Effect of a Science Communication Event on students' attitudes towards Science and Technology

NURIA TORRAS-MELENCHON[1], M. DOLORS GRAU[2], JOSEP FONT-SOLDEVILA[3] and JOSEP FREIXAS[4]

[1]Departament d'Enginyeria Minera, Industrial i TIC, Escola Politècnica Superior d'Enginyeria de Manresa, Universitat Politècnica de Catalunya, Av. de les Bases de Manresa, 71-73, 08242 Manresa, Spain. E-mail: nuria.torras@epsem.upc.edu
[2]Departament d'Enginyeria Minera, Industrial i TIC, Escola Politècnica Superior d'Enginyeria de Manresa, Universitat Politècnica de Catalunya, Av. de les Bases de Manresa, 71-73, 08242 Manresa, Spain. E-mail: dolors@emrn.upc.edu
[3]Departament d'Enginyeria Minera, Industrial i TIC, Escola Politècnica Superior d'Enginyeria de Manresa, Universitat Politècnica de Catalunya, Av. de les Bases de Manresa, 71-73, 08242 Manresa, Spain. E-mail: j.font@upc.edu
[4]Departament de Matemàtiques, Escola Politècnica Superior d'Enginyeria de Manresa, Universitat Politècnica de Catalunya, Av. de les Bases de Manresa, 71-73, 08242 Manresa, Spain. E-mail: josep.freixas@upc.edu

Abstract

This study investigates the effect of participation in the Knowledge Fair, a Science Communication Event at Catalonia (North East of Spain), on the attitudes of secondary school students towards science and technology. Specifically, this study focuses on answering the following research question: Did students change their attitude towards science and technology after participating in the Knowledge Fair? A total of 1,293 students (aged 14-18 years) from 23 Catalan secondary schools participated in the study following a quasi-experimental pre-test-post-test research design. Data were collected in April 2014 and April 2015, when the fourth and fifth editions of the Knowledge Fair took place, through two questionnaires taken at the beginning and at the end of the event. Four attitude components are evaluated: interest in learning science, technology, engineering, and mathematics (STEM) disciplines; perception of science and technology education; perception about the importance of science and technology research for society; and choice of the future field of study. For data analysis, descriptive statistics and statistical tests are used. The results of the study show that the students developed more favourable attitudes towards science and technology after participating in the event, with few significant differences between male and female students.

Keywords: attitudes; science and technology education; science communication event; science fair; secondary school

1. Introduction

While the job opportunities in science, technology, engineering, and mathematics (STEM) fields are expected to increase over the next years, qualified workers with STEM skills and knowledge will be essential for the economic growth of Europe. According to the CEDEFOP forecast of skills supply and demand in Europe [1], technicians and associate professionals (including physical, engineering, life science, health and teaching associate professionals) will be the most important occupational group in 2020. However, several research and policy reports [e.g. 2-5] have revealed that the number of students who choose a STEM career has been into decline for more than a decade in the more developed countries of Europe. Consequently, the shortage prediction linked to too few young people studying STEM to meet future demand is a matter of global concern and debate.

Actually, the problem of the decrease in the number of students who choose STEM degrees does not apply equally to all of these disciplines [6]. The university enrolments in life and health sciences, such as medicine, biology and biochemistry, are considered sufficient to meet projected demand in most developed countries. In contrast, there are predictions of widespread shortages in most engineering disciplines and many OECD (Organisation for Economic Co-operation and Development) countries report serious under-enrolments in university in physics, mathematics and, to a lesser extent, chemistry courses [7].

The situation in Catalonia, in the North East of Spain, is not different from the rest of Europe. The number of enrolled students for the first semester of the studies in scientific and technological fields at Catalan universities is critical. According to data collected by the Catalan Institute of Statistics [8], students in science and engineering studies (excluding Medical science) at Catalan universities during the 2014-2015 academic year represent only the 27% of all university enrolments, compared with around 55% of the students in social sciences, arts and humanities studies. In addition, the proportion of students choosing technological studies has particularly decreased in recent years, from 29% in 2004 to 21.5% in 2014. In the whole of the Spanish state, the number of students at tertiary education enrolled in the fields of science, engineering, manufacturing and construction had declined drastically in the past decade in comparison to other European countries (see Fig. 1).

The reasons why fewer students aspire to STEM-related studies are varied and complex. Some researchers [10-13] have explored the influences on the students' decision-making to understand how they decide on their future studies. The results of some of these studies suggest that choosing a STEM career is directly influenced by a combination of factors such as individuals' personality types (self-efficacy, interest, attitude, and motivation), socio-economic factors and the influence of teachers, parents, and gender. These factors can be grouped into four categories [14]: (a) students' engagement in the study of STEM in school, (b) career information, (c) personal characteristics, and (d) social perception of the industry work related to STEM. In many research studies, the declining trend in the percentages of STEM students is mainly associated with a lack of interest in these disciplines [15-17]. However, as pointed out by Zeid et al. [18], the most evident factor that contribute to the enrolment of high school students into college STEM programs and careers appears to be the pre-college preparation. Our educational system has failed to prepare students adequately for careers in STEM.

Results from the Programme for International Student Assessment (PISA) for 2006 [19] indicated that students, in general, expressed more interest in learning about health or safety issues that they perceive as being relevant to their lives than those that they perceive as being of little relevance to themselves. According to Swarat et al. [16], the lack of interest among young students not only threatens the production of the next generation of scientists, but more importantly, impedes students from becoming scientifically literate citizens, as they are unlikely or even unable to engage with important science-related societal issues. Looking specifically at the case of Catalonia, a recent study [20] revealed that the university studies in science and technology have been perceived as attractive, to have high social prestige, and to offer good employment opportunities, among the majority of Catalan students. However, many of them recognize that they decide not to choose these studies because they have low expectations for own success.

To overcome this situation, educational organizations across the country are developing and implementing activities and projects designed in part to increase students' motivation in these subjects and careers, such as conferences, competitions, and workshops. Scientific and educational organisations recommend that efforts to interest students in STEM careers begin at the middle school level, time when students are developing their own interests and recognizing their academic strengths [21]. This paper reports on our own experience with one of these initiatives: the Knowledge Fair.

2. Description of the Knowledge Fair

The Knowledge Fair is a two-day Science Communication Event at Catalonia, organized annually by the EXPLORATORI: Natural Resources [22], which is a project from the International Campus of Excellence Barcelona Knowledge Campus (BKC), presented by the Universitat Politècnica de Catalunya (UPC) together with the Universitat de Barcelona (UB) and the Berga Town Council. The specific objective related to the Knowledge Fair is to introduce the most recent science and technology research projects held in the two universities, UPC and UB, as well as in other research institutions, to young people. The event was designed to promote young people's interest and attitudes in STEM subjects and careers, as well as society in general. This is achieved by encouraging the spirit of learning in the research context [23].

Even though a precise definition of what constitutes a Science Communication Event has not been specified for the moment [24], the Knowledge Fair shares the same purposes and philosophy as these events. According to the White Book "Science Communication Events in Europe" [25], the objectives of a Science Communication Event are to raise public awareness of science, to promote the dialogue between science and society, and to engage young people in science. Among the actions and initiatives aimed at raising the level of public understanding of science, Science Weeks and more specifically Science Fairs are perhaps the events that better promote the closest interaction between scientists and the public [26].

The Knowledge Fair consists in the participation of nine research groups as exhibitors, four from the UPC, four from the UB, and one from an external research institution. Each research group is represented in the Fair by at least two PhD students and is provided with a stand space in Berga Town. The research groups and projects presented at the Fair are different in every edition. Table 1 lists the research groups and projects presented at the fourth and fifth editions of the Knowledge Fair. As shown in Table 1, the research projects involve a broad spectrum of science and technology topics, such as electrical engineering or nanotechnology issues. The majority of these projects (67%) belong to technological research, while the others are predominantly scientific studies.

At the stands, the PhD students present their research projects to the secondary school students. The close age between them allow providing participants with an enriching exchange of their academic experiences that surely promote to the creation of new scientific and technical vocations. In particular, young scientists communicate to students the required effort to reach valid results and conclusions in their research. Exhibitors also convey the message that developing designs, prototypes, and experiments require some fundamental knowledge on core subjects such as algebra, geometry, chemistry, or physics.

Simultaneously, and in the same building, the event includes exhibitions and conferences. In 2014 edition, two exhibitions were organised, one of minerals, given that the United Nations declared 2014 as the International Year of Crystallography: "The minerals and elements in everyday life", organized by the EXPLORATORI: Natural Resources, and "Chemistry and society", organized by the Resources Chemistry Teaching Group (GReDiQ). In the case of fifth edition, the exhibition which could be visited was "Energy", from Gas Natural Fenosa Foundation Gas Museum. A printed survey composed of several questions about the exhibitions was administered to all students with the purpose of helping them to learn its contents. At the same time, in 2014 edition, the conference "Atoms, crystals and laser or light control?" was given by a member of the Institute of Photonic Sciences (ICFO). Given that 2015 was been declared as the International Year of Light, the conference which was held in 2015 edition was entitled "Nanophotonics: when the light opens the nano world", given by an ICREA Research Professor at ICFO.

3. Research Question and Hypotheses

The purpose of this study is to measure the effect of participation in the Knowledge Fair on students' attitudes towards science and technology. Specifically, this study focuses on answering the following research question: Did students change their attitude towards science and technology after participating in the Knowledge Fair?

To answer the question posed above, and as attitudes cannot be measured directly, the current study evaluates the students' attitudes before and after the event using these four observable components related closely to attitudes: (1) interest in learning STEM disciplines, (2) perception of science and technology education, (3) perception about the utility and the importance of science and technology research for society and (4) choice of the future field of study.

Therefore, the following hypotheses were formulated to guide the research study:

H1. The participation of students in a Science Communication Event such as the Knowledge Fair increases the level of interest of student in learning STEM disciplines.
H2. Students have a more positive perception of science and technology education after participating in the Knowledge Fair.
H3. The Knowledge Fair helps to raising students' perception of the relevance of science and technology to their everyday lives.
H4. The Knowledge Fair encourages the students to pursue studies in the fields of science and technology.

4. Method

The experimental design adopted for this study to assess the effect of the Knowledge Fair on students' attitudes towards science and technology is the quasi-experimental with a one-group pre-test-post-test design. The sample characteristics, the instrument development and the data collection procedure are described in this section.

4.1 Participants

All of the students who attended the Knowledge Fair 2014 and 2015 were invited to participate voluntarily in the study. A total of 1,293 students from 23 secondary schools in Catalonia completed and returned the surveys, which represents an overall response rate of more than 85%. The sample included both public and private schools, located in urban and semi-urban areas. The age of the students ranged essentially from 14 to 18 years with a mean age of 15.5 years (SD=0.9) for the 2014 edition and 15.9 years (SD=1) for the 2015 edition. Table 2 provides a more detailed background of the sample.

4.2 Instrument

A self-designed pre-test and post-test were applied to determine if the students' attitudes towards science and technology changed after the participation in the event. These questionnaires were developed by the research team based on a literature review of similar previous studies [e.g. 27-28]. The pre-test was administered before the Knowledge Fair began and the post-test immediately after students completed their participation.

The pre-test questions were somewhat different from the post-test questions, but they measured the same variables (see Table 3). The reason for not using a single questionnaire for pre- and post-measure is that students could remember past responses or learn from the questionnaire itself, especially when the measurements are close in time. As Siegel and Ranney pointed out [29], evaluating students repeatedly with the same questionnaire is not adequate. The main dependent variables, which were measured both before and after the event with the pre- and post-tests, were: level of interest in learning STEM disciplines (X_5), perception of science and technology education (X_7), perception about the utility and the importance of science and technology research for society (X_8), and choice of the future field of study (X_9).

In the first section of both questionnaires, students were asked to indicate basic demographic information about themselves, such as age, gender, education level, and school. The second part of the instrument was designed to obtain information about the knowledge and attitudes about science and technology of students. Some questions restricted the respondents' answer by providing them with explicit response choices (closed-ended questions), such as "yes" or "no", but most of them left the respondents to give their own answer (open-ended questions). The open-ended questions were useful in this research for collecting information about attitudes, beliefs, and behaviours of the students without forcing them to select from a defined list of choices, although data from an open-ended question required more time and effort to be analysed than a closed-ended type of question.

4.3 Data collection and analysis

Data were collected in April 2014 and April 2015, when the fourth and fifth editions of the Knowledge Fair took place. The research team administered the pre-test to the students two weeks before the visit to the Knowledge Fair. At the end of the event, the post-test paper was given out to students. They were asked to complete the questionnaires anonymously at class and returned them to the researchers. In all cases the time period that elapsed between the pre- and post-test did not exceed one month. All questionnaires received were included for assessment.

The first part of the questionnaire regarding the demographic information and all collected data of closed-ended questions (where possible answers were "yes" or "no" or multiple choices) were analysed by means of descriptive statistics and chi-square tests. Descriptive statistics includes frequency distributions, arithmetic means, and standard deviations. The answers of the open-ended questions were collected and summarized into different categories. For all these questions, the answer choice was converted into a numerical value. For example, a value of 1 for "yes" answers and a value of 0 for "no" answers were assigned. Statistical tests were conducted using Minitab 17 Statistical Software to determine if there were statistical differences between the pre- and post-tests measures. In all tests, a *p*-value of less than 0.05 was considered statistically significant.

5. Results

The data obtained from the pre-test and post-test have been compared to determine the effect of the Knowledge Fair on students' attitudes towards science and technology. This section first presents results from the comparison between pre-test and post-test for each of the four attitude components.

5.1 Interest in learning STEM disciplines

One question on the surveys asked students how much interest they had in learning about the following broad science and technology areas: biology, geology, physics, chemistry, technology, and mathematics. Respondents' interest was measured on a four-point scale, assigning simple numerical scores of -2, -1, 1, and 2, to the response categories of "not at all interested", "not very interested", "fairly interested", and "very interested", respectively. The neutral midpoint ("neither interested nor disinterested"), which would be scored as 0, was not included in the surveys to force the respondents to choose between a positive or negative direction. An independent samples *t*-test was used to determine whether there is a statistically significant mean difference in students' interest before and after the event. Table 4 summarizes the results of the analysis.

The analysis of *t*-test reveals that in the 2014 edition there are statistically significant differences between the pre-test and post-test mean scores for the areas of physics ($p<0.001$) and chemistry ($p=0.008$). However, contrary to expectations, in the 2015 edition there is a statistically significant decrease in the mean scores from pre-test to post-test in students' interest in learning biology ($p=0.024$).

The results also indicate that the most interesting area to learn for male students was technology, while this area received the lowest interest rate among female students. In contrast, female students had higher interest in learning biology, whereas male students considered it as one of the least attractive. Both male and female students ranked geology as an uninteresting area. These findings coincide with those obtained in this study related to students' interest towards secondary school subjects (X_6): male students strongly agreed that technology was their favourite subject at school, while biology was an unpopular subject, and vice versa for girls.

5.2 Perception of science and technology education

Students were asked, through a closed-ended question, about the perception of science and technology education before and after the event. This question implicitly raises two questions, which can be expressed as follows: (1) do science and technology studies are interesting to study? and (2) how is the level of difficulty of science and technology studies, easy or hard?. Thus, the answers to this item have been studied individually for each of the two questions. This has been so because students could mark up to two of four pre-specified options ("Interesting", "Uninteresting", "Easy" and "Hard").

The first analysis of the responses to this question shows that the proportion of students who conceive science and technology studies as uninteresting and hard is higher in girls than in boys, independent of educational level. This situation does not only occur in the first questionnaire but also after visiting the Knowledge Fair. However, statistical analysis of the differences in responses between students before and after their participation (see Table 5) confirms that the Knowledge Fair has a significant influence on the personal perception of science and technology studies, regarding the level of interest in studying them (p=0.027 for 2014 edition; p=0.009 for 2015 edition).

In relation to the perceived difficulty of the science and technology studies, there was an apparent decrease in the proportion of students who found hard science and technology studies, either a general perspective of all students or taking gender or educational level disaggregated data. But, though the statistical analysis of the data, no statistically significant difference was found in 2014 edition (p>0.05), so we cannot say that the Knowledge Fair have a positive significant effect on this particular dependent variable. However, the p-value for the 2015 edition is not clearly conclusive (p<0.15) and the binary conclusion taken by the hypothesis test is not fully reliable, so we conclude that the possible effect of the Knowledge Fair is too weak to be significant.

5.3 Perception of the importance of science and technology research for society

Analysis of the responses reveals that nearly 93% of the students shared a positive perception about the utility and the importance of science and technology research for society, without significant differences between male and female students. With confidence interval (CI) of 95%, we can say that the proportion of students in the population who agree with this idea is between 91% and 94%.

After the event in the post-test were posed the same question, but with a different nuance in meaning: Do you think that research projects, which were presented at the Knowledge Fair, are useful in everyday life? About 80% of the students recognized that these projects have relevant future applications for everyday life. In this case, the CI of 95% ranges from 75.6% to 80.8%. The fact that this percentage is lower at the post-test than at the pre-test moment is quite normal: the research projects presented at the Knowledge Fair are still under development and far from everyday practice.

5.4 Choice of the future field of study

The influence of the Fair on students' study choice is also examined in this study. Before visiting the Fair, the students were asked about their field of study aspirations. Before participating in the Knowledge Fair, 41% of the participants (95% CI: 38% - 43%) had already decided their academic future. Similar values have been obtained between the 2014 edition (38%) and 2015 edition (43%). This leads us to think that the Knowledge Fair or any other similar action can hardly influence the decision of a large number of participants.

The results also show that there were some differences between male and female students. In general, female students had clearer ideas related to their career plans than the most of male students, who indicated to have more than one alternative choice. Only 13% of the students (95% IC: 11% - 15%) were not at all clear about what specifically they want to do when they will finish secondary school.

Further, different results can be achieved through the following question, which appears only in the post-test: "Has the visit of the Knowledge Fair helped you make a decision about your academic future?" First, we calculated the proportion of students who made a decision regarding their academic future after visiting the Knowledge Fair. Taking together the data of two years (see Table 6), the number of students responding affirmatively to the question and specifying what decision they took was 76. Therefore, the proportion of these students in the participants group, excluding those who had already decided their academic future before participating in the Knowledge Fair (N=187 for 2014 edition; N=209 for 2015 edition), is the following:

$$\hat{p} = \frac{76}{(483-187)+(485-209)} = 0.13 \qquad (1)$$

The proportion of Eq. (1) can also be interpreted in terms of conditional probability. Let A be the event that a student makes a decision after visiting the Knowledge Fair; and let B be the event that a student had not yet decided their academic future before participating in the Knowledge Fair:

$$\hat{p} = P(A|B) = \frac{P(A\cap B)}{P(B)} = \frac{76/(483+485)}{(296+276)/(483+485)} = 0.13 \quad (2)$$

The percentage $\hat{p}$ is small but qualitatively important. This confirms that the Knowledge Fair has a certain impact on the selection of decision of future career of the students. Within this percentage, the proportion of students who communicated through the questionnaire the decision to choose a university degree related to science and technology after visiting the Fair Knowledge (see "Baccalaureate: science and technology", "University studies: science" and "University studies: engineering and architecture" responses from Table 6) is:

$$\hat{p}_{st} = \frac{53}{76} = 0.68 \qquad (3)$$

Eq. (3) can be written in terms of conditional probabilities as $P(C|AB)$, where event C means that the student chooses a STEM degree after visiting the Knowledge Fair, and event AB means that the student makes a decision after visiting the Knowledge Fair and had not yet decided their academic future before participating in the Knowledge Fair.

However, from almost of 70% of students who have decided to study a scientific or technical field of almost 13% of the total number of participants we must subtract the students who will already have opted for one of these studies, without visiting the Knowledge Fair. To estimate quantitatively this expected value, we used statistical data on enrolments in the first year of the twelve universities belonging to the Catalan university system between the years from 2010 and 2015 (see Table 7). As shown in Table 6, the proportion of new students in university studies which belonged to the branches of science and engineering has hardly changed over this 5-year period. This percentage is approximately 25%. Therefore, considering that the participants are a good sample of the Catalan pre-university student population, the proportion of students who have chosen a science or technology field through the visit of the two editions of the Knowledge Fair is on the order of 5.6%:

$$P = 0.13 \cdot (0.68 - 0.25) = 0.056 \qquad (4)$$

A very close result was also achieved in a recent national study [31], carried out over two school years and more than 2,500 secondary education students who participated in activities promoted by Fundación Española para la Ciencia y la Tecnología (FECYT) and CosmoCaixa Science Museum in Barcelona.

6. Discussions

The results of this study reveal in first place that there are few statistically significant differences in students' interest towards science and technology between pre-test and post-test scores. On the one hand, the most notable differences associated with an increase of interest in STEM disciplines were observed in participants of the 2014 edition, who become more interested in learning physics and chemistry after visiting the Knowledge Fair. On the other hand, results show that there were opposite responses between male and female students about their favourite subject at school and the level of interest in learning STEM areas. For example, male students strongly agreed that technology was the most interesting area to learn and biology was the broad science area that they had less interest in learning about, while it was vice versa for female students. These findings are similar to the results of previous studies in science education [32-34] which reported that female students have less interest in technology and physics but they express stronger interest in biology, unlike male students.

There are also significant differences between the pre-test and the post-test data regarding the perception of science and technology education. Science and technology studies were perceived by students who attended the Knowledge Fair as more interesting to study after the event. Furthermore, surveyed students shared a positive perception about the utility and the importance of science and technology research for society. These results are similar to those found in the ROSE study [35], which demonstrated that girls and boys in the 35 countries that took part in the study showed pronounced agreement with the statement "Science and technology are important for society", with small differences between genders.

To end with, our results also demonstrate that the Knowledge Fair motivated some of the participants to continue their studies in post-secondary education and to pursue studies in the fields of science and technology. Although the proportion of these students may seem small (5.6% of all the participants), it is still significant given the short time of the event. In addition, in the current education system, the teenagers aged 15-16 years are required to make the first important career decision and it is a difficult and anxious task for many of them. The career decision is identified as the most important concern for most high school students [36]. The same result was also achieved in a recent national study [31].Therefore, the experience of Science Communication Events such as the Knowledge Fair has demonstrated to be a great way to assist students in this process.

It should be mentioned that the Knowledge Fair does not provide information about university studies, as opposed to other fairs. Thus, the reason why some of the participants changed their decision about the future field of study is probably due to a change in the students' perception of scientists and engineers. According to [37], students' knowledge about a profession influences their future decisions about careers. Research indicates that students tend to hold stereotypical views of engineers, which would hinder engineering as a career choice.

Although the results indicate a general positive impact on participants, one important limitation of our study should be noted. This is a quasi-experimental pre-test-post-test study without a control group with which to compare these results. As there is no control group, we cannot be certain that observed changes in students' attitudes can be only attributed to the event. Therefore, our study does not consider some variables that might affect the outcomes, such as gender, educational level and socio-economic status. However, we had collected data from a high number of participants (n<1,000) and the duration of the event is extremely short, making it difficult to compare the results obtained with a control group.

Thus, for future research, the effect of Knowledge Fair on students' attitudes towards science and technology needs to be demonstrated with stronger research designs, such as a quasi-experimental design that uses both an experimental and a control group. Similarly, qualitative approaches may be taken to further examine how this event influences on students' attitudes. Moreover, different components and contexts, e.g. the perceptions of scientists and engineers, could be explored in depth. These suggestions are expected to be implemented in the next editions of the Knowledge Fair.

7. Conclusions

In this study, the effect of an initiative designed to bring science and technology closer to secondary school, the experience of the Knowledge Fair, on students' attitudes towards science and technology is described and quantified. A quantitative research is conducted using a self-designed questionnaire, which was administered to participants before and after the event. This research demonstrates that there are some statistically significant differences in students' attitudes towards science and technology from the initial to the final assessment, such as the level of interest in studying science and technology, and some differences between male and female students are observed. The data shows that the fair had positive impact on affecting students' attitudes toward science and engineering. The findings and methodology have potential to be applicable to other engineering schools. In answering our research question, we conclude that some of the students developed more favourable attitudes towards science and technology after participating in one of two editions of the Knowledge Fair.

Acknowledgements

Núria Torras-Melenchon acknowledges the financial support from the Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR) of the Generalitat de Catalunya through the grant for universities and research centres for the recruitment of new research personnel FI-DGR 2013.

Josep Freixas acknowledges the Spanish Ministry of Economy and Competitiveness (MINECO) and the European Union (FEDER funds) under grant MTM2015-66818-P (MINECO/FEDER).

References

[1] European Centre for the Development of Vocational Training, Future skills supply and demand in Europe, Publications Office of the EU, Luxembourg, 2012.

[2] J. M. Gago, Europe needs more scientists. Report by the High Level Group on Increasing Human Resources for Science and Technology in Europe, Brussels, 2004.

[3] Organization for Economic Co-operation and Development, Encouraging student interest in science and technology studies, Global Science Forum, Paris, 2008.

[4] J. Osborne, S. Simon and R. Tytler, Attitudes towards science: An update, Annual Meeting of the American Educational Research Association, San Diego, California, 2009.

[5] L. Johansson, Mathematics, science & technology education report, European Round Table of Industrials, Brussels, 2009.

[6] F. Jensen and M. Bøe, The Influence of a Two-Day Recruitment Event on Female Upper Secondary Students' Motivation for Science and Technology Higher Education, *International Journal of Gender, Science and Technology*, 5 (3), 2013, pp. 318–337.

[7] M. V. Bøe, E. K. Henriksen, T. Lyons and C. Schreiner, Participation in science and technology: Young people's achievement-related choices in late-modern societies, *Studies in Science Education*, 47(1), 2011, pp. 37–72.

[8] Idescat Institut d'Estadística de Catalunya, http://www.idescat.cat/, Accessed 26 April 2016

[9] UNESCO Institute for Statistics, http://data.uis.unesco.org, Accessed 13 May 2016

[10] L. Archer, J. Osborne, J. DeWitt, J. Dillon, B. Wong and B. Willis, ASPIRES: young people's science and career aspirations, age 10-14, London: King's College, London, 2014.

[11] F. S. Becker, Why don't young people want to become engineers? Rational reasons for disappointing decisions, *European Journal of Engineering Education*, 35, 2010, pp. 349–366.

[12] Institution of Engineering and Technology (2008). Studying STEM: What are the Barriers – A Literature Review of the Choices Pupils Make. Stevenage, United Kingdom: IET.

[13] D. Panizzon and M. Westwell, Engaging students in STEM-related subjects: What does the research evidence say? Flinders Centre for Science Education in the 21st Century, 2009. Retrieved from http://www.flinders.edu.au/shadomx/apps/fms/fmsdownload.cfm?file_uuid=A5917489-C8D7-01A1-D537-13FFAA534FEB&siteName=flinders

[14] Centre de Recerca per a l'Educació Científica i Matemàtica, Career decisions: which factors influence career choices and how do people make career decisions? Observatory Methodology. Public

Report of the InGenious - ECB project, 2011. Retrieved from http://www.ingenious-science.eu/c/document_library/get_file?uuid=e234e812-67eb-4fc4-b05f-1b51e074614e&groupId=10136

[15] M. Ainley and J. Ainley, Student engagement with science in early adolescence: The contribution of enjoyment to students' continuing interest in learning about science, *Contemporary Educational Psychology*, 36(1), 2011, pp. 4–12.

[16] S. Swarat, A. Ortony and W. Revelle, Activity matters: Understanding student interest in school science, *Journal of Research in Science Teaching*, 49(4), 2010, pp. 515–537.

[17] P. Potvin and A. Hasni, Analysis of the Decline in Interest Towards School Science and Technology from Grades 5 Through 11, *Journal of Science Education and Technology*, 23(6), 2010, pp. 784–802.

[18] I. Zeid, J. Chin, S. Kamarthi and C. Duggan, New Approach to E ffective Teaching of Courses in High Schools, *International Journal of Engineering Education*, 29(1), 2013, pp. 154–169.

[19] R. Bybee and B. McCrae, Scientific Literacy and Students Attitudes: Perspectives from PISA 2006 science, *International Journal of Science Education*, 33, 2011, pp. 7–26.

[20] Everis, Factors Influencing the Choice of Studies in Science, Technology, and Mathematics, 2012. Retrieved from http://www.everis.com/catalonia/WCLibraryRepository/Factors%20influents%20eleccio%20estudis%20CTM.pdf

[21] M. W. Kier, M. R. Blanchard, J. W. Osborne and J. L. Albert, The Development of the STEM Career Interest Survey (STEM-CIS), *Research in Science Education*, 44(3), 2014, pp. 461–481.

[22] N. Torras-Melenchon, M. Grau, J. Font-Soldevila and J. Freixas, EXPLORE: An action to bring science and technology closer to secondary school, *Journal of Technology and Science Education*, 5(2), 2015, pp. 75–86.

[23] D. Grau, J. Font and N. Torras, The knowledge fair: an activity for high school students, *Procedia - Social and Behavioural Sciences*, 46, 2012, pp. 1037–1041.

[24] V. de Semir, G. Revuelta, K. Dimopoulos, H. P. Peters, A. Allansdottir, N. Allum, et al., The PLACES Toolkit for the Impact Assessment of Science Communication Initiatives and Policies, European Commission, 2011.

[25] European Science Events Association, White Book on Science Communication Events in Europe, European Science Events Association, Vienna, 2005.

[26] M. J. Martín-Sempere, B. Garzón-García and J. Rey-Rocha, Scientists' motivation to communicate science and technology to the public: Surveying participants at the Madrid Science Fair, *Public Understanding of Science*, 17(3), 2008, pp. 349–367.

[27] S. M. Glynn, G. Taasoobshirazi and P. Brickman, Science Motivation Questionnaire: Construct validation with nonscience majors, *Journal of Research in Science Teaching*, 46, 2009, pp. 127–146.

[28] W. Romine, T. D. Sadler, M. Presley and M. L. Klosterman, Student Interest in Technology and Science (SITS) Survey: Development, Validation, and Use of a New Instrument, *International Journal of Science and Mathematics Education*, 12(2), 2013, pp. 261–283.

[29] M. A. Siegel and M. A. Ranney, Developing the changes in attitude about the relevance of science (CARS) questionnaire and assessing two high school science classes, *Journal of Research in Science Teaching*, 40(8), 2003, pp. 757–775.

[30] WINDDAT Indicators on teaching quality of the Catalan University System, http://winddat.aqu.cat/ca/, Accessed 13 May 2016

[31] FECYT, Social Foundation “La Caixa”, everis, How can we stimulate a scientific mind? A study of scientific vocations, 2015. Retrieved from http://www.ecsite.eu/sites/default/files/how_to_stimulate_on_sciences_stemscience_museums.pdf

[32] P. Miller, J. Blessing and S. Schwartz, Gender differences in high-school students’ views about Science, *International Journal of Science Education*, 28(4), 2006, pp. 363–381.

[33] K. Scantlebury, D. Baker, A. Sugi, A. Yoshida and S. Uysal, Avoiding the issue of gender in Japanese science education, *International Journal of Science and Mathematics Education*, 5(3), 2007, pp. 415–438.

[34] A. Baram-Tsabari and A. Yarden, Quantifying the gender gap in science interests, *International Journal of Science and Mathematics Education*, 9(3), 2010, pp. 523–550.

[35] S. Sjøberg and C. Schreiner, How do students perceive science and technology? *Science in School*, 1, 2006, pp. 66–9.

[36] CW Sham, SC Tan, KM Lam and C. Surya, Raising the Interest of Students in Engineering with an Integrated Summer Programme, *International Journal of Engineering Education*, 28(3), 2012, pp. 515–522.

[37] R. Hammack, T. A. Ivey, J. Utley and K. A. High, Effect of an Engineering Camp on Students’ Perceptions of Engineering and Technology, *Journal of Pre-College Engineering Education Research*, 5(2), 2015, pp. 10–2.

Biographies of the authors

Núria Torras-Melenchón. She received a degree in technical Industrial Engineer in Chemical Engineering in 2009 from Universitat Politècnica de Catalunya (UPC). In 2012 she completed a degree in Chemical Engineering at UPC. Her final project was awarded with the BASF Award for Best Thesis Work. During her studies she obtained various grants from UPC to collaborate on “technology transfer activities” and to aid the organization of the activities of the “EXPLORATORI of natural resources”. Currently, she is a PhD student in Natural Resources and Environment, with a FI-DGR 2013 grant from the Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR) of the Generalitat de Catalunya.

M. Dolors Grau. She received a degree in Chemistry from Universitat de Barcelona (UB) and PhD in Chemistry from Universitat Politècnica de Catalunya (UPC). She is Tenured Professor at UPC and Co-Director of EXPLORATORI: Natural Resources, project promoted by the International Campus of Excellence Barcelona Knowledge Campus: UB-UPC (since 2010). She received the PhD Prize (UPC-2002), Teaching Initiative Award in the 13th Prize for the Quality in University Teaching -UPC 2010, Jaume Vicens Vives Distinction for university teaching quality 2010 - Generalitat de Catalunya.

Josep Font-Soldevila. He received a degree in Geological Sciences from Universitat de Barcelona (UB) and the PhD in Geological Sciences from Universitat Politècnica de Catalunya (UPC), Agricultural Technical Engineer (UPC), Engineer of Mines (UPC) and Diploma in Groundwater Hydrology (UPC). He is Tenured Professor at UPC. He is chief of Survey and Research Group inside the Mining Engineering and Natural Resources Department of the UPC. Co-Director of EXPLORATORI: Natural Resources, project promoted by the International Campus of Excellence Barcelona Knowledge Campus: UB-UPC (since 2010).

Josep Freixas. He received the PhD in Mathematics from the Technical University of Catalonia, in 1994. He works in the Department of Mathematics and in the High Engineering School of Manresa. He was a visiting professor in the Bergamo University (Italy) in 1996 and in the Union College of Schenectady in

New York (USA) in 2000. His research interests mainly include Decision and Game Theory, Reliability and Operations Research. He has published papers on these topics and gave several invited lectures in different universities. He was supervisor of several PhD. students. He is currently leading a research project on Game Theory and Decision-Making. He is associate editor of two journals.

Figures and tables

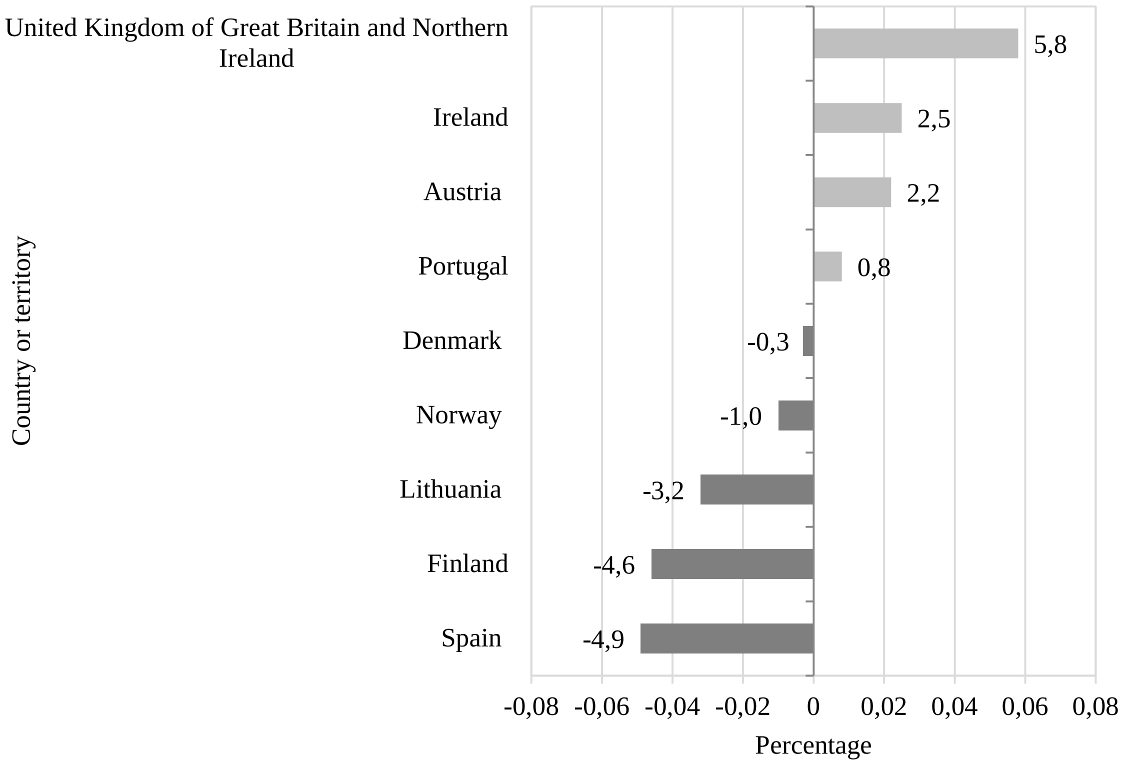

Figure 1. Average annual percentage change between 2003 and 2013 in students' enrolments at tertiary education in the following fields: science, engineering, manufacturing and construction. Source: Authors' elaboration based on data from UNESCO Institute for Statistics [9]

Table 1. Research groups and projects presented at the 2014 and 2015 editions of the Knowledge Fair

	2014 Edition		
	Research groups - University	Research project	Main knowledge branch
1	EXPLORATORI: Natural Resources - UPC and UB	You are the research	Chemistry Engineering
2	Optical Communications Group - UPC	The Raman spectrum: the fingerprint of a pigment	Optical Engineering
3	CIM Fundation - UPC	Make your 3D designs	Technology
4	Modelling, Interaction and Visualization in Virtual Reality - UPC	Virtual reality, gateway to knowledge	Telecommunications
5	Engineering of the Natural Resources and Environment - UPC	Valentí Masachs Geology Museum	Mining Engineering
6	Bullipedia Unit - UB	Making the kitchen an	Food Science and Technology

	Research groups - University	Research project	Main area of knowledge
		academic discipline	
7	Research in Food and Nutrition - UB	Study of the viticulture and enology	Food Science and Technology
8	Institute of Nanoscience and Nanotechnology - UB	Have you ever seen an atom?	Nanotechnology
9	Physics of materials - UB	Since the recording memory to the magnetic levitation	Physics
		2015 Edition	
	Research groups - University	Research project	Main area of knowledge
1	Gas Natural Fenosa Foundation	The Past, Present, and Future of light and energy	Electrical Engineering
2	NanoSat Lab UPC Remote Sensing Lab - UPC	[3]Cat-1: the first Catalan nanosatellite	Telecommunications
3	Research Group from the UPC Optics and Optometry Department - UPC	Beyond the distorted vision - Diagnosis of skin cancer	Optical Engineering
4	Intelligent Communications and Avionics for Robust Unmanned (Aerial) Systems - UPC	Improving operational drones in the Single European Sky	Telecommunications
5	Sustainable Mining Research Group - UPC	The exploitation of geological resources in a safe and sustainable way	Mining Engineering
6	Pastry Guild School of Barcelona - UB	Science and Chocolate: sensory	Food Science and Technology
7	Bullipedia Unit - UB	Science and Chocolate: history and classification of the plant	Food Science and Technology
8	Barcelona Chocolate Museum - UB	Science and Chocolate: workshops	Food Science and Technology
9	Unit for Studies and Research in Science and Cooking - UB	Science and Chocolate: crystallography and the effects of cocoa on the immune system	Food Science and Technology

Table 2. Background of the respondents

		2014 edition	2015 edition
Variables	Categories	Percentage (n=594)	Percentage (n=699)
Gender	Male	45.1	47.1
	Female	54.9	52.9
School district	Urban (more than 10,000 inhabitants)	75.1	70.0
	Semi-urban (2,000 to 10,000 inhabitants)	24.9	30.0
	Rural (less than 2,000 inhabitants)	0	0
School type	Private	27.4	29.7
	Public	72.6	70.3
Educational level	CSE	75.4	59.7
	Baccalaureate	24.6	39.2
Grade (age)	CSE 3rd year (14-15)	23.1	10.2
	CSE 4th year (15-16)	52.4	49.5
	Baccalaureate 1st year (16-17)	22.9	37.9
	Baccalaureate 2nd year (17-18)	1.6	2.4

Note. CSE = Compulsory Secondary Education

Table 3. The dependent variables of the questionnaire of the Knowledge Fair

Dimension	Variable	Definition of the variable	Type of variable
A. Demographic information	X_1	Educational center	Polytomous qualitative
	X_2	Academic year	Polytomous qualitative
	X_3	Age	Discrete quantitative
	X_4	Gender	Dichotomous qualitative
B. Learning STEM disciplines	X_5	Level of interest in learning STEM disciplines	Polytomous qualitative
	X_6	School subject preference	Polytomous qualitative
C. Perception of science and technology	X_7	Perception of science and technology education	Dichotomous qualitative
	X_8	Perception about the utility of science and technology research for society	Dichotomous qualitative
D. Choice of the future field of study	X_9	Choice of the future field of study at the moment of completing the questionnaire	Polytomous qualitative
E. Participation at the Knowledge Faire (only in the post-test)	X_{10}	Transmission of new contents	Dichotomous qualitative
	X_{11}	Transmission of similar contents to those acquired at school	Dichotomous qualitative
	X_{12}	Recognition of the research projects	Dichotomous qualitative
	X_{13}	Stands preference	Dichotomous qualitative
	X_{14}	Level of satisfaction with the event	Discrete quantitative

Table 4. Descriptive statistics of responses and *t*-test results for comparison of the students' interest in learning science and technology related disciplines before and after the Knowledge Fair

2014 Edition								
	Pre-test			Post-test				
STEM disciplines	N	Mean	SD	N	Mean	SD	*t*	*p*
Biology	590	0.339	1.477	481	0.335	1.496	0.04	0.962
Geology	591	-0.524	1.267	481	-0.661	1.524	1.57	0.116
Physics	590	-0.524	1.470	481	-0.162	1.475	-4.01	<0.001
Chemistry	585	-0.231	1.517	478	0.015	1.490	2.66	0.008
Technology	586	-0.034	1.541	480	-0.088	1.578	0.56	0.574
Mathematics	587	0.145	1.480	480	0.119	0.775	0.29	0.775
2015 Edition								
	Pre-test			Post-test				
STEM disciplines	N	Mean	SD	N	Mean	SD	*t*	*p*
Biology	558	0.534	1.455	482	0.330	1.444	2.26	0.024
Geology	557	-0.643	1.264	481	-0.740	1.718	1.02	0.307
Physics	560	-0.125	1.504	483	-0.137	1.615	0.12	0.902
Chemistry	556	-0.022	1.443	484	-0.076	1.538	0.58	0.561
Technology	555	-0.061	1.563	485	0.002	1.620	-0.64	0.525
Mathematics	557	0.443	1.353	483	0.449	1.372	-0.07	0.944

Table 5. Two-proportion *Z*-test results for comparison of the students' perception of science and technology education before and after the Knowledge Fair

2014 Edition						
	Pre-test		Post-test			
Perception	N	%	N	%	*Z*	*p*
Interesting vs. uninteresting	72	63.2	53	48.6	2.21	0.027
Hard vs. easy	221	94.4	155	92.8	0.65	0.514
2015 Edition						
	Pre-test		Post-test			
Perception	N	%	N	%	*Z*	*p*
Interesting vs. uninteresting	48	49.5	27	31.0	2.60	0.009
Hard vs. easy	171	94.0	96	88.9	1.45	0.148

Table 6. Absolute frequencies of students' responses about the choice of the future field of study at the moment of completing the questionnaire

	2014 Edition			2015 Edition		
Field of study	Male	Female	Total	Male	Female	Total
Baccalaureate	0	0	0	2	0	2
Baccalaureate: science and technology	6	3	9	8	8	16
Baccalaureate: humanities and social sciences	0	0	0	1	1	2
Vocational training in science	0	1	1	0	0	0
University studies	0	0	0	1	0	1
University studies: science	3	7	10	1	3	4
University studies: medical sciences	1	1	2	0	1	1
University studies: social sciences and humanities	0	0	0	1	0	1
University studies: engineering and architecture	2	0	2	11	1	12
No scientific-technological university studies	5	4	9	0	4	4
Total			33			43

Table 7. Number of students enrolled in first year of university studies in Catalan universities, disaggregated by knowledge branch. Source: Authors' elaboration based on data from [29]

	Academic year				
Knowledge branch	2010-11	2011-12	2012-13	2013-14	2014-15
Arts and humanities	5,274	5,117	5,560	5,074	4,820
Sciences	2,829	3,007	3,098	3,160	3,150
Medical sciences	5,755	5,956	7,869	8,113	8,195
Social sciences and humanities	25,220	24,684	24,868	23,922	24,045
Engineering and architecture	9,499	8,847	9,962	9,795	9,453
Total	48,577	47,611	51,357	50,064	49,663