chemical attack, the disadvantage of this type of material being that it is very fragile.

Precisely for this reason, the use of containers made of polyethylene, which have the advantage of good mechanical strength, but also of high chemical resistance, is used.

The **drinking water sample is collected from the tap** by collecting the sample directly in the sampling container. It can be made of plastic or glass depending on the nature of the parameters to be analyzed.

The drinking water collection techniques from the drinking water distribution network are different, depending on the location where the sampling takes place. So:

• from the distribution network (consumer tap, taps) after the water has been allowed to flow for at least 10 minutes;

• from the water tanks, from the tap located at the outlet point;

• from the treatment plant, on different stages of the process, directly from the technological flow.

For the samples that will be used for microbiological analyzes, the sampling is done as follows:

• if the water is taken from the local source and distributed on the network, the end point being a faucet, the faucet is disinfected by flaming and the water is allowed to flow for 10-20 minutes;

• adjust the water flow so as to form a water column about 1 cm in diameter;

• remove the bottle cap together with the paper cap (if a piece of string is inserted between the stopper and the mouth of the bottle, it is thrown away) and both the mouth of the bottle and its stopper are buckled;

• the bottle held by the hand from the bottom, is placed vertically under the water column and the sample is collected;

• the mouth of the bottle and its stopper are buckled again, after which the bottle is closed with the stopper and covered with the paper cap which is tied again with string.

Conservation of water samples is an important step during the collection of water samples from their conservation, because the analysis of water has a limited value if the samples undergo physical-chemical or biological changes during transport or storage.

Usually, it is advisable to pass a very short time (maximum 4 hours) between the time of collection and the analysis of the water sample.

Other important factors that may intervene in the final results of the analysis of water samples are temperature and pressure, as some gaseous substances (O_2, CO_2, H_2S, Cl_2, CH_4) may be lost. For this reason, it is recommended that on the spot, where the samples are collected, specific analyzes be performed for gas determinations, which is difficult to achieve, which is why it is

possible to proceed to the fixing of water samples. Thus, different fixing reagents are used, as follows:

• to fix the *dissolved oxygen* to a water sample with a volume of 200mL add 2mL $MnCl_2$ 50% and 2 mL mixture of KI 15% and NaOH 35%;

• for the preservation of *nitrogen forms and organic substances* in general, (microbial activity can change the balance of ammonia - nitrites - nitrates or can reduce the content of rapidly degrading organic compounds), water samples with a volume of 1000mL are collected separately, in vials into which 2mL H_2SO_4 1: 3 were introduced, the water sample being neutralized before analysis;

Samples for acidity, alkalinity, fatty acids, borates, calcium, chlorine, biochemical oxygen consumption (BOC), hardness, fluoride, tar, magnesium, humic substances, odor, taste are not preserved.

The choice of preservative or agent is made in correlation with the analytical method for determining the characteristic pursued. In case of incompatibilities between the analyzes carried out, the preservatives or the sampling containers, it is necessary to take several samples and to treat each sample according to the analysis to be carried out.

The samples are transported by car, so as to reach the laboratory as soon as possible from the time of sampling.

Bottles with water samples must be transported in isothermal packaging and protected from impact.

The samples collected will be accompanied by a collection form (Annex 1) which must include:

- general information:
  - the name and surname of the person who collected the sample;
  - locality and name of the water source;
  - water use;
  - the date, time and place of the harvest;
  - the purpose of the analysis.

PHYSICAL ANALYSIS OF WATER

Presentation

No.	Parameter	CMA Value	Unit of measurement
1	Temperature		°C
2	Smell	Acceptable to consumers and no abnormal alteration	degree
3	Color	Acceptable to consumers and no abnormal alteration	Degree
4	Taste	Acceptable to consumers and no abnormal alteration	Degree
5	Turbidity, *7)	≤ 5	Degrees or units of turbidity or units of formazine turbidity

7) The water resulting from the treatment of a surface source shall not exceed 1.0 UNT (nephelometric units of turbidity) before disinfection.

Physical analysis of tap water

The physical properties of water are represented by those characteristics that are based on objective methods of determination. They have a high value in terms of highlighting the process of water pollution. Thus, the color of the water can highlight the presence in an increased amount of water-soluble pollutants, while the turbidity shows the presence of insoluble substances.

Determining the water temperature

The principle of the method: it consists in reading the indicators of a thermometer graded in tenths of a degree after its introduction in the water to be analyzed.

The water temperature is determined only at the place of collection and, if possible, directly in the water source (for wells). In parallel with the determination of the water temperature, the air temperature is also determined.

Determining the organoleptic properties of water

The organoleptic properties of water are represented by those characteristics that impress the sense organs. The most important organoleptic properties determined are the taste and smell of water.

Organoleptic analysis of drinking water is performed in bright rooms (preferably natural light), in rooms without foreign odors, at temperatures of 20°C.

Determining the taste of water

The taste of water is given by the content in chemicals, primarily in mineral salts and dissolved gases (O_2 and CO_2). The excess or lack of some of them gives the water an unpleasant taste (fad, willow, bitter, metallic, sweet, etc.).

The particular taste of the water is determined by the presence above certain limits of mineral salts and organic substances. Thus, high concentrations of iron give the water a metallic taste, calcium gives willow taste, magnesium bitter taste, chlorides taste salty.

Drinking water must have a taste acceptable to consumers and without any abnormal changes.

The principle of the method: the assessment of the taste of water is made by people endowed with a finesse and sense of taste, so smokers, alcohol consumers are excluded, but also people who currently consume water subject to analysis. Its determination is carried out at the place of collection, but only if there is no danger of microbial, viral or intoxication contamination, being determined qualitatively and quantitatively.

Determining the water odor

Drinking water must be odorless. If present, the smell of drinking water must be acceptable to consumers and without any abnormal changes.

The principle of the method: the assessment of the smell of water is made both cold (15-30 ° C) and hot (60 ° C), by people who have not previously consumed irritating food or drink for the oral mucosa.

The determination of the odor shall be carried out at the place of collection or in the room free of any particular odor, and qualitative and quantitative determinations shall be made.

Determining the water color

Drinking water has no color; but a value of 10˚ on the Pt / Co scale is allowed, in exceptional cases up to 30˚. According to current legislation, the color of the water must be acceptable to consumers and no abnormal changes.

Color determination is done both qualitatively and quantitatively. The qualitative method consists in comparing the water to be analyzed with the double-distilled water, and in the case of the quantitative method, the color of the water is compared with a colorimetric scale prepared from platinum-cobalt or cobalt dichromate solution. However, to determine the color of the water at the

place of collection, it is more convenient to use colored discs, made of glass whose color corresponds to the intensity of the scale coloration prepared with platinum-cobalt solution.

How to perform the determination is presented in Annex 2.

Turbidity is the optical effect of scattering a luminous flux as it passes through a suspended particle medium.

It is given by the presence of very fine particles in suspension, which do not settle over time.

Water turbidity is expressed in degrees of turbidity or milligrams of SiO_2 / L water. A degree of turbidity corresponds to 1mg SiO_2 / L water.

Turbidity can be determined qualitatively, semiquantitatively and quantitatively. In the case of qualitative determination, the sample is compared with double-distilled water, in the case of semi-quantitative determination the height of the water layer from which the black band of the determining device (turbidimeter) is clearly observed is determined, and in the case of quantitative determination the Tyndall effect is used. Turbid liquid becomes bright when traversed by a luminous beam or by measuring the absorption of light by suspended particles.

PHYSICO-CHEMICAL ANALYSIS OF WATER
Presentation

No.	Parameter	CMA Value	Unit of measurement
1	pH, *3), *6)	$\geq 6,5; \leq 9,5$	pH units
2	Conductivity, *3)	2.500	$\mu S \cdot cm^{-1}$, la 20°C
3	Fixed residue	100 - 800	mg/dm^3

*3) Water must not be aggressive.

*6) For drinking water bottled in bottles or other containers, the minimum value may be reduced to 4.5 pH units. For bottled water that naturally contains or is enriched with carbon dioxide, the pH value may be lower.

Physico-chemical analysis of water

The physico-chemical properties make the transition between those physical and chemical characteristics. These include a number of characteristics that are based on both physical and chemical determinations. They are represented by pH, alkalinity and acidity of water, fixed residue.

Determining water pH

pH is the logarithm with the changed sign of the molar concentration of the solution in hydronium ions.

$$[H_3O^+] = 10^{-pH} \text{ mol/L}$$

$$pH = -\lg [H_3O^+]$$

The pH of the water varies slightly from the neutral pH due to the presence of CO_2, bicarbonates and carbonates.

Colorimetric and electrometric methods are used to determine the pH of the water.

The colorimetric method has as a principle the introduction of an indicator in the sample to be analyzed and its comparison with a calibration scale or with colored discs corresponding to different pH values. This type of determination also has some disadvantages: it cannot be used for cloudy or colored waters; waters with high salinity may change the tint of the indicator; residual chlorine may partially destroy the indicator or intensify its color.

The electrometric method has as a principle the measurement of the potential difference between a glass electrode and a reference electrode (calomel - saturated KCl) introduced in the water sample to be analyzed. It is known that this difference varies linearly with the pH of the sample.

It is recommended that the electrodes be inserted directly into the water source to be analyzed, otherwise the sample is taken and the determination is performed on the spot.

This type of method is more accurate and can also be used for cloudy or colored waters.

How to carry out the determination is presented in Annex 4.

Determining the global mineralization of water

Global mineralization is the total amount of salts dissolved in the water sample, including organic substances.

In order to study the composition of the mineralization, the temperature stability of the salts must be known. So:

- *Carbonates and bicarbonates* - at a temperature close to 100° C, sodium bicarbonate (NaHCO3), calcium bicarbonate ($Ca(HCO_3)_2$) and magnesium bicarbonate ($Mg(HCO_3)_2$) begin to lose CO_2 and H_2O to transform in the corresponding carbonates (125° C the whole amount of $NaHCO_3$ passes into Na_2CO_3, for the other bicarbonates the temperature range being longer).

$$NaHCO_3 \xrightarrow{125^oC} Na_2CO_3 + CO_2 + H_2O$$

$$Ca(HCO_3)_2 \xrightarrow{t^oC} CaCO_3 + CO_2 + H_2O$$

$$Mg(HCO_3)_2 \xrightarrow{t^oC} MgCO_3 + CO_2 + H_2O$$

- *Sulfates*:
  - $CaSO_4 \cdot 2H_2O$ loses the first molecule of H_2O in the temperature range 110 ÷ 170° C, the second molecule of H_2O eliminates it at 170° C, the anhydrous $CaSO_4$ being stable at the temperature of 900° C.

$$CaSO_4 \cdot 2H_2O \xrightarrow{110 \div 170^oC} CaSO_4 \cdot H_2O \xrightarrow{170^oC} CaSO_4$$

  - $MgSO_4 \cdot 7H_2O$ eliminates the first 5 molecules of H_2O at a temperature of 140°C, the last being eliminated in the range of 200 ÷ 320°C

$$MgSO_4 \cdot 7H_2O \xrightarrow{140^oC} MgSO_4 \cdot 2H_2O \xrightarrow{200 \div 320^oC} MgSO_4$$

- Na_2SO_4 and K_2SO_4 lose water crystallization relatively easily and are stable over a large temperature range.

- *Nitrates* dehydrate easily. Magnesium nitrate does not completely lose the water of crystallization by heating in the range of 105 ÷ 110°C.
- Sodium and potassium *chlorides* become completely anhydrous by heating to 100°C; the calcium one is completely dehydrated at 260°C, and the magnesium one at 172°C.
- *Silicon dioxide* loses its water of crystallization very hard, becoming completely anhydrous by heating to 1000°C.
- *Organic matter* is generally found in polluted waters; they resist heating to 100°C, then gradually decompose as the temperature rises.

In order to be able to interpret the degree of mineralization as correctly as possible, it is necessary to determine the dry residue, the fixed residue and the calcined one.

The dry residue is all organic and inorganic substances which are dissolved in water and are not volatile at 105°C.

The principle of the method is that these organic and inorganic substances that are dissolved in water are separated by evaporation and then weighed.

The calculation formula for the determination of the dry residue is:

$$mg\ dry\ residue/dm^3 = \frac{(G_1 - G_2)}{V} \cdot 1000$$

where: G_1 – capsule weight with dry residue at 105°C, in mg

G_2 – empty capsule weight, in mg

V – volume of the water sample taken for analysis, in mL

The dry residue also contains water of crystallization and is therefore dried in an oven at 180°C, thus obtaining a *fixed residue*.

The calculation formula for determining the fixed residue is:

$$mg\ \text{fixed residue}\ /dm^3 = \frac{(G_1 - G_2)}{V} \cdot 1000$$

unde: G_1 – capsule weight with dry residue at 180°C, in mg

G_2 – empty capsule weight, in mg

V – volume of the water sample taken for analysis, in ml

By calcining the fixed residue at a temperature of 525 ± 25°C, the organic substances and part of the volatile mineral substances are lost to give the *calcined residue*.

The difference between the residue determined at 105°C and that determined at 525°C is the organic substances present in the water.

The calculation formula for the determination of the calcined residue is:

$$mg\ calcined\ rezidue = \frac{(G_1 - G_2)}{V} \cdot 1000$$

where: G_1 – capsule weight with calcined residue at 525±25°C, in mg

G_2 – empty capsule weight, in mg

V – volume of the water sample taken for analysis, in ml

Determining the electrical conductivity of water

Conductivity is the conductance of water between two platinum electrodes with an area of 1 cm^2 placed at a distance of 1 cm. The electrical conductivity of water is determined and depends on the content of electrolytes and their strength.

The determination of the electrical conductivity of a water sample is based on the property of an aqueous solution to conduct the electric current and consists in measuring the electrical resistance of a solution column of determined length and section.

Water conductivity is measured in the laboratory with devices called conductometers. Electrical conductivity values are measured at or relative to 20°C.

From the value of conductivity, assessments are made on the degree of water mineralization. The sudden change in conductivity indicates the penetration into natural water of highly mineralized wastewater.

The electrical conductivity is measured by Siemens per meter, $S \cdot m^{-1}$ and its submultiples.

How to perform the determination is presented in Annex 3.

CHEMICAL ANALYSIS OF WATER
Presentation

No.	Parameter	CMA Value	Unit of measurement
	Cl^- *3)	250	mg/l
	Ca^{2+}	100 - 180	mg/l
	Mg^{2+}	50 - 80	mg/l
	Hardness	20 - 30	German degrees
	Dissolved Oxygen	6	mg/l
	Ammonia	0 – 0,5	mg/l
	Nitrites	0 – 0,3	mg/l
	Nitrates	45	mg/l

*3) Water must not be aggressive.

*6) For drinking water bottled in bottles or other containers, the minimum value may be reduced to 4.5 pH units. For bottled water that naturally contains or is enriched with carbon dioxide, the pH value may be lower.

Chemical analysis of water

The chemical elements that enter the natural composition of water can be varied. Because they are constantly present, but also due to the importance they have in the characterization of water, only a few are important. For a better characterization of them they were divided into anions (chlorides, sulfates, nitrates, nitrates) and cations (Na, K, Ca, Mg).

Determining the chlorine ion concentration (Cl^-)

Chlorides in natural water can come from the soil or from pollution of human or animal origin, when the concentration varies over time.

To determine them, *the Mohr method* or *the Charpentier - Volhard method* can be used.

The Mohr method has as a principle the reaction between chlorine ion and silver nitrate in a neutral medium and the appearance of a precipitate (AgCl). The end of the reaction is indicated by potassium chromate (K_2CrO_4).

$$Cl^- + AgNO_3 \rightarrow AgCl\downarrow + NO_3^-$$
$$AgNO_3 + K_2CrO_4 \rightarrow Ag_2CrO_4 + 2KNO_3$$

The reaction cannot be specific because all halogens give the same reaction with $AgNO_3$, but due to the very low concentration in the water their interference can be neglected. The reaction can also be influenced by the presence of sulfites. Precisely for this reason, in their presence in the water sample add 1mL H_2O_2 30% or use the Charpentier - Volhard method.

The calculation formula for determining chlorides is:

$$mg\ Cl^-/dm^3 = \frac{V \cdot f \cdot 0{,}7092}{V_p} \cdot 1000$$

where: V – volume of 0.02N $AgNO_3$ solution used for titration, mL

f – $AgNO_3$ solution factor

0.7092 – the equivalent in mg of chlorine of one mL of 0.02N $AgNO_3$

V_p – the volume of water sample, mL

The method of carrying out the determination is presented in Annex 6 (Fătu (Coord), 2005).

The Charpentier - Volhard method is used if the waters contain appreciable amounts of sulphites or phosphates. The principle of this method is that in the presence of HNO_3 with an excess of $AgNO_3$ the chlorides precipitate, the excess reactant being then titrated with ammonium sulfocyanide (NH_4SCN) in the presence of iron alum.

$$AgNO_3 + Cl^- \rightarrow AgCl\downarrow + NO_3^-$$
$$NH_4SCN + AgNO_3 \rightarrow AgSCN + NH_4NO_3$$
$$Fe^{3+} + 3SCN^- \rightarrow Fe(SCN)_3$$

If sulfides, hyposulphites or organic substances are present in the water under analysis, they may introduce determination errors. Precisely for this reason, they are destroyed by oxidation with potassium permanganate.

The calculation formula for determining chlorides is:

$$mg\ Cl^-/dm^3 = \frac{(V \cdot f - v) \cdot 3{,}55}{V_p} \cdot 1000$$

where: V – volume of $AgNO_3$ solution introduced into the sample, mL

f – $AgNO_3$ solution factor

v – the volume of 0.1N NH_4SCN used to titrate the excess of $AgNO_3$, mL

3.55 – the equivalent in mg chlorine of one mL of 0.1N $AgNO_3$

V_p – volume of water sample, mL

How to carry out the determination is presented in Annex 5.

Determining the calcium in water

Calcium is the element present in all waters, especially in the form of bicarbonate, sulfate or chlorides. It is known that excess calcium gives the water a willow taste. Calcium present in water can be determined using the complexometric method. The principle of this method is that calcium ions have the property of forming stable complexes with the sodium salt of ethylenediaminetetraacetic acid (EDTA) at pH between 12 ÷ 13. The end of the reaction is shown by murexid (ammonium salt of purpuric acid), used as an indicator, which changes from pink to purple.

The calculation formula for determining the calcium ions present in the water sample is:

$$mg\ Ca^{2+}/dm^3 = \frac{V \cdot f \cdot 0{,}4008}{V_p} \cdot 1000$$

where: V – volume of 0.01M complexon solution used for titration, mL

f – complexon solution factor

V_p – volume of water sample to be analysed, mL

0.4008 – equivalent in mg Ca^{2+} of one mL of complexon 0.01M

The volume of the water sample to be analysed must ensure a Ca^{2+} content between 5÷10mg. However, there are waters that contain large amounts of calcium bicarbonate, which when NaOH buffer is added precipitates as calcium carbonate, and the result is wrong.

$$Ca(HCO_3)_2 + 2NaOH \rightarrow CaCO_3\downarrow + Na_2CO_3 + 2H_2O$$

To avoid this the sample of water taken in the analysis is evaporated to dryness, then the resulting residue is treated with HCl to decompose the bicarbonates. The excess HCl is then evaporated and the sample is diluted to 50 mL with double-distilled water and then the appropriate steps are followed to determine the calcium content.

How to perform the determination is presented in Annex 6.

Determining the magnesium in water

Magnesium is found in water in the form of sulfates, and in high concentration it gives the water an unpleasant taste and a laxative effect. It can also be found in water samples and in the form of chlorides or bicarbonates.

The amount of magnesium in the water sample can be determined complexometrically or by calculation.

The complexometric method for determining the amount of magnesium present in the water sample has as principle the titration of magnesium ions with a solution of complexon III, after the initial removal of calcium ions as calcium oxalate.

The calculation formula for determining the magnesium ions present in the water sample is:

$$mg\ Mg^{2+}/dm^3 = \frac{V \cdot f \cdot 0{,}2432}{V_p} \cdot 1000$$

unde: V – volume of 0.01M complexon III solution used for titration, mL

f – complexon III solution factor

V_p – volume of water sample to be anlaysed, mL

0.2432 – the equivalent in mg Mg^{2+} of one mL of 0.01M complexon

The calculation method takes into account the volume of complex III solution used for titration when determining the total hardness and the volume of complex III solution used for titration when determining calcium ions.

The calculation formula for determining the magnesium ions present in the water sample is:

$$mg\ Mg^{2+}/dm^3 = \frac{(V_1 - V) \cdot f \cdot 0{,}2432}{V_p} \cdot 1000$$

where: V_1 – volume of 0.01M complexon III solution used in titration to determine total hardness, mL

V – volume of 0.01M complexon III solution used for titration to determine calcium ions, mL

f – complexon III solution factor

V_p – the volume of water sample to be analysed, mL

0.2432 – the equivalent in mg Mg2 + of one mL of 0.01M complexon

How to carry out the determination is presented in Annex 7

Simultaneous determination of calcium and magnesium in water

The method has as principle the simultaneous titration, in the same sample, with complexon III of calcium and magnesium ions, by changing the pH of the sample.

The calculation formula for determining the calcium ions present in the water sample is:

$$mg\ Ca^{2+}/dm^3 = \frac{V \cdot f \cdot 0{,}4008}{V_p} \cdot 1000$$

where: V – volume of 0.01M complex solution used at the first titration, mL f – complexon solution factor

V_p – volume of water sample to be analysed, mL

0.4008 – the equivalent in mg Ca^{2+} of one mL of 0.01M complexon

The calculation formula for determining the magnesium ions present in the water sample is:

$$mg\ Mg^{2+}/dm^3 = \frac{V_1 \cdot f \cdot 0{,}2432}{V_p} \cdot 1000$$

unde: V_1 – volume of 0.01M complexon III solution used in the second titration, mL

f – complexon III solution factor

V_p – volume of water sample to be analysed, mL

0.2432 – the equivalent in mg Mg^{2+} of one mL of 0.01M complexon

Determining the water hardness

The hardness of the water is given by the presence of all the cations in the water except the cations of the alkanine metals. Because calcium and magnesium cations are found in water in much larger amounts than other cations, the determination of hardness will consist in determining the concentration of calcium and magnesium ions in the working sample.

It is known that hard waters have an unpleasant taste, and when boiled the excess salts are deposited on dishes, boilers, pipes, prevent a good cooking of vegetables, form with soaps products and calcium salts that do not foam. However, hard waters also have some advantages when used: they are healthier, they have a less harmful action on the heart; used in brewing a higher quality drink is obtained.

There are 3 types of hardness: total hardness (D_T), temporary hardness (D_K) and permanent hardness (D_P).

Conventionally, hardness is expressed in degrees of hardness, which differ from country to country. Thus, 1 French degree of hardness is equal to 10mg $CaCO_3$/L; 1 German degree of hardness is equal to 10mg CaO/L. In our country, the German degree was adopted to express harshness.

Determining the total hardness

The type of hardness of particular interest is the total hardness, also known as the hydrotimetric titer (T_H).

This type of hardness corresponds to the sum of the concentrations of calcium and magnesium ions present in the sample under analysis.

For the determination of this type of hardness the most frequently used methods are the volumetric ones and especially the complexometric ones.

The principle of the method is based on the property of calcium and magnesium ions to form chelated complexes with the sodium salt of ethylene-diamine-tetraacetic acid, colorless, soluble and inseparable. The end of the reaction is marked by specific indicators, the most used being Eriochrome Black T.

The calculation formula for determining the total water hardness is:

$$degrees\ total\ hardness/dm^3 = \frac{V \cdot f \cdot 0{,}561}{V_p \cdot 10} \cdot 1000$$

where: V - volume of 0.01M complexon solution used for titration, mL
f - the factor of the complexon solution
Vp - volume of water sample to be analysed, mL
0.561 - the equivalent in mg Cao for 1mL 0.01M complexon III solution
10 - mg CaO corresponding to a degree of hardness

If a volume of complexon III solution greater than 5 mL is consumed by titration, a sample with a lower volume will be used.

How to carry out the determination is presented in Annex 8.

Determining the temporary hardness

It is also known as complete alkalimetric titer (T_{AC}) and is given by calcium and magnesium bicarbonates present in water. Other authors consider that this type of hardness corresponds to total alkalinity, carbonate and bicarbonate.

The principle of the method is to neutralize bicarbonates and calcium and magnesium carbonates by titration with a mineral acid in the presence of an indicator.

$$Ca(HCO_3)_2 + 2HCl \rightarrow CaCl_2 + 2CO_2 + 2H_2O$$
$$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$$

For the determination, a test sample with phenolphthalein is initially performed, ie in the water taken in the analysis a few drops of indicator (phenolphthalein are added, and if the sample is reddened the water is alkaline and then determinations of temporary hardness will be made. with phenolphthalein is negative, the water does not contain carbonate and bicarbonate, so it has no temporary hardness.

The calculation formula for determining the temporary water hardness is:

$$degrees\ temporary\ hardness/dm^3 = \frac{V \cdot f \cdot 2{,}8}{V_p \cdot 10} \cdot 1000$$

where: V - volume of 0,1N HCl solution used for titration, mL
f – 0.1N HCl solution factor
Vp - volume of water sample to be analysed, mL
2.8 - the equivalent in mg Cao for 1mL of 0.1N HCl solution
10 - mg CaO corresponding to a degree of hardness

Determining the permanent hardness

Permanent or non-carbonated hardness is due only to calcium and magnesium chlorides and sulphates which persist after the decomposition of carbonates and bicarbonates by boiling the water sample. It is equal to the difference between the total hardness and the temporary hardness.

It can be determined by calculation after the simultaneous determination of calcium and magnesium in water.

The calculation formula for determining the permanent hardness is:

$$degrees\ hardness\ /dm^3 = \frac{(V + V_1) \cdot f \cdot 0{,}5607}{V_p \cdot 10} \cdot 1000$$

where: V - volume of 0.01M complex solution used at the first titration, mL
V1 - the volume of 0.01M complexon solution used in the second titration, mL
f - the factor of the complexon solution
Vp - volume of water sample to be analysed, mL
0.5607 - the CaO equivalent of one mL of 0.01M complexon
10 - mg CaO corresponding to a degree of hardness

Determining the dissolved oxygen in water

The amount of oxygen dissolved in water depends on water temperature, air pressure and the content of oxidizable substances and microorganisms. The decrease in the amount of oxygen in the water leads to the loss of its freshness, impregnating it with a bland taste, also leading to a decrease in the self - purification capacity.

The principle of the method consists in the oxidation of manganese hydroxide ($Mn(OH)_2$) to manganese hydroxide ($Mn(OH)_3$) by oxygen dissolved in water. It, ($Mn(OH)_3$), in an acid medium, removes the iodine from the KI in an amount equivalent to the oxygen dissolved in the water and titrates with sodium thiosulphate ($Na_2S_2O_3$). The chemical reactions that take place during the chemical process are the following:

- Manganese hydroxide ($Mn(OH)_2$) is obtained by the reaction between $MnCl_2$ or $MnSO_4$ and NaOH added to the water to be analyzed:

$$MnCl_2 + 2NaOH \rightarrow Mn(OH)_2 + 2NaCl$$

or

$$MnSO_4 + 2NaOH \rightarrow Mn(OH)_2 + Na_2SO_4$$

$$2Mn(OH)_2 + \frac{1}{2}O_2 + H_2O \rightarrow 2Mn(OH)_3$$

- Acidification of the sample is performed with HCl or H_2SO_4:

$$2Mn(OH)_3 + 6HCl \rightarrow 2\,MnCl_3 + 6H_2O$$

or

$$2Mn(OH)_3 + 3H_2SO_4 \rightarrow Mn_2(SO_4)_3 + 6H_2O$$

- Adding KI:

$$2\,MnCl_3 + 2KI \rightarrow 2MnCl_2 + 2KCl + I_2$$

or

$$Mn_2(SO_4)_3 + 2KI \rightarrow 4MnSO_4 + 2K_2SO_4 + 2I_2$$

- Titration of free iodine with sodium thiosulphate in the presence of starch.

$$I_2 + 2K_2S_2O_3 \rightarrow Na_2S_4O_6 + 2NaI$$

The calculation formula for determining dissolved oxygen is:

$$mg\ O_2\ /dm^3 = \frac{V \cdot f \cdot 0{,}2}{V_p - 4} \cdot 1000$$

where: V - volume of 0.025 N sodium thiosulphate solution used for titration, [ml];

f - sodium thiosulphate solution factor 0.025N;

0.2 - the equivalent in mg O2 of 1 ml of 0.025N sodium thiosulphate solution

Vp - volume of water sample to be analysed, [ml];

4 - the amount of reagents introduced for oxygen fixation, [ml].

How to carry out the determination is presented in Annex 9.

Determining the ammonia in water

Ammonia in water results from incomplete degradation of organic substances containing nitrogen, but also from the soil. It represents the first stage of decomposition of organic substances with nitrogen content in the molecule and indicates a recent pollution of the source of drinking water.

It can be determined colorimetric because it forms a yellow-colored complex with Nessler's reagent, which can be colorimetricized.

$$2[HgI_2]K_2 + NH_3 + 3KOH \rightarrow OHg_2NH_2I + 7KI + 2H_2O$$

As a working method, for the qualitative determination, take 10mL of water sample to be analyzed in a test tube and add 2-3 drops of Nessler reagent. The appearance of a yellow color indicates the presence of ammonia in the sample, which leads to the subsequent quantitative determination of ammonia.

Quantitative determination of ammonia can be performed by the distillation method, either colorimetric (if the ammonia content is below 5mg/dm^3) or volumetric.

For the volumetric determination of the ammonia content in the water, 500 mL of water to be analyzed are distilled together with 10 mL of phosphate buffer KH_2PO_4 *și* $K_2HPO_4 \cdot 3H_2O$) and 2-3 pieces of pumice stone. The distillate thus obtained is collected in a titration vessel containing 50 mL of 0.1 H_2SO_4 $0{,}1N$ solution. Collect approximately 150mL of distillate. Excess sulfuric acid is titrated with 0,1N NaOH solution in the presence of 2-3 drops of methyl red.

The calculation formula for determining the ammonia content of water is*:*

$$mg\frac{NH_4^+}{dm^3} = \frac{(V - V_1) \cdot f \cdot 1{,}8}{V_2} \cdot 1000$$

where: V – mL 0.1N NaOH used to neutralize 50mL solution 0.1N H_2SO_4

V_1 - 0.1 N mL NaOH used to neutralize excess 0.1 N H_2SO_4 solution

f – 0.1N NaOH solution factor

1.8 – the equivalent in mg NH_4^+ of one mL of 0.1 N NaOH

V_2 – the amount of water to be analyzed, in mL

Determining the nitrites in water

Nitrites in water come from incomplete oxidation of the anomiac in the presence of nitrifying bacteria, representing a more advanced stage of the decomposition of nitrogen-containing organic substances, and their presence in water shows an older pollution.

Also, the concomitant presence of ammonia and nitrogen is a continuous pollution.
Nitrites can also come from the reduction of nitrates in the presence of a reducing flora and a higher temperature.

To determine the nitrogen content, the following steps are followed: if the test sample is colored or has suspensions, add 1 mL of $Al(OH)_3$ suspension per 100 mL of water to be analyzed, shake and leave to stand for a few minutes, then filter remove the first 10mL of filtrate). Take 50mL of the filtrate sample or sample as such (whether or not it was colorless) and neutralize to pH = 7, then add 1mL 0.5% EDTA and 1mL sulphanilic acid, stir and leave rest 10 minutes. Add 1 mL α - naphthylamine, 1 mL sodium acetate buffer and mix well. It is left to rest for another 10 minutes for the appearance of the color, then it is read with the help of the spectrophotometer at a wavelength of 520nm. The value obtained is interpolated on the curve and thus the concentration of nitrites in mg NO_2/dm^3 in the water sample is obtained.

Determining the nitrates in water

Nitrates are the final stage of oxidation of organic nitrogen. Nitrates from nitrates, as well as those from nitrites or ammonia, are a nutrient for plants and, along with phosphorus, are used in intensive cultivation in agriculture. The presence of nitrates in natural waters can be explained by the contact of water with the soil of the river basin.

The penetration of increased amounts of nitrates in the body causes the transformation of certain amounts of hemoglobin into methemoglobin. Methemoglobin cannot bind and turn oxygen into tissues, producing hypoxia. The concentration of methemoglobin in the blood depends on the nitrate content in the body. The condition is manifested especially in young children. There are known cases of intoxication of children who have consumed products that contain large amounts of nitrates. The danger of nitrates in the body lies in the fact that they, as a result of various changes, turn into nitrosamines, which have carcinogenic properties.

BACTERIOLOGICAL ANALYSIS OF WATER

Presentation

No.	Parameteer	CMA Value	Unit of measurement
	Total number of bacteria that develops at 37 °C/cm^3	< 20	**UFC/cm^3**
	Probable number of celiform bacteria (total coliforms)	0	**/100 cm^3**
	Probable number of thermotolerant coliform bacteria (fecal coliforms)	0	**/100 cm^3**
	Probable number of fecal streptococci	0	**/100 cm^3**

Bacteriological analysis of water

Bacteriological analysis of water means the determination of bacteriological pollution of drinking water. These methods of analysis determine the total number of aerobic mesophilic bacteria at 37°C, the probable number of total coliforms, the probable number of fecal coliforms and the probable number of fecal streptococci.

Determining the total number of mesophilic bacteria that grow at a temperature of 37°C

The presence of mesophilic bacteria is highlighted by seeding the sample or decimal dilutions by incorporation into a solid nutrient medium (nutrient agar) incubated at 37°C for 48 hours, followed by counting the developed colonies. The result obtained is expressed by the number of colony forming units/cm3 (CFU/cm3). The calculation formula for determining the total number of mesophilic bacteria that grow at a temperature of 37°C is:

$$Total\ number\ of\ bacteria = \frac{\sum(n \cdot d)}{N \cdot V}\ UFC/cm^3$$

where: n - the number of colonies that develop in a Petri dish;

d - the inverse of the dilution of the seeded sample;

N - number of Petri dishes taken in operation;

V - the volume of the sample to be analysed, [cm^3].

Determining the probable number of coliform bacteria (total coliforms)

The presence of coliform bacteria is highlighted by the presumption test seeding water and / or decimal dilutions in test tubes with liquid enrichment medium (bullion lauryl - sulfate, bullion lauryl - double concentrated sulfate), the positive reaction being highlighted by a confirmation test on solid medium (agar - lactose - eosin medium, methylene blue (GEAM medium)).

Determining the probable number of thermotolerant coliform bacteria (fecal coliforms)

The presence of fecal coliforms is evident from the positive vials and test tubes in the total coliform test by confirming them on a liquid selective medium (purple bromcresol lactose ball bullion (Mac Conkey medium) and bright green lactose ball bullion (BBLV)) at 44°C for 24 hours. The method of calculation is identical to that of determining the probable number of total coliforms.

Determining the probable number of fecal streptococci

The presence of fecal streptococci is demonstrated by the presumption test by seeding the sample in a number of vials and test tubes with liquid enrichment medium at 37°C. The confirmation test is evidenced by the appearance of a positive reaction in a liquid selective medium (double concentrated sodium azide broth medium) at 44°C for 24 hours or on a solid selective medium (agar medium glucose azide sodium triphenyl tetrazole chloride (Slanetz - Bartley medium) at 44°C for 48 hours. The method of calculation is identical to that of determining the probable number of total coliforms.

ANNEX 1
ACCOMPANYING SHEET OF THE COLLECTED WATER SAMPLE

General data	
Sample No.	
First and last name of the person collecting the sample	
Country where the sample was collected	
Localitaty where the sample was collected	
Date, time and place where the sample was collected	
Purpose of analyse for the collected sample	
Water temperature	
Air temperature	
Conservation method	

ANNEX 2
WATER SENSORY ANALYSIS

1. THEORETICAL CONSIDERATIONS

The organoleptic properties of water are represented by those characteristics that impress the sense organs. The most important organoleptic properties determined are the taste and smell of water.

Organoleptic analysis of drinking water is performed in bright rooms (preferably natural light), in rooms without foreign odors, at temperatures of 20°C.

2. PURPOSE OF THER WORK

Determining the organoleptic characteristics of drinking water.

The method is based on determining with the senses (sight, smell, taste) the quality indices: color, smell, taste.

3. EQUIPMENT AND REAGENTS NEEDED

- water to be analysed
- Berzelius glass
- Flat bottom glass flask
- Watch glass
- thermometer
- gas nozzle
- tripod
- asbestos sieve

4. POCEDURE

4.1. Determining the appearance

- Pour the water to be analyzed into a clean, dry flask
- Visually examine the sample

4.2. Determining the odor

- Pour the water to be analyzed into a clean, dry flask
- Cover with a watch glass
- Heats to 60°C
- Shake the content of the flask
- Lift the watch glass and draw the air from the flask

4.3. Determining the taste

- Place 200mL of water at 15-20°C in a clean dry flask
- Take 15mL and hold in your mouth for a few seconds.

5. INTERPRETATION OF RESULTS

5.1. Determining the appearance

- The water must be: clean, transparent, colorless.

5.2. Determining the odor

- The ***odor intensity*** is determined by scores from 0 to 5 as follows:

Score	***Odor intensity***
0	ODORLESS
1	VERY WEAK

2	WEAK
3	PERCEIVABLE
4	ACUTE
5	VERY STRONG

- The ***type of odor*** is determined according to the scheme below:

MOLD
FISH
SOIL
DRY WOOD
POND
AROMATIC

5.3. Determining the taste

- The taste is determined by scores from 0 to 5:

Score	***Taste Intensity***
1	VERY WEAK
2	WEAK
3	PERCEIVABLE
4	ACUTE
5	VERY STRONG

- Taste changes are due to excess salts:

Excess salts	***Changes in tastes***
Fe	Metallic taste
Ca	Brackish taste
Mg	Bitter taste
Cl^-	Salty taste
CO_2	Pungent sour taste
H_2S	Unpleasant, nauseating taste

SAMPLE NO.	**SAMPLE NAME**	**APPEARANCE**	**ODOR**	**TASTE**
1				
2				

ANNEX 3
DETERMINING THE ELECTRICAL CONDUCTIVITY OF WATER

1. THEORETICAL CONSIDERATIONS

Conductivity is the conductance of water between two platinum electrodes with an area of 1 cm2 placed at a distance of 1 cm. The electrical conductivity of water is determined and depends on the content of electrolytes and their strength.

Water conductivity is measured in the laboratory with devices called conductometers. Electrical conductivity values are measured at or relative to 20°C.

The electrical conductivity is measured by Siemens per meter, S·m-1 and its submultiples.

2. PURPOSE OF THE WORK

Determining the electrical conductivity of a water sample.

3. EQUIPMENT AND REAGENTS REQUIRED

- Water to be analysed
- conductometer
- Berzelius glass for the water sample

4. PROCEDURE

- calibrate the device with distilled water
- the electrode is inserted into the water sample whose conductivity is determined
- read the conductivity value on the conductometer scale

  The value of conductivity, determins the assessments made on the degree of water mineralization.

WATER NO.	PROVENANCE OF WATER SAMPLE	ELECTRICAL CONDUCTIVITY, µS/CM
1		
2		

ANNEX 4
DETERMINING THE WATER pH

1. THEORETICAL CONSIDERATIONS

pH is the logarithm with the changed sign of the molar concentration of the solution in hydronium ions.

$$[H_3O^+] = 10^{-pH} \text{ mol/L}$$

$$pH = -\lg [H_3O^+]$$

The pH of drinking water should be between 6.5 and 9.5 pH units.

2. PURPOSE OF THE WORK

Determining the pH of a water sample.

3. EQUIPMENT AND REAGENTS REQUIRED

- distilled water
- water to be analysed
- Berzelius glass for the water sample
- pH paper
- pH - meter

4. PROCEDURE

4.1. Determining the pH of the water sample using the pH - meter

- C alibrate the device with distilled water
  - insert the electrode into the distilled water sample
  - read the pH value on the pH meter scale (if the device works properly pH = 7)
- to determine the pH of the sample to be analysed:
  - insert the electrode into the water sample whose pH is determined
  - read the pH value on the pH – meter scale
  - write down the obtained value

4.2. Determining the pH using the pH paper

- To check the pH paper, determine the pH of the distilled water (pH = 7).
  - Insert the pH paper into the distilled water
  - The pH value is read by comparison
- To determine the pH of the analysed sample
  - Insert the pH paper into the water sample
  - The pH value is read by comparison
  - Write down the value obtained

SAMPLE NO.	PROVENANCE OF THE WATER SAMPLE	pH	
		pH paper	pH meter
1			
2			

ANNEX 5
DETERMINING THE CHLORIDES IN WATER

1. THEORETICAL CONSIDERATIONS

Chlorides in natural water can come from the soil or from pollution of human or animal origin, when the concentration varies over time.

2. PURPOSE OF THE WORK

- determining the chlorides in a water sample using the **Mohr method**

3. PRINCIPLE OF THE METHOD

- the reaction between the chlorine ion and the silver nitrate in a neutral medium and the appearance of a precipitate (AgCl). The end of the reaction is indicated by potassium chromate (K_2CrO_4).

$$Cl^- + AgNO_3 \rightarrow AgCl\downarrow + NO_3^-$$
$$AgNO_3 + K_2CrO_4 \rightarrow Ag_2CrO_4 + 2KNO_3$$

4. SUBSTANCES AND UTENSILS

- 0.1 N $AgNO_3$ solution
- 10% K_2CrO_4 solution
- 0.1 N NaOH solution or 0.1 N H_2SO_4 solution
- acid – base indicator
- burette, Erlenmeyer glasses, Berzelius glasses, graded cylinder

5. PROCEDURE

- take 100 ml of test water in an Erlenmeyer flask, neutralize in the presence of an acid-base indicator with sulfuric acid or sodium hydroxide
- take the same amount of water again and introduce the exact amount of NaOH or H_2SO_4 from the beginning to neutralize the sample
- add a few drops of potassium chromate solution
- titrate with $AgNO_3$ solution until the color changes from yellow to red - brick

The calculation formula for determining chlorides is:

$$mg\ Cl^-/dm^3 = \frac{V \cdot f \cdot 0{,}7092}{V_p} \cdot 1000$$

where: V – volume of 0.02N $AgNO_3$ solution used for titration, mL

f – $AgNO_3$ solution factor

0.7092 – the equivalent mg of chlorine of one mL of 0.02N $AgNO_3$

V_p – volume of the water sample, mL

SAMPLE NO.	PROVENANCE OF WATER SAMPLE	CONTENT Cl^- mg/dm^3
1		
2		

ANNEX 6
DETERMINING Ca^{2+} IN WATER

1. THEORETICAL CONSIDERATIONS

Calcium is the element present in all waters in the form of bicarbonates, sulfates and chlorides. Excess calcium gives the water a willow taste, being incriminated in favor of renal calculus; calcium deficiency seems to play a negative role and can cause functional heart disorders (arrhythmias) or even myocardial infarction.

2. PURPOSE OF THE WORK

- Determining the amount of Ca^{2+} in water sample

3. PRINCIPLE OF THE METHOD

- calcium ions have the property of forming stable complexes with the sodium salt of ethylenediaminetetraacetic acid (EDTA) at a pH between 12 ÷ 13. The end of the reaction is indicated by murexid (ammonium salt of purpuric acid), used as an indicator, which turns from pink to purple.

4. SUBSTANCES AND UTENSILES

- 0.01 M complexon III solution
- 1N NaOH solution
- murexid
- burette, dimensioned balloon, graded cylinder
- Erlenmeyer glasses, Berzelius glasses
- pH indicator paper

5. PROCEDURE

- take 25 ml of test water in an Erlenmeyer flask, dilute with distilled water
- add 5 ml of NaOH solution (pH = 12)
- add about 0.1 g of murexide (a spatula tip)
- titrate with complexon III solution until the color changes from pink to purple

The calculation formula for determining the calcium ions present in the water sample is:

$$mg\ Ca^{2+}/dm^3 = \frac{V \cdot f \cdot 0{,}4008}{V_p} \cdot 1000$$

where: V – volume of 0.01M complexon solution used for titration, mL

f – the factor of the complexon solution

V_p – volume of the water sample to be analysed, mL

0.4008 – equivalent in mg Ca^{2+} of one mL of 0.01M complexon

Titration of Ca^{2-} ion with complexon III solution in the presence of the murexid indicator

At the end, fill in table 1.

NO.	PROVENANCE OF THE WATER SAMPLRE	CONTENT OF Ca^{2+} (mg/dm^3 water)
1.		
2.		

ANNEX 7
DETERMINING Mg^{2+} IN WATER

1. THEORETICAL CONSIDERATIONS

- Magnesium is generally found in water in the form of sulphates and in high concentration gives the water an unpleasant taste and a laxative effect. It can also be present in water in the form of chlorides and bicarbonates.

2. PURPOSE OF THE WORK

- Determining the amount of Mg^{2+} in a water sample

3. PRINCIPLE OF THE METHOD

- Mg^{2+} ions have the property of forming stable complex combinations with complexon III solution (EDTA) at pH = 10. The end of the reaction is indicated by the eriochrome T black indicator which changes from red to clear blue.

4. SUBSTANCES AND UTENSILES

- 0.01 M complexon III solution
- Buffer solution ($NH_4Cl + NH_3$)
- Black eriochrom T
- burette, pipette, graded flask, Erlenmeyer glasses, Berzelius glasses, graded cylinder
- pH indicator paper

5. PROCEDURE

- take 25 ml of test water in an Erlenmeyer flask, dilute with distilled water
- add 1 ml of buffer solution to obtain pH = 10
- add about 0.1 g eriochrome T black
- titrate with complexon III solution until the color changes from red to persistent blue

The calculation formula for determining the magnesium ions present in the water sample is:

$$mg\ Mg^{2+}/dm^3 = \frac{V \cdot f \cdot 0{,}2432}{V_p} \cdot 1000$$

where: V – volume of 0.01M complexon III solution used for titration, mL

f – complexon III solution factor

V_p – volume of water sample to be analysed, mL

0.2432 – the equivalent in mg Mg^{2+} of one mL of 0.01M complexon

Color change at Mg^{2+} ion titration with complexon III solution in the presence of the indicator

At the end fill in the table.

No.	PROVENANCE OF WATER SAMPLE	CONTENT OF Mg^{2+} (mg/dm^3 water)
1.		
2.		
3.		

ANNEX 8
DETERMINING THE TOTAL HARDNESS OF WATER

1. THEORETICAL CONSIDERATIONS

- The hardness of the water is given by the presence of all the cations in the water except the cations of the alkanine metals. Because calcium and magnesium cations are found in water in much larger amounts than other cations, the determination of hardness will consist in determining the concentration of calcium and magnesium ions in the working sample.
- The type of hardness of particular interest is the total hardness, also known as the hydrotimetric titer (T_H).
- This type of hardness corresponds to the sum of the concentrations of calcium and magnesium ions present in the sample under analysis.
- To determine this type of hardness the most frequently used methods are the volumetric ones and especially the complexometric ones.

2. PURPOSE OF THE WORK

- Determining the total hardness in a water sample

3. PRINCIPLE OF THE METHOD

- The principle of the method is based on the property of calcium and magnesium ions to form chelated complexes with the sodium salt of ethylene-diamine-tetraacetic acid, colorless, soluble and inseparable. The end of the reaction is marked by specific indicators, the most used being Eriochrome Black T.

4. SUBSTANCES AND UTENSILES

- complexon III 0.01 M solution
- buffer solution
- black eriochrom T
- burette, graded flask
- Erlenmeyer glasses, Berzelius glasses, graded cylinder
- pH indicator paper

5. PROCEDURE

- take 50 ml of test water in an Erlenmeyer flask, dilute with distilled water
- 1 ml of buffer is added to obtain pH = 10
- add about 0.1 g of eriochrome T black
- titrate with Complexon III solution until the color changes from red to clear blue

The calculation formula for determining the total water hardness is:

$$degrees\ total\ hardness/dm^3 = \frac{V \cdot f \cdot 0{,}561}{V_p \cdot 10} \cdot 1000$$

where: V - volume of 0.01M complex solution used for titration, mL
f - the factor of the complexon solution
Vp - volume of water sample to be analysed, mL
0.561 - the equivalent in mg Cao for 1mL 0.01M complexon III solution
10 - mg CaO corresponding to a degree of hardness

At the end, fill in the table.

NO.	PROVENANCE OF WATER SAMPLE	TOTAL HARDNESS (German degrees of durity)
1		
2		

ANNEX 9
DETERMINING THE OXYGEN DISSOLVED IN WATER

1. THEORETICAL CONSIDERATIONS

- The amount of oxygen dissolved in water depends on water temperature, air pressure and the content of oxidizable substances and microorganisms. The decrease in the amount of oxygen in the water leads to the loss of its freshness, impregnating it with a bland taste, also leading to a decrease in the self - purification capacity.

2. PURPOSE OF THE WORK

- Determining the oxygen dissolved in a water sample.

3. PRINCIPLE OF THE METHOD

- oxidarea hidroxidului manganos ($Mn(OH)_2$) la hidroxid manganic ($Mn(OH)_3$) de către oxigenul dizolvat în apă. Acesta, ($Mn(OH)_3$) în mediu acid scoate iodul din KI în cantitate echivalentă cu oxigenul dizolvat în apă și se titrează cu tiosulfat de sodiu ($Na_2S_2O_3$).
- oxidation of manganese hydroxide ($Mn(OH)_2$) to manganese hydroxide ($Mn(OH)_3$) by oxygen dissolved in water. It removes ($Mn(OH)_3$)in an acid medium the iodine from the KI in an amount equivalent to the oxygen dissolved in the water and titrates with sodium thiosulphate ($Na_2S_2O_3$).

The chemical reactions that take place during the chemical process are the following:

- Manganese hydroxide ($Mn(OH)_2$) is obtained by the reaction between $MnCl_2$ or MnSO4 and NaOH added to the water to be analyzed:

$$MnCl_2 + 2NaOH \rightarrow Mn(OH)_2 + 2NaCl$$

or

$$MnSO_4 + 2NaOH \rightarrow Mn(OH)_2 + Na_2SO_4$$

$$2Mn(OH)_2 + \frac{1}{2}O_2 + H_2O \rightarrow 2Mn(OH)_3$$

- Acidification of the sample is performed with HCl or H_2SO_4:

$$2Mn(OH)_3 + 6HCl \rightarrow 2\,MnCl_3 + 6H_2O$$

or

$$2Mn(OH)_3 + 3H_2SO_4 \rightarrow Mn_2(SO_4)_3 + 6H_2O$$

- Adding KI:

$$2\,MnCl_3 + 2KI \rightarrow 2MnCl_2 + 2KCl + I_2$$

or

$$Mn_2(SO_4)_3 + 2KI \rightarrow 4MnSO_4 + 2K_2SO_4 + 2I_2$$

- Titration of free iodine with sodium thiosulphate in the presence of starch.

$$I_2 + 2K_2S_2O_3 \rightarrow Na_2S_4O_6 + 2NaI$$

4. SUBSTANCES AND UTENSILES

- 50% $MnSO_4$ solution or 40% $MnCI_2$;
  - alkaline mixture (25 g KI and 30 g NaOH is dissolved in a 100 ml volumetric flask);
  - starch, 0.5% solution;
  - sulfuric acid diluted 1: 3;
  - 0.025N $Na_2S_2O_3$ solution;
  - collection bottles with known volume (100 ml volumetric flasks can be used);
  - Berzelius glasses, Erlenmeyer glasses;
  - burette; funnel;
  - 250 ml volumetric flask, graded cylinder.

5. PROCEDURE

- fill a dimensioned flask (100 ml) with water to be analyzed to the mark and place the stopper;
- immediately add 2 ml of 50% $MnSO_4$ solution or $MnCI_2$ and 40% and 2 ml of alkaline mixture;
- put the stopper and shake the bottle;
- in the presence of oxygen a reddish-brown precipitate forms;
- leave the glass flask to rest for approx. 10 minutes for precipitation deposition;
- carefully remove 10 ml of the glass liquid;
- add 5 ml of H_2SO_4 and stir until the precipitate dissolves;
- the contents of the bottle are quantitatively transferred into an Erlenmeyer flask;
- titrate the sample with a 0.025 N $Na_2S_2O_3$ solution until a yellow coloration is obtained;
- add 1 ml of starch and continue the titration until the blue color of the starch is completely discolored.

The calculation formula for determining dissolved oxygen is:

$$mg\ O_2\ /dm^3\ = \frac{V \cdot f \cdot 0{,}2}{V_p - 4} \cdot 1000$$

where: V - volume of 0.025N sodium thiosulphate solution used for titration, mL
f - sodium thiosulphate solution factor 0.025N
0.2 - equivalent in mg O2 of 1mL sodium thiosulphate solution 0,025N
Vp - volume of water sample to be analysed mL
4 - the amount of reagents introduced for oxygen fixation, mL

Carrying out the determination is presented in Annex 10.

SAMPLE NO.	**PROVENANCE OF WATYER SAMPLE**	**O_2 DISSOLVED CONTENT mg/dm^3**
1		
2		

TERMINOLOGY

CONCEPT	DEFINITION
Sampling	Action consisting in taking a representative sample in order to examine the various defined characteristics.
Conservation	Treatment of water samples in order to maintain the water characteristics until performing analytical determinations.
Pollutant	Substance (solid, liquid or gaseous) present in air, water, soil, sludge, sediment with potential for harmful action on health, causing discomfort and / or alteration of the environment.
Suource of pollution	Place, process or activity that generates pollutants.
Sample	Ideally representative part, taken from a defined mass, intermittently or continuously, to examine various characteristics.
Average sample	Intermittent or continuous mixing, in appropriate proportions of at least two samples or parts of samples, from which the average value of the characteristic to be studied can be obtained. Sample ratios are generally calculated from time or flow measurements.
Point sample (localized)	Discrete sample taken at random (in time and or space).
Composite samples	a) samples from the entire depth: water samples taken discontinuously in a determined place of the water mass, either between the surface and the bed of sediments, or between other determined depths and then mixed. b) samples from an entire area: water samples obtained by mixing a series of samples taken at various points of the water body, at a certain depth.
Sampling point (water)	Precise position in a sampling location where samples are taken.
(Water) sampling device (equipment)	Device used to take a sample of water intermittently or continuously, in order to examine the various defined characteristics.
Raw water	Water that has not undergone any treatment or that enters the station in order to be treated.
Surface water	Water flowing or stagnant at the surface of the soil.
Wastewater	Water from the discharges of a community and can be of domestic or industrial origin.
Drinking water	Drinking water. Water of such quality that can be intended for human consumption.
Water used in industrial processes	Any kind of water used for an industrial process or for its development.
Aquifer	Formation that contains water (bed or layer) consisting of permeable rocks, sand or gravel, capable of yielding significant amounts of water.
Well; drilling	Cavity drilled in the ground for capturing water or conducting research. The wells are generally larger in diameter than the boreholes and are dug, not drilled.
Psychrophilic bacteria	Microorganisms that grow at 22°C, able to form visible colonies on nutrient media, under certain culture conditions
Mesophilic bacteria	Microorganisms that grow at 37°C, able to form visible colonies on nutrient media, under certain culture conditions.
Coliform bacteria	Lactose-positive bacteria capable of forming aerobic colonies at 36±3°C on a selective lactose-containing culture medium after 21±3 hours and which give a negative reaction to the oxidase test and a

CONCEPT	DEFINITION
	positive reaction to the β-glucuronidase test
Thermotolerant coliform bacteria	Coliform bacteria that hydrolyze ortho-nitrophenyl-β-D-galactopyranoside and develop in a liquid chromogenic medium at 44.5±0.2°C for 18-20 hours.
Escherichia coli	B-lucuronidase positive thermotolerant coliform organisms that grow in fluorogenic liquid medium after 18-24 h, at 35℃.
Enterococi intestinali	Bacteria capable of reducing 2,3,5-triphenyltetrazole chloride to formazane and hydrolyzing esculin to 44℃ on a selective culture medium.
Molecular absorption spectrometry	Instrumental analysis method based on the measurement of the electromagnetic radiation absorbed by the molecules of the product under analysis.
Visible spectrometry	Part of molecular absorption spectrometry that uses electromagnetic radiation in the visible range.
Blank sample	Solution prepared in the same way as the sample, but not containing the compound to be analyzed; the spectrum of the blank sample is considered the reference spectrum in relation to which the spectrum of the sample is indicated.
Standard solution	Solution of known concentration of the compound to be analyzed; its spectrum is compared with that of the sample to perform a quantitative analysis.
Calibration curve	Graphical representation showing the dependence between the sample concentration and the intensity of the absorption bands.
Volumetric technique	Determination technique based on measuring the volume of the titrated solution that reacted with the substance to be determined.
Total hardness	Total calcium and magnesium concentration.
Hardness due to carbonates (temporary hardness)	Part of the total hardness, equivalent to the carbonate and / or hydrogen carbonate content of the water.
Permanganate index	The mass concentration of oxygen equivalent to the amount of permanganate ions consumed when a water sample is treated with permanganate under defined conditions.
pH	Measurement of the activity of hydrogen ions in the solution
Glass electrode	Electrode indicating the activity of hydrogen ions; belongs to the class of membrane electrodes and is made of a special glass in a spherical shape; Inside the sphere is a constant pH buffer and an internal reference electrode.
Reference electrode	Electrode with constant potential in relation to which the potential of the indicator electrode is measured.
Conductivity	The inverse of the resistance measured under specific conditions in aqueous solution or in an aqueous extract; is a measure of the electrolyte content of a water sample or soil sample.
Measuring cell constant	The ratio between the conductivity of a standard solution of potassium chloride (from the tables) and the conductivity measured in a standard solution of potassium chloride; is determined for the purpose of calibrating the conductometer.
Platinum electrode	Electrodes of conductivity measuring cells made of polished or platinum plated to avoid polarization.

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