

TECHLABS IN SECONDARY SCHOOL: LEARNING AND MOTIVATION IN SCIENCE AND TECHNOLOGY

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Abstract

As part of the Erasmus+ program, project “*DIDACTECH: Approaching the latest technology to secondary students with obstacles as a tool for their inclusion and their access to the technological labor market while they help primary schools without resources*”, we have developed an innovative methodological strategy that brings science and technology to secondary school students, particularly those facing barriers or learning difficulties, through the creation of 3D printing technology laboratories (*Techlab*). The starting point is a simple observation: the digital and technological divide remains a significant barrier in schools in areas facing greater socio-economic challenges. In many of these schools, technology is not introduced with the same intensity or support, leading to inequalities in access to science education and in the future opportunities of their pupils. The *Techlab* strategy has emerged precisely in response to this inequality.

Secondary school students taking part in a *Techlab* join a group (of around 10 pupils) where they get to put their creative skills into practice and explore ways in which they can use them to help build a fairer society. Along the way, they will see how developing their skills and knowledge in mathematics, design and technology opens up a world of possibilities for them.

The *Techlabs* are equipped with 3D printers. In these technology laboratories, students learn through laboratory set-ups produced in-house at the *Techlab* (molecular models, pulley and lever systems, drive chains, hydraulic circuits, anatomical models, etc.). The students have designed, built, and tested functional prototypes such as pulley systems and hoists to measure mechanical advantage, as well as telegraphs and drawbridges operated by syringes to demonstrate Pascal's principle, among other things. Students interact with and handle concrete representations of concepts from STEM subjects. In some cases, it will be the teacher who creates and builds the necessary components, whilst on other occasions it will be the students themselves who are directly involved in the design, experimentation and construction.

Participation in a *Techlab* is expected to promote a special motivation for scientific and technological learning among students. For this reason, we conducted an evaluation of student motivation. The hypothesis of the study is that participation in the *Techlab* is a significant motivating factor for students towards their future studies, particularly in science and technology.

In this paper, we present a study on motivation conducted in secondary schools from Poland, France, Greece and Spain. The study includes a group from each school that underwent a pilot test using the *Techlab* methodology and a control group at the same educational level. The responses are anonymised 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 completing the internship using the *Techlab* methodology have a positive influence on students' 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 secondary education. The results show that students who

undertook work placements at the Techlab were more motivated than those in the control groups, with statistically significant differences.

Keywords: School, secondary education, technology, methodology, research, students, motivation.

1 INTRODUCTION

In the wake of the terrible pandemics that have ravaged Europe, the technology sector has experienced rapid growth and has come to play a major role in the processes of social, economic, health and educational reconstruction.

Science has become a dynamic and effective means of overcoming the constraints of these crises, bringing education to those who were unable to attend school and serving as an increasingly valuable asset for the employability of secondary school students.

However, this technological advancement has not reached all schools equally, and its implementation often fails to reach the schools that need it most: those in areas particularly affected by the social crisis. This creates a paradoxical situation in which the schools and students in deprived regions—who would benefit most from these resources—are the ones with the least access to them, due to the difficulty in making use of them [1,2]. These are regions with few opportunities for employment and entrepreneurship, which leads to apathy and a lack of motivation among young people (especially women) towards an education system they believe cannot offer them any alternatives... thereby greatly increasing the likelihood of them dropping out of school. This situation results in schools lacking resources and staff, with teachers overwhelmed by their day-to-day workload and lacking the time to tackle the challenges of digitalisation or make the most of the few 3D labs that have been set up but which require a significant amount of work to get up and running.

It was against this backdrop that the Erasmus+ project 2024-1-ES01-KA220-SCH-000247893 “DIDACTECH: approaching the latest technology to secondary students with obstacles as a tool for their inclusion and their access to the technological labor market while they help primary schools without resources” was launched. In this project, technology companies have teamed up with secondary schools to develop the innovative methodological strategy known as “Techlabs”. It is an educational strategy that promotes science and technology in secondary schools through the creation of 3D printing technology laboratories where pupils learn by doing. In Techlabs, students work on real-world projects—such as 3D design and printing—to develop STEM skills in a practical way, whilst experimenting, collaborating and applying their knowledge to specific situations. The initiative democratises access to technological innovation and uses it as a tool for inclusion, motivation and personal development.

The Techlab is the physical and educational space where this strategy comes to life. The DIDACTECH project has installed state-of-the-art 3D printers and scanners in the participating secondary schools, at no cost to them, and has developed technical and educational support programmes for the teachers who will be using them. It also has a social dimension, as the products created are shared with other schools, particularly in disadvantaged areas, thereby promoting values of solidarity, fairness and commitment.

The strategy proposes two methodological approaches to make the most of the Techlabs. On the one hand, it is designed to serve as a cross-cutting element within the school, integrating its activities with STEM subjects; on the other hand, it offers support to other areas through interdisciplinary projects, both during school hours and in the after-school period. It also has a social dimension, as the products created are shared with other schools, particularly in disadvantaged areas, thereby promoting values of solidarity, fairness and commitment.

Teachers receive training and resources to help them incorporate 3D printing into their lessons in a straightforward way, without needing to be tech experts. In addition, a team of experts, technicians and researchers supports the school in organising extracurricular activities.

2 METHODOLOGY

In the pilot tests carried out during the 2025–2026 academic year as part of the DIDACTECH project 38 secondary school pupils from five schools in Spain (IES Joanot Martorell and Colegio Sagrada Familia), Greece (1st Epalgematiko Lykeio Kato Achaias), France (Ogec ST Sébastien – ST Joseph) and Poland (Zespół Szkół nr 3 im. Jana III Sobieskiego) have taken part. The students have been working with

laboratory set-ups produced in-house at the Techlab (molecular models, pulley and lever systems, drive chains, hydraulic circuits, anatomical models, etc.). The students have designed, built, and tested functional prototypes such as pulley systems and hoists to measure mechanical advantage, as well as telegraphs and drawbridges operated by syringes to demonstrate Pascal's principle, among other set ups. Students interact with and handle concrete representations of concepts from STEM subjects. Techlabs are spaces that demonstrate how knowledge in science and technology-related subjects can open up a world of possibilities for creativity and contribute to social development.

The project has placed particular emphasis on motivating students in their studies, and in particular in subjects related to innovation and technology. As students see themselves making progress in acquiring the tools and skills that enable them to create, put their ideas into practice or make decisions, they begin to recognise the need to learn new things in order to further develop their abilities. More details on the methodology we follow in this project can be found in the reference [3]

Motivation is revealed to be an essential aspect of learning [4].

In this study, we have sought to provide some quantification to help us establish that participation in Techlabs does indeed foster this motivation towards technology. To this end, the ACRS model proposed by Keller in 2010 [5-7] is of particular interest. The acronym derives from the notion that motivation comprises four domains that can be assessed independently: Attention, Confidence, Relevance, Satisfaction. These four areas are assessed through a series of questions put to the students. The method has been applied at different educational levels and to specific subjects. Reference [5] outlines a series of surveys designed to address specific objectives. In our case, we have used the so-called 'Course Interest Survey', which consists of 34 questions that we have adapted to the language and characteristics of our secondary school students by making minor changes to the wording. Table 1 lists these questions as they are presented to the students. Students respond by selecting a value between 1 and 5. 1: strongly disagree, 2: somewhat disagree, 3: neither agree nor disagree, 4: somewhat agree, 5: strongly agree. However, some questions are phrased in reverse and are scored in reverse order, i.e. 1 is 5, 2 is 4, 3 is 3, 4 is 2 and 5 is 1. Each of the 34 questions is associated with an assessment field, as shown in Table 2. The final result is an average score for the questions in each field and an overall score, which is the average of the four.

Each school that took part in the pilot tests provided two sets of data. One set related to the pupils who took part in the *Techlab*, and the other was a *Control* set, in which the survey was administered to a group of pupils who did not take part in the pilot test. The students in the control group were from the same classroom as those who took part in the *Techlab* or from a group that matched the pilot group in terms of school, year group, teacher and subject area.

To assess the statistical significance of the differences between the *Techlab* groups and the control groups an unpaired Student t-test was performed using Graphpad statistical analysis software using the average value (Mean), Standard deviation (SD) and number of samples (N) calculated in each data series. The p-value threshold was set at <0.05 to consider the results statistically significant.

Table 1. Questionnaire

	1	2	3	4	5
1. Teachers know how to get us excited about the subjects we study.					
2. What I'm going to study at secondary school will be useful to me					
3. I think this term is going to go well for me.					
4. I'm finding very little in the course that captures my attention					
5. Teachers make the things they teach us seem important					
6. To get good marks, you need a bit of luck					
7. I have to work really hard to pass the course					
8. I don't know what the stuff they're teaching me has to do with anything I've seen before.					
9. Whether or not I pass the course is up to me					
10. The teacher builds suspense when explaining something new					
11. The subjects on this course are too difficult for me					
12. I am very happy with what I am studying					

13. I'd like to get top marks					
14. I think the marks I get and the feedback I receive from my teachers are good compared to the rest of my classmates					
15. In this course, my classmates seem to be curious about what we're being taught.					
16. I'm really enjoying studying on this course.					
17. It's hard to know what marks my teachers are going to give me.					
18. I think my grades are fair, given how hard I've worked.					
19. I'm pleased with how things are going this term.					
20. What I'm studying is exactly what I wanted.					
21. Teachers do unexpected and curious things, which turn out to be interesting.					
22. We students take an active part in the lessons.					
23. It's important for my future that I do well in these studies.					
24. We do all sorts of different things in class.					
25. I don't think this course will be of much use to me.					
26. In class, I often find myself thinking about other things.					
27. I think I can do well in my studies if I work hard.					
28. I can clearly see the benefits these studies have for me.					
29. The problems and questions raised in class spark my curiosity.					
30. I think the course is just the right level of difficulty: neither too easy nor too hard.					
31. I've been disappointed with this course.					
32. I think I'm being assessed fairly, both in terms of my marks and the feedback from my teachers.					
33. The amount of work I have to do is appropriate for this type of study.					
34. From what my teachers tell me, I can clearly see whether I'm doing well or poorly on the course.					

Table 2. Guide for the evaluation of the course interest survey

<i>Attention</i>	<i>Relevance</i>	<i>Confidence</i>	<i>Satisfaction</i>
1	2	3	7 (reverse)
4 (reverse)	5	6 (reverse)	12
10	8 (reverse)	9	14
15	13	11 (reverse)	16
21	20	17 (reverse)	18
24	22	27	19
26 (reverse)	23	30	31 (reverse)
29	25 (reverse)	34	32
	28		33
*Some questions are phrased in the negative; in these cases, the scores should be reversed, i.e. 1 becomes 5, 2 becomes 4, 3 remains 3, 4 becomes 2 and 5 becomes 1.			

3 RESULTS

Teaching science using active learning methods can be a key tool in secondary education, particularly in the development of critical thinking skills [8]. The range of potential applications for 3D printing and additive manufacturing in secondary education is vast, limited only by the imagination of teachers and students. The approach to the activities carried out in the pilot tests could be summarised as follows: we want to demonstrate this physical or mathematical effect or concept; we put forward a hypothesis; and we design and build a setup that allows us to test or disprove this hypothesis. The designs are revised as often as necessary, as prototyping is quick and inexpensive.

Secondary school pupils were the main beneficiaries of the TechLab methodology. These pupils, aged between 12 and 16, come mainly from rural areas and disadvantaged socio-economic backgrounds, with limited access to technological resources and innovative educational opportunities. They had the opportunity to acquire STEM knowledge and skills through practical, real-world experiences, as well as cross-curricular skills such as problem-solving, critical thinking, creativity, teamwork and independence. This aspect proved particularly significant for students facing barriers, who were able to access learning experiences and technological resources that are not usually available in all educational settings, thereby broadening their educational and career prospects. It is worth noting that equal opportunities and balanced participation among students were promoted. Participation was virtually equal, with 52% women and 48% men, helping to foster an interest in STEM subjects among all students and encouraging balanced representation in activities traditionally associated with lower female participation. Furthermore, the project incorporated a significant focus on solidarity and inclusion. The students took part in the design and development of activities and resources aimed at other schools with fewer opportunities and less access to technological equipment. This experience enabled them to understand the social value of science and technology, developing skills related to cooperation, responsibility, empathy and a commitment to their community. In this way, the project not only contributed to the development of STEM skills, but also to the formation of a more active, engaged and socially conscious citizenry, aware of the importance of ensuring educational opportunities for all students.

An initial qualitative assessment is based on the impressions of the teachers who have supervised these work placements; they highlight the need for teacher training to carry the project forward, the extra work involved, and the satisfaction derived from the enthusiasm it generates among students and the learning outcomes achieved. However, what we wish to quantify in some way is the effect not so much in terms of the knowledge acquired, but rather in terms of the motivation generated by this methodology. The overall results of the surveys carried out at the four schools where the pilot tests were conducted are shown below, with a total of 38 responses for each question (Figure 1). The overall analysis of the assessment shows a significantly higher motivation score (the sum of the four areas assessed) in the Techlab groups than in the control groups. It is interesting to note that students who have undertaken the practical sessions express significantly positive scores in the area relating to *Attention*, which concerns the extent to which the activities proposed are able to capture the students' curiosity, enthusiasm and interest, thereby fostering a positive attitude towards learning. The difference compared with the control group is also statistically significant in the area of *Confidence*, which relates to how students assess their expectations of succeeding in the activity and, more generally, in learning subjects related to the activities they are undertaking. Questions relating to the *Satisfaction* domain are also highly rated by students, far exceeding those of the control group. However, in the *Relevance* domain, there are no statistically significant differences between the Techlab group and the control group. This domain relates to how students perceive the educational methods in relation to their needs, or their preferences regarding further studies. These are aspects that may have been less addressed by the proposed methodology and deserve attention in the future.

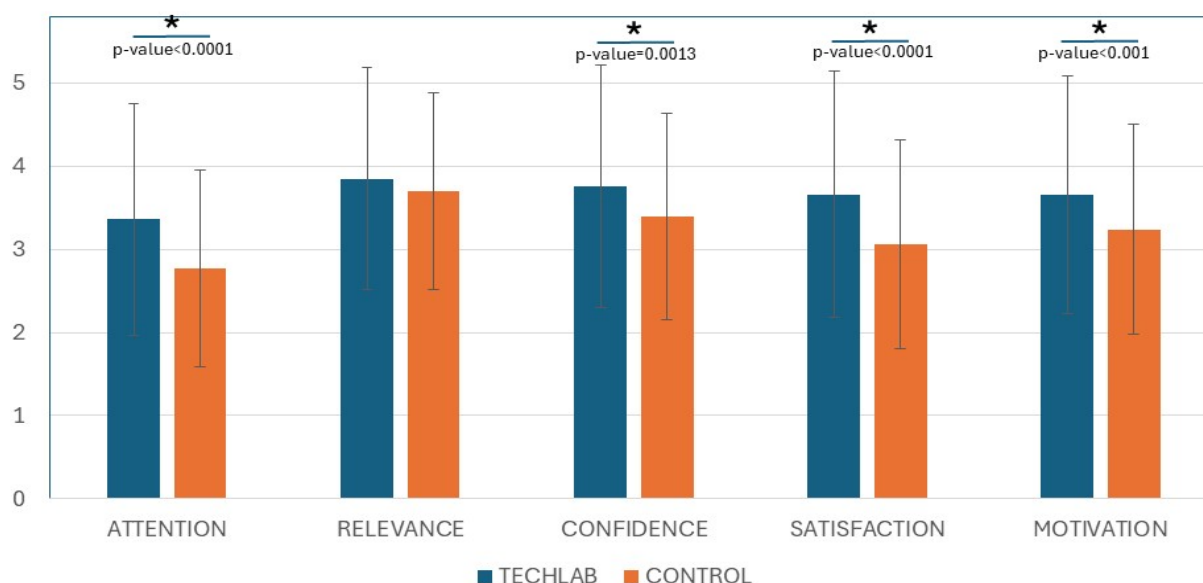


Figure 1. Scores given by students in the survey for each of the four assessment areas, expressed as the mean $\pm$ standard deviation. The overall rating for motivation is the average of the ratings for the four areas above.

4 CONCLUSIONS

Techlab 3D printing laboratories enable secondary schools to develop an active teaching approach that combines the creativity of teachers and students with the teaching of fundamental concepts in STEM subjects. The response from students who have taken part in the pilot tests has been enthusiastic. Evidence suggests that this type of activity has a positive impact on pupils' motivation towards their studies in general and towards technology in particular. The assessment of student motivation using the ARCS model proposed by Keller proved useful for conducting a quantitative analysis, revealing statistically significant differences in motivation towards further study in favour of the students who participated in the *Techlab* groups compared with the control groups.

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REFERENCES

- [1] Elena-Bucea, A., Cruz-Jesus, F., Oliveira, T. *et al.* Assessing the Role of Age, Education, Gender and Income on the Digital Divide: Evidence for the European Union. *Inf Syst Front* **23**, 1007–1021 (2021). <https://doi.org/10.1007/s10796-020-10012-9>
- [2] Dumopoulos, K; Koutsampelas, C; Tsatsaroni, A. Home schooling through onlineteaching in the era of COVID-19: Exploring the role of home-related factors that deepen educational inequalities across European societies. *European Educational Research Journal* 2021, Vol 20(4) 479–497. <https://doi.org/10.1177/14749041211023331>
- [3] Methodological guide for the creation of a *Techlab*. Ikasia Technologies SL (2024). DIDACTECH: approaching the latest technology to secondary students with obstacles as a tool for their inclusion and their access to the technological labor market while they help primary schools without resources. Jointly with Redtree Making Projects Coop.V., Smallcodes Srl, Nanopaint Lda, 1st Epalgematiko Lykeio Kato Achaias, 1st Vocational School of Patras, IES Isaac Peral, Lycée La Fayette. Erasmus Plus Programme. <https://www.didactechlab.eu/methodological-guide/> (accessed on 30 May 2026).
- [4] Reigeluth, C.M. Instructional Theory and Technology for the New Paradigm of Education. *Rev. Educ. Distancia RED* 2012, 32, 1–18. Available online: <https://revistas.um.es/red/article/view/270781> (accessed on 30 May 2026).
- [5] Keller, J.M. *Motivational Design for Learning and Performance: The ARCS Model Approach*; Springer: Berlin/Heidelberg, Germany, 2010.
- [6] Chang, Y.S. Applying the ARCS Motivation Theory for the Assessment of AR Digital Media Design Learning Effectiveness. *Sustainability* 2021, 13, 12296. <https://doi.org/10.3390/su132112296>
- [7] Rodríguez-Bailón, M.; Fernández-Solano, A.J.; Merchán Baezo, J.A.; Vidaña-Moya L. From Clinical Practice to the Classroom. Advantages and Disadvantages of Video and Paper Cases on the Motivation and Clinical Reasoning of Occupational Therapy Students, *Int J Environ Res Public Health* 2021, 18, 9671 <https://doi.org/10.3390/ijerph18189671>
- [8] Rubini, B.; Septian, B.; Permana, I. Enhancing critical thinking through the science learning on using interactive problem based module. *IOP Conf. Series: Journal of Physics: Conf. Series* 1157 (2019) 022001 <https://doi.org/10.1088/1742-6596/1157/2/022001>