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COURSE VIRTUAL

FOR THE TECHNOLOGICAL
TRAINING OF SECONDARY
SCHOOL TEACHERS



1ο Επαγγελματικό
Λύκειο Πάτρας

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1. INTRODUCTION

As a result of the crises that Europe has suffered in recent years, unprecedented technological development has taken place, assuming a leading role in the processes of social, economic, health, and educational reconstruction. Science has become a dynamic and effective mechanism for overcoming the limitations of these crises, bringing education to those who could not attend classes and serving as an increasingly valuable asset for the employability of secondary school students facing obstacles.

Technology has also tried to access the educational field (the EU has made a great effort to digitize teaching by investing more than 1.6 billion euros in Spain until 2027 and 5.7 trillion across Europe).

However, this technological advancement has not reached all schools equally, and its implementation often fails to reach the educational centers that need it most: those in areas particularly affected by social emergencies. Paradoxically, the schools and students in disadvantaged regions who most require these resources are the least able to access them due to the difficulty of utilizing them. These are regions with scarce employment and entrepreneurial opportunities, which generates apathy and a lack of motivation among young people (especially women) towards an education they believe cannot offer them alternatives... drastically contributing to their high dropout rates. This situation results in schools lacking resources and staff, with teachers overwhelmed by their daily workload and lacking the time to address the challenges of digitalization or take advantage of the few 3D labs that have been set up but require a significant amount of work to operate.

In these schools, teachers and administrators work tirelessly every day (far beyond their means) to overcome the obstacles their students face and prevent them from dropping out of school and falling into exclusion. All of this is done without the equipment and support they deserve.

In this context, the Erasmus Plus project “DIDACTECH” emerges, with which we propose a joint strategy, carried out by technology companies together with secondary educational centers, which generates a complete educational process that not only promotes technological training and the interest of students with obstacles through practical projects, but these projects are really useful for primary schools that require it, helping their teachers and alleviating the equipment needs of these centers, even generating materials adapted to the specific obstacles of primary school students with disabilities. A process based on the creation of TECHLABs, technological manufacturing workshops, where students facing obstacles from segregated areas (especially women, since according to the White Paper on Women in Technology (2019), only 16% of professionals in the STEM field are women, and very few teenagers, 0.7%, are interested in studying technology degrees) are involved in production processes that bring them closer to the production systems of the future while helping schools throughout Europe that have few resources.

Didactech

With Didactech, we have brought technology and scientific skills to students with obstacles and help teachers in low-income schools implement free technology education tailored to their needs.



This educational process encompasses both school hours and extracurricular activities, with the firm commitment to promoting the social inclusion of students facing barriers from segregated areas, and especially female students, as they encounter the greatest obstacles not only in accessing the general job market, but also in the scientific and technological fields. We address the obstacles they face in accessing the opportunities offered by both the technological sector and the E+ Program, contributing to the creation of inclusive environments that promote equity and equality and respond to the needs of the community as a whole.

These obstacles usually lead to early school leaving, especially for these students.

Within this strategy is framed the “Virtual course for technological training of secondary school teachers”, a virtual course specifically aimed at secondary school teachers that seeks to promote their training in the latest technological advances and provide them with strategies to motivate students and fight against early school leaving through science and technology.

In summary, with “Didactech” and the “Virtual course for the technology training of secondary school teachers,” we aim to contribute to the modernization of the school education model in accordance with the Council Resolution on a Strategic Framework for European cooperation in education and training towards the European Education Area and beyond (2021-2030). We support improvements in school-level science, technology, engineering, and mathematics (STEM) education by promoting best practices in developing links and cooperation between higher education, research, and businesses with schools at the EU level, and effectively addressing gender gaps and stereotypes in STEM, leveraging Erasmus+ as a key partner.

2.TECHLAB

Techlabs are completely free 3D printing technology labs that have been designed to bring science and technology closer to high school students, especially those with barriers.

A real, motivating and useful educational experience that makes learning tangible and exciting.

Through state-of-the-art digital manufacturing equipment (such as 3D printers), teachers can easily and dynamically incorporate 3D into their students' education, and students delve into the exciting world of science, developing fundamental skills for their academic and professional future.

Thanks to the world of 3D printing, students have the opportunity to become interested in science and technology, awaken their creativity, and develop key and transversal skills, such as critical and scientific thinking. All of this while learning STEM concepts.

In this sense, each classroom becomes an opportunity to learn science in a dynamic and fun way, work as a team, and acquire key and transversal skills. Implementing a Techlab in secondary and primary schools offers many advantages for the school, its teachers, and students. Among the main benefits for teachers are:

1**Integrate 3D into your classes in an accessible and dynamic way.**

You don't need to be a 3D technology expert to incorporate it into your classes. The Techlab methodology allows you to easily integrate 3D into the classroom, without requiring advanced technical knowledge.

2**Spark interest in science and technology in your students.**

The Techlab will allow you to create a space where your students learn science and technology by experimenting, designing, and solving problems. We believe that seeing concepts become tangible objects sparks your students' curiosity and interest in learning.

3**Develop key skills in your students.**

The Techlab offers you the opportunity for your students to acquire key and transversal skills in a dynamic, simple and attractive way.

4**Receive continuous technical and pedagogical support.**

You won't be alone in the Techlab implementation process. You'll have the support of a team of scientists and experts who will advise you throughout the entire implementation and development process.

**Receive specific training.**

The course you are taking is part of the training you will receive for the implementation and development of the Techlab. In addition, you will have access to online and/or in-person workshops and training sessions (depending on the location of your educational institution).

**Transform your classroom into a technological idea lab.**

Imagine your STEM classroom transformed into a dynamic space where learning is interactive, practical and dynamic, where students learn with enthusiasm, experiment and learn by doing.

**It promotes student motivation and prevents school dropout.**

Techlab's innovative methodology encourages student involvement, especially for those with obstacles, learning difficulties, low motivation, etc. By feeling like an active part of the learning process, students show greater interest and commitment, helping to prevent school dropout and improve their academic performance.

3. SCIENTIFIC AND TECHNOLOGICAL EDUCATION

3.1. STEM SKILLS AND THEIR IMPORTANCE IN SECONDARY EDUCATION

The European Commission, in the Council Recommendation of 22 May 2018 on key competences for lifelong learning (2018/C 189/01), addresses the development of key competences from early childhood education and schooling to adult education, defining competence as follows: “Key competences are those that all individuals need for personal fulfillment and development, employability, social integration, sustainable lifestyles, success in peaceful societies, healthy living, and active citizenship. These are developed with a lifelong learning perspective, from early childhood to adulthood, and through formal, non-formal, and informal learning in all contexts, including family, educational institutions, the workplace, the environment, and other communities.” [i]

The implementation of Techlabs in secondary education classrooms constitutes an innovative methodological strategy that enhances the integral development of students in line with the key competences defined by the European Union.

[i]Council Recommendation of the European Union of 22 May 2018 on key competences for lifelong learning (2018/C 189/01). Annex. Key competences for lifelong learning. A European reference framework.

Literacy skills

The European Commission defines literacy as “the ability to identify, understand, express, create and interpret concepts, feelings, facts and opinions orally and in writing, using visual, sound or audio and digital materials in different disciplines and contexts. This implies the ability to communicate and connect effectively with other people, in an appropriate and creative way”^[i].



In Techlabs, students formulate hypotheses, express their opinions, exchange ideas, search for information, and carry out activities both orally and in writing. All of this reinforces their ability to understand, interpret, and reproduce texts and dialogues, promoting the development of this skill.

[i]Council Recommendation of the European Union of 22 May 2018 on key competences for lifelong learning (2018/C 189/01). Annex. Key competences for lifelong learning. A European reference framework.

Mathematical competence and competence in science, technology and engineering

The European Commission defines mathematical competence as “the ability to develop and apply mathematical reasoning and perspective in order to solve various problems in everyday situations. Building on a good command of calculation, the emphasis is on process and activity as well as knowledge. Mathematical competence entails—to varying degrees—the ability and willingness to use mathematical modes of thinking and representation (formulas, models, constructions, graphs and diagrams)” [iii] and competence in science, technology and engineering as “the ability and willingness to explain the natural world using the body of knowledge and methodologies employed, including observation and experimentation, in order to ask questions and draw evidence-based conclusions. Competence in technology and engineering means the application of such knowledge and methodologies in response to perceived human wants or needs. Competence in science, technology and engineering entails an understanding of the changes caused by human activity and the responsibility of each individual as a citizen” [iv]

Techlabs are a fundamental learning space for working on STEM subjects through 3D printing, as they allow students to move from the abstract to the tangible. For example, mathematics ceases to be just numbers and becomes designed objects, technology is learned through innovation, and subjects like biology, physics, and chemistry are learned with three-dimensional models that students can manipulate and understand more easily.



Thus, problem-solving is integrated through concepts from mathematics, physics, biology, technology, and other disciplines applied to 3D design, allowing students to develop critical and scientific thinking skills by observing, experimenting, modeling, and prototyping. Through this approach, we not only foster a critical and responsible attitude but also promote understanding and motivation for science and technology.

For example, at the Techlab we can carry out a practical exercise on molecular models, part of the STEM curriculum for Physics and Chemistry. In this exercise, we will create a model that helps explain and understand the molecular structure of very different substances, from simple molecules like water or the oxygen and nitrogen that largely make up air, to extraordinarily complex molecules such as those that form the components of living systems: proteins, polysaccharides, DNA, and RNA.

The model will help students visualize not only the composition but also the internal mobility—the number of different conformations that molecules can adopt. But, of course, for that we'll need a lot of atoms, and here our 3D printing technology lab (Techlab) will allow us to expand our set of molecules as much as we want.

[iii]Council Recommendation of the European Union of 22 May 2018 on key competences for lifelong learning (2018/C 189/01). Annex. Key competences for lifelong learning. A European reference framework.

[iv]Council Recommendation of the European Union of 22 May 2018 on key competences for lifelong learning (2018/C 189/01). Annex. Key competences for lifelong learning. A European reference framework.

Digital competence

The European Commission defines digital competence as “the safe, critical and responsible use of digital technologies for learning, at work and for participation in society, as well as interaction with them. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), security (including digital wellbeing and cybersecurity-related competences), intellectual property issues, problem-solving and critical thinking.” [v]



The use of innovative 3D printing equipment, modeling software, and digital tools for the implementation of Techlabs makes these technology laboratories a fundamental environment for digital literacy and the acquisition of this skill.

In some cases, the teacher will create and build the 3D models (for example, simple molecules such as water, ethanol, butane, or glucose), while in other cases, the students will be directly involved in the design, experimentation, and construction (depending on the STEM subject).

[v]Council Recommendation of the European Union of 22 May 2018 on key competences for lifelong learning (2018/C 189/01). Annex. Key competences for lifelong learning. A European reference framework.

Personal, social and learning-to-learn competence

The European Commission defines personal, social and learning-to-learn competence as “the ability to reflect on oneself, manage time and information effectively, collaborate constructively with others, maintain resilience and manage one’s own learning and career. It includes the ability to cope with uncertainty and complexity, learn to learn, contribute to one’s physical and emotional well-being, maintain physical and mental health, and be able to lead a healthy and future-oriented life, express empathy and manage conflicts in an inclusive and supportive context.” [vi]



Techlabs promote the development of key critical thinking skills (learning to learn, information search, formulating hypotheses and answers, finding solutions, making decisions, posing problems, critical and scientific analysis...), as well as teamwork, allowing students to gain confidence in their abilities and motivation to learn how to learn.

[vi] Council Recommendation of the European Union of 22 May 2018 on key competences for lifelong learning (2018/C 189/01). Annex. Key competences for lifelong learning. A European reference framework.

Civic competence

The European Commission defines civic competence as “the ability to act as responsible citizens and participate fully in social and civic life, based on an understanding of social, economic, legal and political concepts and structures, as well as sustainability and world events.” [vii]



Techlabs are inclusive and discrimination-free spaces designed to ensure the equitable participation of all students, especially those facing barriers. The implementation of Techlabs promotes equal opportunities and responsible participation in the educational community, contributing to an education based on diversity and equity.

[vii]Council Recommendation of the European Union of 22 May 2018 on key competences for lifelong learning (2018/C 189/01). Annex. Key competences for lifelong learning. A European reference framework.

Entrepreneurial competence

The European Commission defines entrepreneurial competence as “the ability to act on opportunities and ideas and transform them into value for others. It is based on creativity, critical thinking and problem-solving, taking initiative, perseverance and the ability to work collaboratively in the planning and management of projects of financial, social or cultural value.” [viii]



In the Techlab and 3D printing, students learn to identify problems, formulate hypotheses, and propose solutions, fostering initiative, decision-making, and resource management. Thanks to this, they acquire the necessary skills to develop an entrepreneurial attitude geared towards innovation.

[viii] Council Recommendation of the European Union of 22 May 2018 on key competences for lifelong learning (2018/C 189/01). Annex. Key competences for lifelong learning. A European reference framework.

Competence in cultural awareness and expression

The European Commission defines competence in cultural awareness and expression as “the ability to understand and respect the way in which ideas and meaning are creatively expressed and communicated in different cultures, as well as through a range of arts and other cultural manifestations. It involves striving to understand, develop and express one’s own ideas and a sense of belonging to society or of playing a role in it in different ways and contexts.” [ix]



Although Techlabs have a strong scientific and technological focus, they also offer the opportunity to be creative through design projects for subjects such as technology, allowing students to transform ideas into 3D prototypes.

[ix]Council Recommendation of the European Union of 22 May 2018 on key competences for lifelong learning (2018/C 189/01). Annex. Key competences for lifelong learning. A European reference framework.

Multilingual Competence

The European Commission defines multilingual competence as “the ability to use different languages appropriately and effectively for communication. Broadly speaking, it shares the same dimensions of competence as literacy: it is based on the ability to understand, express and interpret concepts, thoughts, feelings, facts and opinions orally and in writing (listening, speaking, reading and writing) in diverse social and cultural contexts according to one's wishes or needs.” [x]



The implementation of Techlabs and the development of activities in the technology laboratory requires students to search for information, manuals and resources in different languages, allowing them to develop technical, scientific and technological vocabulary mainly in English.

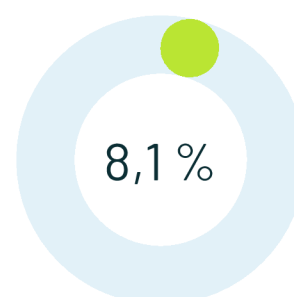
[x]Council Recommendation of the European Union of 22 May 2018 on key competences for lifelong learning (2018/C 189/01). Annex. Key competences for lifelong learning. A European reference framework.

4. STRATEGIES TO MOTIVATE STUDENTS

Early school leaving and social exclusion remain a challenge for Europe:

PORTUGAL

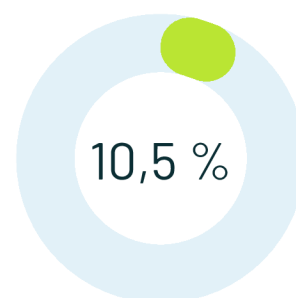
According to Eurostat, in 2023 the school dropout rate in Portugal was 8.1%, higher than the 6.3% rate in 2022. Regions such as the Azores and Algarve have the highest dropout rates in the country, at 22.9% and 16% respectively in 2023, compared to the North region (6.1%).



2023

ITALY

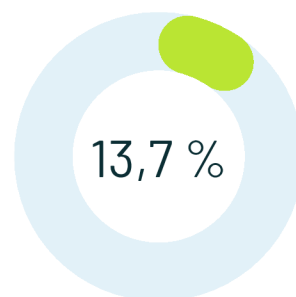
Italy reached 10.5% in 2023 (Eurostat), with large regional differences: southern regions such as Sicily (17.1%) and Sardinia (17.3%) have the highest early school leaving rates in the country, compared to regions such as Umbria (5.6%), Lazio (6.1%), and Friuli-Venzia Giulia (6.6%) with the lowest school leaving rates in the country.



2023

SPAIN

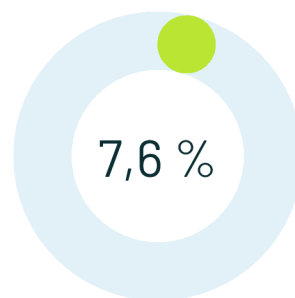
In Spain, for example, the early school leaving rate fell from 32.2% in 2004 to 13.7% in 2023 (National Institute of Statistics – INE[xi]).



2023

FRANCE

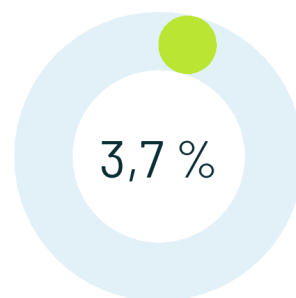
According to Eurostat data, in 2023 the early school leaving rate in France was 7.6%. Analyzing the data by region, French Guiana and Corsica have the highest rates, at 21.7% and 21.5% respectively. The Auvergne and Rhône-Alpes regions have a rate of 7.3%, while Aquitaine has the lowest rate at 4.1%.



2023

GREECE

In the case of Greece, according to Eurostat data, it is among the countries with the lowest rates of early school leaving in the EU, with a rate of 3.7% in 2023[xii].



2023

[xi]Early abandonment of education and training in the population aged 18 to 24 years by Autonomous Communities and in the European Union

[xii]In Spain, for example, the early school leaving rate fell from 32.2% in 2004 to 13.7% in 2023 (National Institute of Statistics – INE[xi]).

Despite the progress made in the last two decades, early school leaving continues to vary considerably across European countries and regions. Therefore, addressing this issue is crucial to ensuring equal opportunities and meeting future social and employment demands.

We believe that one of the mechanisms to combat early school leaving is the motivation of students, especially in secondary education, through strategies that connect secondary education with motivation and the academic and professional future[xiii].

The European Commission highlights the importance of basic skills, including STEM subjects, as fundamental to personal development[xiv]. In this context, science and technology education is a key tool for motivating secondary school students, especially those facing challenges.

Therefore, implementing strategies to motivate students in STEM in secondary education not only allows them to acquire key and transversal skills, but also shows them that science and technology are accessible paths to their future.

Below, we present a set of strategies to motivate students in STEM.

[xiii] Eurostat. (2023). Gender equality in the EU – 10 years in review. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Gender_equality_in_the_EU_-_10_years_in_review

[xiv] European Commission. (2022). Proposal for a Council Recommendation on learning for environmental sustainability [COM(2022) 11 final]. Brussels: European Commission. Available from: <https://eur-lex.europa.eu/legal-content/ES/TXT/?uri=CELEX%3A52022DC0011>

41. PRACTICAL AND EXPERIMENTAL LEARNING IN TECHNOLOGICAL LABORATORIES (TECHLAB)

Hands-on learning is a key tool for motivating students in the classroom, especially those facing challenges, as they become more engaged and show greater interest when they are actively involved in the learning process. In STEM subjects at the secondary level, this methodology presents a significant opportunity to motivate students, since science and technology are best learned through doing rather than simply reading or memorizing.

In this sense, the implementation of a Techlab (technology laboratories) offers teachers the opportunity to bring science and technology closer to students, turning intangible concepts into tangible, dynamic and meaningful learning.

Imagine a space where high school students not only learn science and technology, but also use it to improve their environment. That's what Techlabs are: technology workshops where, through state-of-the-art digital fabrication equipment (such as 3D printers), teachers can easily and dynamically incorporate 3D into their students' education, and students will delve into the exciting world of science, developing fundamental skills for their academic and professional future.

For example, at the Techlab we can conduct a practical exercise on molecular models in the STEM subject of Physics and Chemistry. In this exercise, we will produce a model that helps explain and understand the molecular structure of very different substances, from simple molecules like water or the molecular oxygen and nitrogen that largely make up air, to extraordinarily complex molecules such as those that form the components of living systems: proteins, polysaccharides, DNA, and RNA.

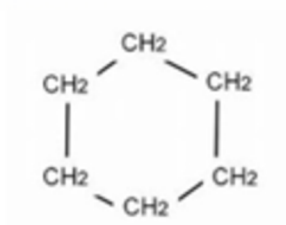
The model will help us visualize not only the composition but also the internal mobility—the number of different conformations the molecules can adopt. But, of course, for that we'll need a lot of atoms, and here our 3D printing technology lab (Techlab) will allow us to grow our set of molecules as much as we want (with patience, of course).



Figure 1. Models of some simple molecules: water, ethanol, butane, and glucose.

Figure 1 shows models of some simple molecules such as water, ethanol, butane, or glucose.

Cyclohexane. The six-carbon ring



Bathtub



Chair

Figure 2. Chair and bathtub conformations of cyclohexane.



Figure 3. Model of a segment of the stretched or coiled polyethylene chain.



Figure 4. Model of the silica crystal lattice.

From here the teacher can encourage students to build models of substances that motivate the understanding of basic phenomena of physics, chemistry or biology of molecules.

We believe that Techlabs are a real, motivating, and useful educational experience for both teachers and students. In these technology workshops, students learn through hands-on learning, interacting with and manipulating concrete representations of STEM concepts. In some cases, the teacher will create and build the models (for example, simple molecules like water, ethanol, butane, or glucose), while in others, the students will be directly involved in the design, experimentation, and construction (depending on the STEM subject).

Participation in a Techlab is expected to foster in students a special motivation for scientific and technological learning, as well as to help them acquire key and transversal skills such as critical thinking, teamwork, etc., which will be crucial for their current and future education and when they enter the workforce in the future.

4.2. REFERENCES

Showing students relatable role models is another strategy to motivate them, break down stereotypes, foster aspirations, and demonstrate that science and technology careers are accessible to everyone. When we see ourselves reflected in a story or concrete example, our motivation and aspirations increase.

This is especially important in the case of female students. The potential of women in science is undeniable. However, the figures are worrying. According to the White Paper on Women in Technology (2019), only 16% of STEM professionals are women, and very few teenage girls, just 0.7%, are interested in pursuing technology degrees.

According to studies by the European Commission[xv], between 2014 and 2022 the proportion of women in STEM and life sciences grew from 15.7% to 17.9%, while men made up 42.4%.

We believe that this gap is not due to a lack of ability, but to various factors such as the stereotypes that associate science and technology with masculinity or the lack of promotion of female scientists among high school students.

In order to counteract these barriers, showcasing current role models in science and technology not only helps to break stereotypes, but learning about real experiences can inspire and increase the motivation of students, allowing them to identify with academic and professional opportunities in STEM.

Below, we present suggestions that allow students to discover role models in STEM.

[xv] Eurostat. (2023). Gender equality in the EU – 10 years in review. Recuperado de https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Gender_equality_in_the_EU_-_10_years_in_review



Talks by scientists (virtual or in-person). These talks bring science and technology closer to secondary school students. During these talks, the guest explains their area of research or development and answers students' questions.

Women in Science Today Campaign. Within the framework of the Erasmus+ project "Didactech," the Women in Science Today campaign was developed—an innovative initiative that presents secondary school students with real-world examples of women contributing to scientific advancements in various fields. The Women in Science campaign was created with a clear objective: to inspire secondary school students to discover the potential of women in science and technology. Unlike other initiatives focused on women throughout history, this campaign focuses on the present, showcasing the crucial role women play today, leading pioneering research centers and directing and working on research projects that will change the future of Europe and the world.



In addition, the campaign also seeks to help high school students naturally perceive that science is an area where gender diversity is key to progress.

We believe this approach is fundamental, as it allows high school students to see that these figures are not distant and that they can see themselves reflected in them.

4.3. COLLABORATION WITH TECHNOLOGY COMPANIES

Creating synergies with technology companies allows the educational center to connect with the professional world, show students the real application of the knowledge they learn in STEM subjects and contribute to their motivation for higher education and future careers.

In this regard, one of the main mechanisms for motivating students facing obstacles through collaboration with technology companies is the creation of the Techlabs mentioned in section 3.2.1. The TECHLABS methodological strategy fosters the direct involvement of technology companies in schools located in disadvantaged areas. This strategy generates an innovative methodology that encompasses curriculum and content development for STEM subjects both during and outside of school hours by creating TECHNOLOGICAL MANUFACTURING WORKSHOPS/LABORATORIES (TECHLABs) equipped with cutting-edge technology. These workshops will produce materials for primary schools with limited resources.



Imagine a primary school with limited resources requesting the creation of atomic models for its visually impaired primary school students. The secondary school students participating in the TECHLAB will design and produce these models through a holistic approach that adapts theoretical subjects (mathematics, physics and chemistry, technology, etc.) into a practical, real-world project by engaging with expert researchers in their classes.

Another mechanism is the Erasmus Plus Programme, which can represent a great opportunity to create synergies between secondary education centers and technology companies, as is the example of the “Didactech” project, in which this course is framed, which promotes the participation of students with obstacles in the technology sector generating synergies between technology companies and educational centers in rural areas or segregated students.

On the other hand, visits to technology companies or research centers can be very useful to show students the work done in professional environments and motivate them, demonstrating that it is a possible future for them.

Finally, there are talks by scientists, researchers, CEOs, or directors of research centers. Unlike the talks with scientists mentioned in the previous section, which aim to inspire and showcase individual career paths, these talks can be a great opportunity to inspire students and show them how the knowledge they learn in class can be applied in real-world contexts.

4.4. MOTIVATION ASSESSMENT

The implementation of Techlabs is an opportunity to evaluate how learning in these laboratories generates additional motivation for STEM learning and for science and technology in general among students, especially those with obstacles.

The study and evaluation of student motivation at any educational level is a fundamental aspect of the educational process, as much of the success in teaching and learning depends on factors related to motivation [Reigeluth 2016]. For an analysis of student motivation to be conclusive regarding the effectiveness of a specific methodology, a model that structures the evaluation is necessary. In this sense, the ACRS model (Attention, Confidence, Relevance, Satisfaction), proposed by Keller in 2010, provides an evaluation framework based on his conception of the motivational design of learning. This procedure allows the teacher to analyze student motivation in response to the introduction of specific teaching material. The procedure is applicable to students in different educational systems, from secondary to university levels [Keller 2010, Rodríguez Bailón 2021]. The model proposes four fundamental elements of motivation: attention, confidence, relevance, and satisfaction. The element of attention refers to how the teaching methodology or materials capture students' curiosity, enthusiasm, and interest, fostering an active attitude toward learning due to its novelty. Relevance relates to how students connect the teaching materials and methods with their learning needs, goals, prior experiences, and study preferences. Confidence relates to the feeling of personal control and the expected success at the end of the learning process with the chosen methodology. Satisfaction refers to the positive attitude students have toward the learning process.

Hypothesis

The hypothesis of the study is that participation in the Techlab is an important motivating factor for students in their future studies, and in particular towards science and technology.

Method.

Study design: The study includes, at each center, a group that will have participated in the pilot test using the Techlab methodology and a control group of the same educational level. Responses will be anonymized and collected in two sealed envelopes, one for the analysis group and one for the control group.

The study seeks to answer the question: Does having carried out the practice following the Techlab methodology positively influence the student's motivation towards their studies?

It is based on a 34-question survey, following the ACRS model of the "Course Interest Survey" (Keller 2010), adapting the language of the questions to the level of study corresponding to secondary education. Responses are scored as follows: 1: strongly disagree, 2: somewhat disagree, 3: somewhat agree, 4: somewhat agree, 5: strongly agree

	1	2	3	4	5
1. Teachers know how to get us excited about the subjects we study.					
2. What I am going to study in vocational training will be useful for me					
3. I think I'm going to do well this year					
4. I'm finding very few things in the course that capture my attention					
5. Teachers make the things they teach us seem important					
6. To get good grades you have to be lucky					
7. I have to work a lot to pass the course					
8. I don't know what what they're teaching me has to do with anything I've seen before.					
9. Whether or not to pass the course is up to me					
10. The teacher creates suspense when he explains a new thing					
11. The subjects in this course are too difficult for me					
12. I am very satisfied with what I am studying					
13. I would like to get very good grades					
14. It seems to me that the grades they give me and the comments that the teachers make to me are good compared to the rest of the					
15. In this course, classmates seem to be curious about what they teach us.					
16. I have a good time studying in this course.					
17. It's hard to know what grades the teachers are going to give me.					
18. I think the notes I get are good considering what I have worked on.					
19. I feel satisfied with what I am achieving this course.					

20. What I'm studying is what I wanted.					
21. Teachers do unexpected and curious things, which are interesting.					
22. Students actively participate in the classes.					
23. For my future it is important that I do well in these studies.					
24. In class we do very different things.					
25. I don't think this course will help me much.					
26. In class I am often thinking about other things.					
27. I think I can do well in my studies if I work hard.					
28. I see clearly what is good for me in these studies.					
29. The problems and questions that are raised in class stimulate my curiosity.					
30. I think the difficulty of the course is fine: neither too easy nor too difficult.					
31. I have been disappointed this season.					
32. I think I am being valued well, both with the grades and with the comments of the teachers.					
33. The amount of work I have to do is appropriate for this type of study.					
34. With what the teachers tell me I can clearly see if I am doing well or badly in the course.					

Guide for evaluating the course interest survey

Attention	Relevance	Confidence	Satisfaction
1 4 (reverse) 10 15 21 24 26 (reverse) 29	2 5 8 (reverse) 13 20 22 23 25 (reverse) 28	3 6 (reverse) 9 11 (reverse) 17 (reverse) 27 30 34	7 (inverse) 12 14 16 18 19 31 (reverse) 32 33
*There are questions phrased negatively; the assigned values must be taken in reverse order, i.e., 1 is 5, 2 is 4, 3 is 3, 4 is 2, and 5 is 1.			

Data analysis

The calculation will be performed using average values of the scores assigned by the students, obtaining a rating for each of the fields and the sum of the four will be considered the final rating of motivation.

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5. INCLUSION AND EQUITABLE PARTICIPATION IN TECHNOLOGICAL PROJECTS

5.1. STUDENTS WITH OBSTACLES

While the technology workshops (Techlab) are aimed at all secondary school students, we place special emphasis on those students who face obstacles, as they are the ones who encounter the greatest barriers to inclusion. These are secondary school students, especially girls, from disadvantaged regions who face economic, social, and employment barriers, encountering serious difficulties in accessing the technology job market and pursuing higher scientific careers, and consequently losing interest in this field.

The main obstacles they face are:

Socioeconomic obstacles

Many students come from low-income families, which prevents them from participating in activities that involve additional costs, such as extracurricular activities or trips to other cities or countries to visit research centers. In this sense, the creation of technology workshops (Techlabs) in the classroom is an opportunity for inclusion, as it allows all students, regardless of the obstacles they face, to participate equitably.

Geographical obstacles

Many secondary schools are located in rural areas where students have limited opportunities to access scientific activities or innovative technology workshops, such as technology fairs. In this regard, implementing Techlabs within the schools themselves is an effective solution, as it brings innovation and technology closer to the students' environment, eliminating physical barriers.



Cultural and social obstacles

Hate speech, such as racism, is a frequent barrier for students from migrant backgrounds or ethnic minorities, who must not only adapt to a new school environment but also endure rejection and exclusion. This is compounded by linguistic barriers that create obstacles to socialization. To combat these barriers, it is essential to create fully inclusive Techlabs that promote coexistence, respect, and equal opportunities.



Specific obstacles that female students face in relation to science and technology

The potential of women in science is undeniable. However, the figures are worrying. According to the White Paper on Women in Technology (2019), only 16% of STEM professionals are women, and very few teenage girls (0.7%) are interested in pursuing technology degrees. We believe this gap is not due to a lack of ability, but rather to various factors such as stereotypes that associate technology with masculinity or the lack of promotion of female scientists to secondary school students.

5.2. MEASURES FOR INCLUSION AND EQUITABLE PARTICIPATION

Ensuring equal participation for all students in technology projects is one of our main objectives. Therefore, we present below a set of measures designed to promote the inclusion of students facing barriers in the Techlabs:

Technological support

It refers to the adaptation of resources and tools that allow all students to participate in learning activities on equal terms, eliminating barriers to access and promoting the autonomy of students.



Support measures

- Free of charge. Although secondary education is free, the availability of materials and resources for certain activities is not covered by the school. Therefore, it is important to offer free materials and equipment in the Techlabs so that all students can carry out the activities under equal conditions.
- Free software. Use free and open-source software for designing 3D models in the classroom, so that students can continue installing and using it at home without limitations or financial barriers. For example, FreeCAD, Blender...

Digital accessibility

Ensuring that all devices used in the classroom meet accessibility criteria (such as screen readers, contrast options, adapted fonts, etc.) will allow students with special educational needs to participate fully.

Support measures

- Activate screen readers, subtitles, and read aloud when needed.
- Adjust the font size, contrast, and use easy-to-read fonts.
- Ensure that documents and platforms are accessible and navigable using a keyboard.
- Incorporate alternative text into images and avoid conveying information solely through colors.
- Allow for the customization of accessibility options according to the needs of the students.



Adaptation of the format and duration of the activities

It is important to consider the diversity of the student body and the different learning paces due to the specific needs of students with learning difficulties. Therefore, we recommend designing activities flexibly, adjusting their length and difficulty to each student's learning pace. This will ensure that all students can participate and achieve the proposed objectives.

Support measures

- Divide and adapt the content and activities to different starting levels.
- Gradually increase the level of difficulty.
- Flexibility in the design of activities.



We can approach the design of a 3D model for the technology subject in several phases, gradually increasing the level of difficulty. First, we will guide the creation of the most basic parts, and in subsequent sessions, students will design more complex parts more independently (with the teacher available to answer questions and provide assistance as needed) until they obtain the final piece, print it, and assemble it.

Individual and group tutoring

Group tutoring allows for observation of general classroom questions and teamwork dynamics, but students don't always feel comfortable expressing themselves in a group setting. Therefore, personalized tutoring is invaluable, especially for students facing challenges, in order to identify difficulties early, boost their confidence, and guide their progress. In secondary education, the role of tutor exists; however, this role isn't necessarily linked to STEM fields or to projects in the Techlab technology lab. Furthermore, the teaching load is heavy.



Support measures

- During the development of laboratory activities, the professor can go around to the working groups or work tables and spend a few minutes talking individually with those who require it.
- If the educational center has a digital platform like Moodle, we can offer students the opportunity to leave questions or comments for help that the teacher will answer.
- In faculty meetings, the specific needs identified can be conveyed to the group tutor in order to implement broader support.
- Request support from the center's team of psychologists.

Joint actions with psychologists from the center

One inclusion measure involves working jointly with the school's guidance and psychology teams to ensure that inclusion measures are tailored to the needs of participating students and to guarantee effective support from support tutors. This will allow us to identify cases requiring specific follow-up. If cases requiring additional support are identified, the guidance team will assist the teacher in implementing individualized support and guidance measures to ensure the student's participation.



Support measures

- Regular coordination with the guidance team to identify and assess the needs of the students.
- Design and implementation of individualized measures when necessary.
- Joint monitoring of student progress and adjustment of support.
- Advice to teachers to promote the participation and inclusion of all students.

Motivational support

Implementing strategies to motivate STEM students in secondary education not only allows them to acquire key and transversal skills, but also shows them that science and technology are accessible paths to their future. The previous section outlines the measures and strategies to motivate secondary school students facing obstacles to participate in technology workshops (Techlab) and to engage with science and technology in general.



Support measures

- Use the Techlab methodology.
- Provide positive reinforcement and recognition of achievements.
- Present challenges with different levels of difficulty to promote success.
- Offer personalized support and guidance to maintain motivation and participation.

6. 3D PRINTING IN EDUCATION

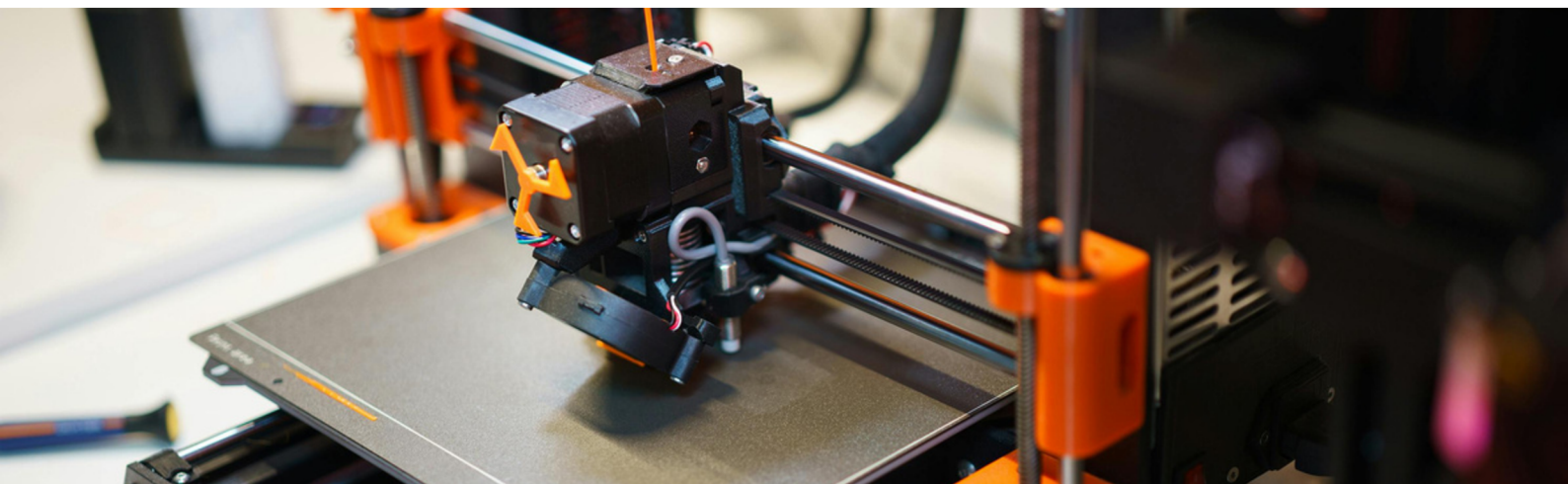
6.1. WHAT IS 3D PRINTING?

3D printing is an additive manufacturing technique, that is, a process by which physical objects are created from a digital model, adding material layer by layer until the piece is complete.

Unlike other traditional manufacturing methods, where material is cut, drilled, or removed, in 3D printing the object is built progressively. This allows for the easy production of complex shapes, reduces material waste, and facilitates the creation of prototypes and customized objects.

Currently, 3D printing is present in industrial, domestic, and educational settings. While industry uses more advanced technologies and complex materials, educational institutions employ accessible, safe, and easy-to-use printers, allowing this technology to be introduced into the classroom without requiring advanced technical knowledge.

From an educational point of view, 3D printing is not just a technological tool, but a pedagogical resource that allows students to design, experiment and materialize ideas, promoting a more practical, visual and meaningful learning experience.



6.1.1. THE 3D PRINTING PROCESS



Object design (3D model)

It all begins with the digital design of the piece. This is done using 3D modeling software. In an educational context, there are free and easy-to-use tools that allow users to get started without prior experience, such as:

- Tinkercad: especially recommended for beginners and high school students.
- Fusion 360 (educational license): more advanced, ideal for technical design.
- FreeCAD: free software based on parametric modeling.
- SketchUp Free: useful for simple designs and architectural environments.

It is also possible to download pre-designed models from royalty-free online 3D model databases, making it easy to start working without having to design from scratch.



Exporting the file: STL format

Once the object has been designed, it needs to be exported to a format compatible with 3D printing. The most common format is the STL file.

The STL format is the file that represents the geometric shape of a 3D object using a mesh of triangles. It's a universal format that works the same on any computer and with any design software. Its main function is to serve as "raw material" for the slicing program, since it only contains the visual information of what we want to print, regardless of which machine will be used afterward.



Model preparation: the laminator (slicer)

The STL file cannot be directly interpreted by the printer. Therefore, a program called a slicer is used, which divides the model into layers and generates the instructions necessary to print it.

Some examples of free and easy-to-use laminators are:

- Ultimaker Cura
- PrusaSlicer
- Bamboo Studio
- IdeaMaker

In this phase, parameters such as print quality, part infill, and temperature are configured, although many programs include pre-configured profiles that facilitate their use in the classroom.



Generating the print file: G-code

After the lamination, the program generates a file called G-code.

G-code is the set of instructions that the 3D printer will follow step by step: it indicates how to move, when to deposit material, what temperature to work at, etc. It is, essentially, the language that allows the machine to manufacture the object.

Unlike STL, G-Code is individual and unique; a file generated for a specific printer will not work correctly on a different one, since each machine has its own parameters.



Impression of the object

Finally, the G-code file is sent to the 3D printer, which begins to build the piece layer by layer.

This process can take anywhere from a few minutes to several hours, depending on the size of the object and the quality selected.



Post-processing (optional)

Once printing is complete, minor adjustments may be necessary, such as removing supports or improving the finish of the part.

During this process we recommend taking into account all risk prevention measures, as well as environmental sustainability practices (see topics 9 and 10 of this course).

6.2.TYPES OF PRINTERS AND FILAMENTS

6.2.1.TYPES OF PRINTERS

Although there are various 3D printing technologies, in this context we will focus on those most common in educational centers due to their accessibility and ease of use.

1. FFF / FDM printers (the most common in education)

FFF (Fused Filament Fabrication) and FDM (Fused Deposition Modeling) printers refer to the same technology, although the term FDM is more widespread in the industrial field.

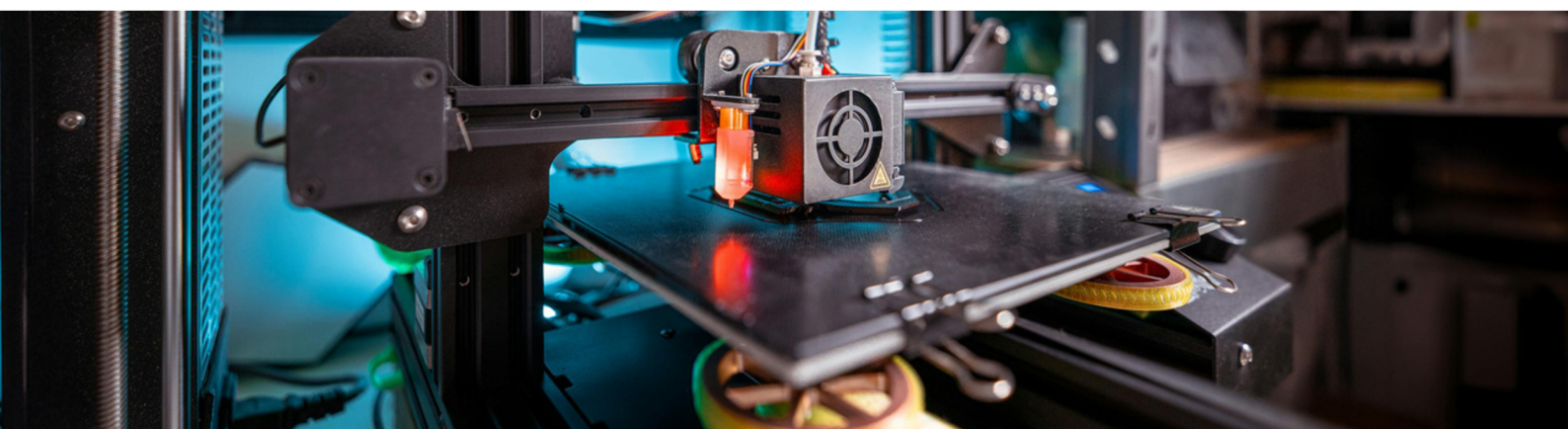
These printers work with a thermoplastic filament (usually in spool form) that is fed into an extruder. The material is heated to its melting point and deposited through a nozzle onto the print bed.

The object is constructed by successively layering very thin layers of material, following instructions previously generated by the software.

2. Resin printers (SLA / MSLA)

Resin printers use a different technology based on the photopolymerization of a liquid resin using ultraviolet light.

Instead of extruding a filament, the printer solidifies a liquid resin layer by layer using a light source (LCD screen or laser).



6.2.2.FILAMENTS

PLA (Polylactic Acid)

It is a thermoplastic polymer derived from renewable resources such as corn starch or sugarcane. In 3D printing, it is one of the most widely used filaments due to its ease of use and low environmental impact.

For optimal use, it should be printed at relatively low temperatures (between 205°C and 220°C) and a bed temperature between 50°C and 60°C. Therefore, it is easier to use on simpler printers. Furthermore, it has a rapid cooling process, allowing for detailed printing.

The main characteristics of this filament are:

- Biodegradable.
- Rigid and relatively fragile.
- Low contraction, that is, it shrinks little.
- Glossy and smooth surface.

Advantages

- Ease of printing
- Low environmental impact.
- Low extrusion temperature.
- It generates a very low level of emissions and odors during printing, making it more suitable for education.

Limitations

- It has low heat resistance. It deforms at temperatures above 60°C.
- It has less resistance to impacts.
- It is not flexible, meaning it can break under tension.
- It is not suitable for prolonged exposure to sunlight or humid environments.

ABS (Acrylonitrile Butadiene Styrene)

ABS is a thermoplastic polymer (a plastic material that becomes flexible or malleable when heated and solidifies when cooled) derived from petroleum, known for its high durability and strength. It is widely used in industrial manufacturing and functional prototypes (casings, supports, etc.). Unlike PLA, it is printed at higher temperatures (between 240°C and 260°C) and with a heated bed between 90°C and 110°C to prevent warping and ensure proper adhesion of the material to the bed.

On the other hand, during printing it may release strong-smelling fumes that require ventilation.

As a fun fact, LEGO pieces are made with ABS.

The main characteristics of this filament are:

- Very tough, hard and rigid material.
- High heat resistance.
- More flexible; can withstand impacts without breaking
- It can deform and shrink when it cools.
- A more matte surface than PLA.
- You can get translucent pieces because it has 91% transparency in its natural state.

Advantages

- Very strong and durable.
- It withstands higher temperatures without deforming.
- Flexible.
- It allows sanding, gluing and post-processing (e.g., using acetone).

Limitations

- It emits vapors.
- Difficult to print for beginners.
- It may shrink when it cools
- It may be less accurate for fine details due to shrinkage.
- Higher cost.

PETG (Polyethylene Terephthalate Glycol)

PETG is a strong and durable thermoplastic filament that is printed at temperatures between 230°C and 250°C, with a heated bed between 70°C and 90°C. It deforms less than ABS and has greater impact resistance than PLA.

The main characteristics of this filament are:

- Translucent, with a glossy finish
- Less ABS contraction
- Stable over time, it does not degrade easily.
- Impact resistant

Advantages

- Easier to print compared to ABS
- Flexible in the face of impacts
- Water and moisture resistant
- Smooth and glossy finish



Limitations

- Bed adhesion is more complicated than with PLA
- It is neither biodegradable nor compostable
- Less rigid than PLA

6.3. PEDAGOGICAL ADVANTAGES

Integrating 3D printing into a Techlab offers numerous educational advantages. These labs provide an innovative and practical tool for teaching STEM subjects and fostering a more inclusive, motivating, and scientifically oriented education.

Integrating 3D into the classroom in an accessible and dynamic way

The Techlab makes it easy to incorporate 3D printing technology into classrooms, without requiring advanced technical knowledge. This promotes an innovative methodology focused on hands-on learning and facilitates the modernization of teaching in any STEM subject.

It sparks students' interest in science and technology.

Implementing a Techlab sparks students' curiosity and fosters their interest in science and technology, as it offers an innovative educational environment where learning is based on experimentation, design, and problem-solving.

Development of key competencies in students

Learning in these technology labs (Techlab) allows students to acquire key and transversal skills, such as critical and scientific thinking, creativity, problem-solving, teamwork...

Transforming the classroom into a technological laboratory of ideas

The Techlab transforms STEM classrooms into dynamic spaces where learning is interactive, hands-on, and engaging. Classrooms become workshops for creation and discovery, fostering student motivation and commitment.

Promoting student motivation and preventing school dropout

Techlab's innovative methodology encourages student involvement, especially for those with obstacles, learning difficulties, low motivation, etc. By feeling like an active part of the learning process, students show greater interest and commitment, helping to prevent school dropout and improve their academic performance.

7. HOW TO INTEGRATE 3D PRINTING INTO THE CLASSROOM

Once the Techlab is implemented at the school, the next step is to integrate 3D printing into the classroom. It's a simple, progressive process, accessible to all teachers, regardless of their prior experience with 3D printing.

The Techlab methodology has been designed to facilitate this integration through activity pathways, prepared materials, specific training, and ongoing support. In this way, teachers can dynamically incorporate 3D printing into their classes without requiring advanced technical knowledge.

Below, we propose the steps to integrate 3D printing into the classroom:



Integrating 3D printing into the educational program

Integrating 3D printing into the curriculum means using the Techlab as an educational tool to work on content, skills, and learning objectives within your lesson plans. It's not about carrying out isolated activities, but about incorporating 3D printing as part of the teaching and learning process.

What is it for?

Integrating 3D printing into the curriculum allows the activities developed in the Techlab to have a clear educational purpose and be aligned with STEM subject content. Furthermore, it fosters the development of key competencies, meaningful learning, and the connection between theory and practice.

In this way, 3D printing becomes a tool for working on curricular concepts in a tangible, motivating and dynamic way.

How is it done?

To integrate 3D printing into your teaching program, you can follow these steps:

- Identify the curriculum content you want to work on in your subject.
- Select the key skills you want to develop.
- Link the Techlab activity to a teaching unit or learning situation.
- Define the learning objectives of the activity.
- Determine how to assess student learning.



In a STEM subject like Physics and Chemistry, you can explore molecular structure by 3D printing molecular models. In this case, 3D printing is integrated into the curriculum as a hands-on activity that facilitates the understanding of abstract concepts.

2

Select the activity from the Techlab itinerary

Within the framework of the Erasmus+ project “Didactech,” we have developed a series of activities designed to facilitate the integration of 3D printing in the classroom at the primary and secondary levels, as well as for extracurricular activities. These activities are designed to address STEM content and develop key competencies through hands-on learning, aligned with the official education curriculum.

What is it for?

Selecting an activity from the itinerary allows teachers to get started easily and safely, using pre-prepared materials and activities aligned with the educational curriculum.

Furthermore, these activities are designed to facilitate active learning, teamwork, and problem-solving.

How is it done?

To select an activity from the Techlab itinerary:

- Open the document:
<https://www.didactechlab.eu/training-itineraries/>
- Check out the available activities.
- Identify the activity that best suits your subject and educational level.
- Analyze the learning objectives of the activity.
- Check the necessary materials and resources.
- Plan when and how to develop the activity in your schedule.

Each activity in the itinerary includes all the necessary resources, including 3D printing files and teaching materials, which facilitates its implementation in the classroom.

3

Preparing the 3D print

This step involves preparing the 3D model printing and the printing process before developing the activity in the classroom.

What is it for?

It ensures that the models are ready for use in the classroom, facilitating the development of the activity and optimizing the available time.

In the activity itineraries we provide, you have the opportunity to download two types of files: STL and GCODE

How is it done?

To prepare for 3D printing:

- Download the files provided in the Techlab itinerary.
- Save the file to the 3D machine's SD card.
- Select the file within the machine.
- Start printing.
- Verify that the printed pieces are ready for use in the classroom.

STL: This file represents the geometric shape of a 3D object using a mesh of triangles. It's a universal format that works the same on any computer and with any design software. Its main function is to serve as "raw material" for the slicing program, as it only contains the visual information of what we want to print, regardless of the machine used afterward.

G-code is the result of processing the STL file in the slicer and contains the specific instructions that the printer must execute step by step to print the object. Unlike STL files, G-code is individual and unique; a file generated for a specific printer will not work correctly on a different one, as each machine has its own parameters.



Develop the activity in the classroom

This step involves bringing the Techlab activity into the classroom and working with students using 3D-printed models. In some cases, the teacher will create and build the models (for example, simple molecules like water, ethanol, butane, or glucose), while in other cases, the students will be directly involved in the design, experimentation, and construction (depending on the STEM subject).

What is it for?

Developing the activity in the classroom allows students to learn through experimentation, teamwork, and problem-solving.

3D printing turns abstract concepts into tangible objects, facilitating understanding and meaningful learning.



How is it done?

To develop the activity in the classroom:

- Present the activity and its objectives to the students.
- Explain the context or problem they need to solve.
- Organize the students into work teams.
- Distribute the 3D printed models.
- It guides the learning and experimentation process.

During this process, students manipulate models, formulate hypotheses, analyze results, and construct their own learning.



Reflect on and consolidate learning

This step involves analyzing the activity performed and consolidating the learning acquired.

What is it for?

Reflection allows students to connect practical activity with curricular content and reinforce learning.

Furthermore, this process facilitates the assessment of learning and the development of critical thinking.



How is it done?

To reflect on and consolidate learning:

- Hold a group discussion with the students.
- Analyze the results obtained.
- Relate the activity to the theoretical content.
- It answers your questions.
- Evaluate learning.

8. HOW TO CREATE ACTIVITIES FOR A TECHLAB

Once you have started working with the activities in the Techlab itinerary, you may want to design your own proposals adapted to your subject, your students, or your educational context.

Below, we propose how to design these types of activities step by step.



Identify the content and learning objective

It consists of selecting what curricular content you want to work on and what the students should learn.

What is it for?

This step ensures that the activity has a clear educational purpose and is integrated into your teaching program.



How is it done?

- Select a topic from your subject (for example, geometry, molecular structure, forces...)
- Define what you want the students to understand.
- Relate the activity to key competencies (mathematical, scientific, digital thinking...)

2

Design the materials for the activity

It consists of designing or downloading the 3D printing models that you will need to carry out the activity.

What is it for?

It allows you to create or obtain the materials needed to carry out the activity. These materials allow you to move from the abstract to the concrete, facilitating understanding and promoting meaningful learning.

How is it done?

- Ask yourself: how can I "materialize" this concept?
- Design or find templates that represent that content. You don't need to design the templates from scratch. There are numerous free platforms where you can find royalty-free resources ready to use or adapt:
 - Thingiverse
 - Printables
 - MyMiniFactory
 - Cults3D
 - Sketchfab

EXAMPLE**Activity: Pythagoras**

Triangle and square cards. A right triangle (Legs: 30mm and 40mm; Hypotenuse: 50mm), a 30x30mm square, a 40x40mm square, and a 50x50mm square.



3

State the challenge or problem

It consists of presenting a learning situation that the students have to solve.

What is it for?

Learning at Techlab is based on problem-solving. The challenge sparks curiosity, activates critical thinking, and gives meaning to the activity.

How is it done?

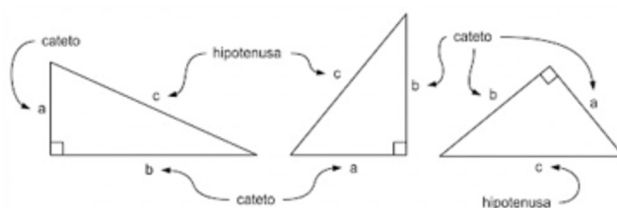
- Pose a clear question or challenge
- Avoid giving the answer directly.
- Design a situation that requires investigating, testing, and deciding.

EXAMPLE**Activity: Pythagoras**

This activity is a geometric visualization and deduction exercise designed to transform an abstract formula into a tangible reality.

The starting point is the physical manipulation of a triangle and three squares of different sizes. The challenge is for participants to discover the physical relationship between the sides of the triangle and the areas of the squares, fostering the transition from concrete thinking (touching the pieces) to abstract thinking.

$$a^2 + b^2 = c^2$$



Once the visual relationship is established, the activity evolves towards arithmetic verification, using the measurements of the printed pieces to verify that the sum of the areas of the smaller squares is exactly equal to the area of the larger square, but only under certain geometric conditions (right triangle).



Design the classroom session

It consists of defining what the students will do with the printed pieces, as well as establishing the steps that will be necessary to implement the activity in the classroom.

What is it for?

It will facilitate its subsequent implementation.



How is it done?

- Define specific actions: measure, compare, fit, group...
- Design situations where making mistakes is part of the learning process.

We recommend using the following structure:

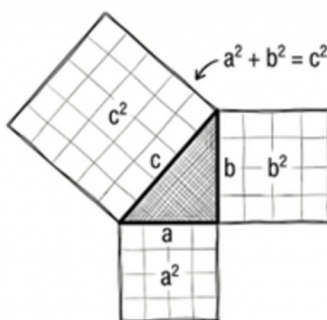
- Challenge presentation: simple description of the challenge.
- Clear instructions: A simple explanation of how to complete the challenge.
- Establish reflective questions with a clear purpose and a mechanism to guide students.



Activity: Pythagoras

Each group's table is placed on a random set of 9 squares (3D printed tiles) of different sizes.

The challenge is to bring order to the chaos. Within these 9 pieces, there are exactly three independent "families" or triads. Each family is composed of 3 squares that mathematically and geometrically satisfy the Pythagorean Theorem.



Here is a proposed plan for managing the activity with the groups (4 students per group recommended):

Presenting the Challenge: Hand out the 9 mixed-up tiles. Explain that there are no extra or missing pieces. They all belong to the same group.

Clear Instruction: "You have 9 squares. Here are 3 perfect sets of three mixed together that fulfill the Pythagorean rule. Your job is to measure, calculate, and separate the pieces into their three correct groups. No piece can be left loose."

Question 1.

- Purpose: To encourage the use of empirical data (measurement) versus imprecise visual intuition.
- Guide: "At first glance, that 30mm square and that 32mm square look the same. How can we be sure?" (They should use the ruler.) "Make a list of the measurements of all 9 sides before you start trying random combinations."

Question 2.

- Purpose: Intensive practice of the formula.
- Guide: "Have you tried squares with sides of 3, 4, and 6? Let's see: $3^2 = 9$, $4^2 = 16$. $9 + 16 = 25$. But the largest square is 6 ($6^2 = 36$). Is 25 equal to 36? No. So that combination is ruled out."

Question 3.

- Purpose: To connect numerical calculation with spatial properties.
- Guide: "You say these three go together because their numbers match. Now place them on the table corner to corner, forming a triangular gap in the center. If you use the corner of a sheet of paper, does it fit perfectly in that gap?"

Closure: If it fits, you've found the right triangle. If it doesn't fit (the gap is obtuse or acute), you've chosen the wrong pieces.



Implement the activity in the Techlab

It consists of carrying out the activity in the Techlab, organizing the materials, the space and the development of the session with the students.

What is it for?

This step allows putting into practice everything that has been previously designed, ensuring that the activity is carried out in an organized, dynamic and learning-focused manner.



How is it done?

- Prepare the 3D printed materials needed for the activity beforehand.
- Organize the Techlab space (group work, distribution of materials, etc.)
- Clearly explain the challenge and the rules of the activity
- Make sure all students understand what they need to do before starting



Guide the learning

It consists of accompanying the process with questions that guide the students' reasoning.

What is it for?

Questions help structure thinking and foster critical thinking

How is it done?

- Ask open-ended questions
- Avoid giving direct answers
- Guide the activity gradually.



Activity: Pythagoras

Once students begin to manipulate the pieces, measure and calculate, they are guided with the following questions to structure their reasoning:

- Can you group the cards by simple visual inspection or do you need a more precise tool?
- If you randomly select three squares and calculate their areas, is the sum of the two smaller ones equal to the large one?
- Once you believe you have found a triad (3 pieces), how can you physically prove that they are a "Pythagorean family" without using a calculator?

9. RISK PREVENTION IN THE CLASSROOM

For the implementation of the “Techlab” technology laboratories, it is essential to know the risk prevention measures that will guarantee that the activities carried out are safe for everyone (both students and teachers).

9.1.IDENTIFICATION AND PREVENTION MEASURES OF RISKS

Below, we describe the main risks we may encounter with the aim of preventing them.

MECHANICAL RISKS

Although 3D printers don't have dangerous mechanisms like some other industrial machines, they do have moving parts that can cause injuries. These include components like the print head and the print bed, which move along the machine's various axes (X, Y, Z).

Possible risks:



- Head strike in motion.
- The printer will fall if it is accidentally pushed.
- Slight pinch when inserting the hand during printing.
- Put your finger on the extruder.
- Touch the moving fans.

Prevention mechanisms:

- Do not allow students to handle the printer during printing.
- Always wait a few minutes after printing is complete before removing the part or touching the machine.
- Maintain a minimum safe distance
- Place the printer on a stable surface

THERMAL RISKS

This is one of the main risks that we must identify and prevent in the use of 3D printers.

3D printers print by melting filament at high temperatures:

- Nozzle: Depending on the filament used, the nozzle will be at a specific temperature to melt the filament and allow printing. This temperature can range between 180°C and 260°C.
- Heated bed: This is the surface on which the part is printed. While temperatures are lower than at the nozzle, it can reach 50°C for filaments like PLA.

It is important to note that, even after printing has finished, the machine maintains the temperature for a few minutes while it cools down.

Possible risks:

- Burns from touching the nozzle.
- Burns from touching the hot bed.
- Burns when touching the molten filament.

Prevention mechanisms:

- Do not allow the printer to be touched during printing
- Always wait a few minutes after printing is complete before removing the part or touching the machine.
- Use tools such as tweezers to touch the filament or clean the nozzle
- Removal of pieces preferably by the teacher
- Inform students about hot surfaces

ELECTRICAL HAZARDS**Possible risks:**

- Damaged cables
- Improper handling
- Liquid spill near the printer
- Cramps

Prevention mechanisms:

- Turn off the machine immediately if it causes electric shocks and inform the distribution company.
- Unplug the machine from the power outlet
- Do not place liquids nearby
- Visually inspect the condition of the power cord
- Do not allow students to manipulate connections

CHEMICAL RISKS

Due to gas emissions

During 3D printing, the filament heats up and can emit small amounts of gases and volatile compounds into the air. This phenomenon occurs, but when using appropriate materials, the risk is low.

It is important to keep in mind that:

- It is not an immediate risk
- There is no risk of sudden poisoning
- These are prolonged exposures in poorly ventilated spaces

We recommend reviewing the material specifications provided by the manufacturer to ensure student safety.

The emission level depends on the material used. Therefore, we recommend using PLA as the primary printing material because, in addition to the advantages explained in previous sections, it offers the following benefits:

- It emits very low levels
- It generates fewer odors
- It is safer for educational use

General comparison:

- PLA → Low Emission
- PETG → Low-moderate emission
- ABS → Higher emissions

Therefore, we recommend avoiding the use of ABS in classrooms, especially if there is no adequate ventilation.

Possible risks:

- Discomfort caused by odors
- Stagnant air in enclosed spaces
- Prolonged exposure without ventilation

Prevention mechanisms

- Use PLA as the main material
- Maintain natural ventilation of the classroom
- Avoid printing for many consecutive hours in unventilated spaces.
- Do not place multiple printers in small, unventilated spaces
- If using polymers such as ABS, place the machine in a secure chamber protected with filters that capture chemicals from the air.

Due to particle emission

The risk of particles arises during post-processing. That is, once the 3D printing is complete, we may need to make adjustments to the part, such as filing or sanding.

Possible risks:

- Ingestion of particles
- Insert into the eyes
- Transporting them to other places. For example, if we carry them in our hands and touch something, we transfer them and others can touch them.

Prevention mechanisms



- Usar EPI
- Wear masks
- Wear glasses
- Wear gloves
- Pay attention to the cleanliness of the space. We recommend vacuuming.

ENVIRONMENTAL RISKS

The use of 3D printers can have an environmental impact if the materials and waste generated during the printing process are not properly managed.

In addition, some plastic materials are not biodegradable and require proper waste management.

During the use of 3D printers, it is common to generate:

- Filament remnants
- Failed pieces
- Printing media
- Packaging of materials
- Dust from sanding or post-processing

These wastes, if not managed properly, can generate environmental impact or dirt in the classroom.

In addition, some plastic materials are not biodegradable and require proper waste management.

Possible risks:

- Accumulation of plastic waste
- Environmental pollution due to poor waste management
- Classroom dirt
- Scattering of small pieces or fragments

How can we prevent them?

- Have a specific container for 3D printing waste
- Encourage the reuse of failed parts whenever possible
- Keep the workspace clean and tidy
- Clean the space by vacuuming to avoid the displacement of particles.
- Clean with a damp cloth/paper and store in a plastic bag to avoid polluting the air.
- Collect the remains after each session
- Use more sustainable materials whenever possible (such as PLA)
- Avoid printing unnecessary or non-educational materials
- Reuse materials whenever possible through material collection programs (see next section).

IMPORTANT!

The recommendations included in this document are indicative and preventative in nature, based on the common educational use of 3D printers in school environments.

Each educational center must:

- Review the technical data sheets and safety data sheets (SDS) of the materials used
- Follow the printer manufacturer's safety instructions
- Comply with current regulations regarding occupational risk prevention and workplace safety

The correct application of these measures is the responsibility of the educational center and the staff in charge of using the equipment.

9.2.SECURITY PROTOCOL

Before printing

- Check that the printer is on a stable surface
- Check the power cord connection.
- Check that the area is clear
- Verify that the students know the basic rules
- Check that the file to be printed is correct
- Confirm that the classroom is ventilated

During printing

Printing time depends on many factors (size of the part, support requirements, etc.), so it can last from a few minutes to several hours. Therefore, the teacher doesn't need to be present the entire time. However, we recommend:

- Monitor the printing process periodically.
- Check that it develops normally.
- Prevent students from handling the printer.

After printing

- Wait a few minutes for it to cool down
- Remove the piece (preferably by the teacher)
- Turn off the printer if you are not going to use it anymore.

9.3.CHECK LIST

Before printing:

- ☐ Printer on stable surface
- ☐ Cabling in good condition
- ☐ Clear area
- ☐ Well-ventilated classroom
- ☐ Teacher present
- ☐ Students informed
- ☐ File checked
- ☐ Correct filament

During printing:

- ☐ Visual supervision
- ☐ Distance learning
- ☐ No printer handling

After printing:

- ☐ Wait for cooling
- ☐ Remove part carefully
- ☐ Turn off printer if not in use
- ☐ Tidy area

10. ENVIRONMENTAL SUSTAINABILITY

In recent years, the green transition and sustainable development have become fundamental pillars. The European Union is promoting measures and initiatives that contribute to the green transition and the implementation of sustainable practices. In this context, as explained in the Council Recommendation on learning for environmental sustainability: “As in other sectors, action must also be taken in education and training to respond to the climate emergency and the planetary crisis—with regard to its own activities and, in particular, how these prepare students for the future.[xvi]”

It highlights the importance of creating and implementing short-term measures that not only support educational centers and teachers, but also help students develop the skills and critical awareness for the ecological transition.

In this context, we consider the incorporation of sustainable practices in Techlabs to be a priority in these laboratories; they are not only to reduce the ecological footprint, but also to teach students to be more environmentally responsible and to acquire critical awareness about it.

As we mentioned earlier, 3D printing is carried out through a layer-by-layer additive manufacturing process, reducing the amount of material used compared to more traditional manufacturing methods. However, environmental sustainability in a Techlab depends not only on this printing factor, but also on other factors such as the printing material chosen, the design of the parts to be printed, and work routines.

[xvi] European Commission. (2022). Proposal for a Council Recommendation on learning for environmental sustainability [COM(2022) 11 final]. Brussels: European Commission. Available from: <https://eur-lex.europa.eu/legal-content/ES/TXT/?uri=CELEX%3A52022DC0011>

Therefore, following the European Commission's guidelines on learning for the ecological transition and sustainable development[xvii], the Techlabs:

- Learning about sustainable development is a priority at Techlab.
- They provide students with the opportunity to learn about climate change, sustainable practices, and to develop critical awareness.
- They support teachers in implementing sustainable practices to combat climate change.
- They are learning environments that promote sustainability in all their activities.
- They actively involve the students.

[xvii] European Commission. (n.d.). Learning for the green transition and sustainable development [Web page]. European Education Area. Retrieved from <https://education.ec.europa.eu/es/focus-topics/green-education/learning-for-the-green-transition>



10.1. SUSTAINABLE PRACTICES IN THE IMPLEMENTATION OF TECHLABS

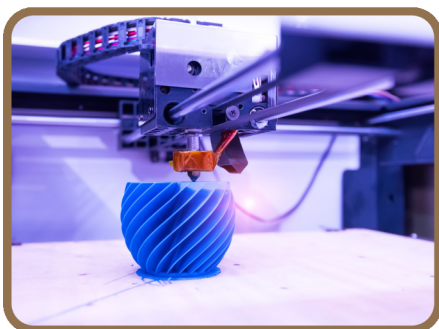


Selection of printing materials

There are various printing materials available for 3D printing. However, some materials are more sustainable, utilizing recycled or biodegradable materials to reduce plastic waste. PLA is one example.

PLA (polylactic acid) filament is a biodegradable thermoplastic material derived from renewable natural resources such as corn or sugar cane.

PLA is characterized by its ease of use, low thermal contraction, and good surface finish, making it especially suitable for educational environments. It does not emit toxic gases during use and is safe for educational activities.



Efficient design of each piece

When designing a part for 3D printing, there are many factors to consider. However, there are some practices that will allow us to reduce the environmental impact without reducing the quality and usefulness of the part, such as:

- Group several pieces into a single print to optimize energy use.
- Review the 3D models to reduce unnecessary thickness or support without compromising the quality of the piece at an educational level.
- Calculate the estimated filament consumption before printing.



Recycling of printing materials

All 3D printing generates some waste, however small (supports, the initial extrusion line or purge line, defective parts, etc.). Therefore, it is important to know recycling practices for this material:

- Separate and store the scraps: Place a box or container in the classroom for students to dispose of leftover materials and defective pieces. If different types of materials are used (such as PLA, PETG, ABS, etc.), it is advisable to separate them by material type if known.
- Collection programs or recycling centers. If you accumulate a significant amount of material, you can take it to a recycling center or contact organizations that collect 3D printing plastics. First, you should find out if your center has an established recycling program with a recycling company. If not, there are several options:
 - CITY COUNCIL RECYCLING SERVICE. The easiest way is to contact the city council's waste management services or the local recycling centers to ask if they accept 3D printing filament waste.
 - UNIVERSITIES. Many universities have recycling centers for waste such as 3D printing filaments.

**Efficient use of energy and responsible machine maintenance**

- Group several pieces into a single print to take advantage of warm-up times and printing time.
- Turn off the printer when not in use.
- Analyze the estimated printing time.



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