

How can we stimulate a

SCIENTIFIC MIND?

A study of scientific vocations

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GRAPHIC DESIGN AND LAYOUT

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INDEX



- 05** Encouraging student interest in science subjects: a better future for everyone
- 12** Evaluation of the impact of outreach activities in terms of promoting careers in science and technology
- 27** Recommendations for improving the impact of outreach activities aimed at promoting careers in science and technology
- 33** Authors
- 34** Bibliography

The wellbeing of modern society depends largely on continual progress in scientific knowledge and applications thereof. The changes in technology and science over recent decades have been extraordinary, the fruit of many professionals' labour. Our society's hard work requires high levels of professional qualifications, and scientists and technologists, in their various disciplines, will be key to development and the driving force behind many future changes which will have an impact on our daily lives. Therefore, as European Commission studies have demonstrated, we are in need of more science and technology professionals.

However, we have seen that the number of students choosing these courses has been declining year on year, affecting industry and the economy in terms of competitiveness and growth and hindering the development of competitive global programmes in research and responsible innovation.

Science museums, centres and spaces have a more active role in mediation and provide a meeting point for scientists and citizens. They are active agents at this essential juncture for sharing questions, challenges and answers, as well as playing an active role in attempts to encourage young students to accept the adventure and challenge of becoming science and technology professionals.

We, the Spanish Foundation for Science and Technology, in conjunction with the "la Caixa" Banking Foundation and Everis, have initiated an assessment to identify the impact of our science dissemination activities on encouraging careers in science. Does going to the CosmoCaixa science museum help young people choose science? Are science outreach activities a further link in the chain of influences for young people deciding to become science and technology professionals? Do we need to improve the design of our activities so that they have a greater impact on their career decisions?

The project was carried out over two academic years: 2012/2013 and 2013/2014, and over 2,500 secondary education students in Spain took part. To strengthen the scientific nature of the project, we consulted a panel of experts who approved the study and we would like to thank them for their help, along with the participating students, teachers and schools.

We are proud to present our project results. We are delighted to present a study that aims to be useful to all science museums and centres, as well as to all entities and professionals committed to science outreach targeted at arousing young people's interest in science and technology.



ENCOURAGING STUDENT INTEREST IN SCIENCE SUBJECTS: A BETTER FUTURE FOR EVERYONE

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Developing STEM¹ competences among future citizens is vital for the growth of our society, not simply because the demand for qualified professionals in the technology and research sectors is, and shall remain, high (European Commission, 2012c), but also because people will only be able to tackle current and future challenges if these skills are available (European Commission, 2012b).

The demands of the world today, evermore diverse and interconnected, have brought with them the need for organisations such as the OECD (Rychen & Salganik, 2003) to define the skills and knowledge required for citizens to be able to actively and successfully take part in running our society. These competences include mathematical and scientific skills, which are important not only for anyone wanting to be STEM professionals, but for society as a whole. There is no doubt that everyone needs to have a solid knowledge base of STEM disciplines: in order to participate in European progress, by actively taking part in research and innovation subjects (in line with the RRI framework), making informed decisions (European Commission, 2013).

- The practical argument: people need to be trained in science and technology because this training is very often required for decision-making in everyday life. Human beings benefit from and enjoy the results.

- The democratic and civic argument: many discussions in people's lives arise from different aspects and effects of science and technology and in order to participate in these democratic processes, we need to be informed and also understand what is being criticized or defended.
- The cultural argument: science forms part of culture and a cultural heritage that influences our view of reality. Knowing about the objects and phenomena that surround our world enhances our personal environment.
- The economic argument: the science and technology workforce will be much more productive and therefore also decisive in terms of a country's economic development.

With regard to the last point, recent studies suggest that the supply of STEM competences will be insufficient, in terms of quantity (the number of STEM professionals will not be able to meet expected demands) and in terms of quality (the quality of STEM graduates does not always meet labour market requirements) (European Commission, 2013). However, there may be various aspects to the recurring demand for more STEM professionals. On the one hand, a number of critical voices are questioning whether the majority of future work in Europe will focus on the STEM sector (Wilson & Zukersteinova, 2011). In general terms, the laws governing supply and demand indicate that, right now, there is no lack of STEM workers compared to demand, except in a few sectors that require large numbers of STEM professionals, such as the IT sector, some engineering sectors and other specific profiles depending on the country (Brodie Brazell, 2013; European Commission, 2012a). However, the future might be different: while current data does not indicate

overwhelming demand for STEM workers, except in the aforementioned sectors, a number of employment forecasts are predicting an increase in demand for STEM workers over the next decade.

It is becoming increasingly clear that labour markets and the skills required are changing rapidly and it is likely that future jobs will require higher levels of skills and a combination of different skills, competences and qualifications (European Commission, 2009). Actions are desperately required right now to make our economy competitive; numerous studies have stated that STEM professions should expect to undergo the most growth. Compared with 3% growth expected for all occupations in 2020 in Europe, the expected growth for STEM professionals is 14% and 7% for professionals from fields related to STEM – (table 1) (European Commission, 2012a).

	2010	2020	Change 2010-2020	Demand growth 2020	Demand replacement 2020	Total demand 2020
Physical science, mathematics and engineering professionals	8,290	9,470	14%	1,183	2,364	3,546
Professionals related to the physical science, mathematics and engineering fields	8,333	8,877	7%	543	2,253	2,797
All professions	223,219	230,219	3%	7,627	4,617	12,244

But this increase will only be possible if successful innovation and scientific-technological progress programmes are implemented, which is undoubtedly linked to the existence of a strong line-up of high-quality STEM personnel (Cedefop, 2012; European Commission, 2011a; Wilson & Zukersteinova, 2011). Therefore, if we want to reach the intended targets in the future, the citizens of the future will have to be equipped now with the skills required for these professions (Vassiliou, 2012) and attract talented students to STEM courses (European Commission, 2014; Wilson & Zukersteinova, 2011). And that's not all. The labour market today requires scientific-technical competences in many jobs that have not traditionally been considered STEM jobs. The world of leisure, music, media and cultural products and services, representing an important part of today's national production, very often depend on a solid base of STEM competences.

Unfortunately, we have to accept that, according to the latest results from the PISA report, 24% of 15 year old students have lower achievement levels in maths while the percentage for science is 16% (MECD, 2013). These percentages and the lack of improvement over recent years, casts a doubt over achieving the 2020 benchmark to bring the figure for low achieving students in maths and science below 15% (European Commission, 2011b). On the other hand, the percentage of high achieving students is only 8% in maths and 5% in science. There are very similar results in primary education, according to the last 2009 General Diagnostic Assessment. Primary Education. *Fourth grade (2010)*.

Apart from the worrying low level of STEM skills among our young students and regarding details on future STEM professionals in our country, the statistical data available shows that, in recent years, the level of students choosing a STEM career has dropped (graph 1). While the overall trend among the 27 EU countries seems to indicate slight improvement, in 2012 the percentage of students studying STEM careers in our country dropped nearly 5 points on 2003. Despite being in line with the European average, this percentage is far from that of other countries such as Germany (32.9%).

In the light of this situation, it is not surprising that the various bodies involved in science education and dissemination are concerned and are doing everything possible to change the situation. The objectives are clear: help students reach the expected levels of STEM competences and encourage them to continue their studies in the areas of science and technology and to consider careers in science as a possible professional future.

Addressing both problems is a complex process so despite both issues being closely related, as we will see later on, we shall focus on the latter: how to promote careers in science and technology among students.

Promoting scientific and technical vocations: what aspects need to be taken into account?

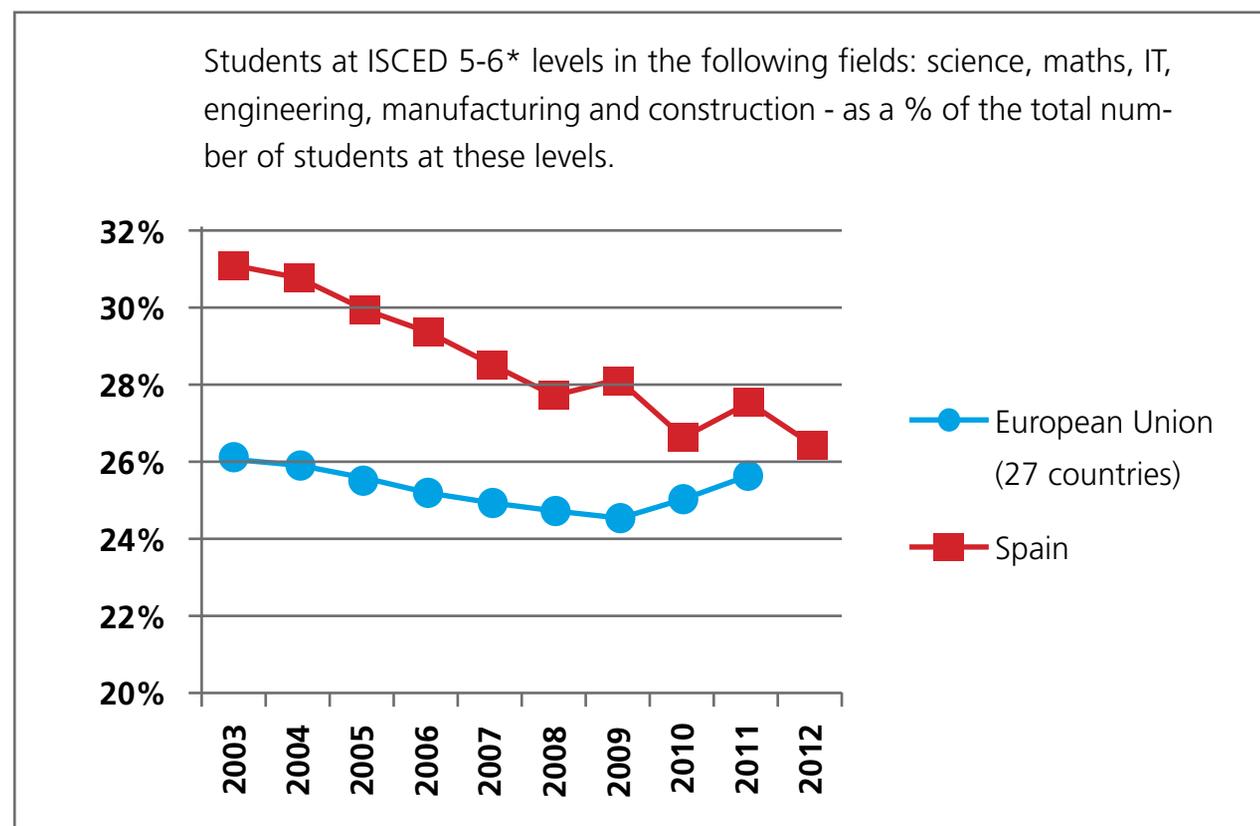
In order to increase the number of students seeking a professional career in science and technology, we need to know what reasons and circumstances will encourage them to do so. There is no doubt that encouraging younger students to become interested in scientific-technical education and in science and technology in general is important in order to

reach this target. However, the results of research into the psychology, sociology and teaching methods of science and technology confirm that the process of choosing a possible future course related to STEM is greatly influenced by other factors such as the students' own perception and their family, educational and social environment.

Interest in scientific-technological education

A necessary but insufficient condition (L.Archer, 2013; Dewitt et al. Archer, 2013; 2013; The Royal Society, 2004), for a person to choose a STEM career is that they must feel attracted

to the related school subjects (such as science, maths and technology). This factor is without doubt closely related to STEM competence: a profound knowledge of specific STEM subjects is essential for young students to enjoy studying these disciplines. In fact, negative experiences at school with regard to scientific-technical disciplines seem to dissuade students from choosing to continue studying STEM, acting as a barrier in terms of their professional aspirations in these fields. Aschbacher, Li and Roth (2010), through longitudinal interviews and surveys with students, found that science is often perceived at school as difficult and disheartening, while Cleaves (2005) confirmed prior studies that related



Graph 1. Students at ISCED 5-6* levels in the following fields: science, maths, IT, engineering, manufacturing and construction – as a percentage of the total number of students at these levels (*ISCED 5-6: diploma courses, degrees and doctorates) - Source: Eurostat (2013a) (on-line code: educ_iterpt; TP02_1)

negative attitudes towards science among secondary education students to disillusionment with the science curriculum in schools. Therefore, a curriculum or method of teaching that is not appealing reduces student interest in STEM subjects, just like teaching methods that show STEM disciplines as particularly difficult, frustrating students that want to be successful in class and distancing them from STEM careers (Becker, 2010).

However, what we see in our country is that 41.9% of the population perceive their scientific education as low or very low (FECYT, 2013). Studies such as the ROSE project (Sjøberg & Schreiner, 2010), which assesses the views and attitudes towards science in schools, the scientific community and the future expectations of 15 year old students, confirm that science education at school still needs to improve a great deal if we want to change this perception. The results of this project in our country² indicate that less than 50% of the young students surveyed claimed to be more attracted to science subjects than other subjects or want more hours of science classes. Along these same lines, less than 40% believe that science subjects at school have opened their eyes to new and exciting jobs.

Although this problem is common to the entire education system, it is more acute in early school years, given that attitudes towards science at school among young students develop before they are 14 years of age. According to Murphy (2005), a large part of the teaching profession agrees that students in primary education enjoy learning about science. However, numerous studies have shown that this interest in science begins to drop off at around 10 years of age and this drop is much more evident when students move on to secondary education. Nevertheless, the results of some recent

studies seem to suggest that this drop might be avoided (Dewitt et al., 2013). Whether the attitude of students aged around 14 years towards STEM subjects is positive or negative, it has already been formed (Archer et al., 2010).

A number of authors in the field of teaching methods, aware of the problems associated with the traditional teaching methods for science and the influence thereof on the diminishing interest and the quality of learning, have defended a series of ideas aimed at breaking this trend. We know that students' interest in scientific education is clearly related to curriculum content and in particular to the method in which it is taught at school. We know that if students do not have the chance to delve deep into one or more STEM subjects, if they do not tackle the intellectual, achievable and satisfying challenges, they are unlikely to show any interest in science (COSCE, 2011). There is a consensus among experts concerning the belief that teaching science needs to be more authentic with regard to scientific practice in the classroom, including guided and open studies, but without forgetting conceptual learning to master the main scientific explanations, through the use of scientific language and arguments (Osborne & Dillon, 2008). It is not about abandoning essentially factual and reproductive teaching for simply manipulative teaching; it is about uniting the exploration of phenomena and investigation with the conceptualisation of big ideas (not the details or the vocabulary) of science.

In spite of all of this and the importance that an interest in scientific-technical education may have on the students' future choices (both in terms of studies and careers), recent research in the field confirm that this is not the only factor to be taken into account (Dewitt et al., 2013). As we will

see below, there are many different factors influencing youngsters' professional aspirations.

Interest in science and technology

The decision to choose a STEM career is undoubtedly affected by the social perception of science and technology. In this regard, the FECYT's latest *Survey on the social perception of science* (FECYT, 2013) indicates that the majority of Spaniards associate science and technology with a better quality of life (88%) and with economic development (87%). The same survey shows that the interest in science and technology has increased by 19% since 2010 and in the case of 15 and 24 year olds, by 40%. Although we could consider these results to be positive, there are also certain studies that warn us about two aspects to be taken into account when talking about the interest in science and technology and fostering STEM careers. On the one hand and according to some authors, Western countries are lacking general awareness on the importance of companies related to the science and technology fields or of the social responsibility thereof, or of a good image of the environmental impact of industries (Becker, 2010). Although up until now we have referred to the interest in scientific disciplines throughout education, this interest does not necessarily have to coincide and in fact, it does not always coincide, with an interest in science and technology. Some studies indicate that there is only a moderate interrelationship between attitudes towards science and students' academic achievements (Osborne et al., 2003).

Along these same lines, a number of studies highlight a divergence between an interest in science and positive views of professionals in the scientific-technical fields and an interest in wanting to be a scientist (Aschbacher et al., 2010; Bennett &

Hogarth, 2009; Dewitt et al., 2013). Therefore, once again we can see that promoting an interest in science and technology, including science and technology at school, is not enough to stimulate youngsters into continuing their academic and professional careers in the field of STEM.

Key aspect for promoting scientific-technical vocations

As outlined above, the process of choosing a possible STEM-related academic and professional future is much more complex than it may seem at first. The results of research into the psychology, sociology and teaching methods of science and technology confirm that the process is greatly influenced by other factors such as a student's perception of themselves and their family, educational and social environment. There is no doubt that whether or not a young student chooses a STEM-related professional future will have a great deal to do with their ability to imagine their professional future in a scientific-technological context and with the imbalance that there may be between the image they have of STEM professionals and their own identity (Dewitt et al., 2013).

According to Holland (1985), individuals choose a professional career they believe suits their personality. Therefore, following this theory, job satisfaction depends on the interests, skills, competences and values of the individual fitting in with the activities, tasks and responsibilities inherent to that job. Consequently, when it comes to promoting scientific-technical vocations, youngsters' self-knowledge will also have to be addressed and they will need to be provided with the information required about possible STEM professions.

With regard to these considerations, the work of Donald Super (1910-1924) gives us an idea of just how much these aspects can make an impact. According to Super, choosing a professional career is a dynamic process that is developed throughout infancy. From the time of birth until around the age of 14 years, an individual's self-concept is being formed (what one thinks of oneself), developing skills, attitudes, interests and needs, while a general perception of the world of work is also being formed. In this regard, Zunker (1994) outlines that this process can be enriched by observing professionals going about their work, enabling a young person to identify with them. More recently Savickas (2009) revised these theories, defending the fact that it is important to focus on what the individual can achieve when carrying out specific tasks and not on what the individual is before taking on these tasks. In other words, according to this author, self-concept is developed as a combination of one's own abilities, the opportunity to watch professionals carrying out specific tasks and the capacity of self-assessment while carrying out these tasks.

Unfortunately, youngsters have a very limited view of the scientific-technical professions and the tasks carried out by professionals in these jobs, thus limiting the opportunity of imagining themselves as these professionals in the future (Dewitt et al., 2013). Despite the fact that many studies carried out by the OECD (2002) claim that youngsters benefit from receiving good quality advice and guidance, designed to build their aspirations, some studies reveal that professional guidance is seldom provided and often too late (Archer, 2013).

Therefore, we need to promote a wider image of science, reflecting the variety of careers that can open up by studying STEM disciplines (Dewitt et al., 2013; Osborne & Dillon,

2008). Raising awareness of the wide variety of scientific careers or those based on science, can help more people form very different environments, find their place by seeing STEM professions as something that will suit them.

Closely related to this, is Bandura's (2001) contribution concerning the concept of auto-efficacy. For this author, learning is more likely to take place by watching someone carrying out an activity if there is a clear identification between the observer and the "model" and if the observer also has a high level of auto-efficacy. Perceived self-efficacy is defined as people's beliefs about their own abilities to produce the expected performance levels. These beliefs determine how people feel, think, motivate themselves and behave; therefore they have a great influence on the events that affect their lives. In this regard, the higher the level of self-efficacy perceived by younger individuals, the wider the range of professional options that they will seriously consider for the future, the greater their interest in these options and the better their training for the jobs they choose. In this respect, research concerning self-efficacy suggests that teachers should focus as much attention on their students' self-efficacy as they do on their real ability (Beier, 2008).

Beyond each individual's intrinsic factors, the results of a number of studies suggest other factors that have a great influence on the attitudes of younger individuals towards scientific-technical studies and professions. On the one hand, the fact that the professional aspirations of boys and girls seem to be formed by parents' perceptions of their children and by teachers' evaluations of their students should be taken into account (Bandura et al. 2001). Many studies confirm that the support received by youngsters from their parents is closely related to their aspirations towards scientific-technical careers

(Dewitt et al., 2013). On the other hand, the influence of peers and friends is a significant factor when explaining why young students choose scientific-technical studies (Osborne et al., 2003). During ages in which, as previously mentioned, a person is developing their self-concept, the expectations of their peers play an important role. Finally, there are “structural” factors that may influence students’ aspirations.

This is not so much because they directly influence their interests, but because they may be key in achieving those aspirations and are associated with factors such as a lack of or difficult access to resources (Dewitt et al., 2013). Expectations related to gender, social class and ethnic group (and the effect of discrimination such as sexism, homophobia, classism, racism and racial discrimination) have a long and intense effect on an individual’s chances, influencing their career and decision choices (Fouad, 2007). Details on this aspect are currently in short supply so a more in-depth study would be required on how these factors affect students’ professional opinions.

Conclusions and implications

There are a wide range of initiatives in our country from different agencies and organisations (research centres, private companies, private foundations, etc.) aimed at promoting scientific-technical vocations. In this regard, recent studies have confirmed that taking part in extra-curricular activities related to science and technology can have a positive impact on

young students’ achievements and confidence with regard to scientific-technical disciplines. However, many of the proposals currently being implemented are based on the idea of offering a more entertaining form of scientific-technical education. As we have seen, this is not the only relevant factor to be taken into account therefore suggesting activities of this sort may not lead to a greater number of students being attracted to scientific-technical professions (Dewitt et al., 2013).

To enrich current initiatives it is vital to take into account other factors such as the degree of information of STEM professions provided by activities, the way in which issues are addressed that can influence the social perception of science and technology or the opportunity to help students overcome challenges and thus improve their self-efficacy perception. However, as reflected in specialised literature, this is not an easy task and it is still a field being studied. Continuous work and sufficient information is required in order to make the relevant decisions.

Together with the numerous theoretical studies aimed at exploring the promotion of scientific-technical vocations among young students (mentioned in this report), the “la Caixa” Foundation, FECYT and Everis, in collaboration with the Pompeu Fabra University and the CRECIM³ at the Autonomous University of Barcelona, decided to offer a tool that would enable anyone responsible for these types of activities to have a better understanding of their target public and to evaluate

the specific objectives that their initiatives should reach more precisely. Without intending to be a “magic formula”, this tool enables the factors closely related to the scientific-technical aspirations of young students to be explored and thus be promoted in activities if we want to have a significant influence on these aspirations.

Barcelona, December 2014

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EVALUATION OF THE IMPACT OF OUTREACH ACTIVITIES IN TERMS OF PROMOTING CAREERS IN SCIENCE AND TECHNOLOGY



EXECUTIVE SUMMARY

One of the objectives of science outreach projects for young people, and in particular, the activity carried out by the Spanish Foundation for Science and Technology (FECYT), “la Caixa” Foundation and Everis in the framework of their CSR, is to promote careers in the field of **STEM** (Science, Technology, Engineering and Mathematics). The number of students who opt for these educational paths is decreasing year after year, affecting the competitiveness and growth of the industry and the economy as well as hindering the development of responsible research and innovation programmes.

With the aim of evaluating the success of the science outreach activities carried out and improving their impact, the FECYT, “la Caixa” Foundation and Everis have conducted a project to define and implement an impact evaluation system that has enabled us to **represent the extent to which the interest in studying STEM increases** in the students taking part in these activities and **identify the key influencing factors** in young people’s career choices.

The project has been developed over two academic years. More than 2,500 secondary school students participated in it, with help from an expert advisory panel which validated the study. This panel included Albert Satorra, PhD in Statistics awarded by the UB, Roser Pintó, PhD in Physics awarded by the UAB and director of the CRECIM (Research centre for education in science and mathematics), and Digna Couso, PhD in Teaching of Experimental Science awarded by the UAB.

Analysis on results from students participating in the outreach activities programme applied in the project has allowed us to draw the following **conclusions**:

- We quantitatively evaluated the impact of carrying out just two outreach activities, an experiment workshop and an interactive lecture with a scientist, on compulsory secondary education students, just before they decide to follow the path of a STEM or non-STEM future in education.
- **There is a 5.63% increase in interest in STEM courses among participating students.** Considering the students participating in the activities of the FECYT in Madrid and CosmoCaixa Barcelona during the 2013-14 academic year, this could mean an increase of 4,834 students in STEM paths in absolute terms. To put this into context, the number of students on STEM high school diploma courses in Madrid and Catalonia is around 85,041, and as such, the percentage of students affected in one year by FECYT and CosmoCaixa activities is 5.7% of the STEM high school diploma students in these geographical areas, with only 2 outreach activities being carried out.
- **We observed a reduction in the educational gap between socio-economic status:** there is a 9.51% increase in interest in studying STEM amongst students from more disadvantaged socio-economic backgrounds. Propensity amongst this group is now close to the propensity measured in students from high level socio-economic backgrounds, who were initially more inclined to choose these studies.
- **There is a greater impact on boys than on girls,** despite girls being the group with the lower initial propensity

to study STEM. It has been observed that the influence on boys is concentrated in the group of students who are less certain about their choice, less interested in STEM and, in general, less convinced about their ability to study in this field.

The impact on girls, however, is mainly observed in the opposite case to that of boys: they are girls with an interest in studying STEM, who are sure about their decision and have high self-efficacy. We have therefore been able to consolidate the decision for girls who already intended to study STEM.

- **We observed a very positive impact on lower-performing students,** who are less inclined to choose STEM paths, with their propensity for these studies increasing by 12.78%, as well as on students who are undecided and moderately motivated.
- **Key influence of parents’ and teachers’ perceived opinion** regarding students’ ability to study STEM. In students who think that their parents or teachers do not believe that they are capable of studying STEM (although this may not necessarily be true), the impact is lower than among those whose parents or teachers have shown them that they do believe in their ability and potential to study these subjects.
- **Key impact factors identified:** to make a positive impact on young people’s interest in studying STEM, it is necessary to improve the actual students’ self-efficacy in relation to STEM subjects (whether or not they believe they are capable of studying these subjects), as well as achieving greater enjoyment and interest in them. Making them see STEM professions as a satisfactory future option for them is also a high impact factor.

- **The influence of friends facilitates the impact of outreach activities**, increasing the interest in studying STEM by up to 8.68% among students who admit the influence that their friends have on their choice of career.
- **Improved careers guidance facilitates interest in studying STEM.** If students do not feel that they are well-informed or given advice with regard to STEM studies and professions, it is very difficult to make them interested in the latter. Only students who consider that they have received good guidance in this regard choose STEM paths. For this reason, an increase of 8.33% has been observed in the interest expressed by students who said that they were worse-informed before they participated in the programme's outreach activities (which included career guidance elements).
- Putting across **STEM lifestyle models** appropriately to young people and allowing them to see how **useful science is to society** have a positive impact on the interest in studying STEM. With regard to the activities programme applied in the study, there was a 7.56% increase in the propensity to study STEM among students with a worse initial perception of the STEM lifestyle, and a 10.07% increase in students who initially had a moderate perception of the usefulness of science to society.

The study conclusions will be applied **to improve the outreach activities of the FECYT and "la Caixa" Foundation to increase the number of people with scientific careers in our country and students' interest in**

science. Likewise, the results and the evaluation method produced by the study will be available to other entities that are also working on boosting careers in science.

MOTIVATION FOR THE IMPACT STUDY

There is currently a growing trend of disinterest amongst young people as regards the study of Science, Technology, Engineering and Mathematics (**STEM**) and this situation is widespread in the most developed countries of Europe and in the United States.

This situation is worrying for society as a whole, from Public Administration, which has included the issue as a priority on the political agenda, to industry, which estimates that the lack of professionals in science and technology fields will leave more than one million jobs vacant in Europe in 2015, which will have a direct effect on competitiveness, growth and development among future emerging sectors. In the sphere of research & innovation and science & technology outreach, this concern runs deeper, because in an increasingly technological society in which scientific progress occurs at an increasingly greater speed and poses social challenges of great significance, citizen participation and involvement is key, and must therefore advance towards the concept of **responsible research and innovation.** This will not be possible without giving our citizens a proper scientific and technological education.

From a collective desire to improve this situation, the Spanish Foundation for Science and Technology, "la Caixa"

Foundation and Everis, in the framework of their SCR, have driven forward a project aiming to analyse factors in depth that influence career choices among compulsory secondary education students in relation to STEM subjects and professions and in particular develop a system that allows us to evaluate the impact that outreach activities and initiatives have on promoting STEM careers, and improve their effectiveness.

OBJECTIVES

Generally speaking, we aim to **understand how secondary school students make decisions regarding courses and future professions**, in accordance with the **group of influencing factors** (social, academic, family, etc.) that affect them, in order to help us focus on activities aimed at promoting careers in science and technology and **evaluate their impact on this decision**.

The study specifically aims to:

- **Identify the different *influencing factors*** that affect a student throughout the process of developing their career/future choice, taking into account the relationships existing between them.
- **Pay special attention to science-technology outreach activities as an *influencing factor*** to try to **evaluate whether they had an impact on students' interest in studying STEM** disciplines.
- **Define a model that allows us to measure the propensity** of young people **to study STEM** and evaluate the impact that a certain science-technology outreach activity or initiative has on this propensity.

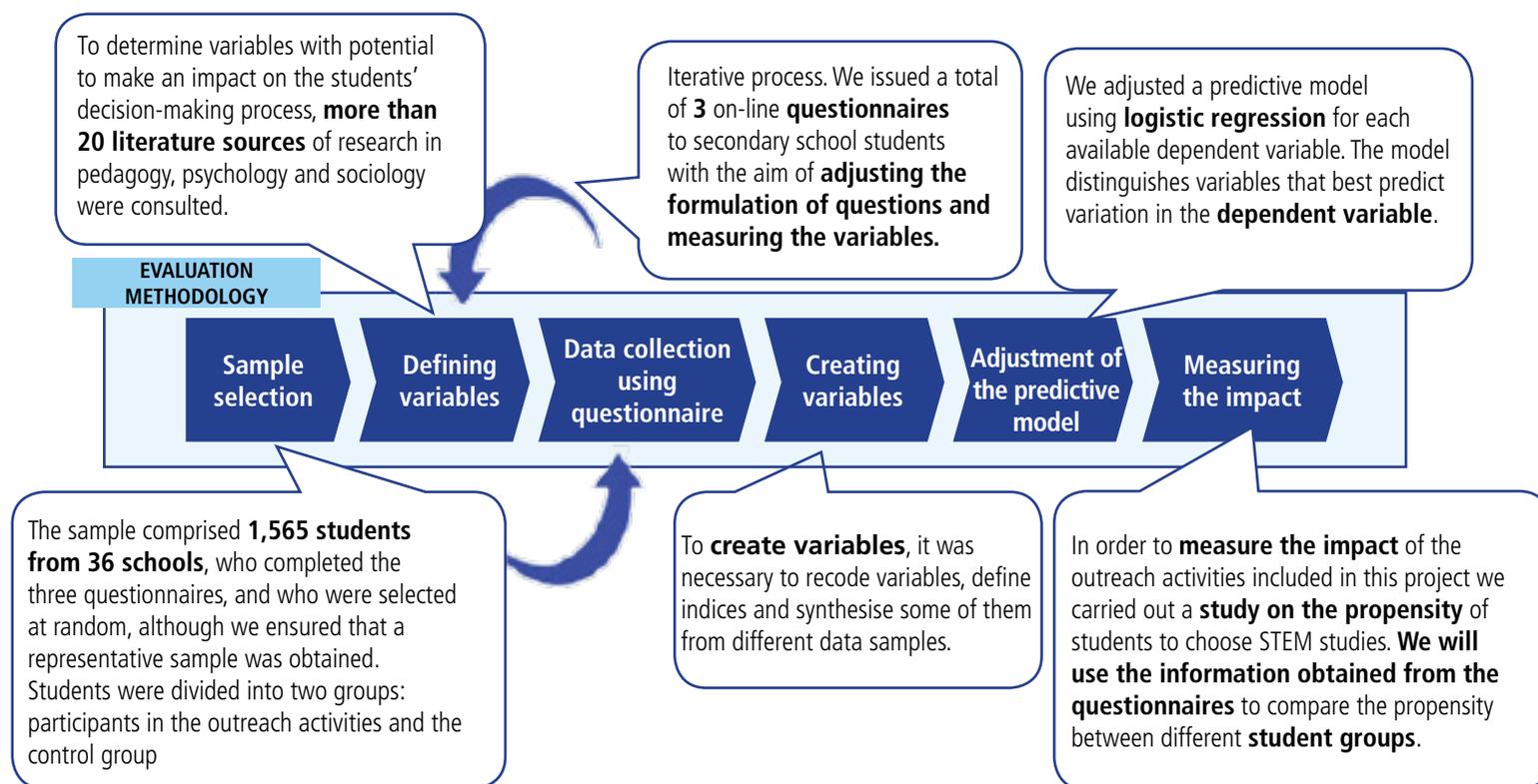
The results of the overall project are as follows:

- Developing a **predictive model on the interest in studying STEM** amongst young people that shows us the propensity of each student **to study STEM** and know **which factors have the greatest influence** on the development of this propensity (and therefore know where we must focus our efforts).

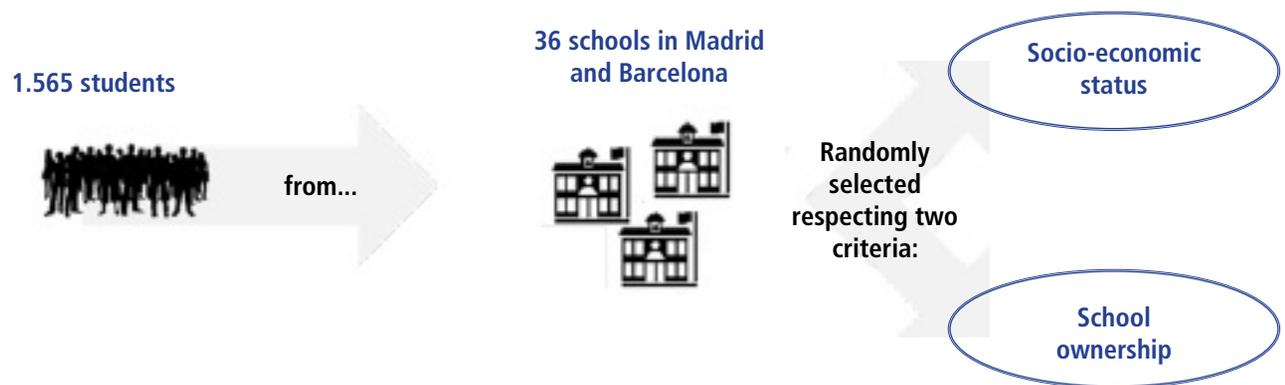
- Implementing the predictive model **in an impact evaluation kit** that allows us to measure and improve how objectives are met for an initiative/activity aimed at promoting STEM careers and that provides **practical recommendations** to increase its effectiveness.
- **Application of the model** to a wide and representative sample of students and analysis on its results, obtaining a **detailed study of the impact on the interest to study STEM** among students participating in the **outreach activities applied in the project**.

METHODOLOGY

The project was developed in two phases, with an iterative approach to the solution. In the first phase, we studied a sample of 450 students from 6 schools and defined a first impact evaluation model. In the second phase of the study we improved the evaluation methodology developed in the previous phase, applying the following measures:



The total sample in the second phase of the project was 1,565 students who were selected completely at random respecting two representation criteria: socio-economic status and school ownership.



The final sample is distributed as follows, in accordance with the main segmentation criteria:

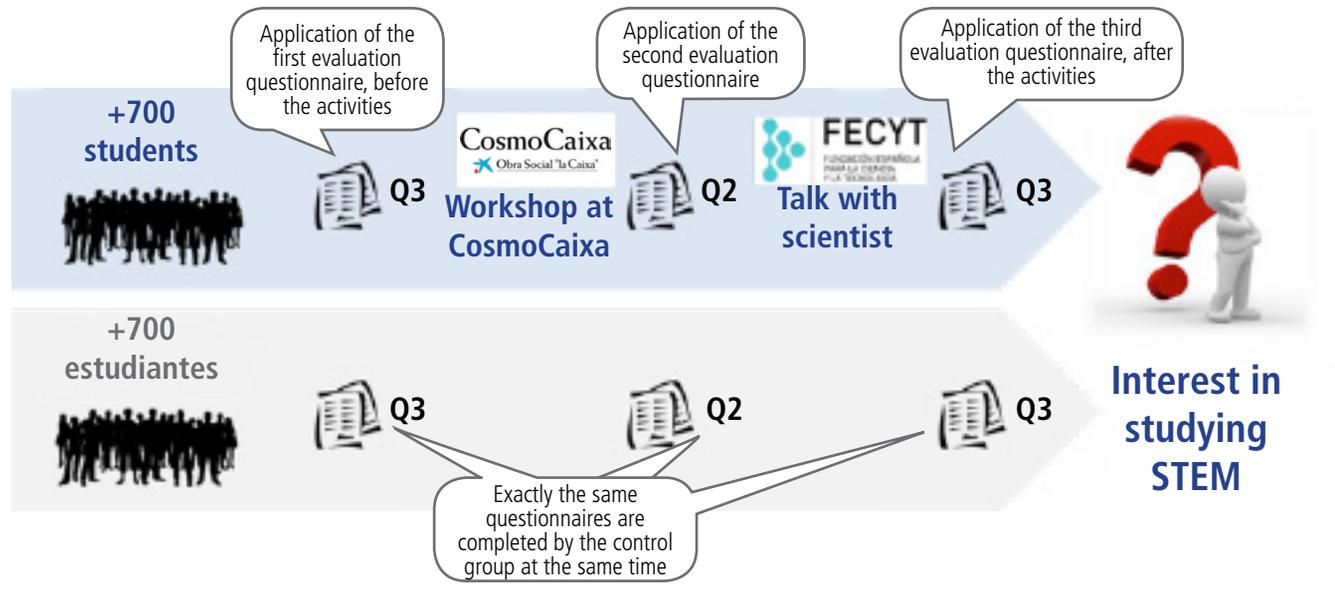
Group	No. students	City	No. students
Treatment	849	Madrid	764
Control	716	Barcelona	801

Socio-economic status	No. students	Ownership	No. students
High	195	Public	536
Medium	939	State-subsidised private school	955
Low	431	Private	74

Two groups were established from the total student sample to correctly validate the model and obtain valid conclusions on the impact of the outreach activities applied in the project.

One student group participated in different outreach activities, and constituted the **experimental group or participating group**, while the rest of the students did not participate in any of these activities, and constituted the control group.

Furthermore, to make sure that the students' perception was not influenced in any way in the two groups, we applied the blind study technique, so that no student in the sample knew the experiment or the relationship between the activities and the questionnaires that they completed during the project.



RESULTS

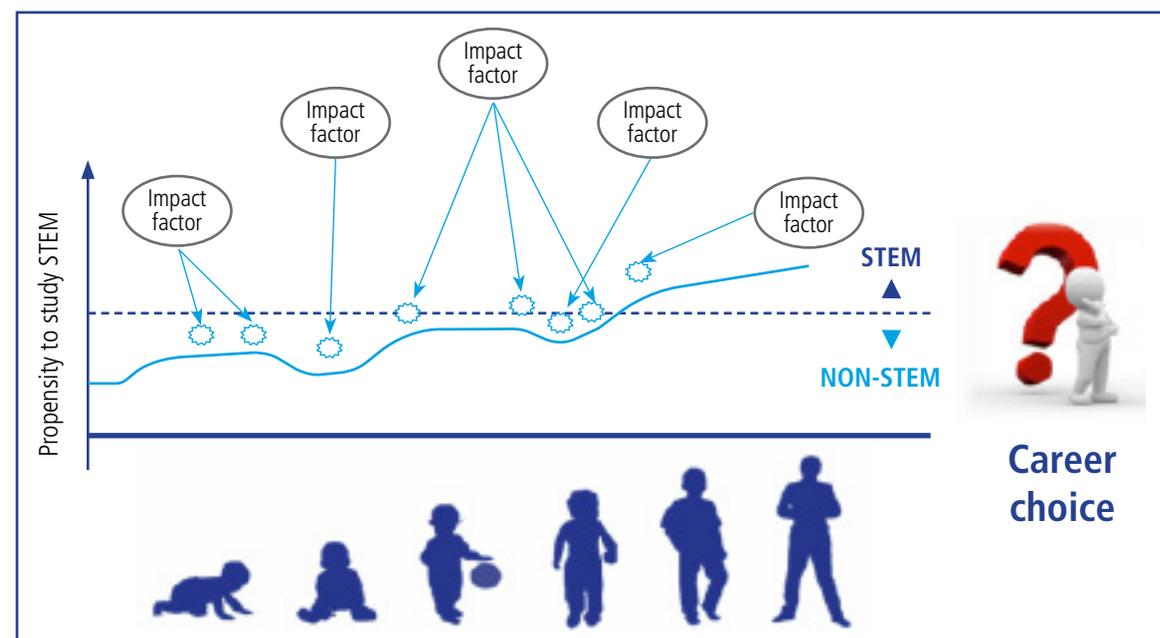
Predictive model

One of the project objectives was to define a **predictive model of the propensity to study STEM amongst secondary school students** by measuring the impact on this propensity from each of the variables or influencing factors in students' decision-making process with regard to their educational and professional career.

The predictive model was adjusted using the **binary logistic regression** technique, with a dependent variable (Y) defined in two categories [0-1] and n independent variables (X) that may be dichotomous or continuous.

We considered the **interest in studying STEM** as a dependent variable (Y), to be measured using the model, understood as the predisposition to study a STEM subject, although this does not necessarily have to be their final choice.

We chose this variable because it is more directly linked to the objective of the outreach activities: **increasing STEM careers**. Although this may lead us to consider a variable that is more directly related to the choice of career (*will you choose STEM?*), we must bear in mind that achieving a change of choice with a one-off activity or a series of activities over a limited period of time is a very ambitious objective, and, as such, it is necessary to have a more accurate variable that can indicate whether we have made progress in achieving this objective even if we have not reached the choice change threshold: **the interest in studying STEM**.



This variable allows us to **determine whether the outreach activity had any type of impact** (positive or negative) on the career choice process.

The conceptual areas defined are: **student body, educational environment, immediate environment and social environment**.

To determine independent variables, we worked on a set of over 30 factors that potentially influence career choice, defined by reviewing more than 70 research sources in the fields of psychology, sociology and pedagogy, as well as using the knowledge from the project's advisory committee.

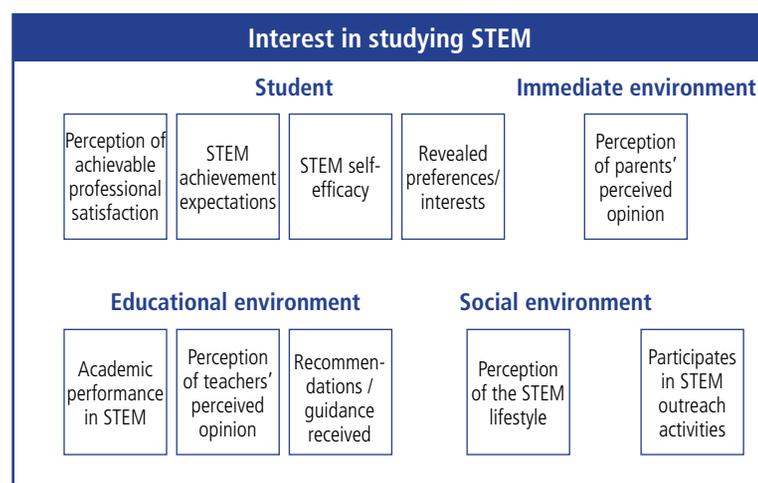
The final variables were grouped into 4 conceptual areas for solely descriptive purposes and we should indicate that in no case were these groupings taken into account either in the predictive model or for statistical purposes.

Conceptual area - Student Self-efficacy in STEM	Intrinsic characteristics of the student <i>Student's self-efficacy expectations in STEM subjects</i>	Conceptual area – Educational environment	Variables relating to the student's educational environment (school, teachers, guidance)
Career conviction	Students' degree of certainty concerning their career interests and preferences	Help at home	Student's perception on whether or not they receive help at home with schoolwork
STEM achievement expectations	Student's idealised preference regarding what they would want and would like to be in the future (does not necessarily mean that the individual will act accordingly in order to achieve it)	Accepted influence (teachers)	Influence of teachers accepted by the student regarding their choice of degree
Interest in STEM subjects	Degree of general interest expressed by the student with regard to STEM subjects	Degree information/knowledge	Student's perception regarding their degree of knowledge about the requirements for accessing higher education and career opportunities
Perception of achievable professional satisfaction	Student's opinion on whether or not STEM professions are interesting and/or stimulating in relation to their professional future	Perception of STEM classes	Students' perception of STEM teachers' attitude towards the teaching of these subjects
Priority for immediate wellbeing	Student's preference for short and/or less demanding studies	Perception of teachers' opinion	Student's perception of the opinion that teachers have regarding their competencies and capabilities in STEM
Social priorities	Student's preference for values of self-realisation and participation (post-materialism) over the traditional values of broadening of financial and citizenship security (materialism)	Perceived recommendation/guidance	Students' perception with regard to having received recommendations or guidance from the teachers and the centre's guidance services
Degree or revealed preferences/interests	Expresses the degree of general interest that the students have in science, technology and mathematics.	In relation to the centre	Student's perception of the activities, outings or events carried out by the centre in relation to the STEM subjects
		In relation to teachers	Which teachers have been a reference for the student and is this linked to their career choice?
		Academic performance in STEM	Student's average grade in STEM subjects

Conceptual area – Immediate environment	Variables relating to the student’s family environment and immediate circle (family members, friends)	Conceptual area – Social environment	Social perceptions and stereotypes of the student regarding science
Economic, social and cultural status of the family	Economic, social and cultural status level of the student’s family	Perception of the social benefit of STEM professions	Students’ assessment concerning the benefit of STEM professionals for society compared with other professions
Accepted influence (friends/peers)	Influence of friends/peers accepted by the student regarding their choice of career	Perception of the effort involved in a STEM degree	Student’s perception of the effort involved in a STEM degree compared with other degrees
Accepted influence (parents)	Influence of parents accepted by the student regarding their choice of career		
Perception of parents’ opinion	Student’s perception of the opinion that their parents have regarding their competencies and capabilities in STEM	Perception of the STEM lifestyle	Student’s perception regarding the lifestyle of a STEM professional in terms of work and residence stability/comfort in comparison with other professions
Person close to them works/studies in STEM field	Student’s perception of having a close family member (parents, brothers/sisters) working or studying in a STEM field	Perception of achievable socio-economic status	Student’s perception of the socio-economic status that can be achieved through STEM degrees/professions in comparison with other degrees/professions
		Perceived prestige of STEM professions	Student’s perception of the prestige involved in a STEM-related degree/occupation in comparison with other professions
		Social perception of science	Student’s perception of the world of science and technology as a means to improve or hinder social and environmental conditions (from a general point of view)

One last variable has also been taken into account in the study, which is whether the **students are participating or not in STEM outreach activities**. This variable was determined by the participation or lack thereof of students in a STEM outreach programme defined specifically for the project, which included the study's participating and control groups.

From the work carried out on this group of variables through questionnaires applied to the student sample (participants and control) and the application of logistic regression models, the composition of the model predicting the propensity to study STEM has been established. This includes the following variables:



It should be highlighted that **participation in the outreach activities** was involved in selecting the model variables due to its capacity to predict propensity to study STEM, indicative of its capacity to affect the dependent variable.

The **model's predictive capacity**, in accordance with the goodness of fit test for the classification tables, **was 85.7%**.

Impact evaluation kit

The project aimed to help provide an answer to some of the most important questions that are asked when planning, designing and carrying out STEM outreach activities: is my activity working adequately? What is the participant group like? What are its interests? How can we motivate them? What impact do we have on participants? In short: how can we improve?

The predictive model defined allows us to:

1. **Find out about the key elements that determine STEM as the study choice**, in order to take them into account when designing activities.
2. **Measure young people's propensity to study STEM and characterise them**, so we can determine our participants' profiles and adjust the activity to suit them.
3. **Establish the impact of our outreach activities**, so that we can set up mechanisms to improve them.

The kit consists of a questionnaire whose answers are incorporated into the logistic regression statistics engine, implemented using spreadsheets, and **it displays the propensity of an individual or group of individuals to study STEM**, as well as their **characterisation according to the impact variables** (they have greater or less interest in studying STEM, they have higher or lower self-efficacy, there are more or fewer girls interested in STEM, they feel that their parents and/or teachers think that they are capable of studying STEM or not, etc.).

As such, activity planning and even design can be far more personalised for the participant group and its effectiveness can thus be increased.

By measuring the ex-ante propensity to study STEM and comparing it with the ex-post measurement, we obtain the change between the propensities to study STEM before and after the outreach activity, and therefore a guide on the extent of the impact although to generalise results, the participant sample should be sufficient and representative with a control.

The kit also includes **recommendations** for the design and execution of outreach activities and educational programmes in relation to STEM careers developed from the results obtained in the project.

Analysis of the impact of the programme's outreach activities

From the data collected in the three questionnaires from 1,565 students, we considered **analysing the impact that the programme's outreach activities developed** for the project had on **students' interest in studying STEM** and particularly the differences between the groups in accordance with different segmentation variables, such as the socio-economic status of the student's family or gender.

It is important to note the impact assessment is limited to the specific outreach activities of the programme applied, and it does not allow generalisation for other types of similar activities.

To do this, **we will apply the predictive model** we defined, giving us the **propensity** of the students from each analysis group **to study STEM**.

Once we know the propensity to study STEM at the time when we complete the outreach activities programme for all students, **we will compare the results between the students in the participant group and those in the control group**. Considering the period of time in which they were developed,

the main difference between the two groups with regard to the impact variables defined in the predictive model is determined by the participation or lack thereof in the outreach programme and, by extension, the change in the impact received by each group.

This methodological approach will also allow us **to find out the individual impact of some of the model's independent variables**, not possible using the predictive model, by comparing the participant and control groups segmented by the variable to be analysed.

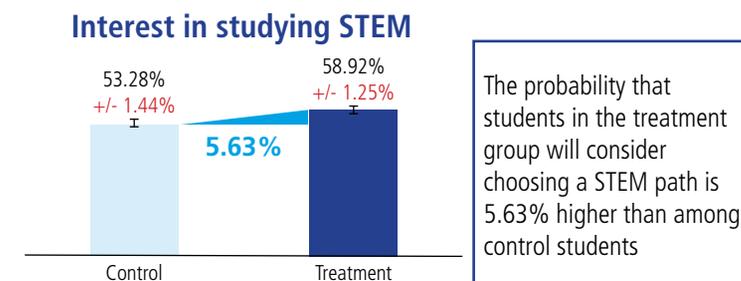
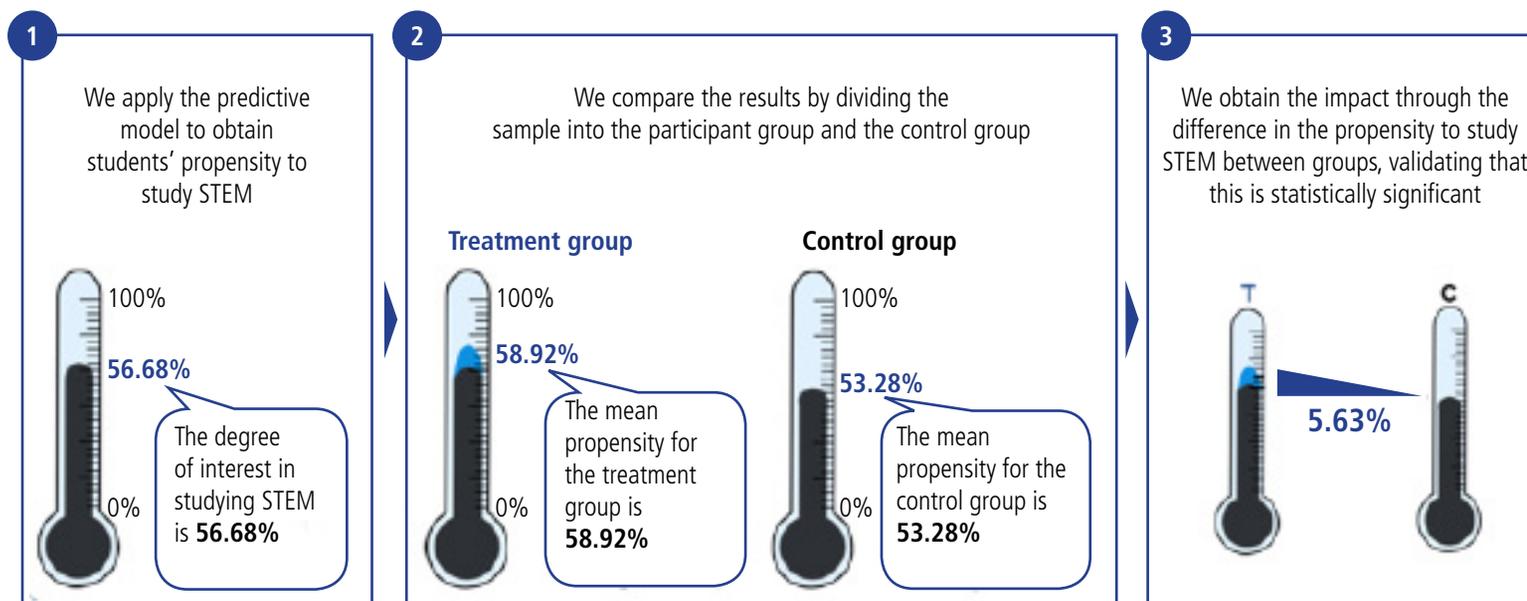
The main results obtained are displayed below.

Outreach activities have an impact on STEM careers

The first and most important conclusion that we can draw from the analysis results is that the **STEM outreach activities can have a positive and significant impact on the young people's interest in studying STEM**.

In the specific case of the outreach activities defined in the programme applied in the project, the impact was demonstrated as a **5.63% increase in the propensity to study STEM** among participating students.

Impact analysis methodology



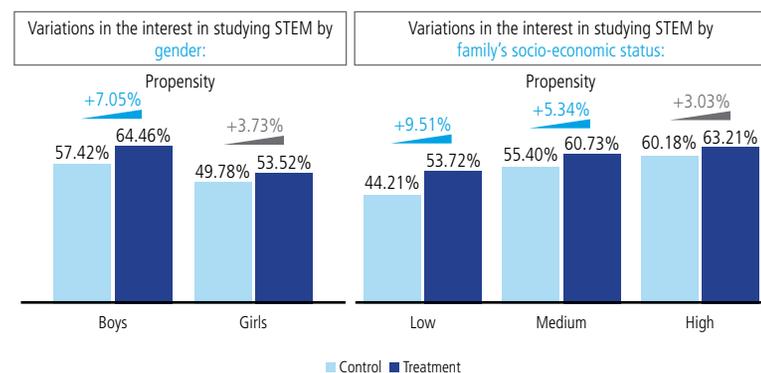
5.63% Significant impact: difference between the means does exceed the cumulative error
 5.63% Non-significant impact: difference between the means does not exceed the cumulative error

The educational gap between socio-economic statuses of students is closing

There is a major social gap in relation to the lack of STEM careers since major differences can be attributed to the socio-economic status of the students' family and their gender. In this regard, the initial position of the study's student sample indicates that both girls and students from disadvantaged socio-economic backgrounds have a lower interest in studying STEM than boys and students of high socio-economic status, respectively.

The outreach activities carried out do not seem to have a significant impact on the group of girls and **the impact is actually only high in the boys' group** (+7.05%).

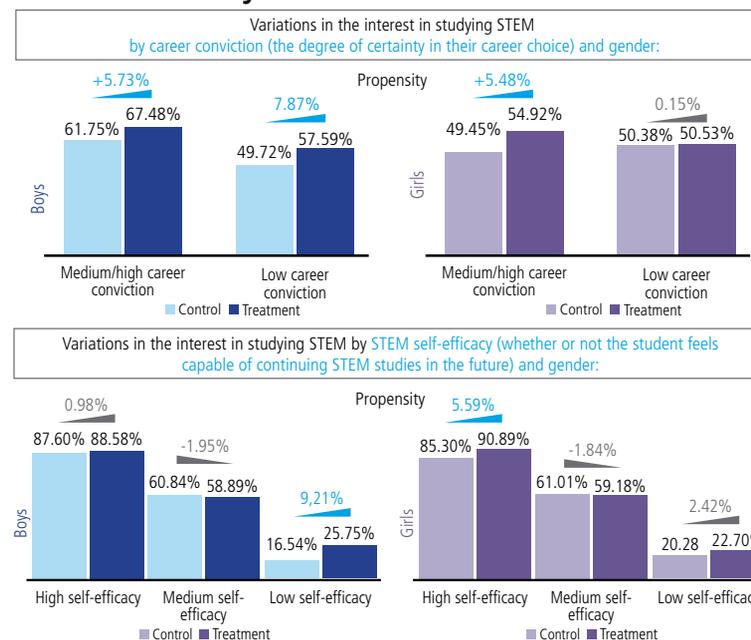
However, the **incidence in socio-economic status is very positive**, demonstrating a **9.51% increase in the interest in studying STEM in students from more disadvantaged socio-economic backgrounds**, versus a non-significant impact on students from high-level socio-economic backgrounds, and, as such, the existing social gap is narrowed, clearly contributing to educational equality.



The gap between boys has narrowed; consolidation of STEM girls

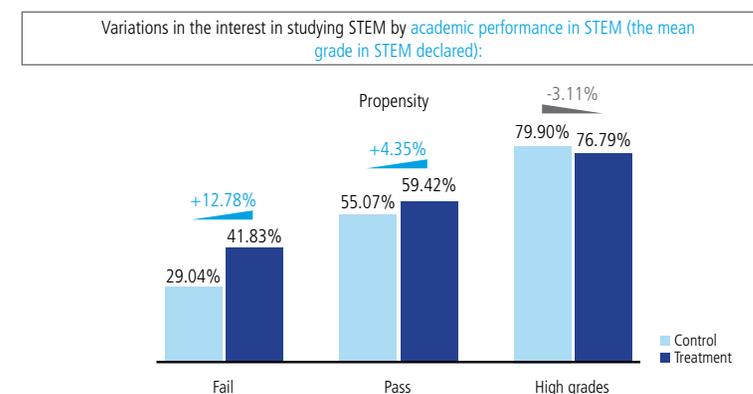
When we study gender differences in more detail, we can see that **the influence on boys is concentrated on the group of students who are less certain about their choice, are less interested in STEM subjects and in general are less convinced about their abilities to study** this subject area. Furthermore, the impact on this group achieves significant levels (>7.5% in all cases). The impact is very low or is not significant among girls in the same groups.

The impact on girls, however, is observed principally in the opposite case to that of the boys: they are girls with an interest in studying STEM, they are more certain about their decision, and have high self-efficacy. The result, therefore, is **to consolidate the decision of girls who very likely already intended to study STEM**.



Very positive impact on lower-performing students

Academic performance is closely linked to the interest in studying STEM and, in particular, the results in these subjects. However, and despite the fact that they do not change this, **the outreach activities applied have had a very positive impact on the group of students with an average fail grade in STEM subjects** (+12.78), which is not the case for the other students.



Impact on students who are undecided and moderately motivated

The prevailing perception that students have about STEM studies is that they are very difficult and require a lot of effort. As such, **students must be willing to assume this effort in their short-/medium-term educational paths** and not prioritise studies that are less difficult and shorter in duration so they may show interest in STEM.

The capacity to make an impact on students who are little or not at all prepared to make an effort seems to be very limited, but for any who are prepared to make a greater effort,

the outreach activities of the programme applied have had a major effect (+8.79%).

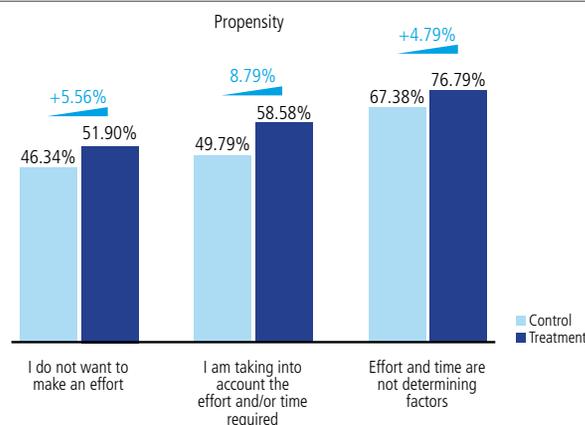
Regardless of the degree of conviction that they have in their decision, the outreach programme **has had a positive impact on students who, a priori, were undecided with regard to studying STEM subjects**, although the impact is much greater in those who were less certain about their decision (+11.17%).

I feel capable, I see myself doing it and I enjoy it: the key aspects for students with STEM careers

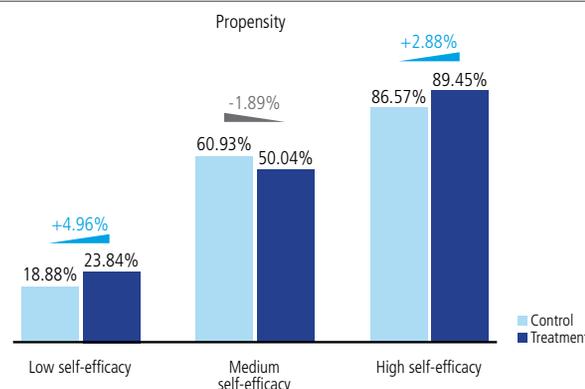
For students who believe that they are capable of succeeding in STEM studies (self-efficacy), those who enjoy these subjects (interests revealed), and those who see themselves carrying out a STEM profession satisfactorily (expectations of achievement and achievable professional satisfaction), the interest in studying STEM is logically very high. To raise the

number of the careers in this field, these are key elements on which there must be an impact, and the results indicate that the outreach activities applied have a moderate influence on them. An above-mean impact is only observed in expectations of achievement, probably due to discussions with practicing professionals.

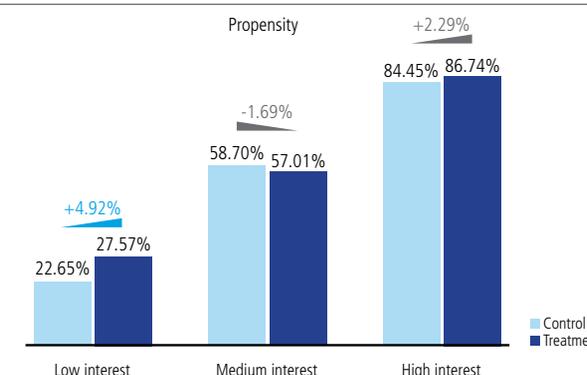
Variations in the interest in studying STEM by priority for immediate "wellbeing" (student's predisposition to effort/preference for easy and short studies):



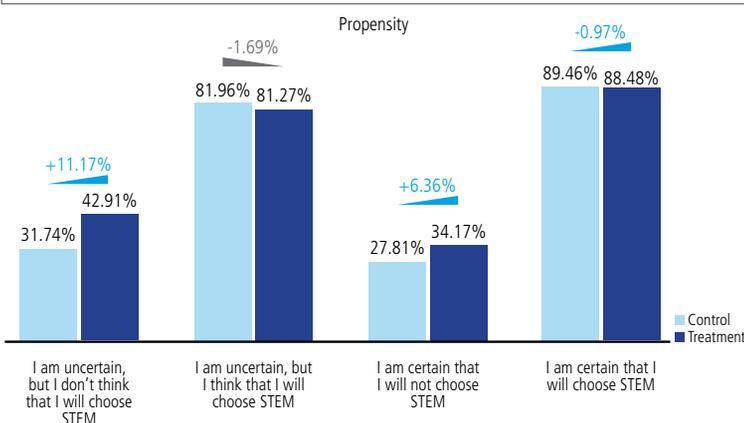
Segmentation by STEM self-efficacy



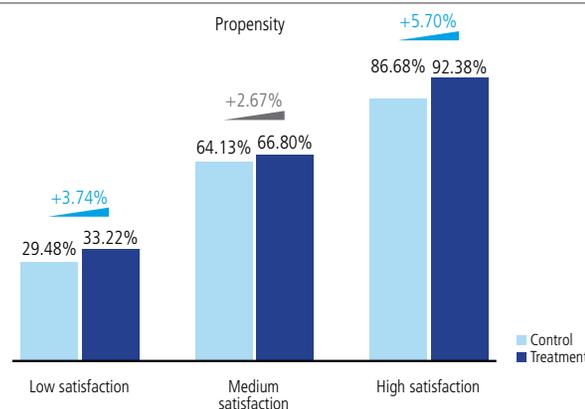
Segmentation by interests revealed



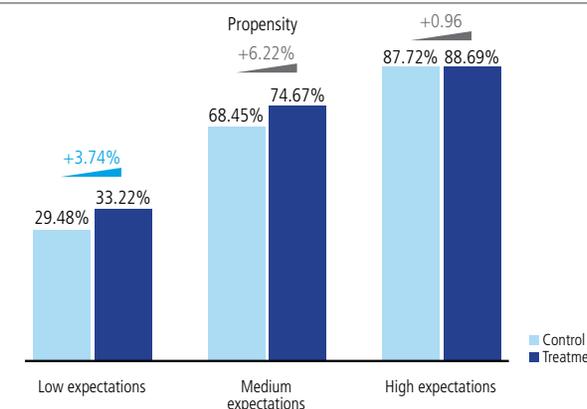
Variations in the interest in studying STEM by career conviction (degree of certainty in their choice) and choice of studies (STEM vs. Non-STEM):



Segmentation by achievable professional satisfaction



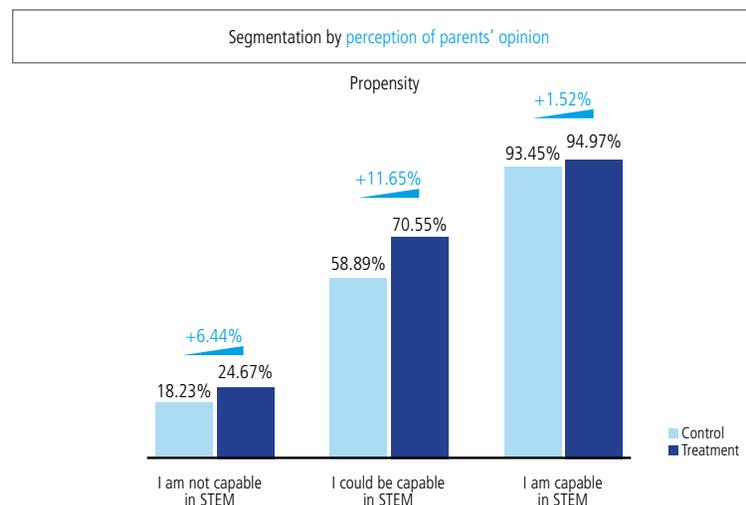
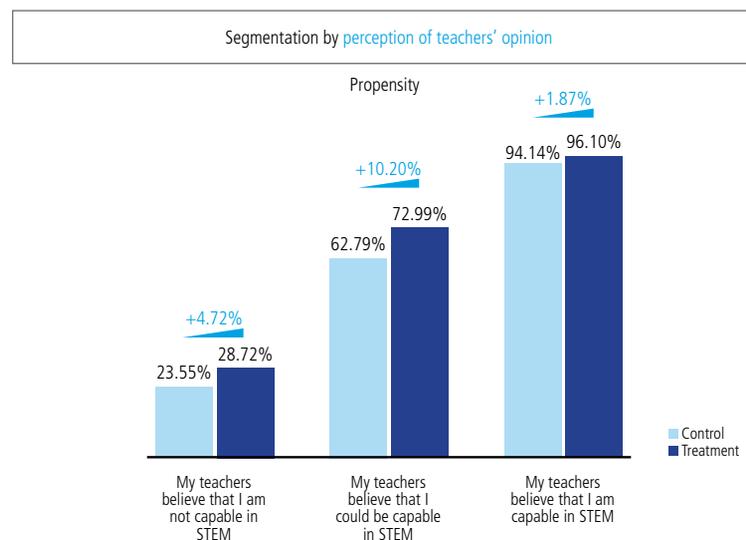
Segmentation by achievement expectations



The perceived opinion of teachers and parents is key in STEM careers

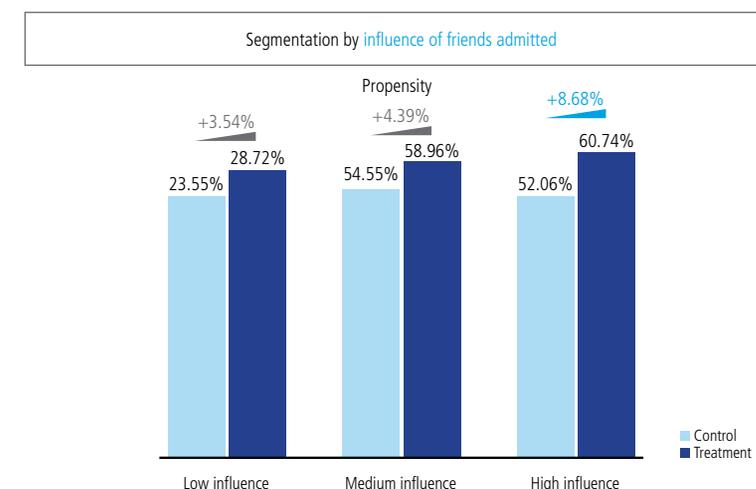
We determined two very similar variables with a high impact on the propensity to study STEM: **the perceived opinion of both teachers and parents**. For students who think that their parents or teachers do not believe that they are capable of studying STEM (although this may not necessarily be true), the interest in studying STEM is lower than for any whose parents or teachers have shown them that they do believe in their capacity and potential in these courses. As such, practically all students who think that their teachers and/or parents believe that they are capable of studying STEM subjects are interested in these studies (>93%). In contrast, a very low percentage of students who think that their teachers and/or parents do not believe that they are capable of studying STEM are interested in STEM paths.

The capacity to make an impact on these groups is very limited. However, for the group of students who do not know the opinion of their teachers and/or parents, the outreach activities applied have a high impact on encouraging them towards a STEM career (>10%).



The influence of friends facilitates the impact of outreach activities

The impact of the programme's outreach activities was much greater in students who admit the influence of their friends (+8.68%). Although they do not have the same degree of influence as parents and teachers, friends can play an important role in the propensity to study STEM and, therefore, in the design of outreach activities.

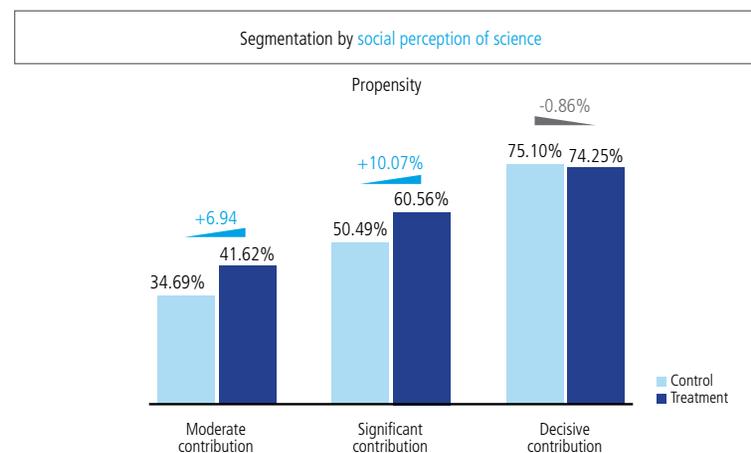
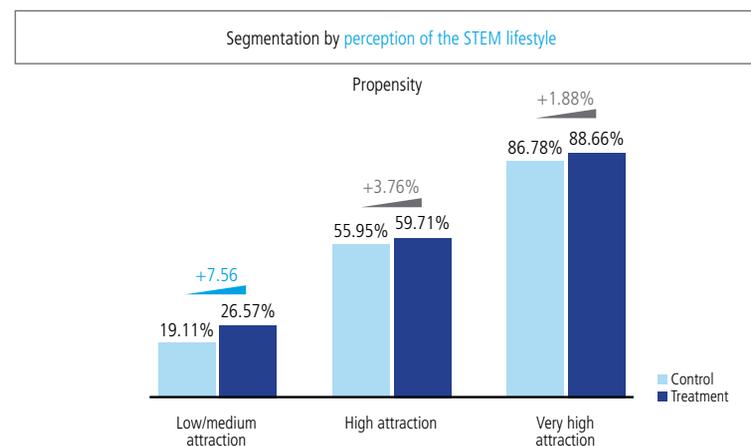
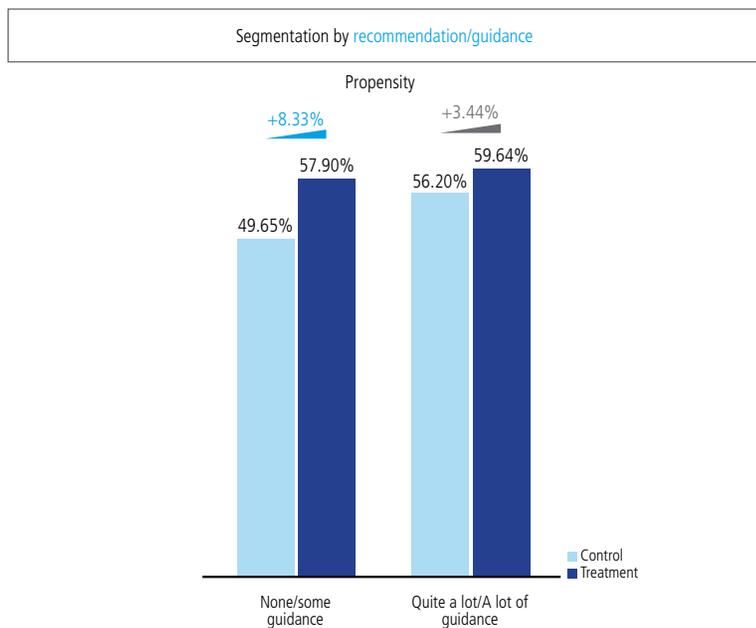


Better career guidance facilitates interest in studying STEM

The career guidance that students receive at school is insufficient on the basis of the results obtained in the study, in which 44% of students declare that they received little or no guidance or recommendations with regard to deciding their future paths. The outreach activities applied were shown to be effective in this regard and significantly reduced the gap in

the interest in studying STEM among students who were less informed and advised in relation to those who did consider themselves to be well advised.

The perception of the usefulness of science to society is in line with the interest in studying STEM and, as such, the outreach activities aimed at showing what science and technology contribute to society have an impact on students' interest in studying STEM (+10.07% in the group whose former opinion was that science has a moderate impact on society).



STEM lifestyle models and observing the usefulness of science to society have a positive impact

Students interested in studying STEM consider the STEM professional lifestyle to be attractive, and as such, showing reference models to young people may have a major impact on their career choice. The outreach activities carried out, including talks from STEM professionals about their life experience in their professional field, made a strong impact (+7.56%) on the group of students who, *a priori*, did not consider STEM professions to be attractive.

RECOMMENDATIONS FOR IMPROVING THE IMPACT OF OUTREACH ACTIVITIES AIMED AT PROMOTING CAREERS IN SCIENCE AND TECHNOLOGY



INTRODUCTION

One of the objectives of science outreach projects for young people is to promote careers in the field of **STEM** (Science, Technology, Engineering and Mathematics). The number of students choosing these educational paths is decreasing year after year, making industry and the economy less competitive with lower growth as well as hindering the development of responsible research and innovation programmes.

In an attempt to improve the success of scientific outreach activities, the FECYT, the “la Caixa” Foundation and Everis have conducted a project aimed at identifying and analysing the factors that influence the selection of STEM courses and how certain outreach activities can have an effect on students in relation to these factors. The project has been developed over two academic years and over 2,500 secondary education students have taken part in it, split into participating and control groups and segmented according to socio-economic status.

FACTORS INFLUENCING THE SELECTION OF STEM CAREERS

In order to determine the influencing factors, we have worked on a set of over 30 that potentially influence the choice of career, defined by reviewing more than 70 research sources in the fields of psychology, sociology and pedagogy, as well as using the knowledge from the project’s scientific committee, made up of members of the Autonomous University of Barcelona and the Pompeu Fabra University.

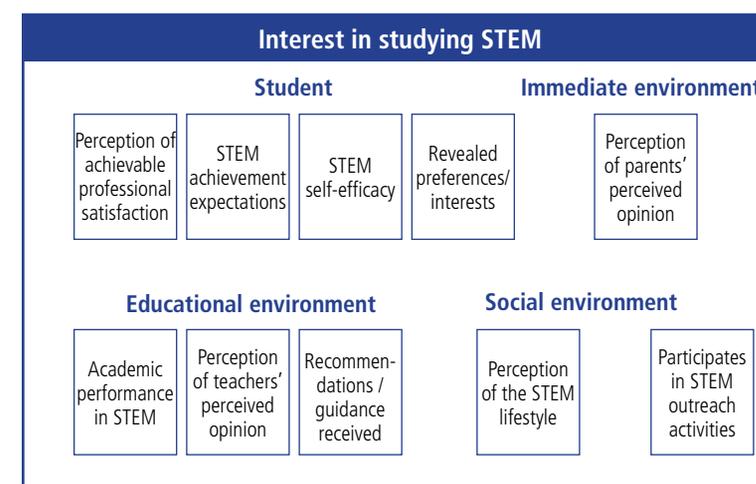
The final variables included in the study were grouped into 4 conceptual areas for solely descriptive purposes: **student body, educational environment, immediate environment and social environment.**

Conceptual field - Student	Student's intrinsic characteristics
Self-efficacy in STEM	Students' expectations regarding their chances of success in STEM subjects
Career conviction	Students' degree of certainty concerning their career interests and preferences
STEM achievement expectations	Students' idealised preferences concerning what they want and would like to be in the future (does not necessarily mean that the individual will act accordingly in order to achieve it)
Interest in STEM subjects	General degree of interest shown by students in STEM subjects
Perception of achievable professional satisfaction	Student's opinion on whether or not STEM professions are interesting and/or stimulating in relation to their professional future.
Priority for immediate wellbeing	Students' preferences for short and/or less demanding courses
Social priorities	Student's preference for values of self-realisation and participation (post-materialism) over the traditional values of broadening of financial and citizenship security (materialism)
Career or revealed preferences/interests	Student expresses their interest in science, technology, engineering and mathematics
Conceptual field - Educational environment	Variables relating to the student's educational environment (school, teachers, guidance)
Help at home	Students' perception on whether or not they receive help at home with schoolwork
Accepted influence (teachers)	Influence of teachers accepted by the student regarding their choice of career
Degree information/knowledge	Student's perception regarding their degree of knowledge concerning requirements for accessing higher education and career opportunities
Perception of STEM classes	Students' perception of STEM teachers' attitude towards the teaching of these subjects
Perception of teachers' opinion	Students' perception of the image the teachers have of them with regard to their abilities and capacities in the field of STEM
Perceived recommendation/guidance	Students' perception with regard to having received recommendations or guidance from the teachers and the centre's guidance services
In relation to the centre	Students' perception of the activities, outings or events carried out by the centre in relation to the STEM subjects
In relation to teachers	Student awareness of the teachers that have been a reference in their career choice
Academic performance in STEM	Students' average grades in STEM subjects

Conceptual field - Immediate environment	Variables relating to the student's family environment and immediate circle (family members, friends)
Economic, social and cultural status of the family	Level of the economic, social and cultural status of the student's family
Accepted influence (friends / peers)	(Accepted) influence of their friends / peers in their career choices
Accepted influence (parents)	Influence accepted by the student from their parents in their career selection
Perception of parents' opinion	Student's perception of the opinion that their parents have regarding their competencies and capabilities in STEM
Person close to them works / studies STEM	Student's perception of having a close family member (parents, brothers/sisters) working or studying in a STEM field
Conceptual field - Social environment	Social perceptions and stereotypes of the student regarding science
Perception of the social benefit of STEM professions	Students' assessment concerning the benefit of STEM professionals for society compared with other professions
Perception of the effort involved in a STEM degree	Student's perception of the effort involved in a STEM degree compared to other degrees
Perception of STEM lifestyle	Student's perception regarding the lifestyle of a STEM professional in terms of work and residence stability/comfort in comparison with other professions
Perception of achievable socio-economic status	Student's perception of the socio-economic status that can be achieved through STEM degrees/professions in comparison with other degrees/professions
Perceived prestige of STEM professions	Student's perception of the prestige involved in a STEM-related degree/occupation in comparison with other professions
Social perception of science	Student's perception of the world of science and technology as a means to improve or hinder social and environmental conditions (from a general point of view)

One last variable has also been taken into account in the study: **whether or not the students are participating in the STEM outreach activity or activities that are the subject matter of the study.** This variable was determined by students' participation or lack thereof in a STEM outreach programme defined ad hoc for the project, which included the study's participating and control groups.

From the work carried out on this group of variables through questionnaires applied to the student sample (participants and control) and the application of logistic regression models, the composition of the predictive model of the propensity to study STEM has been established, which defines the most influential variables for students wanting to study STEM:



Considering elements that affect these variables in the design and execution of scientific outreach activities will enhance the objective of promoting STEM careers.

RECOMMENDATIONS

Based on the study carried out, a set of recommendations has been created in order to design and implement outreach activities and educational programmes in relation to STEM careers.

Based on the results obtained in the study the measures recommended to be generally applied are categorised into 5 areas:

- Self-efficacy
- Information
- Social perception
- Group feeling
- Interest

Focus on girls and low family socio-economic status

In relation to the lack of STEM careers, there is an important social gap, given that there are significant differences in terms of the socio-economic situations of students' families and also according to gender.

In this regard, we may initially find that girls and students from low strata with low socio-economic status seem to be less interested in STEM courses than boys and students with high socio-economic status respectively.

Application in outreach activities: the advocacy capacity of the outreach activities among the groups of youngsters from more disadvantaged socio-economic environments is high, therefore the main recommendation in this case would be to increase the number of activities aimed at this group.

Application in outreach activities: the advocacy capacity among girls is lower and therefore it is harder to influence their career selection. The aspects that seem to have a greater impact are:

- **Self-efficacy:** the percentage of girls with a low self-perceived capacity choosing STEM courses is very low. The outreach activities need to influence this aspect in order to have a significant impact on this group; otherwise all we will be doing is strengthening the careers of girls who have already decided upon a STEM option.
- **Interest in STEM subjects:** as with the self-efficacy issue, it is important to design actions that enable the perception of STEM subjects to be improved among girls who are generally less interested. For example, by designing activities that promote active student involvement, suggesting achievable challenges for them that satisfy their intellectual interests.

Impact on undecided students and those with a moderate predisposition towards work

The perception of the majority of students with regard to STEM courses is that they are very hard and require a great deal of work. Therefore, **we need to get students to be prepared to assume that hard work in the short and medium-term** and not to choose courses simply because they are easier or shorter, encouraging them to show greater interest in STEM courses.

Application in outreach activities: the ability to influence students that are not prepared to put in any effort seems very limited however, with those that are prepared to work a little bit harder, outreach actions are very likely to have an effect.

- **Information and self-efficacy:** it is advisable to identify undecided students and provide information concerning the benefits of STEM courses, despite sometimes requiring a greater level of dedication and hard work, and to strengthen these students' perception of their capacity with regard to these courses.

I feel capable, I can see myself doing it and I like it: key to students with STEM careers

For students that feel they are capable of successfully studying STEM courses (self-efficacy), for those that like these subjects (interest) and can see themselves working well in a job related to STEM (self-efficacy and information), the interest in studying STEM is obviously very high, because these are differentiating factors when selecting STEM courses.

Application in outreach activities: in order to increase the number of careers in this field, these are key elements that must be emphasized and incorporated into the design of outreach activities aimed at increasing the impact on careers. Below are some examples:

- **Self-efficacy and information:** role model activities or activities involving the design and construction of technological elements or scientific workshops that involve overcoming/resolving challenges or problems. Role playing activities in which students take on the role of scientists, engineers or technicians are usually quite successful.

The opinion perceived from teachers and parents is vital for STEM careers

The development of self-belief in being able to study STEM courses (self-efficacy) comes from different sources, but two are vital: **the opinion perceived from both teachers and parents**. The influence on the students' perception concerning their teachers and parents' belief in their ability to study STEM is vital in selecting a career. Hence, practically all the students that feel that their teachers and/or parents believe in their capacity to study STEM are interested in these courses (>93% according to our study). On the other hand, only a very low percentage of students that think their teachers and/or parents do not believe they are capable of studying STEM show any interest in these types of courses. The capacity of influencing these groups in any way is very limited.

Application in outreach activities:

- **Information and social perception:** raising awareness among teachers and parents concerning this situation, very often affected negatively although subconsciously, through apparently harmless comments such as “he/she is just not very good at maths”, “these courses are just for outstanding students”, etc. highlight the skills required by a STEM professional (ability to work in a team, organisation and methodology, analytic, communication, initiative capacity, etc.) and relate these to skills demonstrated by the student.
- **Information and self-efficacy:** encourage teachers and parents to see participating students' results (through scientific experiments, design and construction of technological devices, motivation shown in an activity, etc.).

- **Self-efficacy:** incorporate parent involvement and collaboration with their children plus teachers' input when designing outreach activities.

Friends' influence facilitates the impact of outreach activities

For some students, friends can play an important role when it comes to choosing a career, in particular with regard to their tendency to study STEM, although not to the same extent as the teachers' level of influence. However, the impact of outreach activities may be greater if this group relationship is activated.

Application in outreach activities:

- **Group feeling:** build on other influencing factors when selecting STEM careers by the group (friends) and not only the individual (allow each student to see it individually), so this can be transformed into behaviour imitation attitudes, belonging to the group, positive recommendation among peers, etc.

Improved career guidance furthers interest in studying STEM

Career guidance received by students at school is not sufficient in view of the results obtained in the study, where a high percentage of students claim to have received very little or no guidance or recommendations for making decisions concerning their future. Outreach activities can have a significant impact on students that have received less information and advice, partially or totally covering this gap.

Application in outreach activities:

- **Information:** incorporate professional guidance and information elements concerning future studies into outreach activities, whether this is as part of the activity, through the experience of professionals (lectures, videos, etc.) or any other element. It is important, however, to design these activities properly to ensure they have a positive impact, which is generally achieved by promoting and facilitating greater active involvement of students and focusing on their motivation. Lectures by professionals, for example, could be complemented with a prior activity researching the profession or the sector and preparing issues for the professional to resolve during the lecture, as well as a subsequent forum in which the students' queries can be answered.

STEM lifestyle models and a view of the social benefits of science have a positive impact

Students interested in studying STEM consider the lifestyles of STEM professionals attractive, therefore providing students with reference models, could have a significant effect on their career choice.

Likewise, the perception of the social benefit of science is also associated with the interest in studying STEM, therefore outreach activities aimed at outlining the contribution of science and technology in society tend to have a positive effect among students wanting to study STEM.

Application in outreach activities:

- **Social perception and interest:** STEM reference models have a great impact through various influencing factors on interest in studying STEM, although it is very important to choose wisely. Showing “brilliant” people or those with very high standards of living could lead students to believe that it is unattainable. Some studies show that the more “perfect” the lifestyle is, the more unachievable it seems.
Putting science and technology into real, everyday contexts, showing the social usefulness thereof, can also have a positive impact. Incorporating this view into outreach activities and not simply explaining the natural phenomena (for example), can help to considerably increase the impact of students’ interest in studying STEM.

AUTHORS

This project was jointly promoted by the **Spanish Foundation for Science and Technology** (FECYT), **“la Caixa” Foundation and Everis** in the framework of their social corporate responsibility.

The study was carried out by technical teams from the three promoting institutions working with an **expert advisory committee consisting** of researchers from the **CRECIM group of the Autonomous University of Barcelona (UAB) and Pompeu Fabra University (UPF)**, whose members are:

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Ivàlua, the Institut Català d'Avaluació de Polítiques Públiques, provided methodological advice for the project and its recommendations contributed to improving the defined model.

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