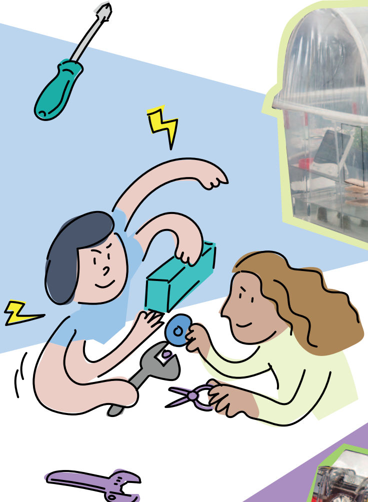
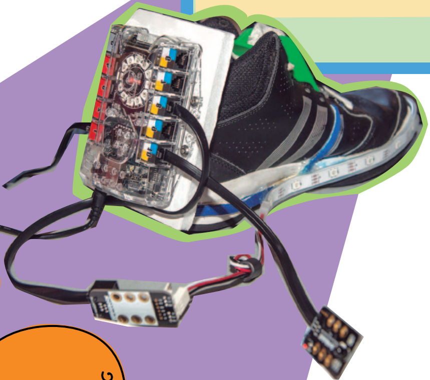
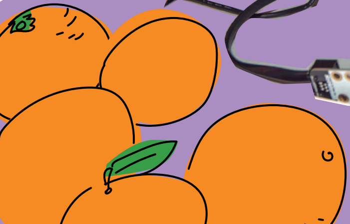
STEAM PROJECT IDEAS

to inspire YOUNG PEOPLE







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1 Project-based learning

Project-based learning is a teaching method by which students acquire knowledge by actively working on a topic that interests them and is directly related to the real world.

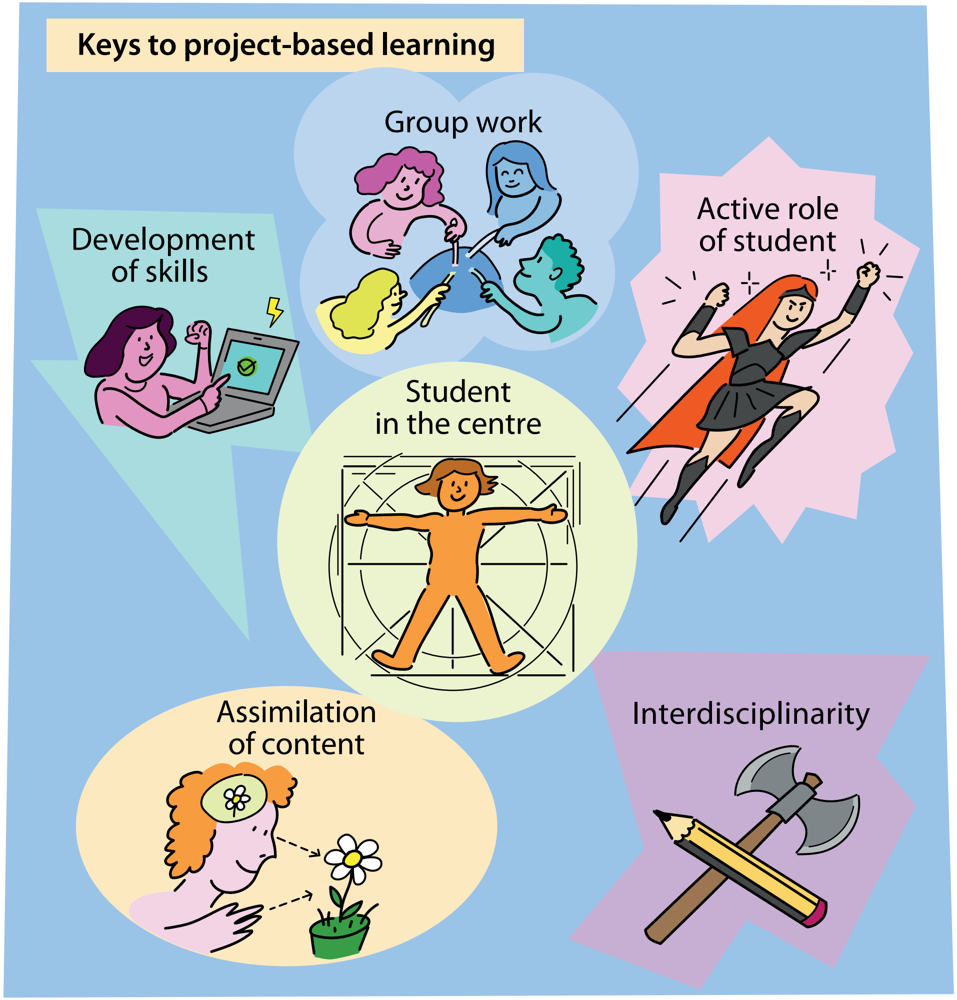
With this teaching approach, students try to solve a real-life problem or answer a complex question, and work on a medium- or long-term project that can last anywhere from a week to the entire school year.

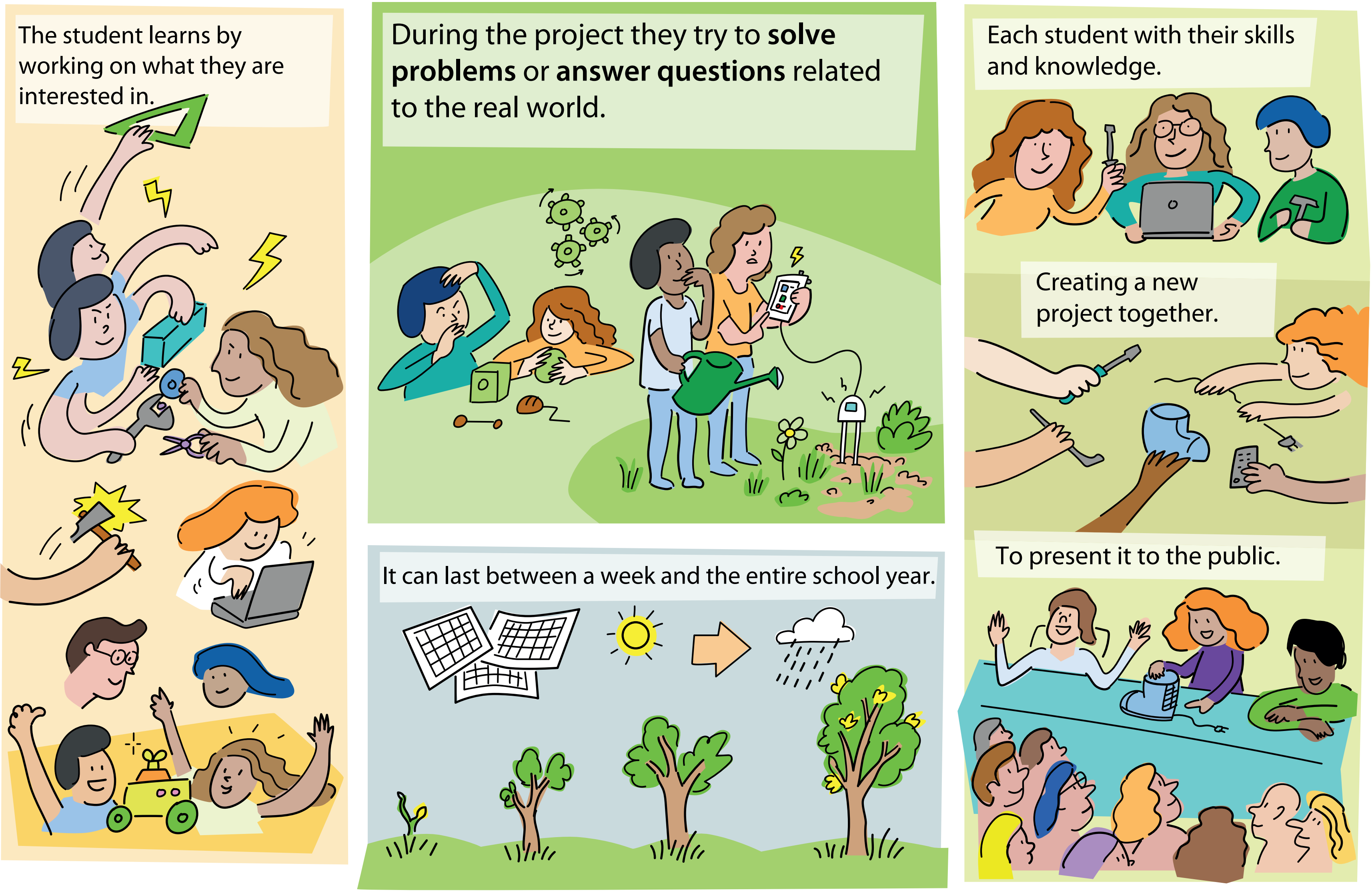
By creating a product and then presenting it in public, each student demonstrates the knowledge and skills they have acquired.

Thus, the students will develop a set of skills, such as:
- critical thinking,
- the ability to cooperate,
- creativity, and
- the ability to communicate,

as well as delve deeper into the content.

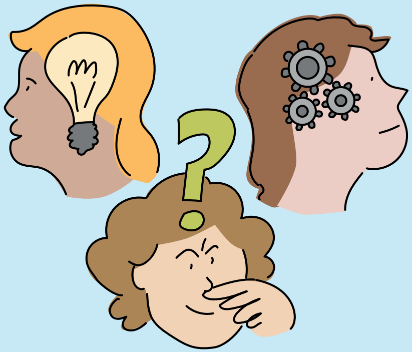
Although project work is not to the liking of every student, it is generally positively viewed by students, especially since it allows them to build on their experience over the years.




The student learns by working on what they are interested in.
During the project they try to **solve problems** or **answer questions** related to the real world.
It can last between a week and the entire school year.
Each student with their skills and knowledge.
Creating a new project together.
To present it to the public.

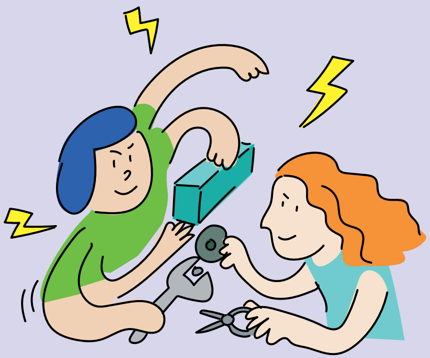
As well as working on content, this type of learning allows the students to develop:

- Critical thinking

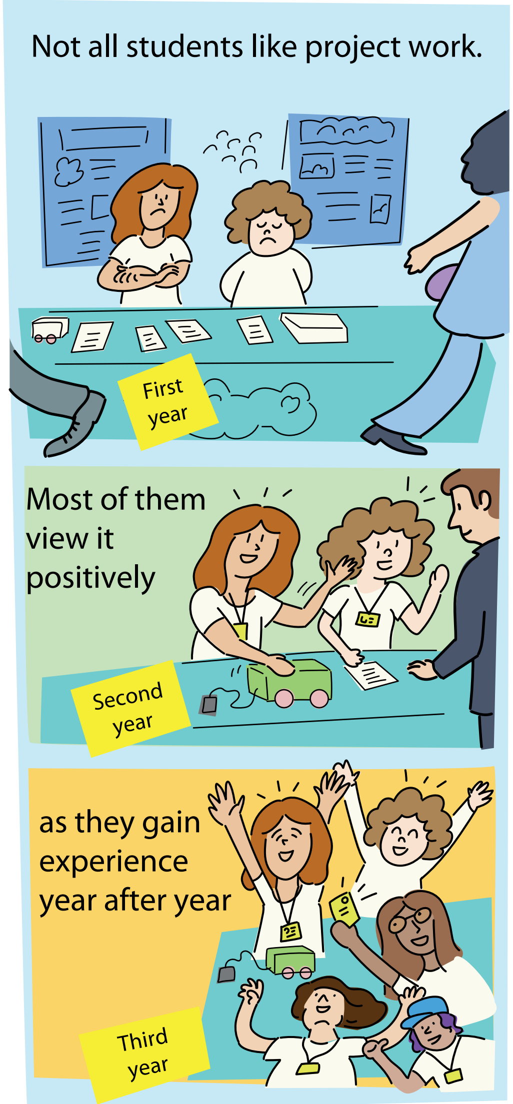


- Cooperation skills

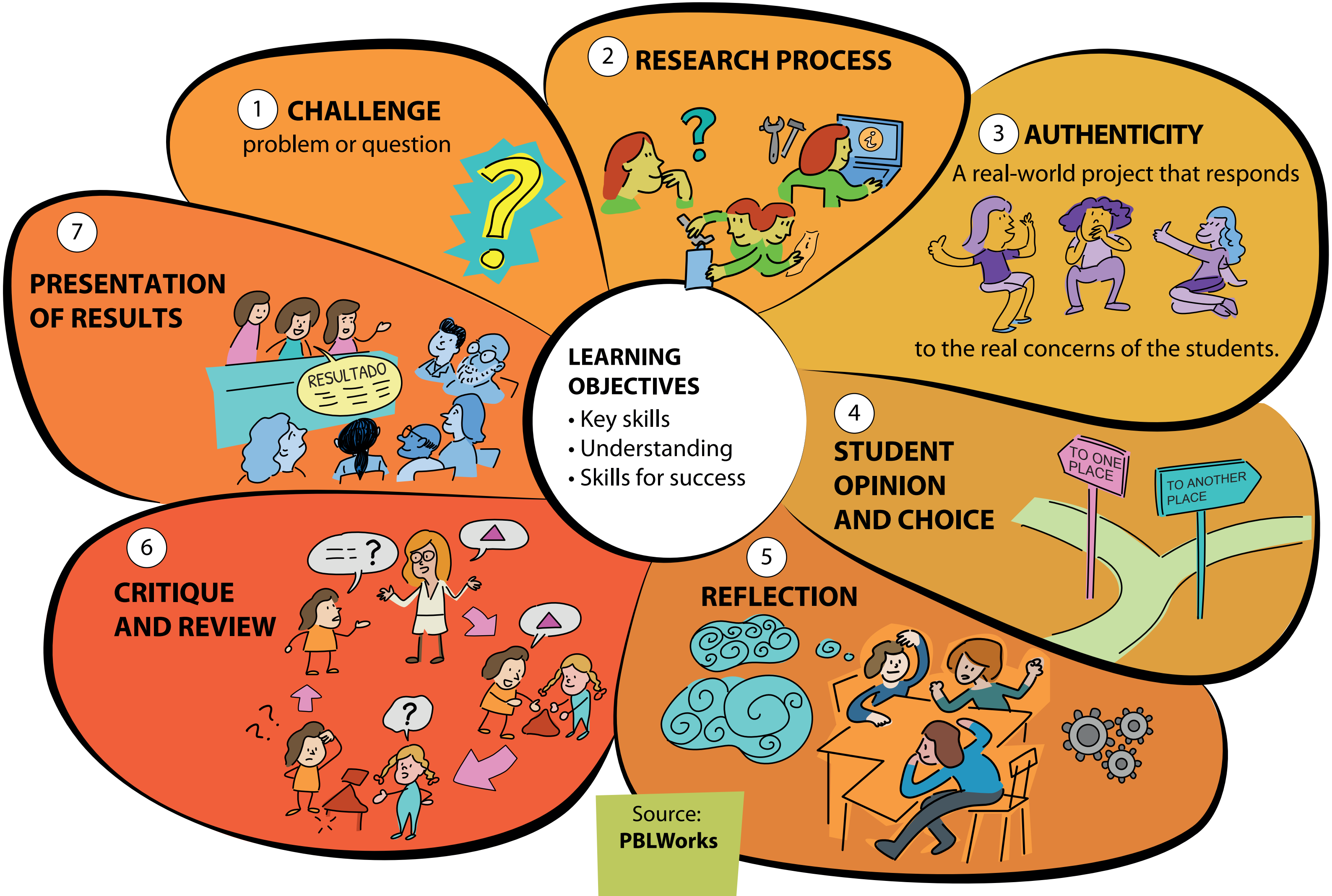
- Creativity



- Communication skills



1A The seven essential elements for project design



1.- Challenge: challenging problem or question

The project is based either on a significant problem to be solved or on a question to be answered, with a level of difficulty appropriate to the project.

2.- Research process

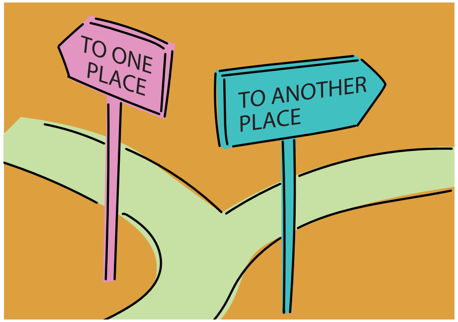
In a rigorous and extensive process, the students ask questions, look for resources and apply the information gathered.

3.- Authenticity

It is a real-world project and responds to concerns, interests or problems that may arise in the studentsí lives.

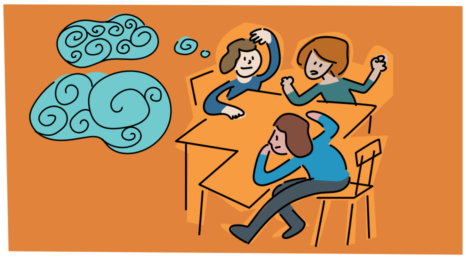
4.- Student voice and choice

The students make decisions about the project, including what they will create and how they will work.



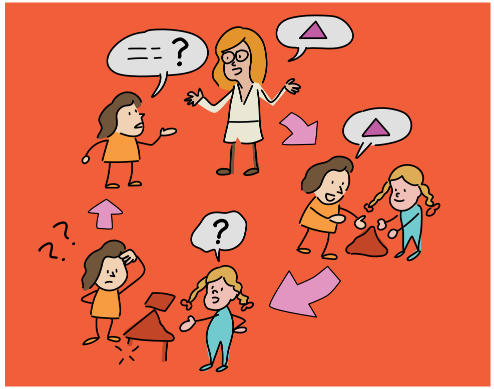
5.- Reflection

The students and teachers reflect on the learning, the effectiveness of their activities and research projects, the quality of the students' work, any obstacles that have arisen and the strategies necessary to overcome them.



6.- Critique and revision

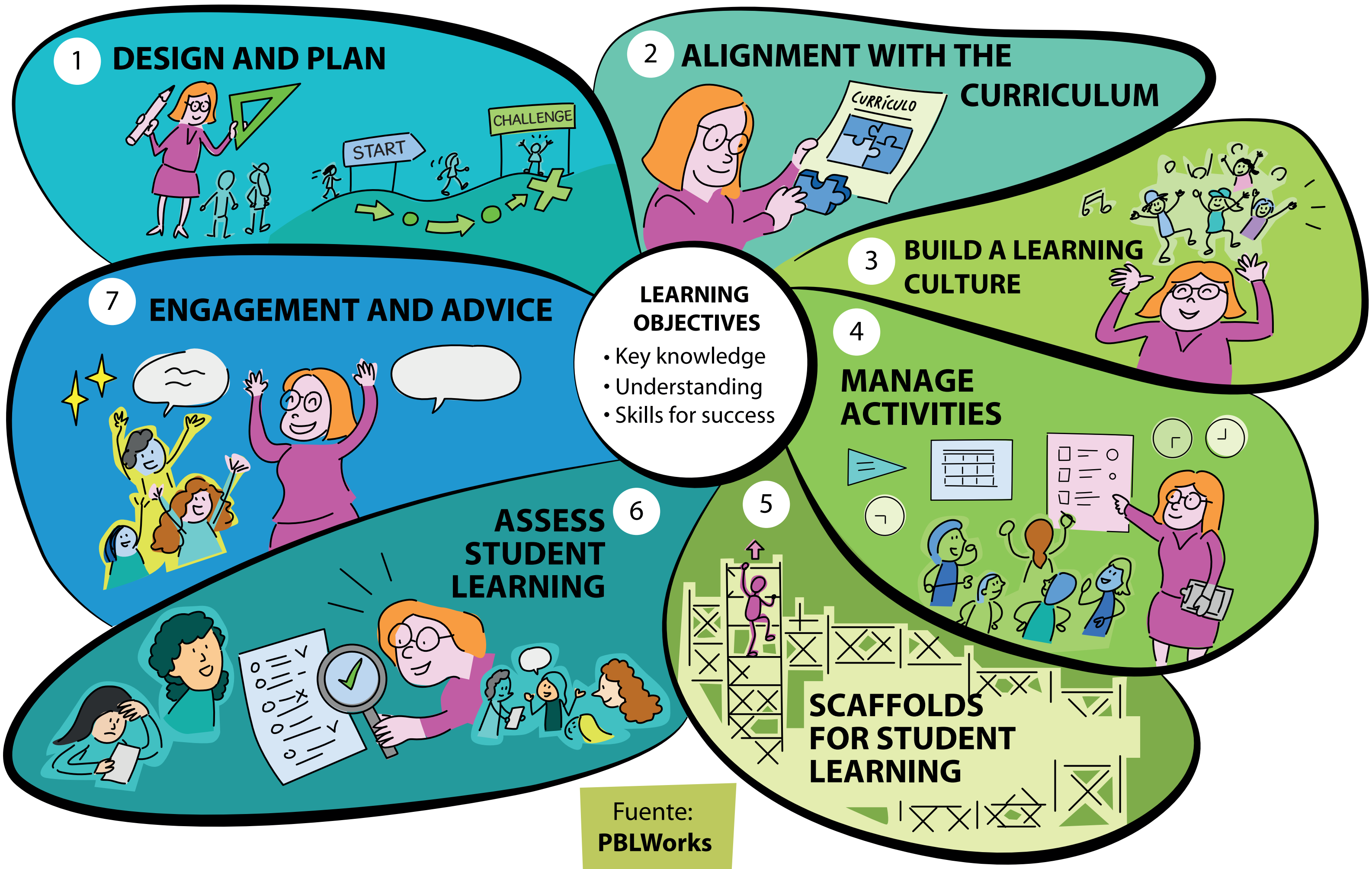
The students give, receive and apply feedback to improve their processes and projects.



7.- Presenting the results

Students present their project to a specific audience, outside the context of the classroom.

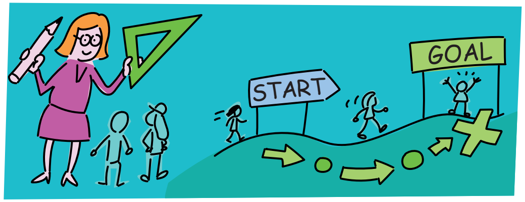
1B The role of teachers in guiding the students in the development of the projects



Fuente: **PBLWorks**

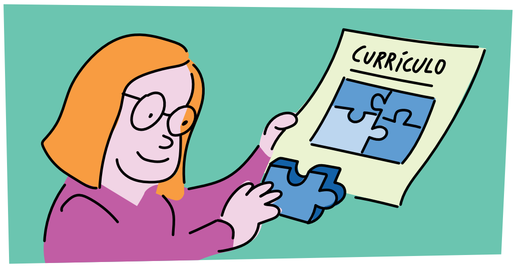
1.- Design and plan

The teacher creates a project adapted to the characteristics of their students. The teacher plans its execution from start to finish, giving the students a limited possibility to participate and make decisions.



2.- Alignment with the curriculum

The teacher aligns the project with the curriculum to ensure that the students work on the key knowledge and skills of the subject.



3.- Build a learning culture

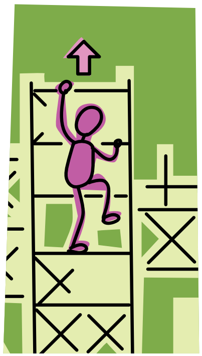
The teacher explicitly and implicitly promotes student independence and growth, team spirit and quality of work.

4.- Manage activities

The teacher helps the students to organise tasks and schedules, set checkpoints and deadlines, look for and use resources, create products, and present the results.

5.- Scaffolds for student learning

The teacher uses different tools and teaching strategies to help students achieve their goals.

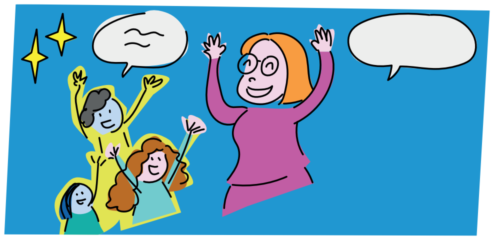


6.- Assess student learning

The teacher uses continuous and final assessments to evaluate the students' knowledge, understanding and skills, including self and peer assessment of individual and group work.

7.- Engagement and advice

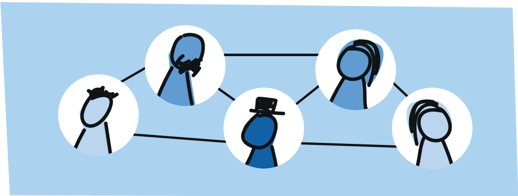
The teacher participates in the studentsí learning and creation process, helps them develop skills according to their needs, advises on adjustments, encourages them and praises their achievements.



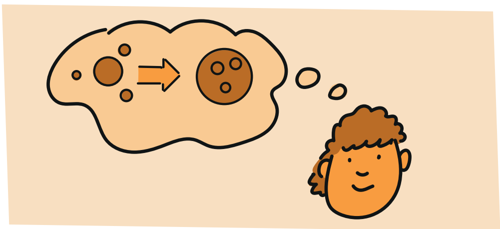
2 21st-century skills

Our goal as educators is to prepare students for life and work, and particularly important are the so-called 21st-century skills. Some of these key skills include:

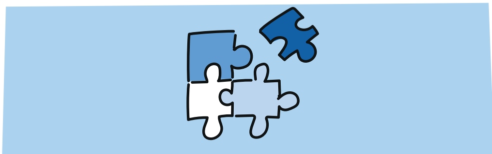
Collaboration
Do the students have to share responsibility and make key decisions with others? Is their work interdependent?



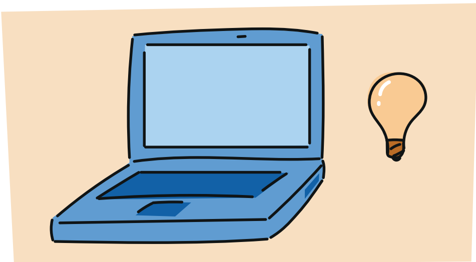
Knowledge construction
Are the students required to construct and apply knowledge? Is this knowledge interdisciplinary?



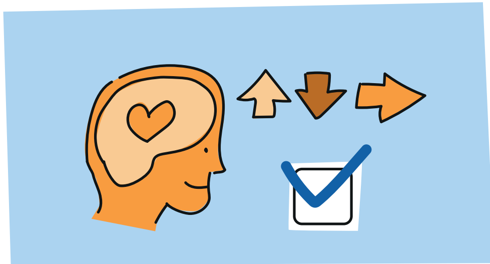
Real-world problem-solving and innovation
Does the learning activity require solving a real-world problem? Are the students' solutions implemented in the real world?



Use of ICT for learning
Are the students active or passive consumers of ICT, or are they designers of ICT products?



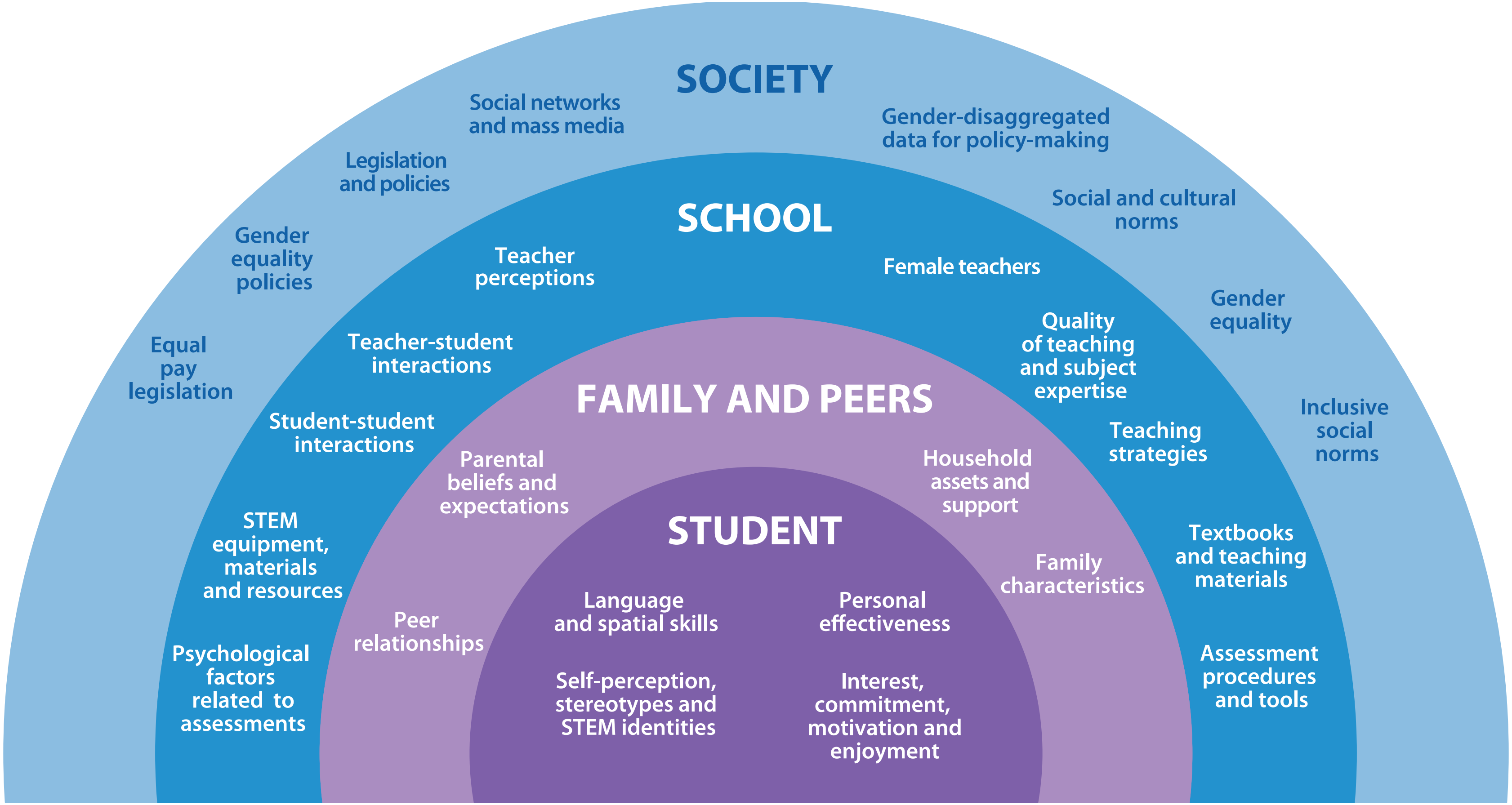
Self-regulation
Is the learning activity long-term? Do the students plan and assess their own work? Do they revise their work following feedback from the teacher?



Communication
When the students communicate their own ideas about a particular concept or topic, are they evidence-based? Is the projectís communication message right for the target audience?

3 Gender equality in STEM fields

Ecological framework of factors that influence female participation, achievement and progression in STEM studies.



What can we do to combat inequality?

Know our prejudices concerning STEM
With regard to STEAM, which student do we consider promising and which do we have the lowest expectation of? How do these beliefs match the image of the STEM professionals we have in mind? We could record a video in a science or maths class and then analyse it afterwards. To see whom we address and whom we do not, and how we give explanations and answers. To try to identify a pattern of behaviour.

Build a relationship of trust with the students
When teachers show confidence in the ability of their students it has a positive influence on their performance. This is especially important in STEAM, where students are encouraged to analyse new situations, tackle difficult problems and take risks with their ideas. The most powerful teaching tool is to dedicate time and attention effectively.

Take advantage of students' extracurricular knowledge and interests
Every student has ideas about the world and how it works, based on their own extracurricular experiences. Making connections between extracurricular and school STEAM experiences is an excellent strategy, as not only does it make them more motivated, but it also makes the projects more meaningful. The studentsí knowledge does not necessarily have to be correct or accurate, as erroneous beliefs are equally valuable for combining them with new ideas. Encourage the students to express their ideas and thoughts in different ways, such as through presentations, role play, drawings, etc.

Group the students in different ways for STEAM activities
Although school culture tends to reward individual effort and achievement, in our society -and even more so in the STEM professions of the 21st century- work is based on cooperation and collaboration. It would be a good idea to have both boys and girls with different backgrounds, ethnicities and languages to work together.

Show examples of similar roles
We should conduct our own studies on the situation of women and minorities, and not wait to receive reports on gender perspective.

Show and talk about STEM professions
Avoid stereotypical images of professionals in the STEM field (for example, a talented white man who spends his day working in his laboratory). Instead, give examples of other STEM professionals that students can connect with more, such as women, young people, those that break the stereotypes, etc.

Invite STEM professionals to the classroom or take students to their workplaces
We can invite STEM professionals (preferably from an under-represented group) related to a project the students are working on. We can help the students prepare questions for the STEM professional, such as "why did you decide to become a ____", and "what do you like best about your job, and why?"

Analyse STEAM-related news articles that we see on the Internet
STEAM-related news articles from the Internet send a strong message to students. We can share and discuss them, keeping in mind the gender and diversity perspective.

Know our prejudices about STEM

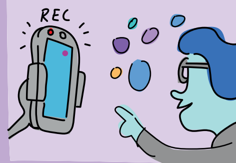
Maybe we are **unconsciously biased** towards the students,

and this can disadvantage someone.

Let's see if we treat some students **differently,**

or expect less from some than others.

We can record a video and then **analyse it.**



Build trust

Showing confidence in their abilities is good for the students.

Take advantage of the students' interests

We can make connections between STEM experiences and their interests outside school.

Encourage them to express their ideas in different ways: presentations, role play, drawings, etc.

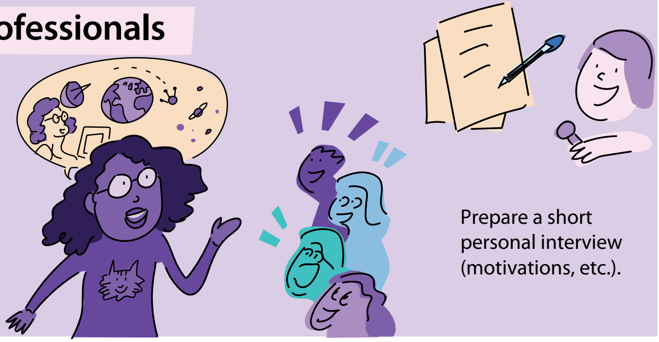
Group them in different ways

In STEM activities, give them the opportunity to work with boys and girls from different backgrounds and who speak different languages.

Give examples of STEM professionals

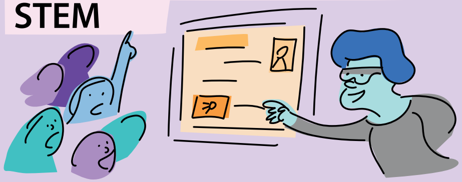
Show the students **examples of diversity**, avoiding the stereotype of the genius scientist.

Put the students in contact with STEM professionals (preferably non-white males), at school and at work.



Prepare a short personal interview (motivations, etc.).

Analyse news articles about STEM



Read through them with the students, focusing on gender, diversity, etc.

4 Types of projects: research projects and technology projects

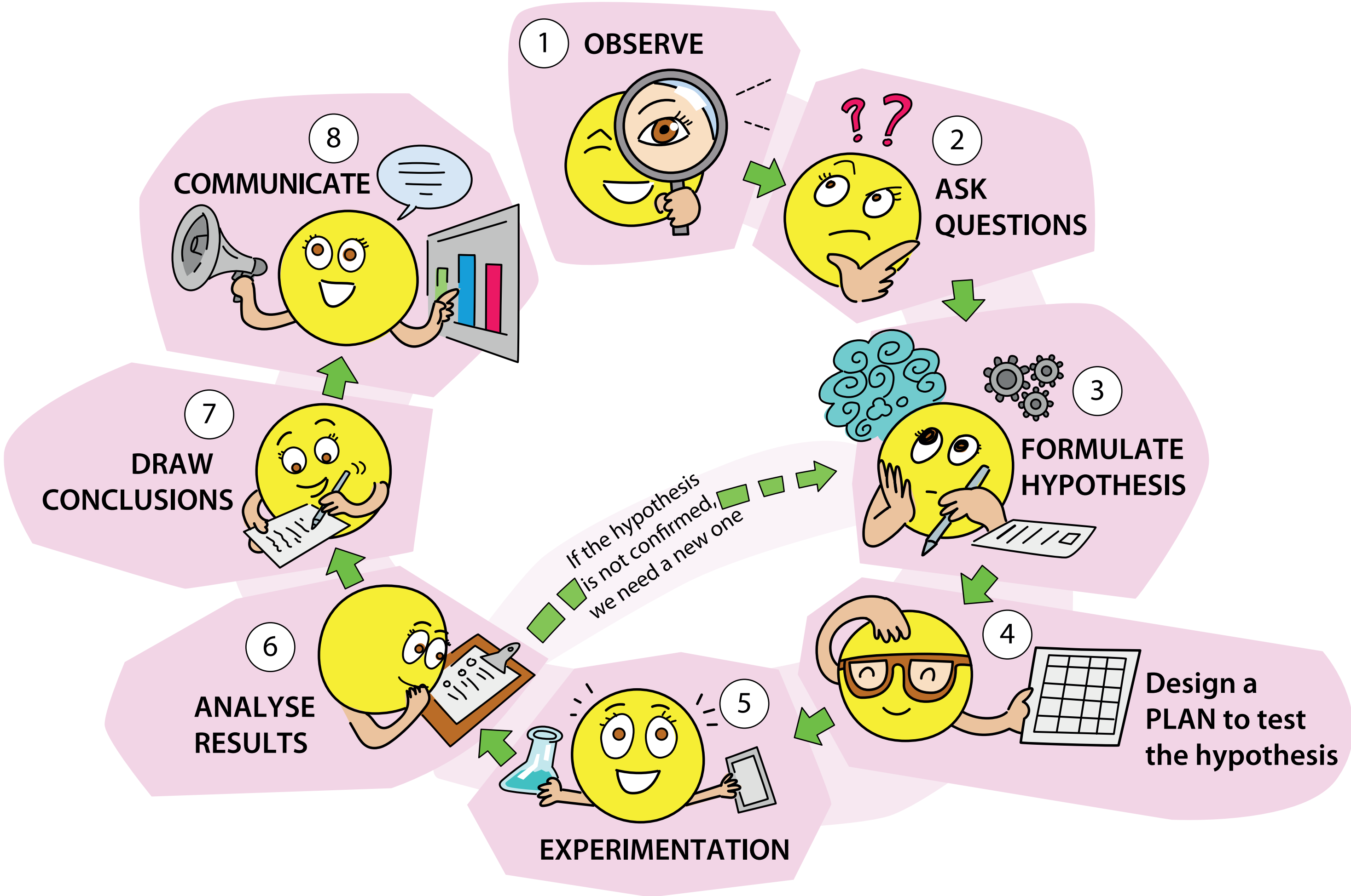
It is difficult to classify the projects carried out by secondary school students by type. Simplifying this classification as much as possible, the projects can be divided into three areas: scientific research, technology, and combined.

If, in order to divide these areas further, we go into more detail, we are presented with various options and difficulties. To solve this problem, several classifications were created, especially for professional research. However, these are not particularly useful for classifying the type of projects carried out in secondary schools (experimental, quasi-experimental, non-experimental, documentary, technological, exploratory, descriptive research, etc.).

Instead, it is more common to classify the subject or field in question when organising secondary school projects, although problems also arise in classifying combined projects and establishing criteria. For example, at the science fair organised by the European Commission, projects are divided into the following categories: biology, computer science, chemistry, earth sciences, engineering, environment, materials, mathematics, medicine, physics and social sciences.

Considering the aforementioned difficulties in establishing and providing a useful criterion, we propose two main project types based on the most commonly used methods: **research projects** and **technology projects.**

4A The scientific method

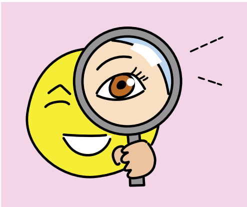


Steps of the scientific method

Most research projects in the field of education are based on experimental research. They follow the steps of the scientific method, although not rigidly since each discipline adapts the steps to its own situation. The most common steps are outlined below:

1.- Observe

We look at the world and focus on what we want to understand. This is what observation is about. It is our natural curiosity that leads us to observe.



2.- Ask a research question

After the observation process, the next step is to ask a question to guide the research process. Many questions are derived from scientific curiosity, but only a few of these are amenable to investigation. The research question must be clear, concise, feasible, novel and ethical.

3.- Formulate a hypothesis

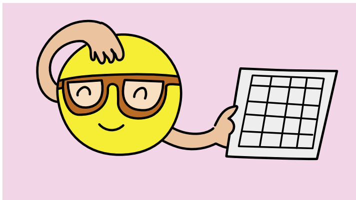
The hypothesis is the compass that guides the research; it reflects what we are looking for or testing. It is also the potential answer to the research question, which explains as clearly and as concisely as possible the relationship between the dependent and independent variables. The hypothesis must be supported or refuted through testing, observation and experimentation. For example, to answer the research question ìhow does compost influence the growth of lettuce?", we might formulate a hypothesis such as: the more compost applied, the greater the growth of the lettuce. (In addition, we could predict that by adding more compost the lettuce would grow twice as much).

4.- Design a plan to test the hypothesis

This involves defining what will be done and in what time frame, evaluating resources and assigning tasks to the work team. The following questions, among others, will be discussed:

- Can the independent variable be manipulated?
- Are we sure that the dependent variable will not be affected by another factor?
- How will the data be collected?
- How will the process be documented?
- How will the results be presented?
- How much time will be spent on each stage?
- How will the work be distributed among the team?
- What human, material and financial resources will be needed? - How much do these resources cost?

Once the research team has answered these questions, they must write a project or proposal that systematises the research design. The teacher should review this document in order to improve the design and to anticipate any problems that might arise.

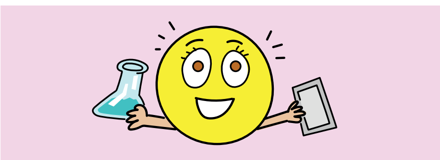


5.- Experimentation and fieldwork

Experimentation involves performing actions to discover, verify or demonstrate a scientific phenomenon or principle. The variables should be modified individually, keeping the other variables constant. In other words, if we are studying the effect of varying quantities of compost on the growth of lettuce, we must "modify" the quantity of compost and keep the pot, lettuce, soil and amount of light and water constant to ensure that we measure the effect of the compost only.

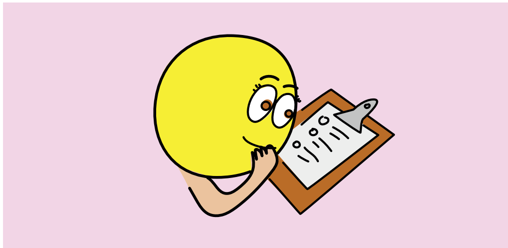
Fieldwork requires taking detailed notes of every experiment, measurement and observation. Good field notes give an account of the process and help substantiate the analysis of the work. The soundness of the research will depend to a large extent on the fieldwork.

The notes should include any observations regarding expected and unexpected events: additional questions, concerns, changes in procedure, new ideas, etc.



6.- Analyse and discuss the results

Once the research is complete, we analyse the results. First, we check whether there is sufficient evidence to support or refute our hypothesis. For the discussion, the results obtained using the theoretical values must be compared with data from other research and with the expected results.



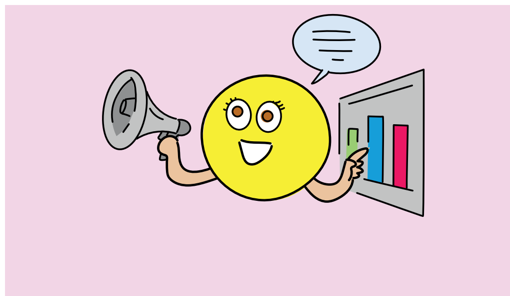
7.- Conclusions

Now we have to summarise the main findings of our work. This should be specific, avoid generalisations, and never include anything that we have not actually done in our project.

Experimental research does not always confirm the hypothesis; in some cases, it disproves it. However, this does not invalidate the process. The desired conclusion may not have been achieved but it has led us to another important discovery.

8.- Communicate

Science and technology have been able to understand and transform our reality, through numerous small and major research studies, which have then been fed back. This is why communication of the project carried out is so important.



4B Technology project

The steps of a technology project are similar, but not identical. Once the target audience has been defined, the aim of a technology project is to find a technological solution to a problem or to improve a specific product or process. Thus, prototypes are made until the final proposal is approved.

The main difference between the technological process in the educational field and the professional field is the last step; since the ultimate goal of technology projects in the education system is not to patent and market a specific product or service (although there have been a few such cases).

Below are the steps to follow:

1.- Identify the problem or need
Identify the problem we want to solve or the need we want to satisfy.

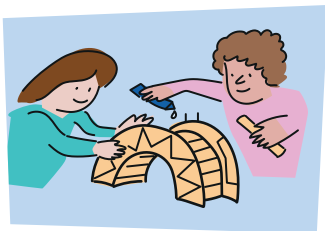
2.- Gather information
Collect and analyse as much information as possible regarding the issues we need to solve or satisfy. Acquiring knowledge in this step is essential for developing a solution.

3.- Look for solutions
In this step, we work on the different ideas for solving the problem.

4.- Project approval
A feasibility study must be carried out to determine the costs, resources and means that will be allocated to production. On the basis of this study, we decide whether or not we will carry out the project.

5.- Design the result
We make a prototype of what we are going to produce, in the form of drawings, sketches and diagrams, which should be as precise as possible.

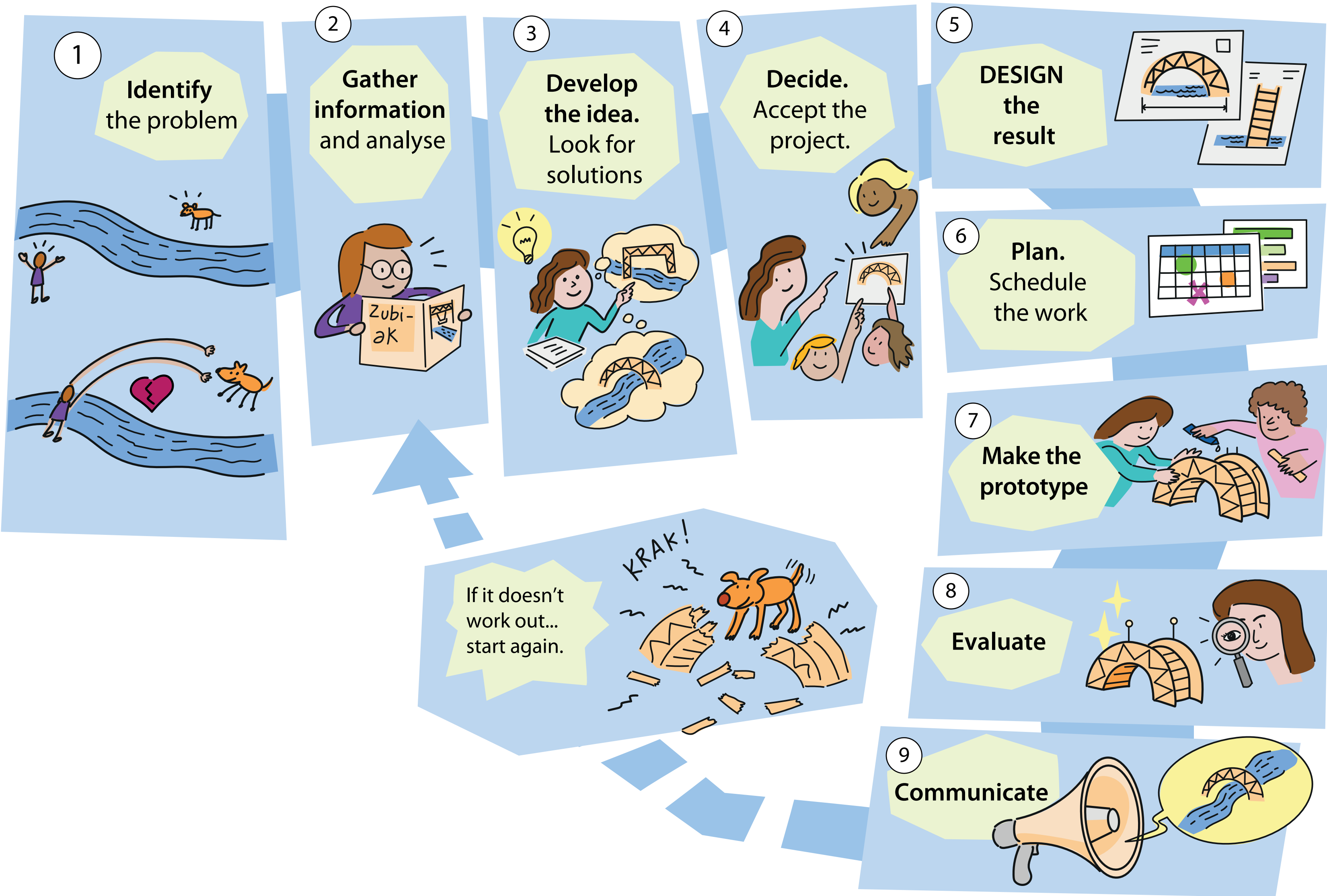
6.- Plan the work
We list and gather the tools and materials we will use, and organise and plan the distribution of the work.



7.- Make the prototype
In the business world, the final product is produced elsewhere, while in the educational field it is the students who make the final prototype.

8.- Verification and evaluation
Here we find out whether the product functions in the way we hoped it would, and whether it meets the expectations we had in the early stages. Its usefulness and value must be evaluated. The product is submitted for evaluation by people outside the work team, keeping the target audience in mind.

9.- Communicate
Communicating the product or service created Although, in cases like these, patents are obtained and the product or service is marketed, the main objective of the project is to develop the studentsí skills.


1
Identify the problem
2
Gather information and analyse
Zubi-ak
3
Develop the idea. Look for solutions
4
Decide. Accept the project.
5
DESIGN the result
6
Plan. Schedule the work
7
Make the prototype
8
Evaluate
9
Communicate
If it doesn't work out... start again.
KRAK!

5 Methodological strategies for teachers

Teachers play a key role in student projects. Although the students take on the role of researchers, they have not yet developed their research abilities with regard to autonomy, experience, procedures, theoretical knowledge, and knowledge about the use of resources. Managing all these aspects in a medium- or long-term project is a major challenge for the students, especially since their experience in project work is still modest. Teachers, therefore, must assume different roles in order to respond to the needs of the students: guiding, explaining, creating learning situations, contrasting work, inspiring, helping with organisation, etc.

Teachers can also use different methodological strategies in the student learning process. Some of these are outlined below, together with some common problems.

5A Creating groups for project work

Project-based learning offers many advantages, including the opportunity for students to work with people of different backgrounds. While working together on projects, they acquire valuable skills for collaboration, for developing their own strengths and for managing group dynamics and conflict. There are several ways to create groups for project-based learning, but they must be well-planned beforehand.

Questions to ask when creating groups

• What size will they be? Think about the age, gender and experience of the students and the complexity of the projects.

• What involvement will students have in creating the groups? Will we make the decision for them? When grouping students we can consider different variables such as friendships, hobbies, roles, identity, age, gender, experience with projects, etc.

• What skills will the teams need for developing a particular project? Organise into different groups students with an advanced linguistic level, knowledge of programming language or other skills.

• What do you know about the students' hobbies, needs and interests? Before we start, we can carry out an activity to learn about them.

• As the course progresses, we should create opportunities for collaboration between the groups.

Advantages of cooperative learning

• Real cooperation between the team members increases the quality of the learning, not only by improving social relations but also by creating greater understanding and autonomous learning.

• As well as fostering teamwork, we must also encourage cooperation between the team members, using specific teaching strategies.

Myths about teamwork

✗ With teamwork, individual responsibility is less important and the only ones who learn are those who show the greatest interest.

✗ Students will learn in a cooperative way just by putting them in groups.

✗ When grouping students, it is better to create homogeneous groups of the same level so that they progress together.

Ideas for fostering cooperation in groups

• Form groups of 3-4 students.

• Heterogeneous groups.

• Establish a clear goal, but one that is impossible for a single student to achieve on their own.

• Supervise the work of the group so that individual responsibility is not diluted within it.

• Show models and strategies for developing the social skills involved in cooperative behaviour, explaining clearly which behaviours are cooperative and which are not.

• Avoid strategies that encourage group members to stick to the tasks they are best suited to.

• Monitor the social interactions of the group and discussion regarding the scientific contents of the work, in order to optimise both learnings.

5B Knowledge required for developing the projects

Every sound project has, in principle, an exhaustive, well-thought-out list of the knowledge required. Consequently, students are aware that they will need to undertake rigorous and continuous research to acquire such knowledge. When reviewing the knowledge required, students maintain their interest and commitment, and have a sense of accomplishment as they acquire knowledge by answering questions. This allows the formulation of new questions based on their opinions.

In addition, mastery of content language is essential in STEAM education.

Effective vocabulary teaching involves assessing the terminology known by the students, and then strategically directing them to unfamiliar terms.

Bear in mind that the lexicon they use in the statements is derived from the lexicon they acquire; in other words, students can understand a more complex language than they can produce.

A more informal language should not be used to the detriment of academic vocabulary. Remember, the vocabulary assimilated by the students is broader than that used in their projects. Students should hear the terminology used correctly and then plan how to use it in meaningful dialogue. Remember, students benefit from lexicon amplification, not simplification.

5C Information search

Whatever the project, we must first gather as much information as possible on a given subject. It is very important to have diverse and reliable sources.

With a research project, information from general or popular science media can be useful for guiding the search and finding appropriate sources, but an article in a popular journal should not be confused with one written for a scientific publication. Students must know how to make this distinction.

There is no standardised criterion regarding the number of sources that should be used, but a minimum of ten is recommended.

With a technology project, we decide what challenges or real problems we want to solve, as well as who our target audience will be. To do this, we need to look at the existing options, identifying the strengths and weaknesses of each one and considering the target audience they are aimed at.

5D Working with external experts

Teachers cannot be expected to master all scientific and technological matters. You can seek the help of research experts who will advise you on the topic you want to cover and on planning and designing the research.

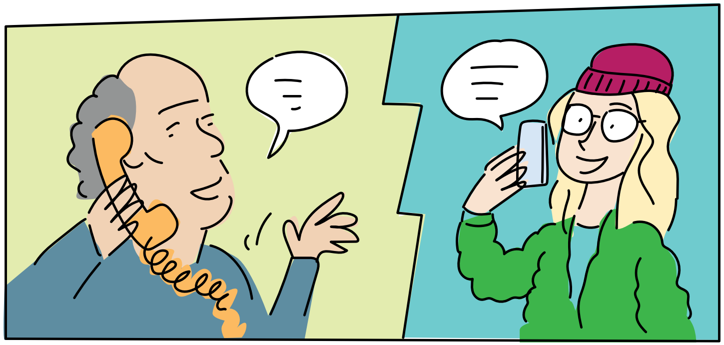
It should be the teachers who contact the researchers, and they should closely monitor the researchersí interaction with students, so that the experience is as beneficial as possible.

The participation of external experts immediately increases the authenticity of a project, which in turn increases the responsibility and enthusiasm of the students. Students of all ages tend to produce better quality work if they know that it will be reviewed by someone other than their teacher. External experts can also provide more rigorous and meaningful feedback in the critique and review stages. The presence of external experts for the final presentations increases commitment to quality.

Ideally, students should have the opportunity to work with experts throughout the project. If an external expert can only dedicate a limited amount of time to the students, we should think strategically about when their involvement would be most beneficial. This may be at any stage in the project, and may vary from one project to another.

We must also consider that most of the external experts have not been in a classroom for a long time, so will require some adaptation and preparation in order to meet our expectations. We can contact these experts by video conference, telephone or email, to explain what the students are learning and the aspects they are researching, in order to determine what final product the students will develop. We can also share assessment rubrics with the experts. The more prepared the experts are, the greater their contribution to the students and their learning will be.

We must be clear about what level of commitment we require from the experts. For how long? When? In the classroom, in the community, virtually? How? Video conference, telephone, email? We will try to identify and share dates and schedules, and be flexible to fit in with their availability.



5E Preparing and conducting interviews

The students conduct interviews as another element of their project-based learning. In some cases, these interviews help students to identify the needs of clients or a target audience for the development of a particular design, solution or communication strategy. Sometimes the experts interviewed by the students (scientists, historians, activists, etc.) have specialised knowledge or direct experience of the topic the students are working on.

As well as helping to achieve the projectís objectives, conducting effective interviews enables students to develop important active communication and listening skills, expand valuable social competences and increase their empathy through their relations with people from different environments. As they gain more interviewing experience, they will realise that people can be one of the most enriching "primary sources".

One way of preparing interviews is to write questions in small groups and then compare them with other groups to ensure that they are clearly understood. We can then do a role-play in the classroom, through which students will learn how to interview external experts.

5F The ethical aspect of research

Ethics leads us to assess the consequences of changing, removing or eliminating elements from the surrounding environment of the living beings we are studying, and helps us determine whether the learning derived from the research activity truly justifies endangering their lives, changing their habits or destroying their environment. We must also define the procedure for finding a response that causes the least possible disturbance and reflect on whether the objective we are pursuing justifies our intervention and the consequences it would have for the natural environment.

Conducting research in an ethical manner does not mean that we cannot act in nature, but that we must be aware of the consequences of our actions and try to minimise them, and be clear about the objective of our research.

We need to create spaces for debate and dialogue regarding the consequences and justifications of research actions and the impact on our environment.

Many science fairs specify the ethical aspects and rules that projects must comply with (for example, it is prohibited to interfere with birdsí nests).

5G Contrasting the work

Providing feedback is one of the teacherís most important tasks. Below are the key elements of feedback:

1. Feedback is not advice, praise or evaluation, but information about the efforts made to achieve a specific objective.

2. If students understand that mistakes are considered a natural part of the learning process they are more likely to use the feedback throughout the entire learning process.

3. The feedback given by the students to the teacher may be even more valuable than that given by the teacher to the students.

4. If we include a grade as part of the feedback the students will not see beyond it. It is therefore advisable to keep these separate.

5. Effective feedback is that which is given while there is still time to make improvements.

6. Most of the feedback that students receive is from their peers —and it is sometimes not correct—.

7. Students should be clear about the objective of the learning and the specific skills they need to acquire. The feedback should indicate HOW to acquire these skills.

8. The most effective way is to give just a few ideas at a time.

9. Compare the student's work with a standard reference that shows their progress.

10. Inform them how far they have come and give them guidelines for improvement.

11. We will learn from the students' reactions to the feedback they receive.

12. Discuss the feedback with them.

5H Fostering reflection

Reflection is a cognitive process that we use to make sense of our experiences. In project-based learning, students should have the opportunity to reflect on what and how they are learning, both individually and collectively.

Providing the time and structure for reflecting on a project transforms the «project development process» into authentic «project-based learning». In this respect, John Dewey argued that «we do not learn from experience, we learn by reflecting on it».

It is therefore essential to teach reflection techniques and to foster individual and group reflection. When planning, we need to find the right balance between reflection and action, leaving some time at the end of the projects for feedback and in-depth reflection.

5I Preparing the project mural in the classroom

The project mural is a fundamental element for building a learning culture in the classroom as it helps students to take ownership of their learning and their work. Having a dedicated space in which the students can see what is being learned and how, and where they can follow the progress of the project, fosters self-management and the assumption of responsibilities, thus reducing dependence on the teachers. The project mural can also serve as a useful reference for visitors to the classroom, as it immediately explains what the students are doing and why.

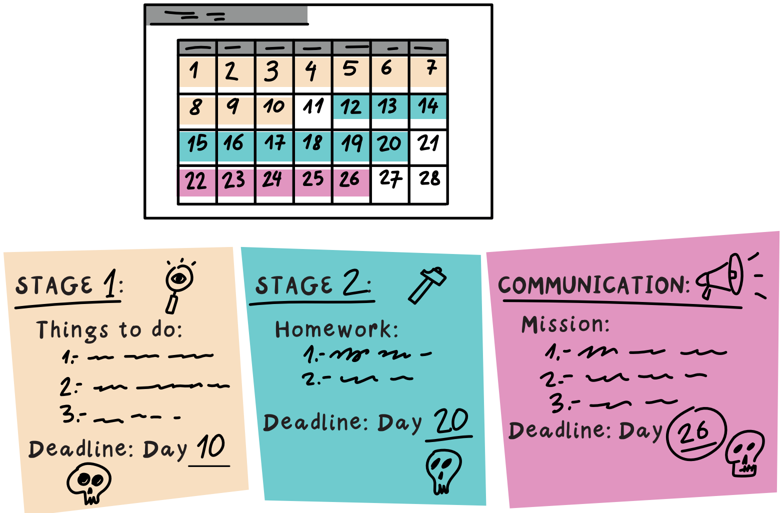
Although teachers can organise their own project mural in the way they wish, most murals include the following:

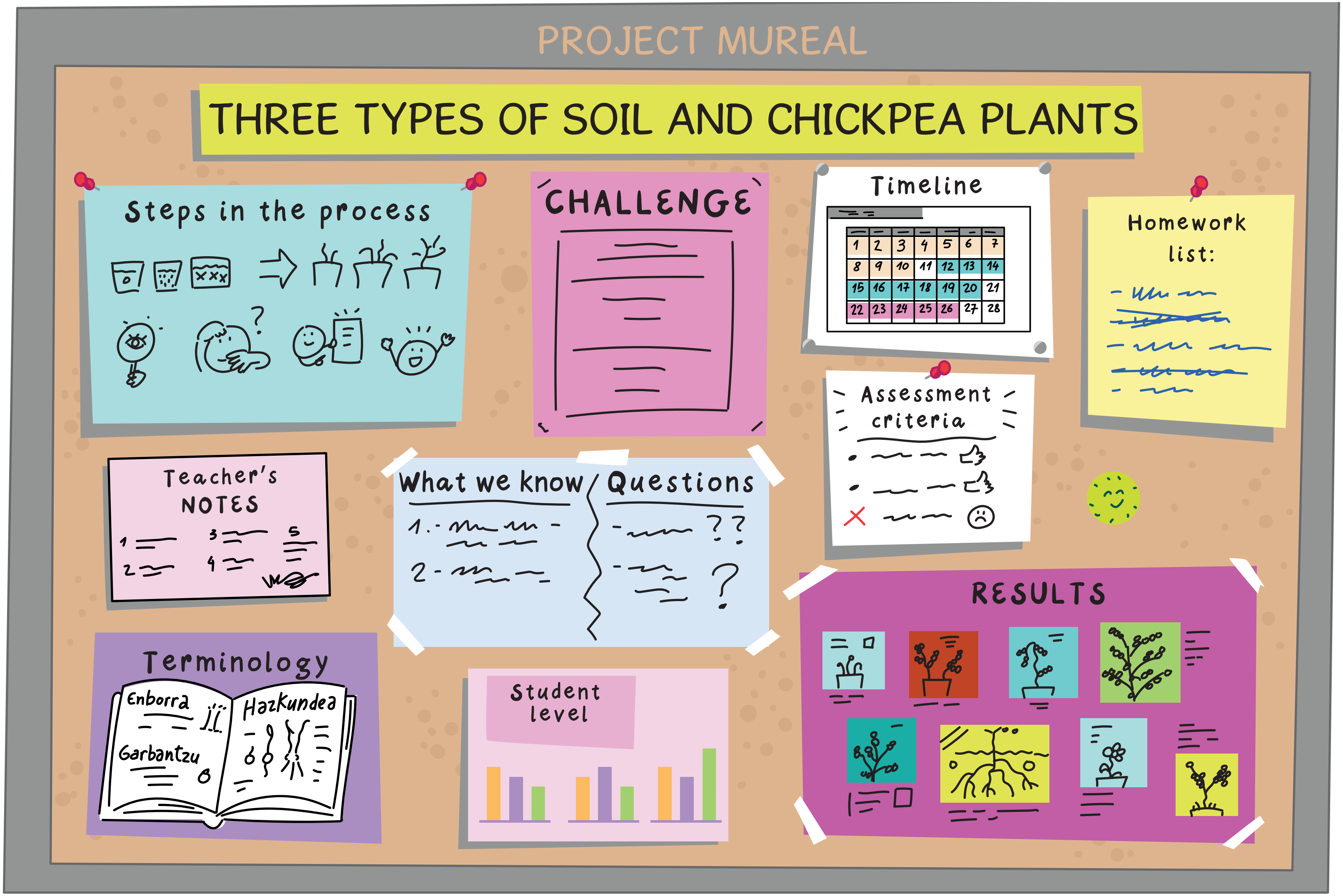
- A diagram showing the steps of the project process
- The results of the learning
- A question or challenge to guide the research
- A list of the aspects we know and those we need to explore
- Timetable
- Evaluation criteria or rubrics
- Terminology: key words and other important content
- The studentsí level of progress
- Examples of results
- Student observations and tasks

Timetable

Organising time is essential for the successful completion of the research. Once the topic, research question and methodology have been defined, a list of actions to carry out at each stage must be drawn up, giving clear deadlines for each one.

Communication is the last step in the process, so deadlines are often tight. For this reason, we should allocate a little more time than expected to the communication tasks in our schedule.





PROJECT MUREAL
THREE TYPES OF SOIL AND CHICKPEA PLANTS
Steps in the process
CHALLENGE
Timeline
Homework list:
Assessment criteria
Teacher's NOTES
What we know
Questions
RESULTS
Terminology
Enborra
Hazkundea
Garbantzu
Student level

5J Communicating the completed work

Project report

The key communication element is the project report. This is a document that can be presented at science fairs or conferences, and is also useful for exchanging experiences with other students.

The report structure is as follows:

TITLE. This should explain the content of the report. It should be brief and illustrative and not contain any abbreviations or ambiguous terms.

AUTHOR/S. Group participants, in alphabetical order. Sometimes the name of the teacher and the school are included.

SUMMARY Includes the most important aspects of the research, such as the problems addressed, the methodology and the conclusions. No images or bibliographical reviews. Maximum of 250 words.

TABLE OF CONTENTS. Description of the different sections of the report and their corresponding page numbers.

INTRODUCTION AND JUSTIFICATION. Brief explanation of what has been researched and why, with solid and convincing arguments. Details the objective and questions addressed by the research, its justification, the general context, how and where it was carried out, the variables and definitions, and its limitations.

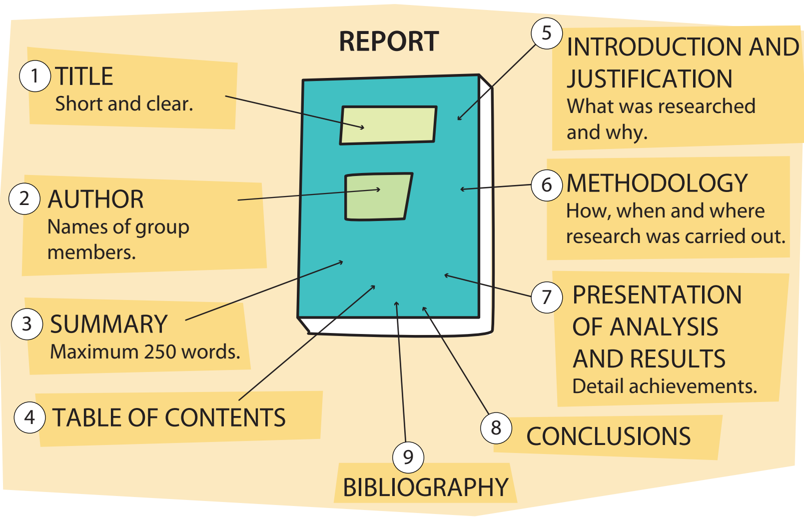
METHODOLOGY. Explains how, when and where the research was carried out and gives the necessary information to allow replication of the experiments. Describes in detail the process of data collection, observations, design of measurement devices, etc.

PRESENTATION AND ANALYSIS OF THE RESULTS. For which we recommend the following:

• Organise the results in a precise, orderly and logical way.
• Use text, tables and graphs, avoiding redundancy; in other words, do not present the same information in both the text and the tables, or repeat the same data in tables and graphs.
• Highlight the most important achievements.

CONCLUSIONS. This is where we summarise the main achievements of the work. It should be specific, avoiding generalisations, and must not include anything that has not been done.

BIBLIOGRAPHY. Includes all the documentation consulted for justifying and substantiating the study, and the names of the people interviewed.

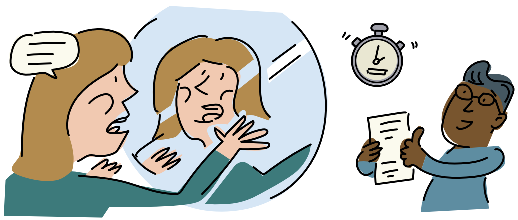


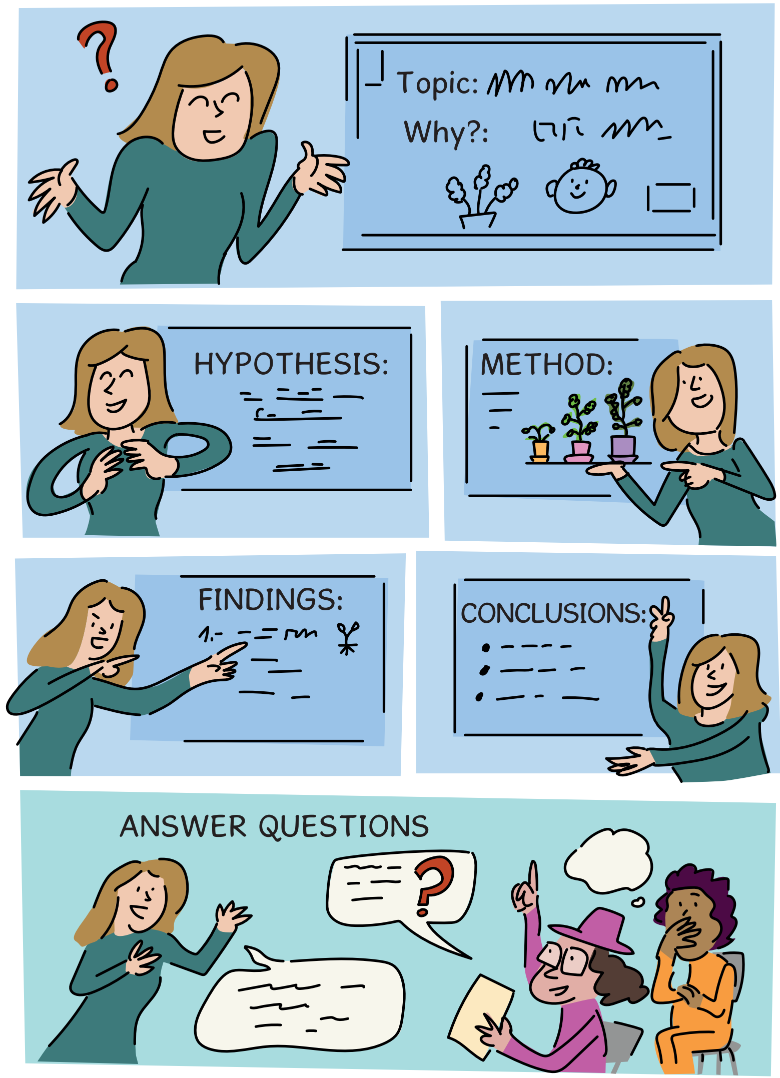
Oral presentation of the research

The oral presentation should be prepared taking into account where and to whom the work will be presented. To deliver a good oral presentation it is essential to practice and calculate the time it will take. Students can practice with their friends or family.

For science fairs, the following structure can be used:

• Present the topic Why are we researching this problem?
• Present the hypothesis or research question.
• Describe the method used. How did we carry out the research?
• Describe the findings. What did we find?
• Present conclusions and assumptions.
• Did we accept our alternative hypothesis? Or did we answer the initial question? What questions arose? How, or by what means, could the research proceed?
• Duration of presentation: 10-15 minutes, plus 5 minutes for questions.
• Language: formal.
• Support material: poster or digital presentation (maximum of 20 slides).
• It is sometimes useful to have a quick three-minute presentation of the project ready.

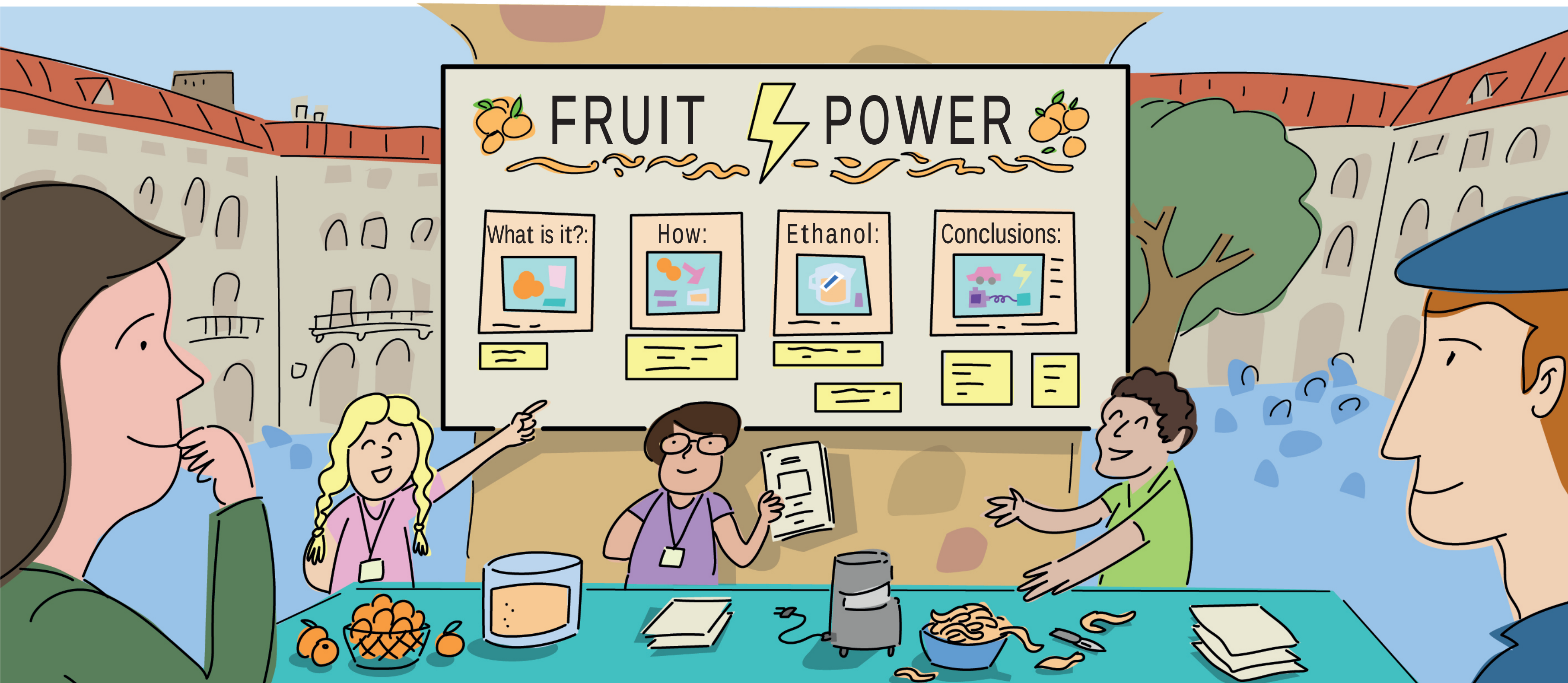




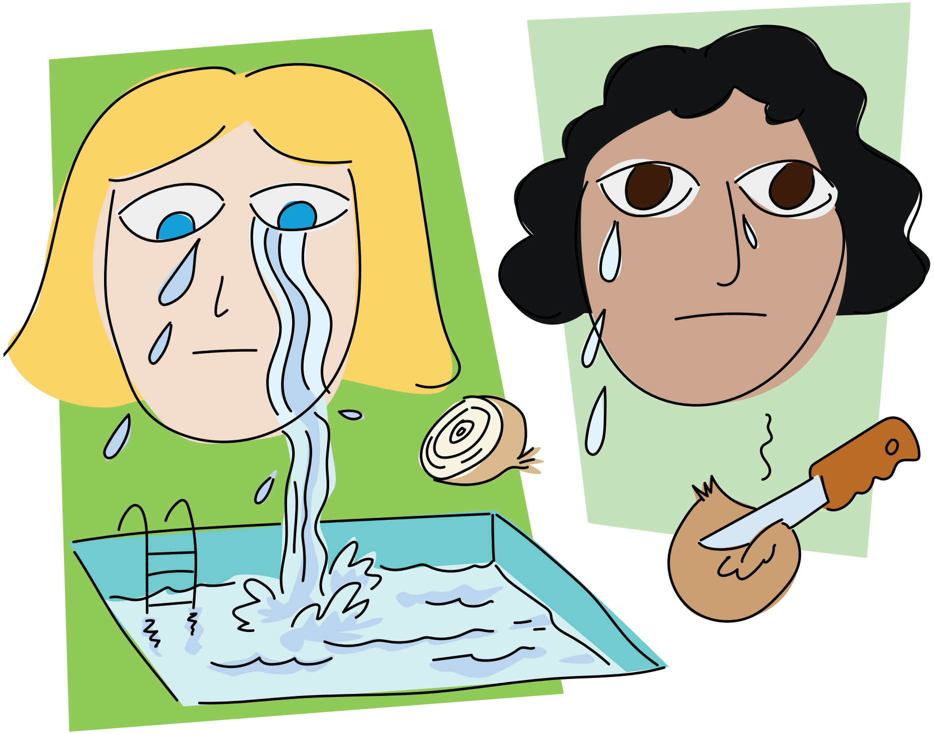
Project poster

If the project has been selected for participation in a science fair, the information must be presented as clearly and as attractively as possible. Here are some suggestions for preparing the poster:

- **Choose a good title.** The title should make the visitor want to find out more about the topic, so it needs to be short and draw interest.
- **Use photographs.** As well as attracting visitors, they help explain the work carried out.
- **Organisation.** The key ideas or actions must be presented logically and be legible. The text size should be large enough to be readable from a distance of one metre.
- **Eye-catching.** Both the wording of the texts and the quality of the images.



Tears caused by onions, depending on the type and the colour of someone’s eyes



Authors: Nora, Maite, Lander and Julen.

Area: Biology, Chemistry.

Level: 1st and 2nd year secondary school.

Challenge: Does the colour of someoneís eyes influence the tears caused when cutting an onion? Do all types of onions have the same effect? This is precisely what we will analyse in this research project.

Teacher’s notes: This research project is conceptually easy to understand, with simple control and subordinate variables. However, designing the research project may be more complex. How do we rigorously measure the time? How many people will we need for each eye colour? What other variable will be controlled in the sample? Gender, age, use of glasses, etc.

The effect of sport, and the hours dedicated to it, on the academic performance of students

Authors: Mohamed, Marta, Leire and Jon.

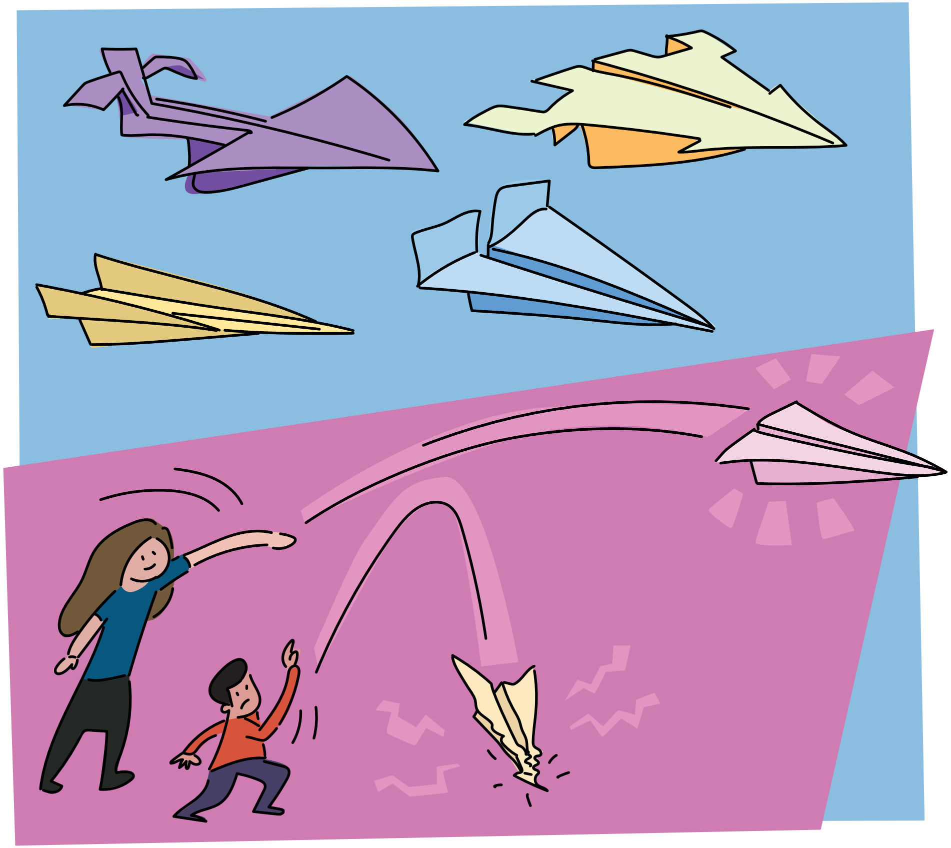
Area: Psychology.

Level: 1st and 2nd year secondary school.

Challenge: Practising sport has an effect on our academic performance, but we are not sure how this effect is produced. We will test with different types of sport and the number of hours we dedicate to each one. Let's see if it affects our maths results!

Teacher's notes: Research projects related to performance or memory are usually very popular with students and do not require many resources. The main difficulty lies in the size of the sample, since a considerable amount of data and a homogeneous sample is needed in order to obtain meaningful results.

The effect of the design, angle and launch speed of paper planes on their flight range



Authors: Leire, Mikel, Marta and Lurdes.

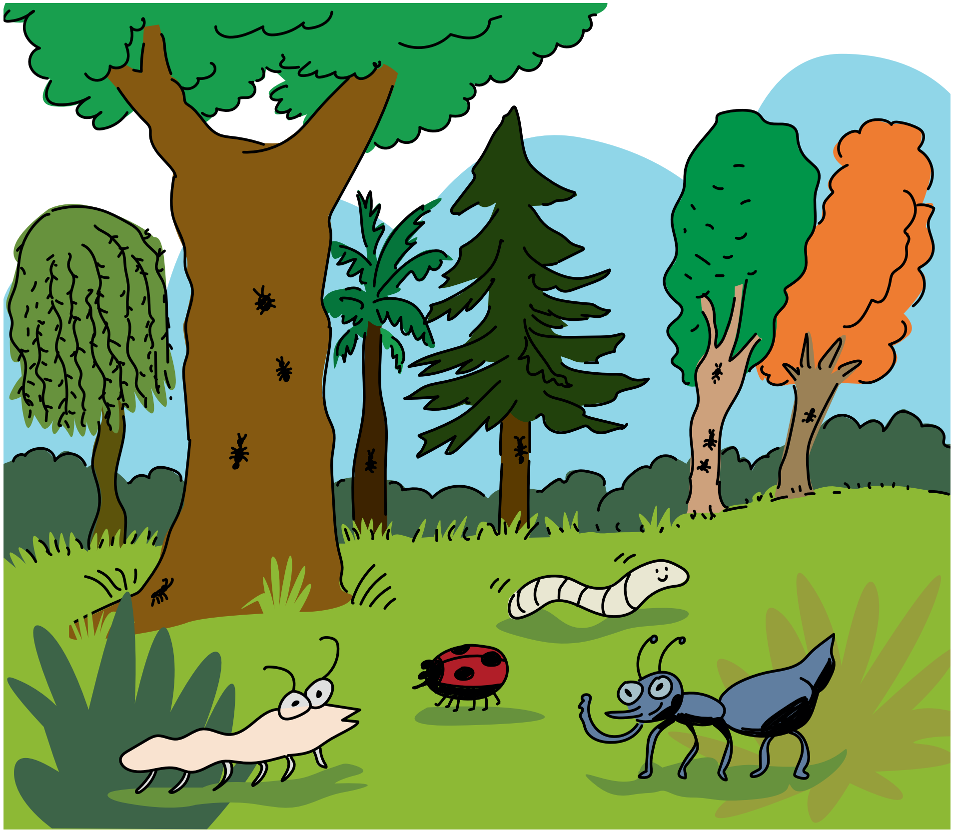
Area: Physics, Engineering.

Level: 1st and 2nd year secondary school.

Challenge: We will design paper planes in the classroom and then see how the design of the plane and how it is launched has an effect on how far they fly. When we are clear about our idea, we will go to the classrooms of the youngest children in the school and explain different tricks to them.

Teacher's notes: This research is influenced by various factors, both theoretical and procedural. To control all these variables, it is advisable to carry out prior testing and to prepare the instruments we are going to use, such as the angle gauge, aircraft launcher, speedometer, etc.

Comparative study of insect populations present on the surface, branches or roots of six tree species



Authors: Garazi, Miriam, Josu and Iker.

Area: Zoology.

Level: 1st and 2nd year secondary school.

Challenge: To study the number of insects on the trees in our local park, as we do not know whether there is an equal number on the surface, branches and roots depending on the type of tree.

Teacher’s notes: We can start with an ethical debate. Is it permissible to kill the insects we are going to trap? How do researchers in this field work? How do the insects we are going to find benefit the ecosystem?

The effect of soup cooling methods on the speed of cooling

Authors: Lucia, Ander, Joannes and Irma.

Area: Physics.

Level: 1st and 2nd year secondary school.

Challenge: When soup is too hot and we are in a hurry, we almost always burn our tongue. Enough To prevent this happening again, we will experiment with different methods for cooling soup and, of course, we will identify the quickest one.

Teacher's notes: There are many methods for cooling soup: blowing on it, stirring it, pouring it into another recipient, or just waiting. By carrying out some simple research, we can easily find out which is the most effective method. As well as identifying the best method, we should continue to discuss the reason why and come up with other ideas for continuing the research.

Design and construct a circuit for reusing water used for personal hygiene

Authors: Lucinda, Itziar, Jose and Lur.

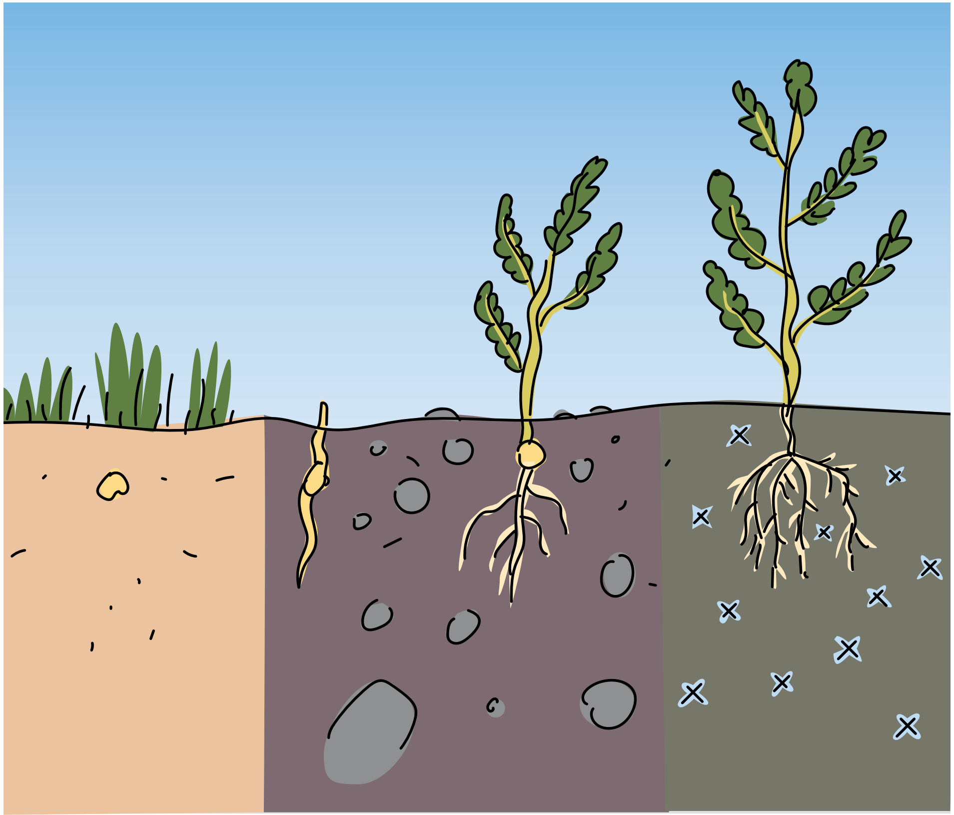
Area: Technology.

Level: 1st and 2nd year secondary school.

Challenge: We use a lot of water we shower and brush our teeth, and this water could be given a second use. We are going to design and test a system for this. Let's see if we can get a patent for it!

Teacher's notes: A common mistake in technology projects is to make a single prototype and focus exclusively on it. Remember that the aim of the prototypes is to provide an idea for solving a specific problem. The prototype is improved as new versions are developed, and we need to ensure the quality of the documentation describing it.

The influence of three soil types on the height of a chickpea plant, the growth of the stem and the colour and number of leaves



Authors: Ainara, Ane and Unax.

Area: Botany.

Level: 3rd and 4th year secondary school.

Challenge: Soil type influences the growth of plants, their height and their health. To carry out these tests, we will use a chickpea plant and three different types of soil. We will control the growth, as well as the height, development of the stem, and the colour and number of leaves. We will then draw conclusions about these three different types of soil.

Teacher's notes: When planting in the pots, add an extra potted chickpea plant for each soil type so that if one dries out we will have a spare one.

Mathematics in fashion

Authors: Jonatan, Oihana and Maite.

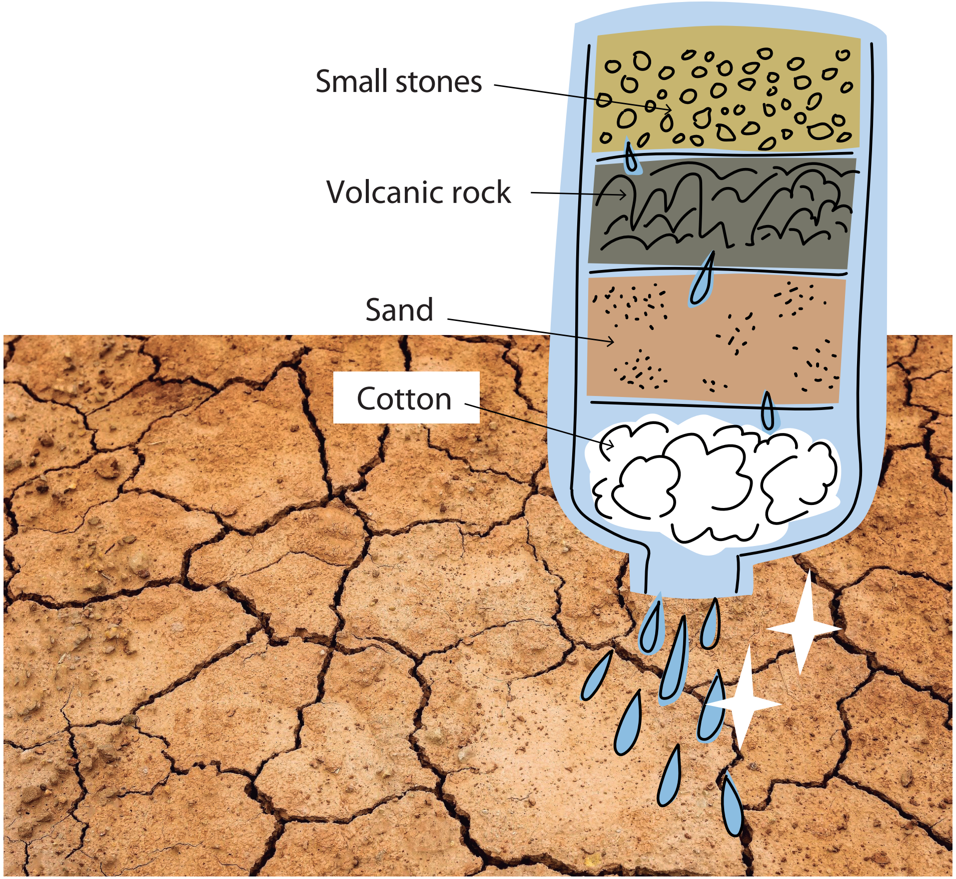
Area: Mathematics.

Level: 3rd and 4th year secondary school.

Challenge: To study the influence of mathematics on fashion. To do this, we will classify the geometric shapes on clothing and accessories that appear in magazine photographs.

Teacher's notes: Science and technology project work has had a longer tradition than purely mathematics project work. However, owing to the interdisciplinary nature of STEAM education, we can now find interesting projects in which maths plays a major role.

Project for producing drinking water in Ethiopia



Authors: Leire, Klara and Hodei.

Area: Technology.

Level: 3rd and 4th year secondary school.

Challenge: We want to build a prototype for a water-washing system for use in Ethiopia, and find out which filter works best for settling and filtration. We will make a prototype for three systems and then choose the one that gives the best results.

Teacher's notes: Water-related projects offer excellent possibilities for combining technology, engineering and the environment, such as those focused on irrigation systems, decanting, filtration, measuring pH, etc.

Study on measures to combat the Asian wasp

Authors: Erik, Amagoia and Violeta.

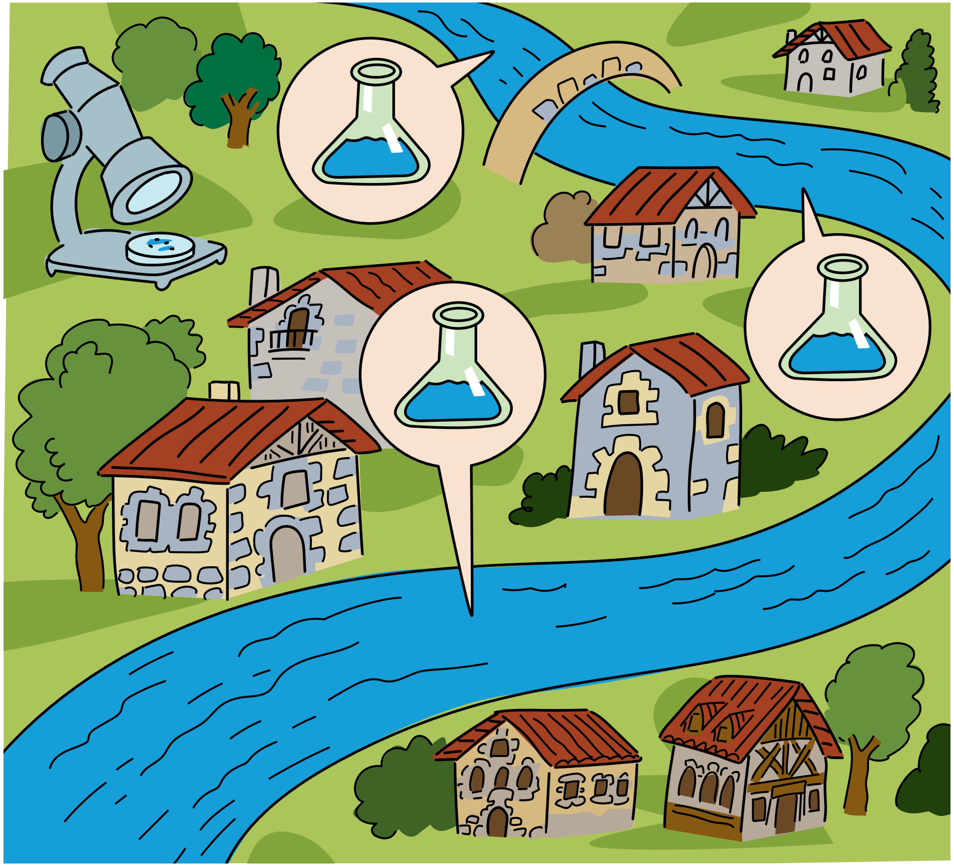
Area: Ecology, Technology.

Level: 3rd and 4th year secondary school.

Challenge: We will design different traps for capturing Asian wasps, and find out which one is the most effective. We will speak to an entomologist and then design three traps. We will also test three substances for attracting wasps.

Teacher's notes: The key element here is the involvement of external researchers, as without the help of an entomologist or bee keeper the project would be much more difficult. As well as providing technical support, the involvement of experts will make the project seem more authentic to the students. The most difficult part is obtaining permission to place traps in the hives.

Study on the water quality of the streams in Leitza, depending on the riverbed and season of the year



Authors: Joana, Olatz and Jaime.

Area: Environment.

Level: 3rd and 4th year secondary school.

Challenge: To analyse the quality of the water in Leitza, we first decide which part of the stream to take the sample from. We will then obtain or build the instruments we need for analysing the stream. When everything is ready, we will do the sampling and then the physical-chemical analysis. Once this is done, we will do the sampling for the biological analysis. After this, we will go to the laboratory to classify the species obtained from the stream and study the aquatic bacterial colonies.

Teacher's notes: Programmes such as *Ibaialde* offer various resources for carrying out this type of project. Another option is to use material for aquariums, as there are many affordable products for analysing water.

Immediate effect of coffee on blood pressure

Authors: Igor, Esti and Ana.

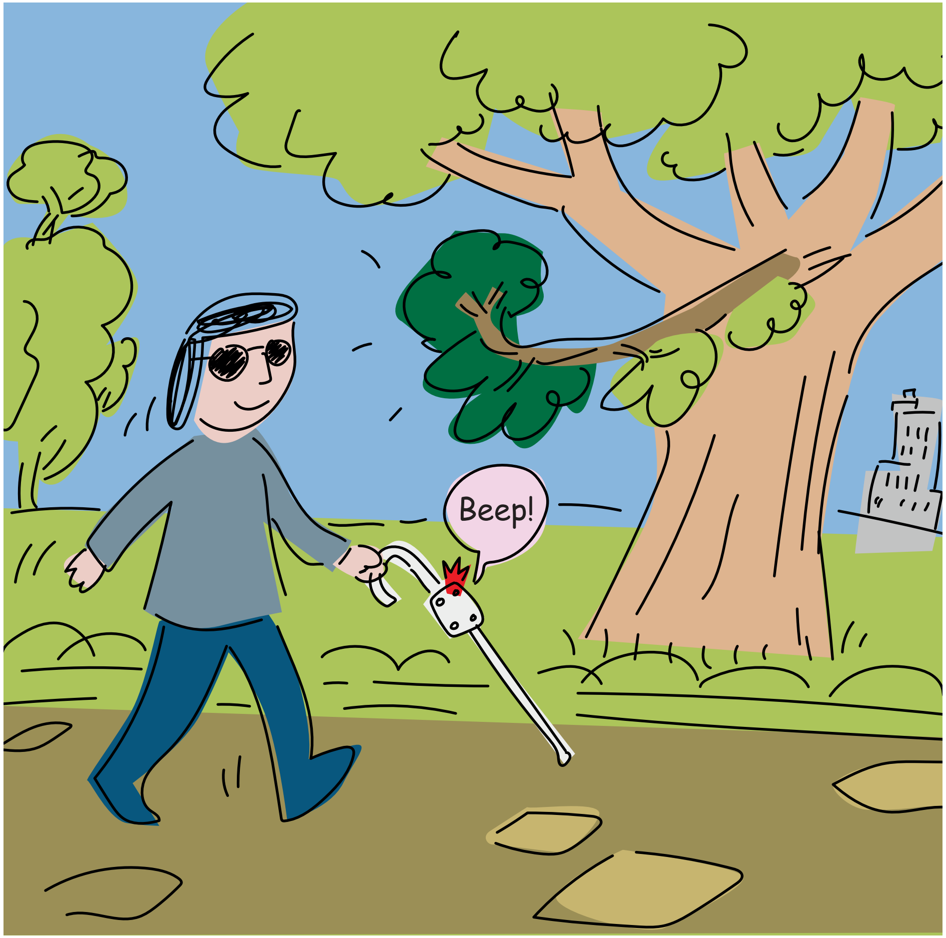
Area: Medicine.

Level: 3rd and 4th year secondary school.

Challenge: To determine the effect that drinking coffee has on blood pressure we will use a blood pressure measuring device. For the research design, we will visit a medical professional, select the samples, familiarise ourselves with the blood pressure data and decide on our target group. Let's see what we get!

Teacher’s notes: When carrying out health-related projects, we must be particularly careful about the protection of personal data. In these cases, we must stress to students the obligation to adhere to the special conditions regarding anonymity and data storage, although it may sometimes seem a bit trivial to us.

A cane with a sensor for blind people



Authors: Nahia, Iker and Pili.

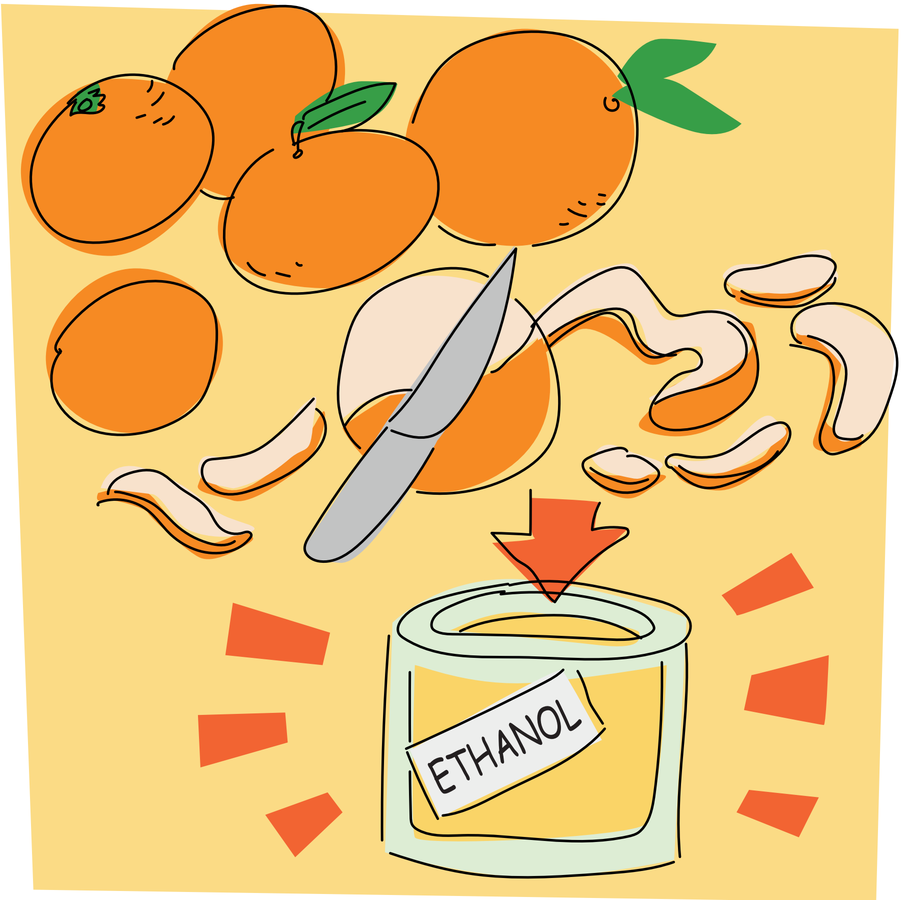
Area: Technology.

Level: 3rd and 4th year secondary school.

Challenge: We decided to design and make a cane for blind people. We will begin our project by interviewing a blind person in order to identify their needs. Our cane will vibrate when it detects an object at a distance of 200 cm. The sensor will be adapted to the height of the blind person and it will also need to detect suspended objects in order to protect the personís head and chest. We will test the prototype and see how it can be improved, so that the next project will be a continuation of the first.

Teacher's notes: There is a vast number of technological projects and it is impossible for teachers to know them all: Arduino, 3D printers, Scratch, Makey-Makey, etc. In these cases, as well as looking for information on the Internet, it is a good idea to involve experts to help with specific topics (these may be older students in the school).

From fruit waste to energy



Authors: Nekane, Amaia and Ekhi.

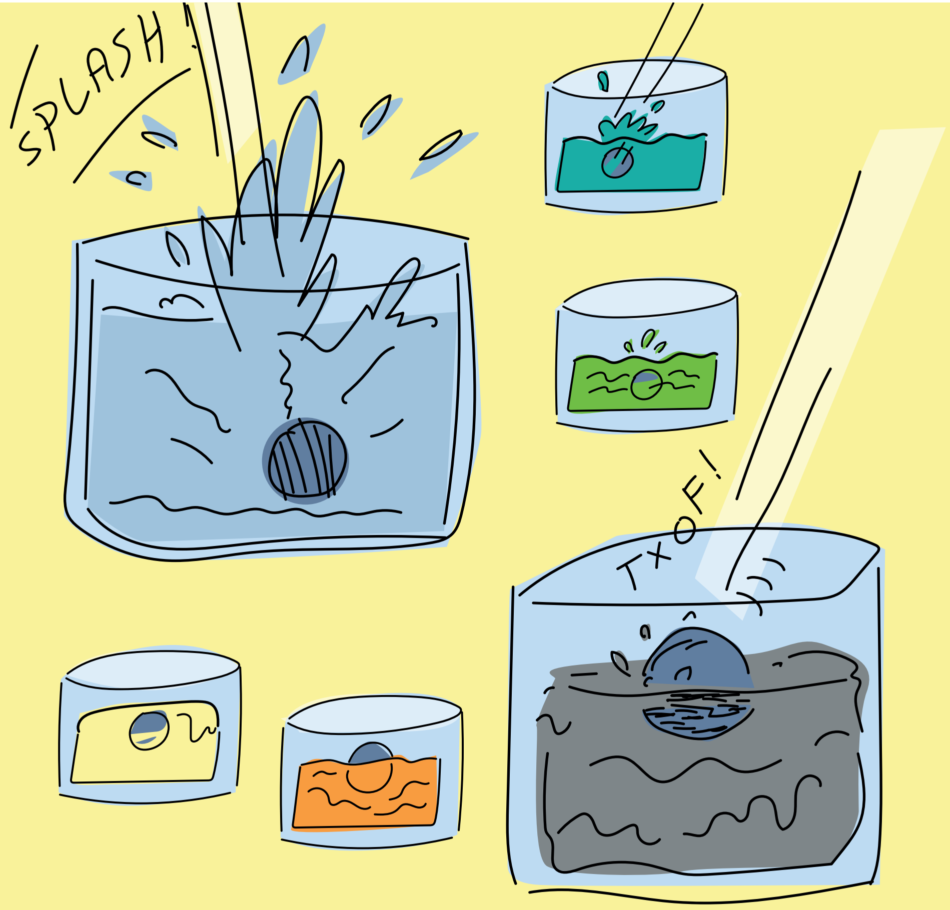
Area: Energy, Technology.

Level: 3rd and 4th year secondary school.

Challenge: To produce ethanol from orange waste, using oranges discarded by stores. Using photometry, we test to see which fruit juice contains the most sugar and whether the decay of the fruit increases the sugar content.
We will then distil the juice and produce ethanol. We will see that it is possible to produce ethanol, but we would need many oranges to produce it in large quantities. So we are now looking for situations in which it might be viable.

Teacher's notes: There are several commercial kits for carrying out energy-related projects. These are ideal for first-time energy projects as they contain all the material we need, together with explanatory manuals. As we acquire more experience, we can abandon the kits and instead buy resources individually, which will give us more room for creativity.

Effect of the viscosity of six liquids on speed of freezing



Authors: Miren and Elias.

Area: Physics.

Level: High school.

Challenge: There are various techniques for measuring viscosity. For this experiment we will use a ball and a test tube. Alternatively, we can pour the liquid we want to analyse into the test tube and then place the ball inside. We will calculate the time it takes for the ball to fall to the bottom of the test tube. Once we have calculated the viscosity of each of the six liquids, we will then calculate the time it takes for them to freeze using the freezer.

Teacher's notes: Owing to the complexity of this project, the students have made various adjustments over the past three years and we have studied the projects of others who have researched the same subject, in which we have incorporated some improvements. Continuing to improve a specific project based on what has already been done should not be construed as a lack of originality.

Study on food preservation methods

Author: Maitane.

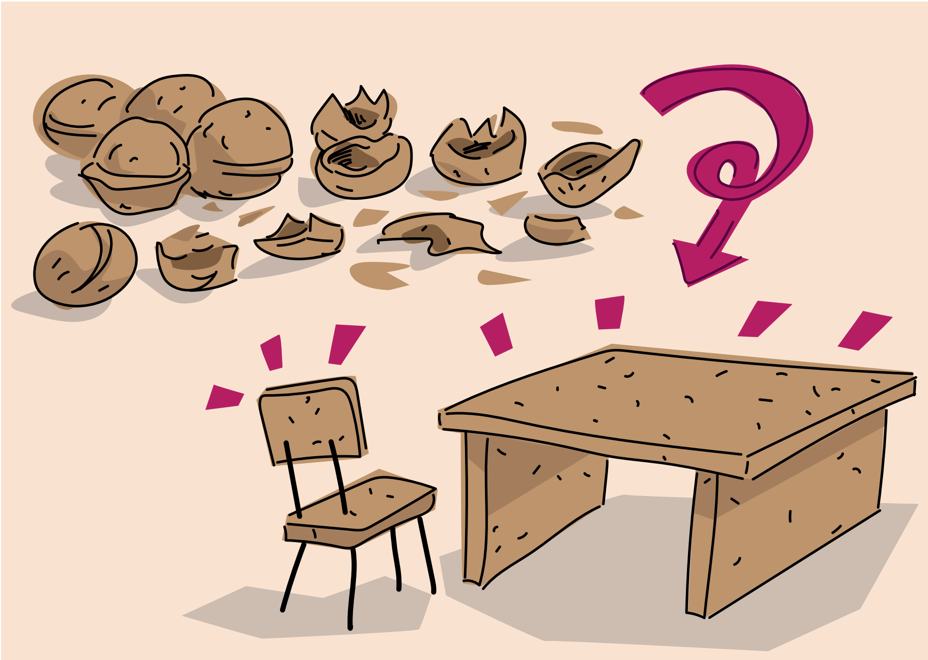
Area: Technology.

Level: High school.

Challenge: Maitane started when she was young to look for an alternative to current preservation methods to extend the shelf life of food, so that she wouldnít have to depend on chemicals that could harm her health. So her challenge was to find a cheaper, more sustainable and healthier method. And she succeeded! This work has won her several international awards.

Teacher's notes: Taking their own project to science fairs benefits students in many ways: they gain confidence, meet young people with the same interests and improve their communication skills, and it helps them to become better researchers.

New material using nut shells as an alternative to chipboard: characteristics and economic viability of its industrial use



Authors: Alaitz and Aritz.

Area: Environment, Technology.

Level: High school.

Challenge: Our challenge is to create an alternative material to chipboard, using walnut shells. Using different sensors, we will analyse its temperature and soundproofing capacity in comparison to other commercial materials.

Teacher's notes: In recycling projects, the economic viability of the result is extremely important, as a product may be good but not economically viable.

Antibiotic properties of breast milk

Authors: Yolanda and Alicia.

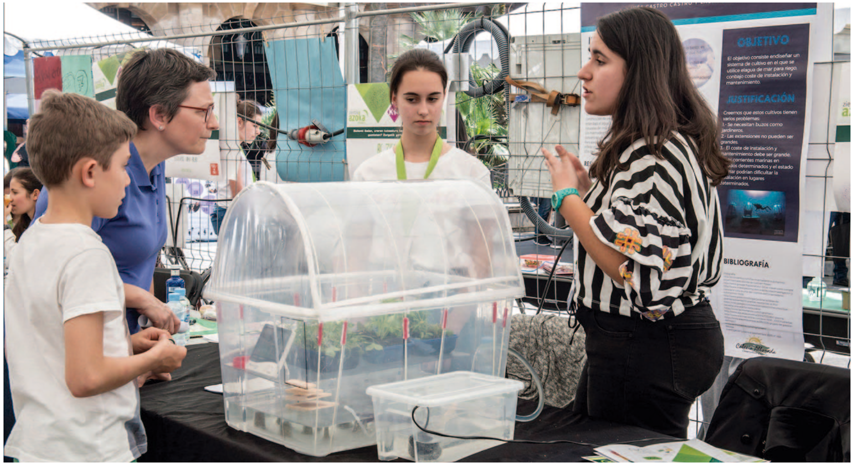
Area: Microbiology.

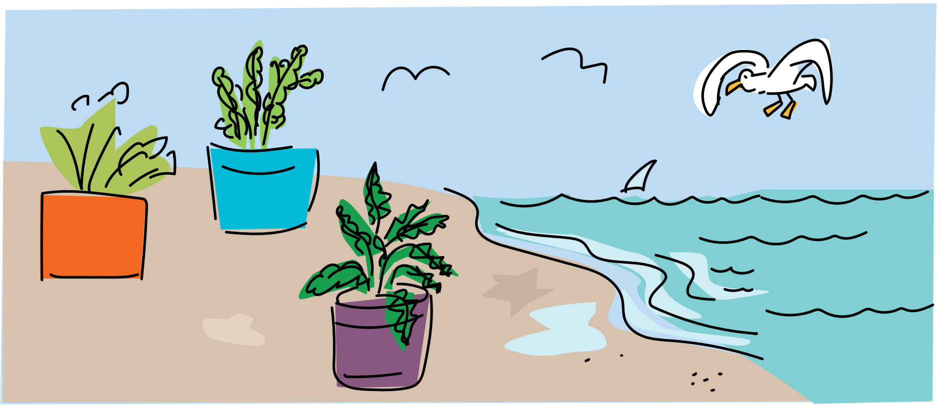
Level: High school.

Challenge: Everyone is talking about the recent opening of the milk bank. Questions come to mind such as why do we need a milk bank, what are the benefits of breastfeeding for newborns, what immunity do babies acquire, etc. We will compare all this information with the shortage of antibiotics.

Teacher's notes: The fact that several tasks have been undertaken for this project gives us an idea of its complexity: residents of Etxebarri received a survey regarding this topic and interviews were carried out in the hospitals of Galdakao, Basurto and Cruces.

Design a greenhouse that uses desalinated sea water for watering plants





Authors: Ines and Laura.

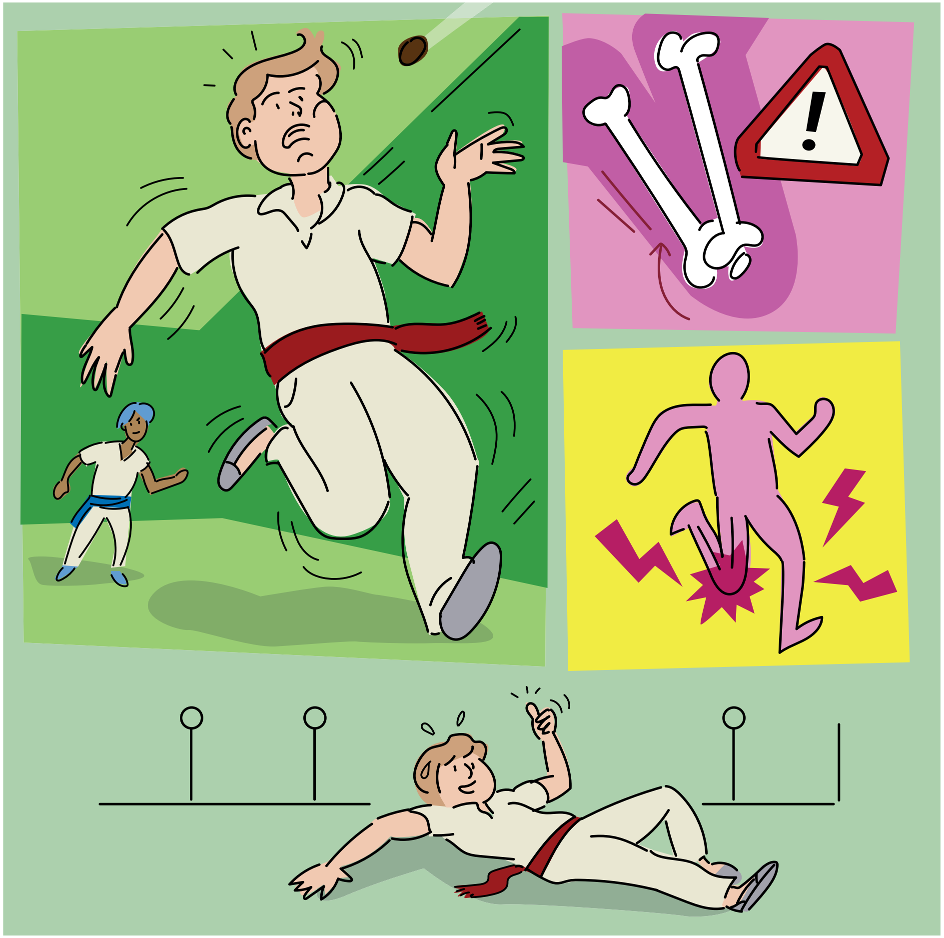
Area: Environment, Technology.

Level: High school.

Challenge: To design prototypes of greenhouses that do not require the use of drinking water. We start with experiments based on underwater crops, with pots inside the bells submerged in a bucket of sea water, and we will study the effectiveness of these tests. We will test with different plant species, such as lentils, rocket and parsley. The final design is a model that would be located close to the coast, a covered "pool" that would be supplied with sea water and have cultivation platforms.

Teacher's notes: This project is four years old and, after each edition, the different prototypes have been presented at science fairs to receive the feedback of the judges and to continue making improvements.

Microchip that prevents the tearing of ligaments



Author: Beñat.

Area: Technology, anatomy.

Level: High school.

Challenge: Using Arduino technology and free software, we created our own microchip to measure the degree of torsion between the tibia and the femur. When this torsion exceeds 35 degrees, it sends an electric shock to the vastus lateralis of the quadriceps. This immobilises the person and prevents tearing. This solves one of the most common injuries in ëpilotaí players.

Teacher's notes: This project stems from the author's personal interest and he decided to carry it out alone. Individual works are not usual, but we must be flexible and consider the needs and wishes of the students.

7 Bibliographic references and sources to follow deepening the issues

PBLWORKS - Buck Institute for Education
https://www.pblworks.org/

Guía de apoyo para la investigación científica escolar - Programa EXPLORA. Comisión Nacional de Investigación Científica y Tecnológica, CONICYT Gobierno de Chile Enero 2010
http://www.exploravalparaiso.ucv.cl/wp-content/uploads/2014/04/Gu%C3%ADa-de-apoyo-para-la-investigaci%C3%B3n-cient%C3%ADfica-escolar.pdf

Australian Society for Evidence Based Teaching
https://www.evidencebasedteaching.org.au/

Las 10 reglas de oro para dar feedback a tus alumnos – Javier Touron
https://www.javiertouron.es/las-10-reglas-de-oro-para-dar-feedback/

21CLD Learning Activity Rubrics - Microsoft Corporation
https://www.creatingrounds.com/uploads/9/6/2/4/96240662/21cld_student_work_rubrics_2012.pdf

"Enseñando ciencia con ciencia";
https://www.fecyt.es/es/publicacion/ensenando-ciencia-con-ciencia.
February 2020 edition, published by FECYT and the Lilly Foundation.
Coordinators: Digna Couso, M. Rut Jiménez-Liso, Cintia Refojo and José Antonio Sacristán.

Inspiring projects

elhuyar