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Children's and Adolescents' Specific Interest in Science and Technology, Participation in Out-of-School Activities and Inclination to Become Scientists

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Abstract

Recently, the literature has repeatedly reported an interesting decrease in science and technology (S&T) among youngsters, and a drop of students choosing professions related to these knowledge areas. This study pursued to assess the interest of primary and secondary pupils in specific fields of S&T and to relate this interest to their predisposition to engage in S&T-related out-of-school activities and their inclination to become scientists in the future. A questionnaire on S&T interests and attitudes was administered to a sample of 1336 pupils. Results show that, overall, the inclination to become scientists was low. However, we found a relationship between pupils' interest in areas of S&T and their predisposition to participate in out-of-school S&T activities, and also between their interest and their inclination to become scientists. Moreover, significant age- and sex-related differences concerning all these aspects were identified. We discuss the importance of acknowledging children's and adolescents' specific interest to promote their participation in S&T-related school activities and out-of-school activities. We also urge that information about scientific and technological careers be disseminated in schools in order to increase students' interest in these areas.

Keywords Out-of-school activities · Specific interests · Science and technology · Scientific work

Introduction

Many studies of young people's science and technology (S&T) interests have been carried out in the last decade (see, for example, Krapp and Prenzel 2011; Potvin and Hasni 2014; Renninger and Hidi 2011; Schraw and Lehman 2001). One reason for focusing on this issue is the growing gap identified by some international studies between society's demand for professionals with scientific and technical knowledge and the number of young people who choose to study these subjects at advanced level in schools (OECD 2006, 2008). This gap is associated with a common finding of studies: students are losing interest in S&T-related subjects, which they often consider as excessively abstract and irrelevant to their lives (Osborne et al. 2003; Potvin and Hasni 2014; Tytler and Osborne 2012). Another related finding is that students have little inclination to work in science in the future (Baram-Tsabari and Yarden 2009; Hidi and Harackiewicz 2000; Khoo and Ainley 2005). These results reflect the clear need to promote the development of S&T-related competences among students at school and university, not just because of the high demand for skilled labor in the S&T sectors but also because the younger generations will only be able to face the challenges of contemporary society if they possess skills of this kind (European Commission 2012; Osborne and Dillon 2008). Therefore, identifying young people's interests and understanding of how these interests are constructed are key steps in addressing the problem of their apparent indifference towards S&T, in broadening their knowledge in these areas, and in helping to bridge the increasing gap between the needs of society and the labor market and students' career choices.

Specifically, in this article, we focus on the relationships between students' interest in specific areas of S&T, their predisposition to participate in out-of-school activities, and their

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intention to work as a scientist in the future. First of all, we aim to describe the interest of a broad sample of students in specific S&T areas that differ according to age (10, 13, and 16 years) and gender. The following research question is posed: (1) Does interest in S&T differ according to age and gender? Second, we analyzed the evolution of the relationship between the S&T interests of students in the sample and their predisposition to participate in out-of-school S&T-related activities. In this case, we formulated two research questions: (1) Does the predisposition to participate in out-of-school S&T activities differ according to age and gender? and (2) does the predisposition to participate in S&T activities depend on the breadth of children's and adolescents' specific interests? In addition, we intend to analyze the relationships between the S&T interests of students at the three ages in the sample and their inclination to work as scientists in the future. For this purpose, we posed three questions: (1) Does the inclination to work as scientists in the future depend on age and gender? (2) What reasons do students mention with regard to their decisions to work or not to work as scientists in the future? (3) Does the inclination to work as scientists in the future differ according to the breadth of children's and adolescents' specific interests?

Review of Literature

The Notion and Research on Interest

Before focusing specifically on S&T, we will first outline the theoretical perspective of our approach to the concept of *interest.* The authors agree that interest is a highly complex, dynamic phenomenon (Krapp and Prenzel 2011; Renninger and Hidi 2011), which is linked to different contexts of activity (Azevedo et al. 2016; Barron 2006). These same authors conceptualize interest as the meaning given to the relationship between a subject and an object. Even so, it is habitually confused with related concepts such as attitudes or motivation. The notion of interest can be distinguished from other similar concepts by the fact that it is directly related to one field or specific area (Jidesjö 2008; Krapp and Prenzel 2011; Potvin and Hasni 2014). Interest is mostly defined in two different aspects: situational interest (emerging from the environment as a momentary psychological state) and individual interest (as an enduring and often stable disposition). The most important aspect concerning study or vocational choices is the latter one (Ainley and Ainley 2011).

Regarding interest in science, a general interest can be distinguished from an interest in single science subjects or domains (Krapp and Prenzel 2011). Thus, interest is best described in relation to specific subjects—for example, biology, botany, and physics—or through a specific area of knowledge, such as the study of animals (Hidi and Renninger 2006; Krapp 2007; Krapp and Prenzel 2011; Renninger and Hidi 2011, 2016). Indeed, Jidesjö (2008) proposes the use of the concept of "content orientation" in place of other concepts such as attitude in order to understand the changes in a young individuals' interest in S&T when they matriculate from primary to secondary school.

Several studies have highlighted the impact of individual variables on students' interest in S&T. For example, Potvin and Hasni (2014) found that gender and age had a considerable influence on students' interests in these areas of knowledge. Girls' interest in S&T tended to be focused specifically on issues relating to health, medicine, or caring for other people, while boys' interest was more closely associated with areas such as technology, mechanics or action (Potvin and Hasni 2014; Sjøberg and Schreiner 2010). One of the most salient results was that children's interest in S&T waned as they got older, and particularly during adolescence (Sjøberg and Schreiner 2010; Vedder-Weiss and Fortus 2011). However, Anderhag et al. (2016) stressed that this does not mean primary schoolers lose interest in science when they reach secondary education—rather, that their interest probably did not really form in the first place. In fact, recent studies have suggested contradictory evidence of student interest in S&T. Bennett et al. (2013) note that although much of the literature shows that interest in these areas decreases during the years of secondary education; in other cases, the levels of interest remain relatively high. According to Lavonen et al. (2008), how interesting a science topic is perceived to be is probably a function of how important adolescents consider the respective topic to be in their personal daily lives.

Another key aspect of the notion of interest is its mediating role in parameters of learning: that is, in what, how, when, and where we learn (Krapp et al. 1992). Interest guides or influences people's participation in the contexts of activity in which they learn (Azevedo et al. 2016); importantly, though, interest is also built in the contexts of activity in which people participate and learn (Coll 2013). So the relationship between interest and learning activities is two-directional. Similarly, in the context of the new ecology of learning (Barron 2006; Coll 2013), emphasis is now placed on increasing and diversifying the contexts and activities that enable learning experiences, thanks to the emergence of ICT. It has become clear that learning experiences are not confined to formal education settings; people learn in a wide range of socio-institutional contexts, including the family, the school, the workplace, the community, and peer groups (Leander and Hollett 2017; Leander et al. 2010). Some authors have suggested that young people's interest in S&T both guides and is constructed by their participation in S&T activities inside and outside school (Azevedo 2011; Azevedo et al. 2016; Barron 2006; Barron et al. 2010; Bergin 2016; Renninger and Hidi 2016).

A third fundamental aspect of the concept of interest is that it is situated in processes oriented towards either near or distant purposes. This purposive character of interest was already identified by Dewey at the beginning of the twentieth century (Dewey 1913), to distinguish it from being a personality trait of the person or a feature of the object (Azevedo et al. 2016). Potvin and Hasni (2014, p. 94) also conclude that "interest (is) most often seen as something that drives positive action towards the object of interest." Two features of the notion of interest that appear in their review deserve our attention: the first is that this concept shares with the concept of attitude the idea of a positive or negative inclination (like or dislike) towards an object, and the second is the linking of attitudes, among other aspects, with career aspirations. In our article, we will consider the concept of interest by relating it to specific areas of S&T, and we will use the concept of attitude by linking it to the predisposition to engage in S&T-related out-of-school activities and, in the longer term, in a career in S&T. In the same line of argument, Hasni and Potvin (2015) note the influence that a high interest in S&T can have on students' participation in scientific tasks and on the subsequent decision to study for a science or technology degree. These authors state that this influence can be examined at different levels, for example in student participation in S&T classes, or in their intention to pursue studies or careers in these areas. Despite these advances, however, we need to know more about young people's interest in specific areas of science and technology and its link with the predisposition to pursue studies or careers in S&T (Hidi and Renninger 2006). Our hypothesis is that it is more plausible that a student with a very narrow and focused interest in a particular topic of S&T will be more inclined to follow a deep and focused career path than those not as focused. However, the depth as to why students with different ranges of interest in S&T either select or reject a future career in science needs to be understood.

Out-of-School Activities and Specific Interest

Focusing on the relationship between specific interest and out-of-school activities, one of the most important characteristics of interest, as we mentioned above, is its relation to a predisposition to engage in activities linked to the object of interest (Azevedo et al. 2016; Hidi and Renninger 2006). Ainley and Ainley (2011) highlighted the need for further research on the specific cultural and educational contexts in which students participate, as interest in S&T seems to depend on what is learned in these contexts. Bearing in mind that in the new ecology of learning, children and adolescents participate in a wide variety of activities outside school, and that many of these activities are considered to be more meaningful than in-school activities. Out-of-school activities are particularly relevant in the construction of the interest in S&T. In fact, some studies have shown a greater predisposition to participate in S&T activities outside school than inside, a greater preference for these activities among boys than girls, and a progressive waning of interest as pupils grow older (Bennett and Hogarth 2009; Jenkins and Pell 2006). With respect to age, there is broad agreement among researchers that at the start of adolescence, between 11 and 14 years, a time that coincides with the transition between primary and secondary stages of education, there is a decline in positive attitudes of students towards S&T-related subjects (Bennett and Hogarth 2009; Potvin and Hasni 2014; Tytler and Osborne 2012). In addition, other studies have suggested that the involvement of students in science activities outside school is related to patterns of achievement and interest in science. Therefore, suggestions for education changes and reforms should have a broader focus and go beyond school science (Archer et al. 2010).

There is a growing body of research on the ways in which extracurricular activities and learning experiences promote learning and favor the emergence of an interest in (and positive attitudes towards) the learning of science, technology, and mathematics (Bell et al. 2009; Bevan et al. 2013). Often, these studies pursue a fuller understanding of where and how people learn, and as such, they attempt to provide an explanation of human learning that is more in line with the characteristics and requirements of the framework of the new ecology of learning. These studies may also focus on the relation between out-of-school learning and in-school learning with the aim of recording data that can guide the design of new projects for learning science, mathematics, and technology (Barron 2013; Bell et al. 2013). Therefore, more precise information is required on the relationship between the interests of young people and the S&T activities in which they participate in their daily lives in order to promote and improve the learning of S&T within the school context, and whether this predisposition to participate in out-of-school S&T activities differs according to age and gender variables (Bennett and Hogarth 2009; Jenkins and Pell 2006).

Moving on now to the relationship between young people's interests and the choice to work as a scientist, studies such as Krapp (2000) and Potvin and Hasni (2014) coincide in stressing that interest has a key influence on this choice. Interest in S&T tends to wane as children grow into adolescence, with a corresponding fall in the number of young people who intend to choose professions related to these fields (Baram-Tsabari and Yarden 2009; Hidi and Harackiewicz 2000; Jenkins and Nelson 2005; Khoo and Ainley 2005; Miller et al. 2015). Archer et al. (2010) differentiated between "doing science" and "being a scientist" and highlighted the issue of why an interest in science does not necessarily transform into a desire to be a scientist. Analyzing conversations about science in classrooms from the perspective of identity, they found that science seems to be construed as too feminine by many boys and as too masculine by many girls. Hence, the representations of science that are formed could explain the resistance to many of the interventions that are designed to increase young people's participation and involvement in science and to encourage them to become scientists.

Further studies on why students select or reject science and technology professions would be useful in the attempt to increase the number of people with training in these fields (Bennett et al. 2011). Feldman et al. (2013) indicated that teachers should be trained through participation in scientific research groups in order to enable them to teach their students about the real process of scientific research. Other studies highlight the potential of creating an environment shared by teachers, students, and scientists in which students engage in real scientific research; this participation is likely to enhance their understanding of science and also their attitude towards it (Houseal et al. 2014).

Method

Participants

A total of 1336 students participated in the study (398 age 10, 432 age 13, and 506 age 16), who were attending 12 public primary schools and 12 public secondary schools from various towns in Catalonia, Spain. Participants were asked to answer a questionnaire. The basic sampling unit was the schools, which were selected according to the following criteria: education level (primary, secondary); regional location (urban, towns with over 10,000 inhabitants; rural, towns with fewer than 10,000 inhabitants); socioeconomic status of families (high and high-middle, or low and low-middle); and percentage of immigrant students (under 15% or over 15%). The secondary sampling unit was the class groups, which were selected according to the criteria of availability. In most cases, the questionnaires were completed by entire classes of students (from the 4th year of primary school and the 1st and 4th years of secondary school). Questionnaires completed by students who were not 10, 13, or 16 years old were not included in the analysis. The aim was not to obtain a representative sample of Catalan schools, but to ensure the participation of a sample of subjects that included different combinations of the four criteria mentioned above.

The three selected ages correspond to three points at life in which we can reasonably assume that there are significant changes in students' activities, as age and educational level are variables that are recognized in the literature as clearly influencing students' S&T interests (Bennett and Hogarth 2009; Potvin and Hasni 2014; Tytler and Osborne 2012). Furthermore, the choice of entire class groups ensured that there were similar numbers of male and female participants. As mentioned above, previous studies have found that gender also influences the aspects analyzed in this study.

Table 1 shows the main characteristics of the sample of students that responded to the questionnaire, in accordance with the aims of the study.

Table 1 Demographic characteristics of the sample

	Gender				Total sample	
	Girl		Boy			
Age	*N*	%	*N*	%	*N*	%
10 years	207	52.01	191	47.99	398	100
13 years	207	47.92	225	52.08	432	100
16 years	269	53.16	237	46.84	506	100
Total sample	683	51.12	653	48.88	1336	100

Instrument

The questionnaire was devised to gather information on students' S&T interests and attitudes. It was divided into two parts and designed for online use. The first part included 30 items selected and adapted from the first part of a questionnaire created by Schreiner and Sjøberg (2004) as part of the ROSE Project. The items were designed to explore students' interest in specific S&T areas and in learning about these areas. Specifically, in this part of the questionnaire, students were asked whether they wanted to find out more about a set of topics that, while not exhaustive, referred to the environment and sustainability (for example, *What can we do to look after the environment*; *How does pollution affect marine animals*); health, sexuality, and demography (for example, *What should we eat to be healthy*; *How do alcohol*, *tobacco*, *and other drugs affect our body*; *How does my body grow and develop*); life sciences, such as genetics, biology, and zoology (for example, *How did the first animals appear on the Earth*); technologies and machines (for example, *How does the engine in a motorbike or car work*; *How do computers or mobile phones work*); and earth sciences such as geology and the universe (for example, *What are the constellations and how can I find my way by the stars*; *What causes earthquakes*, *tsunamis*, *tornados and cyclones*). Students could choose between three options: *yes*, *no*, *I do not know.* The last option was included so that they were not forced to make a decision. Two versions of the questionnaire were drawn up with variations in the way some of the items were written, to adapt them to the age of the participants: one version was for the 10-year olds, and the other for the 13- and 16-year olds.

The second part of the questionnaire included questions adapted from an instrument created by Bennett and Hogarth (2009), the "Attitudes to School Science and Science," designed to gather information about attitudes to S&T inside and outside the school. We prepared a group of statements about out-of-school S&T activities in order to elicit information about pupils' predisposition to engage in these activities. These statements were: "I like watching documentaries, read magazines or books on science and/or technology"; "I like fixing things like bicycles or opening up machines"; "I like science or technology games (games to do with chemistry, optics, electricity...)"; "I like visiting science museums, the zoo, the aquarium"; and "I like taking care of the plants in the house or working in the garden." For each of the statements, the students had to say whether they agreed, neither agreed nor disagreed, or disagreed.

The questions related to attitudes to S&T also included a set of questions about how S&T is valued in society, and students' inclinations to take S&T-related courses in the future. In accordance with the objectives of our study, another question we focused on was "I would like to work as a scientist." Students could choose between three responses to this question: agree, neither agree or disagree, or disagree. Depending on students' answers, the questionnaire automatically presented a series of pre-established reasons for the choice, as well as an open response option, in which they could write their own explanation. For example, 10-year-old students who agreed with the statement "I would like to work as a scientist" were shown a new window where they could select whether they had made their choice because scientists (i) "Always have important jobs," (ii) "Do interesting jobs," (iii) "Are generally well paid," (iv) "Are people who can change the world for the better," (v) "Are important people who are well-known in society," and/or (vi) "Another reason."

Procedure

Once the first version of the questionnaire had been drawn up, a pilot study was carried out administering the instrument to groups of students of different ages to assess its validity and reliability, and to make the adjustments required to improve it. In this first part of the application, the students' understanding of the statements they had to evaluate was checked, and on the basis of their answers, the necessary adjustments were made. In addition, in order to check the face validity (Cohen et al. 2000), the type of validity proposed by Schreiner and Sjøberg (2004) in their original questionnaire, participants were also asked what they thought each part of the questionnaire measured and whether they believed that it was measured adequately. Their answers confirmed the instrument's validity. As in regard to reliability, Cronbach's alpha was calculated with respect to the different items that made up interest, with results of 0.895 in the questionnaire for the 10-year olds and 0.882 for the 13- and 16-year olds.

The final questionnaire was administered online during the 2014–2015 school year to students at the schools selected using the convenience sampling criteria mentioned above, under the supervision of their tutors and the two researchers. Students received assurances that their responses would be treated confidentially and would only be used for the purposes of the research. Students spend between 20 and 30 min approximately to answer the whole questionnaire. The data were tabulated and analyzed using the SPSS statistical package. With regard to the more descriptive analysis, the corresponding frequencies and percentages were calculated for the total of the sample and according to age and gender. For the inferential analysis, significant differences ($p < 0.05$) were found between groups of variables using the Pearson chi-square test.

Results

The results are presented in three blocks, each one reflecting one of the three objectives of the study. The first block displays the results for pupils' interest in specific areas of S&T according to age and gender. In the second block, we analyze the predisposition of children and adolescents to participate in S&T activities outside school and the relationship between this predisposition and their specific interests. The last block presents the relationship between students' interest in S&T and their inclination to work as scientists in the future.

Specific Interests of Students by Age and Gender

Tables 2 and 3 show the interest of 10-year olds and 13- and 16-year olds respectively in specific S&T topics, according to their questionnaire responses. The three types of shading indicate different levels of interest, depending on the number of students that marked every item. Thus, according to the number of students who have chosen any of the 30 items related to S&T, we have distinguished three ranges of interest: great interest (those 10 items selected by a greater number of students in the sample), low interest (those 10 items chosen by the lower number of students), and intermediate interest (see the legend of Tables 2 and 3).

As shown in Table 2, the specific interests of the 10-year olds were mainly related to the areas of sustainability and the environment (items A, Q, and E), life sciences (items AB and H), and earth sciences (items N, AC, and X). However, some items in these three areas were also among the ones that aroused the least interest (items G and C, sustainability and the environment; items M, Y, and K, life sciences; and items T and Z, earth sciences, specifically the universe). In addition, little interest was shown in specific topics related to health and demographics (items O and R) and technologies and machines (items T and S).

Table 3 shows that a large proportion of the 13-year olds were interested in specific topics related to health, sexuality, and demographics (items M, D, V, P, K, and R). To a lesser extent, the areas of life sciences (items P, K, and AB), sustainability and the environment (items Q and A), and earth sciences (item I) were also of interest. In contrast, some specific interests related to some of these areas were among the items that participants did not select frequently: for instance, certain topics of health, sexuality, and demographics (items Y and O)

Table 2 Specific S&T interests of 10-year-old students (in percentages)

		10 years $N = 398$
A.	What can we do to look after the environment: recycle, reuse, save energy	***75.63***
B.	Why do children generally look like their parents	*57.04*
C.	What are the advantages of growing plants without using pesticides and other chemicals	*52.01*
D.	How do alcohol, tobacco and other drugs affect our body	*56.78*
E.	How does pollution affect marine animals	***71.36***
F.	Why did the dinosaurs disappear	***61.81***
G.	How can we stop the hole in the ozone layer from getting bigger	**44.22**
H.	What plants are used to make medicine	***61.81***
I.	How can we use the sun, wind or waves to generate electricity	**59.05**
J.	How do computers or mobile phones work	**60.30**
K.	How does a baby form in its mummie's womb	*55.28*
L.	How is a robot built	**57.04**
M.	How do genetically modified foods affect our body	*44.72*
N.	What is the Earth like inside	***65.83***
Ñ.	How do satellites work and what are they for	**60.05**
O.	Why do more people live in China than in Europe	*47.99*
P.	How does my body grow and develop	**59.55**
Q.	How can we protect endangered animals	***72.86***
R	How can we combat epidemics or serious illnesses such as cancer or AIDS	*54.77*
S.	How does the engine in a motorbike or car work	*45.48*
T.	What are trips to Mars like	**56.78**
U.	Why are some babies girls and others boys	**58.29**
V.	What should we eat to be healthy	***63.82***
W.	How do planes fly	60.05
X.	What are comets or meteorites and where do they come from	***64.07***
Y.	How are babies made	*56.03*
Z.	What are the constellations and how can I find my way by the stars	*56.53*
AA.	Why are there wild animals in Africa but not in Europe	**58.79**
AB.	How did the first animals appear on the Earth	***66.58***
AC.	What causes earthquakes, tsunamis, tornados and cyclones	***64.07***

Italicized values represent 10 items of low interest. Values in bold represent 10 items in intermediate interest. Values in bold italics represent 10 items of great interest

and life science topics (items Y and B) in which the participants showed little interest. Finally, technology topics (items J, K, T, Ñ, W, and S) clearly did not attract adolescents of this age.

The results in Table 3 for the 16-year olds show that the items of most interest to this age group were related to technology (items S, W, Ñ, T, I, J); sustainability and the environment (items C, G, AA); and, to a lesser extent, earth sciences (item Z). In general, there was little interest in topics of health and sexuality (items K, R, D, M, V) and life sciences (items AB, K, P, U).

Students of all ages (10-, 13-, and 16-year olds) showed an interest in sustainability and the environment, above all looking after the environment, preserving natural resources, and understanding the consequences of phenomena such as pollution and cloning on animals. In contrast, an interest in understanding the benefits of organic agriculture or the preservation of the ozone layer appeared only in the 16-year-old group. Thirteen-year olds were clearly interested in the area of health, sexuality, and demographics, but this was one of the areas of least interest to the 16-year olds. The results show that 10- and 13-year olds were interested in certain animal-related aspects of the life sciences (for example, knowing what animals are like in different parts of the Earth), but this interest disappeared at 16-year olds. Thirteen-year olds were also interested in items related to the development of their body. There was a striking lack of interest in the life sciences at 16-year olds, when a high interest in technology and machines was identified. This was the area that aroused by far the most

Table 3 Specific S&T interests of 13- and 16-year-old students (in percentages)

		13 years $N = 432$	16 years $N = 506$
A.	What can we do to preserve our natural resources	***54.86***	*47.63*
B.	Why do we study the genetic code and how could this knowledge be used	*39.12*	**49.41**
C.	What are the benefits of organic, eco-friendly agriculture that does not use pesticides and artificial fertilizers	*35.19*	***69.57***
D.	How can alcohol, tobacco and other drugs affect our organism	***61.81***	*32.61*
E.	How is animal cloning carried out	**46.76**	**51.19**
F.	How can meteorites, comets or asteroids cause disasters on Earth	***55.09***	**49.60**
G.	How does human behaviour affect the ozone layer and the greenhouse effect	**47.22**	***59.68***
H.	What are the medicinal uses of plants	**46.06**	**53.95**
I.	How can we use the sun, wind, tides or waves to generate electricity	**50.69**	***63.44***
J.	How do we encode and transmit information using digital technologies	*45.37*	***61.46***
K.	How do we reproduce and what are the implications	***52.55***	*42.69*
L.	How are X-rays, ultrasound and lasers used in medicine	*44.68*	**53.36**
M.	What exercises can we do to keep our bodies strong and in shape	***64.58***	*29.64*
N.	Why do dangerous and threatening animals exist	**46.30**	**51.98**
Ñ.	How are satellites used for communication and other purposes	*37.96*	***67.98***
O.	What are the reasons for eating disorders such as anorexia and bulimia	*44.44*	**48.02**
P.	How does my body grow and how does it develop	***57.18***	*36.76*
Q.	How can we protect endangered animals	***59.49***	**48.62**
R.	How can we combat epidemics and diseases that cause great loss of life	***52.31***	*41.90*
S.	How does a nuclear power plant work	*32.18*	***76.48***
T.	What knowledge has helped to build space rockets, satellites and space travel	*38.43*	***65.81***
U.	What are sexually transmitted diseases and how can we protect ourselves from them	**51.16**	*36.17*
V.	What should we eat to keep healthy and fit	***61.34***	*28.66*
W.	How can crude oil be transformed into other materials such as plastic and textiles	*32.64*	***76.28***
X.	What are the theories that explain the origin of the universe	**46.76**	**48.22**
Y.	What are the biological aspects and ethical implications of abortion	*33.56*	**57.71**
Z.	How can we use the stars to find our way	**46.53**	***65.81***
AA.	What are animal species like in other parts of the world and what is their risk of extinction	**50.23**	***58.70***
AB.	What is the origin and evolution of life on earth	***52.08***	*43.08*
AC.	Why do natural catastrophes exist	**50.23**	*46.64*

Italicized values represent 10 items of low interest. Values in bold represent 10 items in intermediate interest. Values in bold italics represent 10 items of great interest

interest among the 16-year olds, while the 10- and 13-year olds did not show a specific interest in this field. Finally, the 10-year-old students showed a specific interest in the earth sciences.

We found significant differences between boys and girls in relation to certain specific topics in our three age groups. In the 10-year-old group, significant differences were revealed between both genders in responses to six items. Specifically, girls at this age showed greater interest in health-related items (item D) and life sciences (item E), while boys showed more interest in technology-related items (items J, S, W) and earth sciences (item X). At 13-year olds, significant differences were found between boys and girls in their responses to 11 of the 30 items in the questionnaire. The girls showed greater interest in two specific health-related items (items D, O). In contrast, the boys showed greater interest than the girls in technology-related items (items L, S, T, W, X), life sciences (items E, N, AA), and earth sciences (item F, X). Finally, in the group of 16-year olds, significant differences were found between boys and girls in their responses to 17 items. Girls showed more interest than boys in topics related to health and sexuality (items D, K, O, R, Y) and life sciences (items B, K, Y). Boys mainly showed more interest than girls in technology-related aspects (items I, J, Ñ, S, T, W), life sciences (items E, N, AA), earth sciences (item X), and sustainability and the environment (items C, AA).

The Predisposition to Participate in S&T Out-of-School Activities and Its Relationship with Pupils' Interest in S&T

Depending on the students' responses, we distinguished three patterns of predisposition to participate in S&T out-of-school-related activities: "high predisposition" (for students who agreed with at least three of the five statements about out-of-school types of activities), "medium predisposition" (for students who agreed with one or two statements), and "no predisposition" (for students who did not agree with any statement). The patterns of predisposition were defined according to two arguments. On the one hand, the distinction was made considering that we only used five types of S&T out-of-school-related activities in the questionnaire. As we have previously explained in the "Instrument" section, those types of activities include different specific activities within the same statement (e.g., "I like fixing things like bicycles or opening up machines"). So, many students can be interested in out-of-school activities belonging to different types of activities (high predisposition) or just one type in particular (medium predisposition). Consequently, we decided to use this distribution as a starting point to develop the three patterns of predisposition. Other criteria that we tested created unequal distribution of groups and did not allow any interpretation.

Table 4 shows that 39.07% of the total sample had a high predisposition to participate in out-of-school S&T activities and 44% a medium predisposition, while 16.47% had no predisposition at all. In addition, significant differences are shown depending on age ($p < 0.01$) and gender ($p < 0.01$). While the proportion of students with a high predisposition fell from 61.81% at 10 years to 23.72% at 16 years, the proportion of those who showed no predisposition at 10 years (5.53%) rose spectacularly to 24.31% at 16 years, reflecting the growing reluctance to participate in out-of-school S&T activities with increasing age. On the other hand, as regards gender, we see that in general, boys had a greater predisposition than girls. Among the girls, 32.50% had a high disposition compared with 45.94% among the boys, and the proportion of "no predisposition" was much higher in girls (23.57%) than in boys (9%).

tfgapSecond, in order to relate the students' predisposition to engage in S&T-related activities with their specific interests outside school, we calculated a value for the range of interest for each age group, based on the number of items or topics in which the students of each age group expressed interest. For each age, the students are distributed into three groups: those who show an interest in only a few topics (low range: below the 33rd percentile), those who show interest in the largest number of topics (high range: above the 66th percentile), and those who showed interest in an intermediate number of topics (middle range: between the 33rd and 66th percentiles). To assess the relationship with the patterns of predisposition to participate in S&T activities outside the school, we focused on the low- and high-range groups.

tfgapFigure 1 shows that approximately half of the 10-year olds with a low range of specific interests had a medium or low predisposition (49%) to participate in out-of-school S&T activities while the other half (51%) had a high predisposition. In the high range of specific interests group, around 70% showed a high predisposition and 30% low.

tfgapFigure 2, which represents the 13-year olds, shows that the vast majority of students with low interest ranges had a medium or no predisposition (approximately 88%), while only 11.54% had a high predisposition. Although there was also a marked difference in the high interest group, it was not quite as pronounced: 81% showed no or medium predisposition and 18.63% showed a high predisposition.

tfgapAs for Fig. 3, 16-year-old students presented much the same trend as the 13-year olds: those with a low interest range generally showed zero or medium predisposition to participate in S&T activities outside the school (93%, compared to 7.10% with a high predisposition), and among those with a high range of interest, the predisposition was zero or medium in 84% and high in 15.46%.

Table 4 Predisposition to participate in out-of-school S&T activities

	Total		Age						Gender			
			10 years		13 years		16 years		Girl		Boy	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
High predisposition	522	39.07	246	61.81	156	36.11	120	23.72	222	32.50	300	45.94
Medium predisposition	594	44.46	130	32.66	201	46.53	263	51.98	300	43.92	294	45.02
No predisposition	220	16.47	22	5.53	75	17.36	123	24.31	161	23.57	59	9.04
Total	1336	100	398	100	432	100	506	100	683	100	653	100

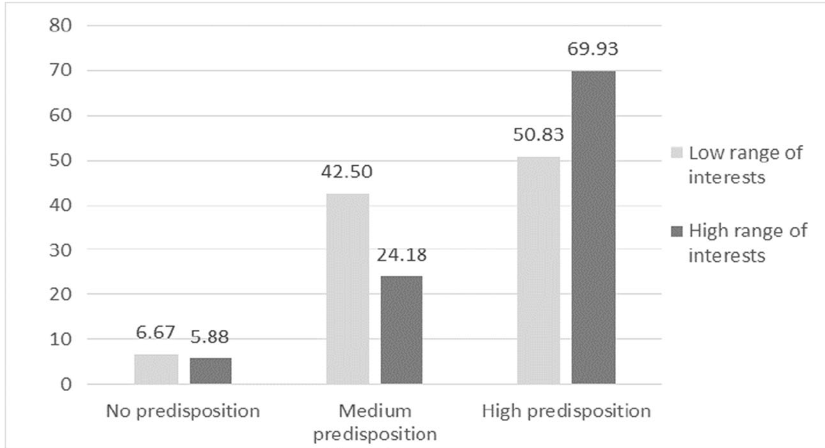

Fig. 1 Relationship between the interests of the children of 10 years and their predisposition to participate in S&T activities outside school

Inclination to Work as a Scientist and Relationship with Interest in Specific Areas of S&T

In this section, we describe students' inclination to work as a scientist and examine the relationship between this inclination and their range of interests.

As shown in Table 5, 51.80% of the 10-, 13-, and 16-year-old students stated that they had no intention of working in S&T in the future, while 25.60% said that they would like to work in this area, and 22.60% were not sure. In addition, statistically significant differences were observed in their inclination to work as a scientist depending on age ($p < 0.01$) and gender ($p < 0.01$). The proportion of students who said they would like to work in S&T in the future was just over 10% higher in the 10-year olds (33.67%) than in the 16-year olds (23.32%). A significantly higher percentage of boys than girls stated that they would like to work in science in the future (29.71% vs. 21.67%). Similarly, more girls (57.54%) said that they would not like to work as a scientist than boys (45.79%).

Many students who agreed with the statement that they would like to work as scientists in the future selected the following reasons: "Because scientists do interesting jobs" (53.8%), "They have important jobs" (53.2%), and "They are people who can change the world for the better" (44.4%). Fewer students chose the reasons: "Because scientists are generally well paid" (27.1%) and "Because they are important, well-known people in society" (23.6%). The most common reasons students gave for disagreeing with the statement were "Because scientists are more concerned about science than about people" (30.1%) and "Because scientists do boring jobs" (28.75%). Less common reasons were "Because scientists try to do new things without thinking about the risks" (16.4%) and "Because they are generally badly paid" (6.2%). However, 29.48% of the students who did not agree with the statement chose to give an open answer. In this case, the most common reasons were a lack of interest, difficulty, or a preference for other professions. In addition, some of the students who gave their own reason for disagreeing with the statement said that they were interested in S&T, but not to work in this field. Finally, students who neither agreed nor disagreed with the statement gave the following reasons, among others: "Because it depends on the type of work" (67.2%), "I've never stopped to think about it" (35.4%), and "I don't know much about what scientists do" (24.5%).

In order to assess students' intentions to work as a scientist in the future in relation to their interest in specific areas of

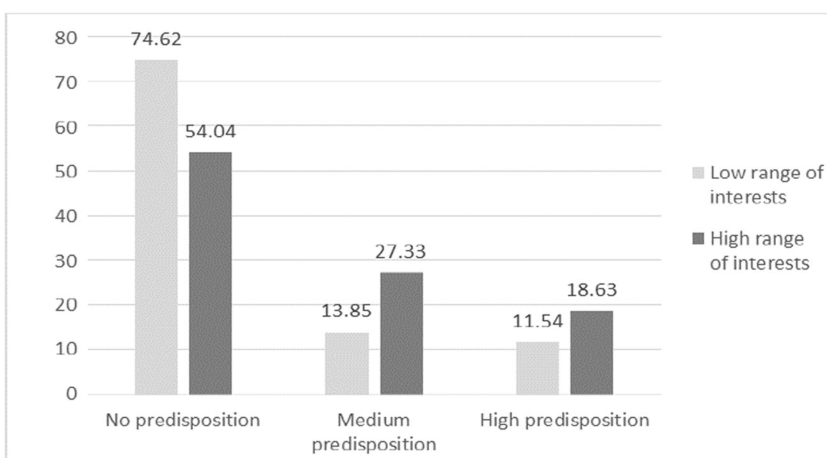

Fig. 2 Relationship between the interests of 13-year olds and their predisposition to participate in S&T activities outside school

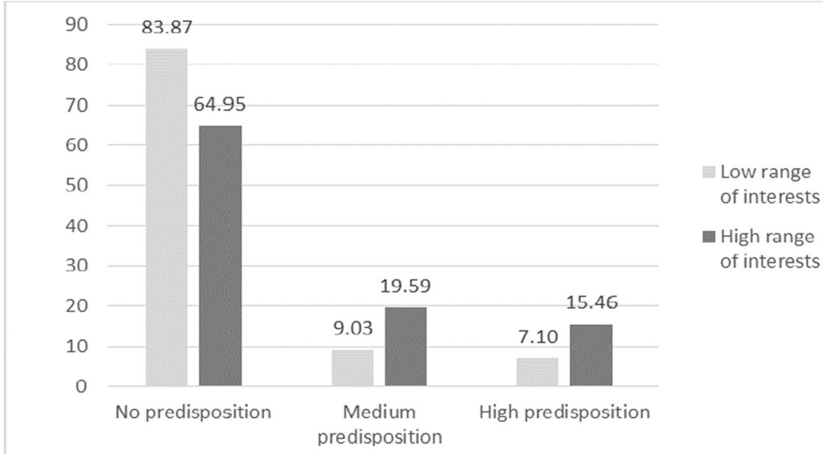

Fig. 3 Relationship between the interests of 16-year olds and their predisposition to participate in S&T activities outside school

S&T, we studied the high and low range of interest groups described in the previous section. Figures 4, 5, and 6 show the relationship between these two groups of students and their inclination to work in science at the three ages, expressed as the percentage of "yes," "no," and "do not know" answers to the question on this issue in the questionnaire. There were statistically significant differences between the range of interest and the inclination to work as a scientist at 10 years ($p < 0.01$), 13 years ($p < 0.01$), and 16 years ($p < 0.01$).

Figure 4 shows that most 10-year-old students with a low range of specific interests stated that they would not like to work in S&T (70%) or were undecided, in contrast to 30% who stated that they would like to work as a scientist. Of the students who had a high range of specific interests, 41.18% stated that they would like to work in S&T, while 58.82% stated that they would not like to or were undecided.

Figure 5 shows that most 13-year olds in both groups stated that they would not like to work in S&T or were undecided (82.31% of the group with a low range of specific interests, and 72.67% of the group with a high range of interests). In contrast, 17.69% of students in the low range group and 27.33% of students in the high range group stated that they would like to become scientist.

Finally, as shown in Fig. 6, most of the 16-year olds in both groups stated that they would not like to work in S&T in the future or were undecided, although there were clear differences between the groups (85.81% of the low-range group compared to 68.04% of the high-range group). This difference is illustrated even more clearly by the proportions of students in both groups who stated that they would like to work as a scientist (14.19% in the low range group compared to 31.96% in the high range) and those who would not like to work as a scientist in the future (68.39% in the low-range group compared to 41.24% in the high-range group).

Discussion and Conclusions

In this study, we aimed to shed more light on the complex phenomenon of interest by examining the changes in children's and adolescents' interest in specific areas of S&T according to age and gender. We also set out to analyze the relationship of these interests to our respondents' predisposition to participate in S&T activities outside school, as well as to their inclination to become scientists.

Regarding the first objective, the results revealed that specific focuses of S&T interest remained relatively stable across all three ages (10, 13, and 16 years), whereas others varied depending on the age. All three ages reported a specific interest in sustainability and the environment and in earth sciences,

Table 5 Inclination to work as a scientist

	Total		Age						Gender			
			10 years		13 years		16 years		Girl		Boy	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Agree	342	25.60	134	33.67	90	20.83	118	23.32	148	21.67	194	29.71
Neither agree nor disagree	302	22.60	84	21.11	102	23.61	116	22.92	142	20.79	160	24.50
Disagree	692	51.80	180	45.23	240	55.56	272	53.75	393	57.54	299	45.79
Total	1336	100	398	100	432	100	506	100	683	100	653	100

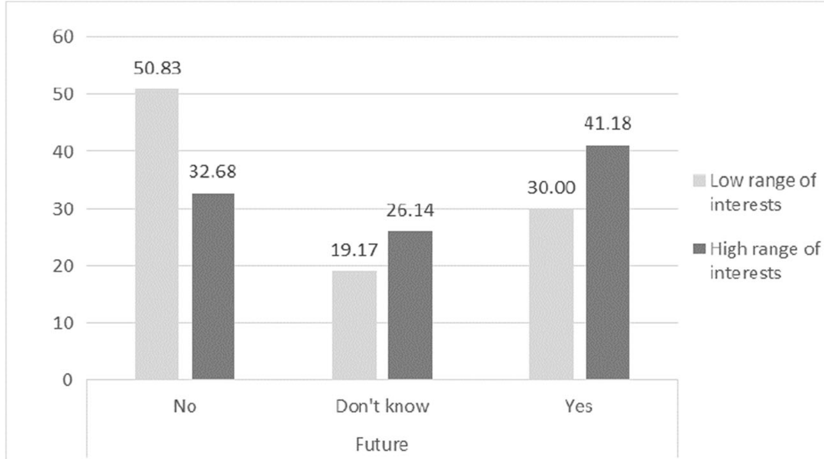

Fig. 4 Relationship between 10-year-old children's interests and their inclination to work as a scientist in the future

while the interest in life sciences was only maintained at 10 and 13 years. Health and sexuality was one of the areas of greatest interest at 13 years but, surprisingly, was one of the areas of least interest at 16 years. In contrast, technology and machines aroused the least interest in 13-year olds, but aroused the most interest by far in 16-year olds. These striking results deserve more attention from researchers in the near future. On the one hand, the results must be contrasted in more thorough investigations; on the other hand, it would be interesting to examine whether the earlier age of sexual initiation of young people today (Finer and Philbin 2013) might explain these results, at least in part. In particular, our results corroborate those of previous authors such as Jidesjö (2008) who stressed the need to bear in mind how children's and adolescents' interest in specific areas of S&T changes with age. Our study also highlights some trends of change in relation to age and the gender in specific areas of S&T. Both outcomes are important to show that even though there is a general evidence of decline of science interests in adolescence, there are many differences in the students' interest in science depending on the topic. Following on from the questions posed by Bennett et al. (2013), our results help to understand why there is conflicting evidence regarding the increase or decrease of interest with age. Also, in agreement with other studies (Hasni and Potvin 2015), our results suggest that school activities should take into account the topics that students show an interest in at each age. The interest that students effectively bring with them to school and further develops a decisive condition for instruction. These interests can relate to context, content, and activities (Seidel and Shavelson 2007). Focusing on students' interests may contribute to increasing their participation in S&T subjects in school, and may help to boost the links between activities inside and outside the school context. It is the school's task to pick up the interest that students bring with them and establish connections between it and the curricular requirements (Krapp and Prenzel 2011).

Furthermore, the differences between boys' and girls' specific S&T interests are similar to those found in previous studies, which showed that girls had a greater preference for health and the environment, and boys for technology and mechanics (Potvin and Hasni 2014; Sjøberg and Schreiner 2010; Jidesjö 2008). Our results also show that there are gender differences

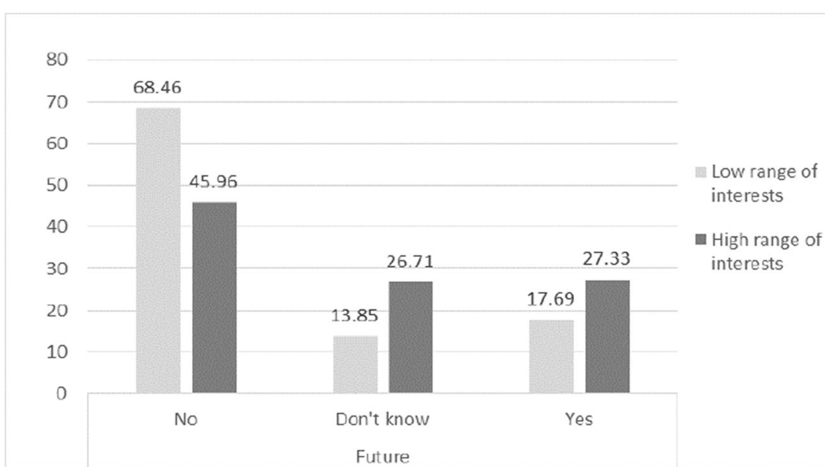

Fig. 5 Relationship between 13-year-old children's interests and their inclination to work as a scientist in the future

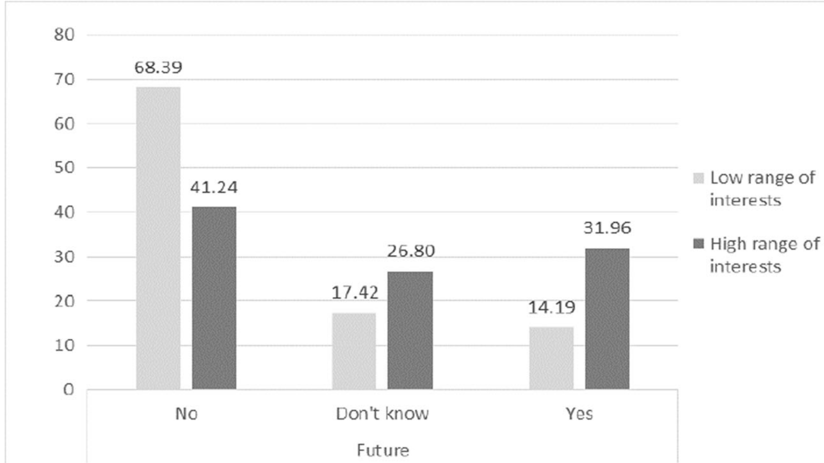

Fig. 6 Relationship between 16-year-old children's interests and their inclination to work as a scientist in the future

in other areas and at all ages. Girls showed more interest in health, sexuality, and life sciences, while boys showed more interest in technology and earth sciences. In addition, these results indicate that gender differences progressively increase in other fields of interest as children grow older. In previous studies (Vázquez and Manassero 2007), differences between boys' and girls' focuses of interest in S&T were linked to experiences of out-of-school activities that are qualitatively and quantitatively different in girls and boys. In our opinion, and in line with conclusions on the implications of the age variable, the activities in which boys and girls participate and the S&T-related learning experiences that are gained in these activities should be taken into account, particularly in the planning of S&T activities at school. In agreement with Archer et al. (2010), we feel that the focus of school science should be reconsidered and expanded. In particular, future research should continue examining the conditions in science instruction as well as in out-of-school environments that support cognitive learning gains and performance, as well as those that stimulate and further develop interest in S&T.

Regarding our second focus, the predisposition to participate in S&T-related activities outside school, the results broadly reproduce the trend found regarding interest in specific areas of S&T, since they reflect the existence of differences by age and gender. Participants' predisposition seems to decrease with age, especially from 10 to 13 years; according to Jidesjö (2008), this suggests that the difference lies in the transition from primary to secondary education. As for gender, the evidence indicates that boys are significantly more disposed to participate in S&T-related activities than girls: more boys present the high predisposition pattern, and more girls present no predisposition pattern. These results corroborate those of previous studies (Bennett and Hogarth 2009; Jenkins and Pell 2006) and indicate the persistence of certain patterns or cultural stereotypes regarding gender.

Our data also shed light on the relationship between the range of interest in specific areas of S&T and the predisposition to engage in S&T activities outside the school. The significant differences between the different groups observed in these two variables suggest that the wider the range of interests, the greater the predisposition to participate in these activities, and vice versa. In line with Azevedo et al. (2016), who point out that young people's interest in S&T guides and is constructed by their participation in S&T activities in different contexts; our results also suggest there is a relationship between the participation in S&T activities outside the school and the development of diverse interests in these areas. In addition, authors such as Hasni and Potvin (2015), the link between the interest in specific areas of S&T and the propensity to engage in S&T-related activities is not a direct one; in fact, it reflects a complex relationship in which the experiences of students in out-of-school activities seem to play a key role (Archer et al. 2010; Hasni and Potvin 2015; Vázquez and Manassero 2007).

Of course, there are certain limitations of the study. Further studies increasing the sample size and expanding the grade band/age level and the area of survey might be important. Another limitation is derived from the use of cross-sectional studies. We are convinced that large-scale assessments can measure interest in a more differentiated way, and that the combination of qualitative and quantitative methods will help to shed light on the development of interests. We have explained that interests are created within the student's participation in activities, and they are situated in particular contexts and experiences with objects and people. In fact, recent assessments of the study of interest (Azevedo et al. 2016; Dierks et al. 2014; Renninger and Hidi 2016) have placed particular emphasis on the learning experiences associated with these out-of-school activities. However, the use of interviews will be recommended to expand their findings in order not only to study the S&T-related activities in which students engage in different contexts, but also to explore their motivation for doing so, the importance and meaning they attribute to these activities, what they learn in them, and how they build their interest in them. By gaining input on those questions, it would be interesting to know the relationship between specific interests and the inclination of students to work on S&T fields in the future. In this sense, the use of ranges of interest instead of particular interest on specific topics will be seen as a limitation but also a strength of the present study, as it opens new lines of research.

Moreover, the scarce number of activities included in our questionnaire (only five) could also be seen as a methodological limitation of the study. Bearing in mind the breadth and diversity of activities and contexts of participation now available within the framework of the new learning ecology (Barron 2006; Leander and Hollett 2017; Leander et al. 2010) future studies of this kind should consider a greater number of out-of-school activities related to S&T.

The results of our study have some practical implications that are worth mentioning. First, they highlight the areas in which participants of different age and gender show particular interest (for example, 16-year-old boys in technology, 10-year-old girls in health), and this information may be useful for the creation and design of S&T activities either inside or outside school. For example, activities regarding health and sexuality may increase girls' predisposition to participate in S&T-related areas and thus reverse the cultural stereotypes (which, as our study has shown, persist). Secondly, closely linked to this idea of taking students' interests into account, a number of theoretical and empirical studies have been carried out under the aegis of a relatively new line of educational research and innovation, known as the personalization of learning (Bray and McClaskey 2015; Penuel and Johnson 2016). This term covers a variety of practices that seek to stimulate students' interest and involvement in the learning process by giving them the opportunity to make decisions about their own learning. Therefore, applying these ideas would involve not only taking the age- and gender-related differences in the interest in S&T into account in the design of educational activities but would also allow students to choose certain aspects of the activities that accord most with their particular interests (Coll 2016). As a last practical implication, it is particularly important that authentic S&T activities should be designed at the school level in order to establish connections between in-school and out-of-school learning experiences (Ito et al. 2013; Roth 2002; Sadler et al. 2010). This would encourage students who currently choose their out-of-school S&T-related activities according to their interests to feel that these interests were also being taken into consideration inside the school. In short, the key idea that we want to convey is the need to promote interest-driven activities (Ito et al. 2013).

Regarding our third objective, our results confirm data from previous studies showing that the percentage of young people who intend to become scientists in the future is low (Jenkins and Nelson 2005). As in previous studies, our results indicate that the desire to be a scientist decreases with age (Baram-Tsabari and Yarden 2009; Hidi and Harackiewicz 2000; Khoo and Ainley 2005) and is lower among girls than boys (Miller et al. 2015). This may be due to the stereotyped image of science and scientists. For example, as far as gender is concerned, a study by Miller et al. (2015) found a direct relation between the existence of stereotypes about science in a country and the number of female scientists in its population. As we suggested above, in order to reverse these trends, projects could be carried out in schools or elsewhere to foster an interest in S&T among girls and to increase the number of girls who want to work as a scientist in the future. Our results confirm that a low interest in science and technology is found among students who have a wide range of specific S&T interests. This again suggests that it is difficult to bridge the gap between wanting to "do science" and wanting to "be a scientist" (Archer et al. 2010). Given the relationship between students' interests and their intention to become scientists, and returning to the practical implications of our study mentioned above, designing projects that aim to increase the predisposition to participate in S&T-related activities outside the school by considering specific areas of interest may also be relevant to the goal of increasing the inclination to become scientists. Regarding students' reasons for wanting to pursue an S&T career, our results indicate that students are intrinsically more interested in the work of scientists and their potential to improve the living conditions of people and society than in salary and social recognition. Some students stated that they did not know much about the work of scientists. This highlights the need to provide information in schools about the role of scientists and their responsibilities in order to increase students' desire to work professionally in these fields (Feldman et al. 2013; Houseal et al. 2014). In the same line, if parents support the "culture of science at home," students will have more opportunities to create positive expectations and abilities to become scientists in the future (Maltese and Tai 2011). We are convinced that family plays an important role in providing early experiences to the children in skills development through science-related activities.

Our study has identified specific interests among children and adolescents who have answered the questionnaire in relation to S&T and their predisposition to engage in S&T activities outside the school context. However, certain key aspects need to be studied in greater depth in view of the recent research findings regarding the construction and management of students' interest in areas of S&T. In particular, we stress the need for further studies to gain a greater understanding of the out-of-school activities in which boys and girls of different ages tend to participate, and of the associated learning experiences. Recent research indicates that interest-based participation can take on a very different character in the various activities and contexts in which boys and girls engage as they travel through life (Azevedo et al. 2016; Bricker and Bell

2014). Well-designed S&T activities outside the school would help to establish connections between students' S&T-related learning experiences inside and outside school, and thus increase students' involvement and engagement in science.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no potential conflicts of interest. Regarding the human participants, the families of the students and students were properly informed before the application of the questionnaire about the research aims and procedures and families signed a document to ensure their informed consent.

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