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Out-of-School Activities Related to Science and Technology

Las actividades extraescolares relacionadas con la ciencia y la tecnología

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Abstract

Artificial and natural environments constitute an extensive educational resource in whose framework the basic experiences that contribute to the development process of human beings occur. These experiences are the source of previous knowledge that students bring to school and that are key for building scientific school learning. This article reports the results of a study that addresses out-of-school experiences related to science and technology, through the application of an inventory list to a sample of students who were in their last year of compulsory education. The results show a relatively low overall frequency of experiences, characterized by some qualitative and quantitative differences according to a few grouping variables such as gender, the choice of an elective science subject, and different scientific topics and disciplines. In spite of its importance for learning, the school curriculum often ignores students' previous experiences. Finally, we discuss the relevance of these results for developing a more equitable science and technology curriculum, from a perspective of a universal, humanistic science education.

Key words: Educational background, socioeconomic background, science teaching, gender differences, science and technology curriculum.

Resumen

El entorno natural y artificial constituye un amplio recurso educativo en cuyo marco suceden las experiencias básicas que contribuyen al proceso de desarrollo de los seres humanos. Estas experiencias son la fuente de los conocimientos previos que los estudiantes aportan a la escuela y que son clave para construir los aprendizajes escolares científicos. Este artículo reporta los resultados de un estudio que aborda las experiencias extraescolares relacionadas con la ciencia y la tecnología, mediante la aplicación de una lista inventario a una muestra de estudiantes que terminaron la enseñanza obligatoria (educación básica). Los resultados muestran una frecuencia global de experiencias relativamente baja, caracterizada por algunas diferencias cualitativas y cuantitativas, según algunas variables de agrupamiento como el género, la elección de asignaturas de ciencias y los diferentes temas y disciplinas científicos. A pesar de su importancia para el aprendizaje, el currículo escolar suele ignorar esta experiencia previa de los estudiantes. Finalmente, se discute el interés de estos resultados para lograr currículos de ciencia y tecnología más equitativos, desde una perspectiva de la enseñanza de la ciencia para todos y humanista.

Palabras clave: Antecedentes académicos, antecedentes socioeconómicos, enseñanza de las ciencias, diferencias de género, currículo de ciencia y tecnología.

Introduction

The reduced innate load of human beings at birth must be compensated for by a long period of intense interaction with the environment, which gives rise to the process of maturing and learning. At the end of this period, of all creatures, humans are the most able to adapt to the hostility of their context. In the early 20th century the American educator, John Dewey (1995), had already argued that there is a solid and productive relationship between experience and education.

From a general innovative educational perspective, the educational value of the out-of-school context as an irreplaceable source of education is widely recognized, in such wise that attention to the experiences of students outside of school is an important complement to school itself. To look at the environment as a source of curriculum and allow it to be present in the school implies opening the school, affirming the educational capacity of the environment, territory and city and overcoming the chronic isolation resulting from the divorce of the school from society (Carbonell, 2001).

As recognized an educational expert as Tonucci (2004), promoter of the importance of the environment and the city as educational agents—while not downplaying the role of the school—argues that the most important experiences for personal development in childhood and adolescence are those occurring outside the school. Students acquire an experiential, anecdotal and informal culture outside of school which is relevant to the individual, whereas the school promotes a public culture, systematic, organized and relevant to society, the result of reflection and humanity's historical journey. The crucial function of the school is to integrate both cultures—experiential and public—for all students, so that this integration makes public culture significant and relevant; in other words, to develop socially relevant learning (Pérez Gómez, 1993). A truly meaningful education should also build on the informal experiences students have before or in parallel with school learning.

Academically, it is common to distinguish between *non-formal* and *informal* education. Although there is still argument about both, we can say that non-formal education is any organized activity (and which therefore has the intention of educating) that takes place outside the formally established system (the school) and that serves the learning needs of objective and identifiable clientele (Coombs, 1973). In contrast, informal education has a broader sense, since it includes all kinds of activities (incidental, spontaneous, supplementary, random, etc.) that are not specifically structured as educational per se, but that can produce learning (Sarramona, 1992).

The Relevance of Science Education project (ROSE)[1], is an international comparative study that seeks to identify the factors crucial to the learning of Science and Technology (S&T) from the students' perspective (Schreiner and Sjøberg, 2004). In this project, one of these factors is the students' out-of-school experiences, which constitute a core of practical learning that students bring with them as previous knowledge to add to school learning. The distinction between non-formal and informal learning is not important here, because the activities considered are mostly informal.

This article studies the background experiences of students from their responses on an inventory list of informal activities of daily life that can be done outside of school and which have some kind of relationship with science and technology. It analyzes the relationship of these activities with the student's gender, the selection of school science subjects and the number of books at home. It discusses the influence of these activities on students' interest in formal school S&T education and learning.

I. Background

Experiences with the physical and natural world are especially interesting for the teaching of science, because—beyond simply identifying pre-existing ideas—they allow the integration of students' previous experiences into classroom activities.

Moreover, they also provide empirical knowledge of nature that is relevant to the learning of science and develop the epistemological thinking that determines the use of metacognitive and learning strategies in S&T (see review in Campanario and Otero, 2000).

Constructivism has emphasized the importance of students' previous ideas as the key element that determines subsequent learning. During the last two decades of the 20^{th} century, a constructivist line of research emerged—one which has generated an enormous amount of results—, focused on previous ideas or alternative conceptions, which are, presumably, a consequence and result of students' previous experiences (Driver, Guesne and Tiberghien, 1989; Duit, 2006; Hierrezuelo and Montero, 1988; Pozo, Sanz, Gómez and Limón, 1991).

Research finds that these ideas exist in students of all ages; they are repeated and reiterated in various historical and cultural contexts. Frequently they are the opposite of the scientifically correct ideas (i.e., they are scientifically heterodox) and, above all, they are very resistant to change, decisively hindering scientific learning in the school environment. Previous ideas act as veritable implicit theories or alternative conceptions to the scientific theories presented in school curriculum and thus constitute an important epistemological obstacle to learning science. Previous ideas are the most significant challenge for teaching the sciences; consequently educational and organizational proposals for science teaching frequently include strategies for overcoming them (Reid and Hodson, 1993).

Nevertheless, the limited success of different teaching methodologies aimed at overcoming previous ideas in the classroom (e.g. cognitive conflict), as well as criticism arising from a more general and theoretical perspective and directed at constructivism as a philosophy and general theory—for example, the mental "perversity" of its design—have contributed to a more realistic rethinking of educational goals (Millar, 1989). It seems clear that previous ideas cannot have another source than the everyday experience that students accumulate in the course of their evolutionary development, which involves cognitive skills, but also, and above all, procedural and affective abilities (Preece, 1984).

Other lines of research and numerous studies have suggested the need to take into account all of the dimensions of the person involved in learning, especially the *procedural* dimension—know-how—and the *attitudinal* dimension –learning the values needed to be a person (Vázquez and Manassero, 1998). In this latter theoretical framework, affective and attitudinal variables, particularly those related to expectations, values, motivation, interests, responsibilities and emotions, play an essential role in classroom learning (Manassero and Vázquez, 2001; Oliva *et al.*, 2004; Vázquez and Manassero, 2007), claiming the attention of various science education forums (Watts and Alsop, 2000).

In today's world, young people live in environments that are not only configured by the natural world, but ever more deeply by the pervasive presence of different artificial environments (technology). The daily opportunities for students to have meaningful and relevant experiences outside the classroom—endless sources of previous ideas—are significant and quite intense.

In the socio-cultural context of youth, Doll, Prenzel and Duit (2003) structure three basic spaces of informal science learning: the family, the peer group and media. For adults, Falk (2002) adds the workplace as a fourth space for informal science learning. In a survey conducted by this author, the findings showed that for a third of the sample the *school* is the main source of knowledge about science and technology, for less than a fourth it is the *workplace* and nearly half of all respondents learned during their *leisure time* (through informal learning experiences such as the Internet, reading books and magazines, visiting museums, zoos and aquariums or by participating in clubs and special interest groups).

Currently, the social environment offers an increasingly attractive array of non-formal cultural and leisure educational institutions (zoos, science and technology museums, school-farms, parks, nature schools, environmental education centers, botanical gardens, factories and industries, planetariums, astronomical observatories, science fairs, etc.): as well as informal activities related to science and technology (workshops, clubs, associations of all kinds, leisure centers, interactive games, etc.).

At the same time, research on science teaching gives increasing importance to the educative influence of these spaces, where science and technology are presented to the general public in an informal and relaxed manner, to the extent that today they constitute not only a thriving line of research around the world (Benlloch and Williams, 1998; Braund, Reiss, Tunnicliffe and Moussouri, 2004; Errington, Stocklmayer and Honeyman, 2001; Griffin, 1998; Jones, 1997; Medved and Oatley, 2000; Oliva *et al*., 2004; Semper, 1990; Stevenson, 1991; Tunnicliffe and Moussouri, 2003), but also real instruments for public communication of science and technology to society (Parque de las Ciencias, 1999; Toharia, 2003).

Although the school continues to be an important source of scientific learning, it has now ceased to be the principal source of science information for most people. Experiences outside of school form a valuable contribution to the organization and teaching of science in the school, since they influence its outcomes (Schibeci, 1989). In fact, students spend three-quarters of their lives outside of school, where learning, because it is informal, never stops. In spite of this, there is no awareness of its importance; indeed, government education policies do not support the informal education sector (Falk, 2002). School teachers tend to forget the powerful influence that out-of-school experiences have on knowledge, motivation, beliefs and attitudes toward science (Oliva *et al*., 2004). In this context, it is to be expected that the importance of informal education will further increase, so the challenge ahead will be to integrate the growing volume of results and studies and identify the critical properties of non-formal learning (in institutions such as museums and others) to properly connect the areas of informal and school-centered science and technology learning (Martin, 2004; Wellington, 1991).

The National Science Foundation (2006) defines *informal scientific education* as voluntary self-directed learning activities for all, motivated mainly by intrinsic interests, curiosity, exploration, manipulation, fantasy, task completion and social interaction. The distinguishing feature of informal scientific education is freedom of choice, which is why one author even calls it "free-choice learning" (Falk, 2002), because learners control and select what and how they learn, increasing the likelihood of being emotionally and intellectually more motivated by the science they are studying. Rennie, Feher, Dierking and Falk (2003) view informal science learning as "self-motivated, voluntary and guided by the needs and interests of learners" (p. 113).

According to Rahm (2002) informal science learning has six characteristics: 1) the science that is taught is not limited to a curriculum, but arises in response to the questions and interests of the students; 2) scientific knowledge is not simply absorbed, it penetrates through the students' interactions with each other and with science; 3) informal environments offer an educational context that is focused on the students, rather than science; 4) it provides a variety of learning opportunities 5) the science is accessible to the participants; and, lastly 6) informal science content is broader than traditional science.

Informal experiences are not only a source of knowledge, they also provide the most basic affective reinforcements (goal achievement, a passion for discovery, satisfaction of curiosity), which are essential for maintaining motivation and interest in the object of the experience. It is commonly accepted that motivation and interest do not produce learning in and of themselves, but are prerequisites for learning. Hence, students' science-and-technology-related experiences are important, because they reflect exposure to and contact with S&T. Thus, they are a significant attitudinal indicator for learning (Eagly and Chaiken, 1993).

Informal learning in diverse contexts such as the home (Schibeci and Riley, 1986), participation in extracurricular science activities (Tamir, 1990) and visits to science museums (Lucas, 1991) are useful for improving the students' scientific reasoning skills (Gerber, Cavallo and Marek, 2001), addressing the problem of attention to diversity in science class (Jones, 1997), awakening positive attitudes and feelings towards science—curiosity, surprise, fascination, fun, self-confidence, interest and so on—(Medved and Oatley, 2000; Rix and McSorley, 1999; Russell, 1990; Stevenson 1991); and even strengthening scientific learning through spontaneous interaction with friends, family and teachers (Benlloch and Williams, 1998; Semper, 1990). Therefore, informal experiences can and should be exploited as a resource for school education. To this end, the first step should be to become familiar with these experiences, not ignore them (Lucas, McManus and Thomas; 1986; Tamir, 1990; Rix and McSorley, 1999).

Although the literature on science learning in informal educational settings (museums, science centers, clubs, etc.) is relatively abundant, few studies relate these experiences with academic learning processes in the school (Lucas, 1991). Many educators worry that school curricula for science and technology are boring, outdated and irrelevant, designed for a minority instead of trying to provide the majority with literacy, understanding and basic reasoning in science and technology (Millar and Osborne, 1998). All this makes the lack of interest in school science the most dramatic problem of science education because it translates into the flight of students from scientific options and majors when the time comes for choosing a course of study in college (Fensham, 2004).

Moreover, science and technology have a clear gender brand that is detrimental to girls and that also extends to previous experiences. Young people's early experiences and out-of-school activities could influence the affinity and differential performance of boys and girls in science (Greenfield, 1996). Female students' disinterest in scientific and technical subjects is circularly reinforced by girls' fewer previous experiences with S&T (Keller, 1985). The imbalance in the previous experiences of men and women is also a decisive factor in the selection of scientific-technological studies and professions; boys make this decision much earlier than girls and through different mechanisms (Alemany, 1992).

In this theoretical framework, the study of previous S&T experiences can be a very interesting element for the teaching of science because informal experiences outside of school control reveal the roots of students' motivation and interest in science and technology, and provide an additional resource for its improvement.

II. Methodology

2.1. Sample

The target population of the ROSE study is the students at the end of compulsory education (aged 15–16) in the participating countries. The study questionnaire was applied in an opinion sample of 32 schools in the Balearic Islands (Spain), in a randomly selected fourth course secondary group (ESO)[*]. We thus obtained a valid sample of 774 students, of whom 443 (57%) were female and 331 (43%) were male; most were 15 (n=466; 60%) and 16 years of age (n=223; 29%), with a minority of 14-year-olds (n=32; 4%); the rest were older as a result of having repeated a previous grade.

The students surveyed had for the first time chosen their elective science subjects (Physics and Chemistry and/or Biology and Geology) during the year in which the questionnaire was applied (55% were enrolled in at least one of these subjects). The group that chose to study science had approximately the same proportion of females (57%) as the group that didn't study science and as the total sample. A social descriptor of the sample is the number of books in each student's home,

[*] Translator's note: Fourth course of the secondary level of education in Spain is the last year of compulsory education, *Educación Secundaria Obligatoria* in Spanish, or ESO, and is the equivalent of the second (Sophomore) year of high school in the U.S. It is followed by the two-year baccalaureate program for qualifying students, which precedes undergraduate university study.

measured on a scale with seven positions, ranging from "no book" (1) to "over 500 books" (7).

2.2. Instrument

The instrument of extracurricular experiences in the ROSE study is a Likert-type inventory list called "My out-of-school experiences: What I've done", which consists of a set of 69 phrases (Schreiner and Sjøberg, 2004). Each phrase describes an activity (see Table I) that can be carried out by the students outside of school, although the relation of each activity with S&T varies; for example, some are simply recreational (playing, fishing) and some are forms of entertainment (reading a horoscope, e-mail). The students rate the frequency with which they have undertaken each activity on the list on a four-point scale, *never* (1), *seldom* (2), *sometimes* (3) and *often* (4).

Table I. Inventory of out-of-school experiences and activities
and the coding applied to each response category

How often have you done this outside school?				
	Frequency			
	1	**2**	**3**	**4**
	Never	**Seldom**	**Sometimes**	**Often**

1. Tried to find the star constellations in the sky	36. Used a camera.
2. Read my horoscope (telling future from the stars)	37. Made a bow and arrow, slingshot, catapult or boomerang.
3. Read a map to find my way	38. Used an air gun or rifle.
4. Used a compass to find direction	39. Used a water pump or siphon.
5. Collected different stones or shells.	40. Made a model such as toy plane or boat etc.
6. Watched (not on TV) an animal being born.	41. Used a science kit (like for chemistry, optics or electricity).
7. Watched the incubation of an egg.	42. Used a windmill, watermill, waterwheel, etc.
8. Watched an animal nurse its young.	43. Recorded on video, DVD or tape recorder.
9. Cared for animals on a farm.	44. Changed or fixed electric bulbs or fuses.
10. Visited a zoo.	45. Connected an electric lead to a plug etc..
11. Visited a science centre or science museum.	46. Used a calculator.
12. Milked animals like cows, sheep or goats.	47. Used a stopwatch.
13. Made dairy products like yoghurt, butter, cheese or ghee.	48. Measured the temperature with a thermometer.
14. Read about nature or science in books or magazines.	49. Used a measuring ruler, tape or stick.
15. Watched nature programmes on TV or in a cinema.	50. Used a mobile phone.
16. Collected edible berries, fruits, mushrooms or plants.	51. Sent or received an SMS (text message on mobile phone).
17. Participated in hunting.	52. Searched the internet for information.
18. Participated in fishing.	53. Played computer games.
19. Planted seeds and watched them grow.	54. Used a dictionary, encyclopaedia, etc. on a computer.
20. Made compost of grass, leaves or garbage.	55. Downloaded music from the internet.

How often have you done this outside school?				
	Frequency			
	1	**2**	**3**	**4**
	Never	**Seldom**	**Sometimes**	**Often**

21. Made an instrument (like a flute or drum) from natural materials.	56. Sent or received e-mail.
22. Built things with wire.	57. Used a word processor.
23. Knitted, sewed, etc.	58. Opened a device (radio, watch, computer, telephone, etc.) to find out how it works.
24. Put up a tent or shelter.	59. Baked bread, pastry, cake, etc
25. Made a fire from charcoal or wood.	60. Cooked a meal.
26. Prepared food over a campfire, open fire or stove burner.	61. Walked while balancing an object on my head.
27. Sorted garbage for recycling or for appropriate disposal.	62. Used magnets.
28. Cared for a sick relative or friend.	63. Used a wheelbarrow.
29. Cleaned and bandaged a wound.	64. Used a crowbar (jemmy).
30. Seen an X-ray of a part of my body.	65. Used a rope and pulley for lifting heavy things.
31. Taken medicines to prevent or cure illness or infection.	66. Mended a bicycle tube.
32. Taken herbal medicines or had alternative treatments (acupuncture, homeopathy, yoga, healing, etc.).	67. Used tools like a saw, screwdriver or hammer.
33. Been to a hospital as a patient.	68. Used a car jack.
34. Used a **m**icroscope.	69. Charged a car battery.
35. Used binoculars or glasses.	

Note: This inventory is one of the instruments applied in the ROSE project.

This questionnaire has also been used in a slightly different form in the Norwegian SISS and in various studies (Sjøberg, 2000, Sjøberg e Imsen, 1987; Vázquez, 1996; Whyte, Kelly and Smail, 1987). For a more generalized analysis, the experiences on the inventory list are grouped according to the scientific discipline to which they are most directly related (Universe, Geology, Physics, Technology, Chemistry or Biology) or as general activities if they do not clearly belong to any of the above fields. In addition, students were requested to provide their sex, the science subject they had chosen to study as their elective course and the approximate number of books in their home.

2.3. Procedure

After preparation with the research team, the teacher of the selected class groups administered the questionnaire, between November 2002 and April 2003. The student's gender, the number of books in his or her home and the science subject chosen by the student in fourth course of secondary education (ESO) were considered as independent variables.

To facilitate the overall assessment of the frequencies of responses to the items on the inventory list, the weighted average of the four response positions was used as a centralizing measure. The differences between groups were studied by means of an analysis of variance, considering the significance probability and the observed effect size (the difference between the averages divided by the standard deviation); on this statistic we carried out the interpretation of the magnitude of the differences.

III. Results

The average scores for the entire sample of different items are distributed fairly evenly in the range between 1 and 4 points on the scale (skewness 0.29), with a slight tendency to accumulate in the lowest scores. The average of the distribution is somewhat below the midpoint of the scale (2.35 points, S.D. 0.91) and, therefore is considered a slightly negative indicator of participation in activities.

The distribution of average scores is negatively skewed, as the number of items with extreme scores is skewed toward the lowest scores; there is a greater number (28% of items) in the lowest range (between 1.5 and 2 points) than in the highest range (3 to 3.5 points), where just 12% of items are found (see Table II).

Table II. Descriptive statistics of raw scores for the total sample.

Item	Mean	No.	S.D.	Item	Mean	No.	S.D.
G01	2.32	774	0.96	G36	3.23	766	0.77
G02	2.71	773	1.08	G37	2.13	770	1.00
G03	2.23	769	0.88	G38	1.83	772	1.02
G04	1.48	755	0.70	G39	1.81	763	0.88
G05	2.30	771	0.98	G40	1.93	769	0.89
G06	2.04	764	1.08	G41	1.74	761	0.83
G07	2.07	770	1.00	G42	1.54	763	0.78
G08	2.75	769	0.96	G43	3.24	769	0.84
G09	2.10	772	1.04	G44	2.32	769	0.97
G10	2.44	773	0.84	G45	2.90	765	1.05
G11	2.19	772	0.86	G46	3.53	773	0.71
G12	1.46	771	0.82	G47	2.83	772	0.92
G13	1.49	774	0.80	G48	2.84	772	0.88
G14	2.45	771	0.89	G49	3.26	768	0.76
G15	2.66	772	0.86	G50	3.53	772	0.77
G16	2.25	768	0.96	G51	3.48	771	0.85
G17	1.50	774	0.87	G52	3.32	772	0.86
G18	2.16	772	0.99	G53	2.99	772	0.95
G19	2.47	774	0.92	G54	3.12	770	0.92
G20	1.57	762	0.83	G55	2.75	771	1.20
G21	1.58	773	0.79	G56	2.75	766	1.18
G22	1.90	773	0.84	G57	2.94	766	1.00
G23	2.09	772	0.91	G58	2.52	773	1.03
G24	2.39	771	0.97	G59	2.45	771	0.98
G25	2.47	765	1.02	G60	2.77	767	0.93
G26	2.42	772	0.99	G61	1.90	768	0.80
G27	2.42	770	0.99	G62	2.12	768	0.83
G28	2.59	769	0.87	G63	2.10	766	0.93
G29	2.61	772	0.87	G64	1.93	766	0.86
G30	2.78	765	0.93	G65	1.74	764	0.89
G31	2.87	770	0.87	G66	2.00	772	1.00
G32	1.67	764	0.91	G67	2.65	769	0.91

Item	Mean	No.	S.D.	Item	Mean	No.	S.D.
G33	1.89	767	0.89	G68	1.58	769	0.86
G34	2.12	772	0.79	G69	1.58	770	0.94
G35	2.20	763	0.96				

The out-of-school activities the students participated in most frequently, which make up the highest range (the items with average scores located approximately one-half a standard deviation above the overall average), and in descending order, are as follows:

- 50. Used a mobile phone (3.53);
- 46. Used a calculator (3.53);
- 51. Sent or received an SMS (text message on mobile phone (3.48);
- 52. Searched the internet for information (3.32);
- 49. Used a measuring ruler, tape or stick (3.26);
- 43. Recorded on video, DVD or tape recorder (3.24);
- 36. Used a camera (3.23);
- 54. Used a dictionary, encyclopaedia, etc. On a computer (3.12);
- 53. Played computer games (2.99);
- 57. Used a dictionary, encyclopaedia, etc. On a computer (2.94);
- 45. Connected an electric lead to a plug etc. (2.90);
- 31. Taken medicines to prevent or cure illness or infection (2.87);
- 48. Measured the temperature with a thermometer. (2.84);
- 47. Used a stopwatch (2.83).

The set of items with the highest frequency of activity is clearly tilted towards activities related to the information and communication technologies (ICT), such as the computer (Internet, games, dictionaries), mobile phone, camera, television and calculators, which dominate the most frequent activities. The only exception is measuring the size of objects.

In the lower half of the most frequent activities are some that fall outside of the framework of electronic technology, forming a category that is actually more manipulative of objects, such as connecting electrical cords, measuring times and temperature, cooking, etc.

On the opposite pole, the least frequent activities (those with average scores located approximately one-half a standard deviation below the overall average) are more numerous than the activities in the most frequent range. In descending order from highest to lowest score, these activities are:

- 61. Walked while balancing an object on my head (1.90);
- 22. Built things with wire (1.90);
- 33. Been to a hospital as a patient (1.89);
- 38. Used an air gun or rifle (1.83);
- 39. Used a water pump or siphon (1.81);
- 65. Used a rope and pulley for lifting heavy things (1.74);

- 41. Used a science kit (like for chemistry, optics or electricity) (1.74);
- 32. Taken herbal medicines or had alternative treatments (acupuncture, homeopathy, yoga, healing, etc.) (1.67);
- 21. Made an instrument (like a flute or drum) from natural materials (1.58);
- 69. Charged a car battery (1.58);
- 68. Used a car jack (1.58);
- 20. Made compost of grass, leaves or garbage (1.57);
- 42. Used a windmill, watermill, waterwheel, etc. (1.54);
- 17. Participated in hunting (1.50);
- 13. Made dairy products like yoghurt, butter, cheese or ghee (1.49);
- 4. Used a compass to find direction (1.48);
- 12. Milked animals like cows, sheep or goats (1.46).

The least frequent activity is milking an animal, an activity that not so many years ago was still common in rural areas, but today is an experience that seems completely out of reach for the average schoolchild. The other activities on this list of the least frequent are now, in fact, out of the reach of most young people in our society, including, of course, the most manual, such as how to make dairy products and composting, but also the most technical, like using a car jack (cars today suffer less flat tires) or charging a car battery (if the battery goes dead or fails, our unsustainable throwaway consumer mentality often results in it being replaced by a new one, because it is safer and cheaper).

As already mentioned, from a comprehensive look at the distribution of the average scores of the responses, the most relevant feature of the results emerges as a certain negative skewness in favor of the lowest scores, which correspond to the least preferred activities. Specifically, this difference focuses on the different number of items located on the symmetrically extreme ends of the range of scores, between those on the high end of the scale (e.g., between 3 and 3.5 points) and those on the low end (e.g., between 2 and 1.5 points). Whereas there are only 8 activities on the high end, the number of activities whose average score is located on the low end is 20, more than double the former number.

This result can have two immediate interpretations: on the one hand, the most evident and direct one is that the less frequent activities are more numerous but are performed much less frequently than the activities which are carried out with a symmetrical intensity. On the other hand, a more indirect interpretation would suggest a hypothesis of broader reach: that science generates more rejection than acceptance among students, which—as suggested by the indicator examined—results in a smaller share of pre-scientific experiences for the students. The asymmetry between the smaller number of activities that are most often undertaken and the larger number of less frequently performed activities would be a consequence and an indicator of this overall tendency toward rejection of science, as manifested in lower overall experience with science-related activities.

3.1. Thematic variables of previous experiences

The individual items of previous experiences have been grouped into more comprehensive thematic variables according to their connection with different scientific disciplines (physics, chemistry, biology, etc.). Each variable is the average of the scores for the items assigned to the theme and is, in consequence, a more global indicator. In addition, these variables are more representative of the theme than the individual items by themselves, since they summarize a set of items belonging to each theme (Table III).

Table III. Descriptive statistics and statistical significance (ANOVA) for the thematic variables, together with the effect size for gender differences and for students who elected science courses

Themes	Mean	No.	S.D.	Mean	No.	S.D.	Mean	No.	S.D.	Effect size	Signific.
	Female			**Male**			**Total**			**Female-Male**	**ANOVA**
Universe	2.760	443	0.715	2.183	331	0.745	2.513	774	0.782	0.79	0.000
Geology	2.018	443	0.601	1.937	331	0.652	1.983	774	0.624	0.13	0.072
Biology	2.177	443	0.445	2.252	331	0.486	2.209	774	0.464	-0.16	0.025
Chemistry	2.225	443	0.523	2.196	331	0.584	2.213	774	0.550	0.05	0.473
Physics	2.175	443	0.431	2.462	331	0.541	2.298	774	0.501	-0.59	0.000
Technology	2.491	443	0.381	2.630	331	0.473	2.551	774	0.428	-0.32	0.000
General	2.166	443	0.579	2.356	331	0.603	2.247	774	0.596	-0.32	0.000
	Science			**No science**			**Total**			**Science-no science**	**ANOVA**
Universe	2.583	423	0.815	2.429	351	0.731	2.513	774	0.782	0.20	0.006
Geology	2.009	423	0.633	1.953	351	0.612	1.983	774	0.624	0.09	0.213
Biology	2.273	423	0.467	2.132	351	0.450	2.209	774	0.464	0.31	0.000
Chemistry	2.256	423	0.564	2.160	351	0.528	2.213	774	0.550	0.18	0.016
Physics	2.368	423	0.487	2.214	351	0.506	2.298	774	0.501	0.31	0.000
Technology	2.616	423	0.419	2.472	351	0.426	2.551	774	0.428	0.34	0.000
General	2.322	423	0.610	2.157	351	0.567	2.247	774	0.596	0.28	0.000

Given the very open and diverse nature of the items, some of their assignments to themes may be surprising, but they were the only possible choices (e.g. read horoscope was assigned to the universe theme). On the other hand, it should be added that these thematic variables are not intended to form subscales based on an analysis of reliability, but only to endeavor to establish a correspondence with the usual areas in which S&T curricular content is generally grouped.

Using as a reference the average overall frequency of the sample (2.35), it can be observed that previous experiences in two themes (universe and technology) obtained average scores above the overall average. In contrast, at the other extreme, previous experiences in geology had the lowest frequency, with a significant differential effect size compared with the overall average. The rest of the themes—which showed great similarity to each other—had slightly lower scores than the general average. It is noteworthy that of this intermediate set, experiences related to physics had the highest score of the group.

3.2. Gender differences

In addition to the transnational comparisons, the ROSE project has stated that an important objective is the analysis of differences between male and female students. The present analysis shows that out-of-school experiences are an important source of qualitative differences between the genders.

Overall, the average frequency of girls' activities (2.30; S.D. 0.86) is lower than boys' (2.41; S.D. 0.93), although the gender gap in this parameter is not statistically significant. Therefore, from this indicator we can conclude that boys performed activities related to science and technology more frequently than girls, although the overall gender difference is not statistically significant.

Another approach for further comparison of previous experiences of male and female students is to compare the most and least frequent activities in one group and the other, using as a criteria, as in the above paragraphs, the activities that are separated by more than one-half a standard deviation from the mean. A qualitative comparison of the lists of boys and girls reveals that many of the activities listed are shared by both genders; although they may be located in different positions of the table. The differences arise in a few activities, which are absent in one or the other gender, and in another small group of activities, where the differences in the respective positions are relatively far apart within this same group. Nevertheless, a table summarizing this type of results is very tedious and the data it reflects is very partial; therefore, the more systematic method of identifying the individual activities which were the cause of significant gender differences was preferred, directly comparing each activity for the boys' group and the girls' group.

Table IV. Items whose gender differences are statistically significant (p <0.01) and favorable to the female students, sorted by the effect size of the differences.

	Female			**Male**			**Effect size female-male**	**ANOVA**
	Mean	**No.**	**S. D.**	**Mean**	**No.**	**S. D.**		**Signif.**
G23	2.45	442	0.90	1.62	330	0.69	1.06	0.000
G02	3.13	442	0.96	2.14	331	0.97	1.03	0.000
G59	2.67	443	0.96	2.16	328	0.94	0.53	0.000
G60	2.97	439	0.88	2.50	328	0.93	0.52	0.000
G28	2.76	442	0.85	2.35	327	0.85	0.48	0.000
G51	3.65	442	0.71	3.26	329	0.96	0.47	0.000
G36	3.38	440	0.71	3.04	326	0.79	0.46	0.000
G05	2.48	441	0.95	2.05	330	0.96	0.45	0.000
G50	3.65	442	0.67	3.38	330	0.85	0.36	0.000
G46	3.63	443	0.65	3.39	330	0.77	0.34	0.000
G61	2.01	439	0.78	1.76	329	0.79	0.32	0.000
G49	3.33	441	0.76	3.15	327	0.75	0.24	0.001

The qualitative analysis of activities where male and female students differ most from each other sheds more light on the differential gender experiences that girls and boys bring to science class as hidden curriculum. Girls reported having participated in the following out-of-school activities with significantly greater frequency than the boys (see Table IV):

- 23. Knitted, sewed, etc;
- 2. Read my horoscope (telling future from the stars);
- 59. Baked bread, pastry, cake, etc;
- 60. Cooked a meal;
- 28. Cared for a sick relative or friend;
- 51. Sent or received an SMS (text message on mobile phone);
- 36. Used a camera;
- 5. Collected different stones or shells;
- 50. Used a mobile phone;
- 46. Used a calculator;
- 61. Walked while balancing an object on my head;
- 49. Used a measuring ruler, tape or stick.

These activities show a more even distribution by theme and less focus on the physics and technology themes than the boys' activities (as shown in the paragraphs below): Universe (read horoscopes); Geology (collected stones or shells); Physics (measuring, mobile phone, messages); Chemistry (making bread, cooking); Biology (caring for the sick).

Out-of-school activities that male students carried out with a significantly higher frequency than female students, listed from least to greatest favorable difference for boys, are the following:

- 22. Built things with wire;
- 47. Used a stopwatch;
- 35. Used binoculars or glasses;
- 20. Made compost of grass, leaves or garbage;
- 45. Connected an electric lead to a plug etc..;
- 53. Played computer games;
- 15. Watched nature programmes on tv or in a cinema;
- 41. Used a science kit (like for chemistry, optics or electricity);
- 42. Used a windmill, watermill, waterwheel, etc.;
- 25. Made a fire from charcoal or wood;
- 58. Opened a device (radio, watch, computer, telephone, etc.) To find out how it works;
- 40. Made a model such as toy plane or boat etc.;
- 69. Charged a car battery;
- 39. Used a water pump or siphon;
- 37. Made a bow and arrow, slingshot, catapult or boomerang;
- 63. Used a wheelbarrow;
- 64. Used a crowbar (jemmy);
- 18. Participated in fishing;
- 44. Changed or fixed electric bulbs or fuses;
- 67. Used tools like a saw, screwdriver or hammer;
- 65. Used a rope and pulley for lifting heavy things;
- 17. Participated in hunting;
- 68. Used a car jack;
- 66. Mended a bicycle tube;
- 38. Used an air gun or rifle.

Grouped by themes, these activities are related predominantly to physics and technology: Physics (binoculars, water pump, electric bulbs, electric outlets, stopwatch, wheelbarrow, crowbar, rope and pulley, mending a tire); Technology (building with wire, bow and arrow, air gun, models, windmill, computer games, open a device, use tools, carjack, charge battery); Chemistry (composting, fire); Biology (hunting, fishing); general activities (watch nature programs on TV, use a science kit). Qualitatively then, the most significant activities for the boys are focused on object manipulation and artificial devices.

In general, one can conclude that boys exhibit a greater frequency of experiences in out-of-school activities, for not only is their overall average frequency of activity higher than that of the girls, but, considering those activities where the boys report a significantly higher frequency than the girls, their number (25) is remarkably higher than the group of activities performed most frequently by the girls (12) (see Table V).

Table V. Items whose gender differences are statistically significant (p <0.01) and favorable to the male students, sorted by the effect size of the differences.

	Female			Male			Female-male effect	ANOVA
	Mean	**No.**	**S. D.**	**Mean**	**No.**	**S. D.**		**Signific.**
G22	1.81	442	0.78	2.01	331	0.91	-0.23	0.001
G47	2.72	443	0.94	2.97	329	0.89	-0.27	0.000
G35	2.09	436	0.91	2.35	327	0.99	-0.27	0.000
G20	1.45	436	0.75	1.73	326	0.91	-0.34	0.000
G45	2.75	438	1.11	3.10	327	0.93	-0.35	0.000
G53	2.85	442	0.94	3.18	330	0.93	-0.36	0.000
G15	2.53	443	0.87	2.83	329	0.82	-0.36	0.000
G41	1.60	436	0.75	1.93	325	0.88	-0.40	0.000
G42	1.40	438	0.65	1.73	325	0.90	-0.42	0.000
G25	2.28	438	1.00	2.71	327	1.00	-0.43	0.000
G58	2.33	443	1.03	2.78	330	0.98	-0.45	0.000
G40	1.72	439	0.76	2.21	330	0.96	-0.57	0.000
G69	1.36	441	0.80	1.89	329	1.03	-0.58	0.000
G39	1.58	436	0.75	2.11	327	0.95	-0.63	0.000
G37	1.88	440	0.92	2.48	330	1.00	-0.63	0.000
G63	1.85	438	0.82	2.43	328	0.97	-0.64	0.000
G64	1.70	438	0.74	2.23	328	0.90	-0.65	0.000
G18	1.89	443	0.90	2.53	329	0.99	-0.68	0.000
G44	2.03	441	0.91	2.71	328	0.92	-0.74	0.000
G67	2.37	441	0.85	3.02	328	0.86	-0.75	0.000
G65	1.47	437	0.72	2.10	327	0.96	-0.75	0.000
G17	1.22	443	0.56	1.88	331	1.05	-0.82	0.000
G68	1.28	441	0.57	1.98	328	1.01	-0.89	0.000
G66	1.62	442	0.76	2.50	330	1.07	-0.95	0.000
G38	1.39	442	0.71	2.42	330	1.08	-1.15	0.000

In some specific items, the effect size of gender differences is unusually large (about one standard deviation), both in favor of the male as well as the female students. For two items, there is a very great effect size that favors the girls, that is, the girls far exceed the boys in their experience:

- 23. Knitted, sewed, etc.;
- 2. Read my horoscope (telling future from the stars);

In contrast, there is a very large effect size in favor of the boys for the following four items, in which they greatly surpass the girls in their experience:

- 17. Participated in hunting;
- 68. Used a car jack;
- 66. Mended a bicycle tube;
- 38. Used an air gun or rifle.

The qualitative analysis of the social significance of the group of activities that are significantly more frequent for one gender group than the other reveals a very striking characteristic. It is clear that, together, the experiences reported by the students reflect a certain maintenance and transmission of gender roles and social stereotypes in the activities themselves. Thus, whereas the girls carry things on their heads, sew, knit, cook and care for people more than the boys, the latter, in contrast, reflect the stereotype of the hunter, fisherman and domestic handyman who uses and manipulates tools, cords, equipment, etc. Therefore, the strength of social gender stereotypes emerges as a powerful determinant and regulator of out-of-school S&T experiences.

From the perspective of the different themes in which the experiences can be grouped, male students surpassed the female students quantitatively in physics and technology activities; still, it should be noted that the girls outperformed the boys in some of the activities in these two groups, such as measurements, the use of cameras, calculators and mobile phones. Girls also surpass boys in themes pertaining to the universe, with a very significant effect size of nearly one standard deviation (Table III).

Certainly, the difference observed in the interest in horoscopes is not unrelated to the difference in this theme.

In summary, although the results of gender differences in out-of-school experiences are not significant overall, still, the more detailed qualitative analysis reveals some interesting differences, which lead to a suspicion of the influence of social gender stereotypes on them. These stereotypes could be summed up as "DIY boys" and "cook and care for people girls"; nonetheless, the incorporation of women in the world of science can also be perceived in the study, in the themes of the universe and technology, where, as already mentioned, the females even surpass the males in some aspects.

3.3. Differences between science students and other students

The election (or not) of a science subject (the class in which the questionnaire was administered) is also expected to be a pertinent indicator for analyzing out-of-school experiences. Overall, the average frequency of activities of students who did not elect to take a science class (2.28; S.D. 0.92) is lower than that of those who did choose science (2.41; S.D. 0.90), and the difference on this global parameter is perched on the very edge of statistical significance. This indicator allows us to conclude that science students participate in the activities on the list more often, overall, than students who choose not to study science.

One way to further compare the previous experiences of *science students* and *non-science students* would be to generate lists of *the most and least frequent* activities in one group and the other, using as criteria the separation from the upper average of one-half a standard deviation. On these lists, many of the activities included for both groups match, although they appear in slightly different positions on the lists; the few that comprise the difference may be absent from one list or the other, making their identification more complicated. Only a few are on both lists, in positions relatively remote from each other.

As in the case of the gender differences, consulting these comparative lists is very tedious and, for the purpose of identifying differences, the data they reflect is very partial, since they only refer to a small percentage of items. We therefore preferred the more systematic method of identifying those activities which directly caused significant differences between the two groups.

Table VI. Items with a statistically significant difference between students who choose to study science and those who do not (p < 0.01), sorted by the effect size of the differences

	Science students			**Non-science students**			**Effect size science-non-science**	**ANOVA**
	Mean	**No.**	**S.D.**	**Mean**	**No.**	**S.D.**		**Signific.**
G56	2.90	420	1.15	2.56	346	1.20	0.28	0.000
G30	2.90	419	0.93	2.64	346	0.92	0.28	0.000
G10	2.54	423	0.87	2.31	350	0.78	0.28	0.000
G38	1.96	422	1.09	1.68	350	0.91	0.28	0.000
G57	3.06	419	0.95	2.79	347	1.04	0.27	0.000
G41	1.84	419	0.86	1.62	342	0.77	0.27	0.000
G52	3.42	422	0.82	3.20	350	0.89	0.25	0.000
G45	3.01	420	1.04	2.76	345	1.05	0.25	0.001
G48	2.93	422	0.88	2.72	350	0.87	0.24	0.000
G01	2.43	423	1.00	2.20	351	0.89	0.24	0.000
G42	1.62	418	0.81	1.44	345	0.73	0.24	0.003
G33	1.99	421	0.93	1.78	346	0.84	0.24	0.003
G11	2.28	422	0.87	2.08	350	0.83	0.23	0.005
G58	2.63	423	1.01	2.39	350	1.05	0.23	0.001
G03	2.32	421	0.90	2.12	348	0.85	0.22	0.004
G39	1.89	416	0.91	1.70	347	0.84	0.22	0.003
G27	2.52	422	1.00	2.31	348	0.97	0.21	0.003
G08	2.84	420	0.92	2,64	349	0.99	0.21	0.002
G55	2.87	422	1.18	2.62	349	1.22	0.21	0.003
G65	1.82	416	0.92	1.64	348	0.84	0.20	0.002
G44	2.41	422	0.97	2.22	347	0.97	0.19	0.005
G66	2.09	422	1.00	1.89	350	1.00	019	0.001
G07	2.15	422	1.02	1.97	348	0.95	0.19	0.010
G12	1.53	422	0.87	1.38	349	0.75	0.18	0.020
G43	3.31	420	0.83	3.16	349	0.85	0.18	0.007
G13	1.56	423	0.84	1.41	351	0.75	0.18	0.022
G14	2.52	421	0.89	2.37	350	0.88	0.18	0.005
G64	1.99	418	0.87	1.85	348	0.84	0.17	0.002
G36	3.29	417	0.75	3.17	349	0.78	0.17	0.010

The qualitative analysis of activities in which the science and non-science students significantly differ sheds more light on the differential experiences that each group brings to science class, perhaps as hidden curriculum. Listed in order of least to greatest difference in favor of the science students, the out-of-school activities in which science students participate with a significantly greater frequency than the non-science students are the following (see Table VI):

- 56. Sent or received e-mail;
- 30. Seen an X-ray of a part of my body;
- 10. Visited a zoo;
- 38. Used an air gun or rifle;
- 57. Used a word processor;
- 41. Used a science kit (like for chemistry, optics or electricity);
- 52. Searched the internet for information;
- 45. Connected an electric lead to a plug etc;
- 48. Measured the temperature with a thermometer;
- 1. Tried to find the star constellations in the sky;
- 42. Used a windmill, watermill, waterwheel, etc.;
- 33. Been to a hospital as a patient;
- 11. Visited a science centre or science museum;
- 58. Opened a device (radio, watch, computer, telephone, etc.) to find out how it works;
- 3. Read a map to find my way;
- 39. Used a water pump or siphon;
- 27. Sorted garbage for recycling or for appropriate disposal;
- 8. Watched an animal nurse its young;
- 55. Downloaded music from the internet;
- 65. Used a rope and pulley for lifting heavy things;
- 44. Changed or fixed electric bulbs or fuses;
- 66. Mended a bicycle tube;
- 7. Watched the incubation of an egg;
- 12. Milked animals like cows, sheep or goats;
- 43. Recorded on video, DVD or tape recorder;
- 13. Made dairy products like yoghurt, butter, cheese or ghee;
- 14. Read about nature or science in books or magazines;
- 64. Used a crowbar (jemmy);
- 36. Used a camera.

The number of experiences where science students reported a significantly higher frequency of activity than the non-science students is very large (nearly half the total list). Grouped by themes, these activities are: Universe (constellations) Geology (map reading); Physics (binoculars, camera, water pump, light bulbs, electrical connections, electrical outlets, stopwatch, thermometer, measuring tape, wheelbarrow, crowbar, pulley, mend tire); Technology (build with wire, air gun, models, windmill, recordings, computer games, downloading music, e-mail, word processor, open a device, Internet); Chemistry (recycling); Biology (watched the birth of an animal, incubation, watched an animal nurse, zoo, milk an animal, make dairy products, grow plants, X-ray, hospital, microscope); General themes (read science books and magazines, visit science museum, use science kit).

In general, there is a prevalence of previous experiences related to technology, physics and biology, a result which in itself would not reflect any special circumstance, except perhaps as a purely numerical and proportional parameter, because these three groups also have the largest number of items, so it might simply be amplifying a general effect favorable to the science students.

The effect size of the differences between the science group and the group that chose not to study science is relatively small for all items. The most notable aspect of the differences between those who selected some science subject and those who did not is the qualitative and quantitative extension of the differences: the former have greater experience in nearly all 69 items on the list. This difference is statistically significant in almost half of them. In contrast the non-science group does not present a single item where their experience is significantly greater than that of the science group.

The differences in relation to the different themes are also in favor of the science students, although the effect size continues to be moderate or small; it is highest in technology, physics and biology (Table III). Thus, even though the differences are not particularly noteworthy in any theme, the qualitative differences are indeed quite large in the vast majority of the themes, conferring on students' out-of-school experiences the character of hidden curriculum, an indicator and inducer to science and technology.

In short, the frequency of out-of-school previous experiences seems to have a definite consequence in the selection of a science course at the end of compulsory education: the students that chose to study a science subject have a superior background of previous experiences in all aspects than those who choose not to study science. These results do not show whether the students' out-of-school experiences are the cause of their choice of science or not, but they certainly furnish a profile and a sharp border: the students who decide not to study science have an out-of-school experience that is clearly inferior in relation to those who choose to study science. Hence, regardless of whether students' early out-of-school experiences are a determining factor or not for the future choice of scientific studies, such experiences should be promoted by all possible means, in-school and out-of-school, as a compensatory measure. In particular, in primary and secondary education, students should find in the science classroom an inexhaustible source of experience for their daily lives that would stimulate their curiosity and their contact with those experiences which will, in the long run, influence their interest in science.

3.4. Differences according to the number of books in the home

The differences according to the number of books in the home are complicated to analyze, because the encoding of the original variable (*books)* has seven categories and a very unequal number of individuals is assigned to each one of them. Under these conditions, the analysis of statistical difference would only indicate that at least two of these groups have significant differences between them. More interesting than the mere significant differences would be the type of variation observed in the frequency of activities over the entire range of categories of numbers of books in the home, whether monotonous (increasing or decreasing) or irregular; however, with seven groups, this variation is difficult to interpret. Although a correlational analysis might be considered (though the merely ordinal nature of the rating scale with only four points does not make this plausible), we opted for the same analysis of variance. To this end, we collapsed the original variable into a new variable of only four groups (few books, some books, quite a lot of books and many books). With this greater balance in relation to the sample and with fewer groups, the analyses of variance were performed on these four groups of the new variable (comparison between pairs of groups).

Table VII. Descriptive statistics and statistical significance (ANOVA) for items whose differences, according to the number of books in the home, are statistically significant ($p < 0.01$), in order of the effect size of the differences

	Few books			**Some books**			**Quite a lot of books**			**Many books**			**ANOVA**
	Mean	**No.**	**S.D.**	**Mean**	**No.**	**S.D.**	**Mean**	**No.**	**S.D.**	**Mean**	**No.**	**S.D.**	**Signif.**
G27	2.06	32	0.88	2.17	295	0.98	2.57	355	0.96	2.88	85	0.96	0.000
G46	2.88	33	0.99	3.49	297	0.74	3.59	355	0.65	3.68	85	0.58	0.000
G59	2.00	33	0.97	2.37	296	0.97	2.49	354	0.96	2.78	85	1.02	0.000
G47	2.30	33	1.05	2.79	296	0.93	2.87	355	0.89	3.04	85	0.89	0.001
G57	2.38	32	1.04	2.89	294	1.07	2.99	352	0.95	3.14	85	0.86	0.001
G05	2.15	33	1.00	2.15	297	0.96	2.38	352	0.98	2.55	86	0.93	0.002
G19	2.42	33	1.12	2.37	297	0.90	2.48	355	0.92	2.80	86	0.84	0.002
G32	2.00	31	1.10	1.57	296	0.87	1.66	349	0.89	1.93	85	1.01	0.002
G03	1.85	33	0.83	2.16	295	0.92	2.28	353	0.82	2.44	85	0.97	0.003
G48	2.45	33	0.94	2.79	297	0.88	2.86	355	0.88	3.07	84	0.79	0.004
G24	2.12	33	0.93	2.29	296	0.95	2.45	354	0.97	2.64	85	0.96	0.006
G52	2.94	33	0.97	3.25	296	0.91	3.41	355	0.77	3.35	85	0.90	0.006
G01	1.94	33	0.90	2.24	297	0.96	2.40	355	0.96	2.42	86	0.93	0.013

Only a few items of out-of-school experiences have significant differences depending on the number of books in the home (see Table VII). In the vast majority of these (with the exception of the G19 and G32 experiences), there is also a pattern of increasing monotony between the groups that have books and a greater frequency of out-of-school experiences; in other words, as the number of books in the home increases, the frequency of reported activities also increases. The content of the experiences with significant differences and a monotonous increase in relation to the number of books in the home are the following:

- 27. Sorted garbage for recycling or for appropriate disposal;
- 46. Used a calculator;
- 59. Baked bread, pastry, cake, etc;
- 47. Used a stopwatch;

- 57. Used a word processor;
- 5. Collected different stones or shells;
- 3. Read a map to find my way;
- 48. Measured the temperature with a thermometer;
- 24. Put up a tent or shelter;
- 52. Searched the internet for information.

As can be seen at first glance, these activities are very diverse and pertain to many different themes. If we agree to consider the number of books in the home as an indicator of the cultural level of the family, some of these activities–such as searching the Internet, word processing or making collections–could plausibly be interpreted as being related to a higher household cultural level in the strictest academic sense; still, others such as baking, setting up a tent or reading a map could hardly be explained with an interpretation of this nature.

These results establish that previous S&T experiences are only weakly related to the number of books in a home, and that this relationship is predominantly positive in the case of items with the most significant differences. The number of books variable is a modest indicator of out-of-school experiences; the dozen variables of experiences that show significant differences are an indicator that supports a moderate significance of the variable of books in the home on the out-of-school experiences.

IV. Discussion

The experiences that students pursue in their daily life outside of school form a previous parallel background, often hidden (or ignored) by the school, which appears insensitive to them, but they are the source of previous ideas that continually interact with the construction (or reconstruction) of school learning. From a constructivist approach to learning, it seems reasonable to argue that students' previous science-related out-of-school experiences affect school learning of science and technology. In the case of an intense and enriching experience, it facilitates school S&T learning, whereas in the case of inadequate or deficient experiences, they hinder it. In the latter case, especially in compulsory, universal education and a humanistic scientific education, focused on scientific literacy, the school should play a compensatory role in relation to the initial inequalities among students, as a guarantee of genuine equality of educational opportunities (Acevedo, Vázquez and Manassero, 2003).

This study helps to reveal this hidden background, giving voice to the protagonists—the students—in order to clarify the intensity and diversity of the previous experiences that students bring to school. In general, the analysis of the students' out-of-school experiences offers interesting elements for the teaching of science, as a general indicator of attitudinal disposition to S&T. The main results obtained show that the greatest differences do not appear as a social indicator (the number of books in the home) or an indicator of interest (electing to study a science subject)—where the detected differences are certainly visible, although minor or moderate—but specifically as the gender variable.

The results demonstrate that boys and girls have a background of science-related experiences that are clearly different, both qualitatively and quantitatively. This difference intensely reflects social gender stereotypes translated into the well-known gender brand of science ("DIY boys" and "cook and care for people girls"). From the perspective of science teaching, this differential background is very important, because it can dramatically condition school learning of science for male and female students. If the organization of school science education is more in line with the male pattern of previous experiences (DIY) as some studies suggest (Barton, 1998; Brickhouse, 1998; Jiménez and Álvarez, 1992), it will be encouraging science learning in the boys while discouraging girls' interest in science as well as their learning of it. This differential background may also explain some of the indicators of gender differences in science which are common in evaluation studies, such as female students' inferior school performance and poorer attitudes toward science compared with male students; less interest in science in general on the part of girls, as well as girls' flight from scientific and technical studies, in which the incompatibility of school science and females is discerned (Farenga and Joyce, 2000; Sahuquillo, Jiménez, Domingo and Álvarez, 1993).

The heavy burden of gender stereotyping is manifest in the dominant and differential experiences of each of the genders. Presumably, the gender differences in out-of-school S&T experiences can be an (additional) indicator of the different socialization of girls and boys from birth, through the action of gender roles and stereotypes in society, whose influence on young people can determine the very different previous S&T experiences of girls and boys and the subsequent implications for the learning of science and technology.

In the teaching of science—which seems to favor males to the detriment of females—and faced with the reality of gender inequity with its social roots, the school must strengthen its role in compensating for initial inequalities. This compensatory function could be accomplished by:

- "Girl-friendly" S&T curricula that take into account the experiences of girls (Rosser, 1997; Smail, 1991).
- The explicit compensation of the deficit of girls whose profile shows insufficient previous experiences (McCormick, 1994; Rubio, 1991; Willis, 1996).

This study provides sufficient data and evidence for an innovative approach to science curriculum that takes both of the above issues into account, facilitating the design of a science curriculum focused more on previous experiences in general and more gender balanced in particular. One possible design approach would be to develop the experiences most frequently detected in girls as key motivational elements while the experiences in which the girls are deficient could guide the development of compensatory curriculum and classroom activities (selecting examples, materials and motivational or compensatory elements) to better accommodate girls in science class. In both cases, not only would the boys not be adversely affected, but they could also benefit, in turn, by compensating their own group imbalances in relation to science and technology.

Informal out-of-school experiences not only provide extra initial support for school learning (Lucas, McManus and Thomas; 1986; Tamir, 1990; Rix and McSorley, 1999), but can also be a relevant indicator of general attitude towards science and technology (greater previous experience would indicate a better attitude and more interest in S&T). The school must interrelate both ways of learning, informal and academic, to avoid disconnection or fragmentation between the achievements of one context and the other, or even, possible conflicts between them (Wellington, 1991).

Furthermore, there is increasing evidence that the contexts that offer informal out-of-school experiences contribute to science learning; they improve not only the learning of more traditional features of school science (e.g., the development and integration of concepts, authentic and comprehensive practical work and access to up-to-date materials and high-level science), but also more generic, basic, attitudinal and social dimensions, such as personal development, responsibility, socialization and attitudes towards school science, which help stimulate further learning (Braund *et al.*, 2004). Formal science teaching should revisit aspects of informal learning, in order to supplement, enrich and improve the science education that is usually offered in the more formal classroom situation (Griffin, 1998; Oliva *et al*., 2004).

Today we observe increasingly significant efforts to promote, coordinate and integrate the growing influence of out-of-school education, informal and non-formal, with school education. Some examples are: the Center for Informal Learning and Schools under the Exploratorium of San Francisco (http://www.exploratorium.edu/cils/documents/bridging_k12-isi.pdf), the Center for Integrating Out-of-School Learning into the School Curriculum of Israel, (http://www.weizmann.ac.il/acadaff/Scientific_Activities/current/Davidson_center.html), the program “Science Linkages in the Community” (SLIC) of the American Association for the Advancement of Science (http://www.aaas.org/programs/education/slic), the program of the Coalition for Science After School (http://qt.exploratorium.edu/csas/) or the Michigan Gateways Guide of the state of Michigan (http://www.gateways.msu.edu/203pn.html).

The European Union has recently recognized the educational value of non-formal and informal education in young people’s contexts: non-formal and informal activities can provide significant value to society, to the economy and to young people themselves; they are effective instruments of the educational process that make learning attractive; they promote a disposition in young people to lifelong learning, social integration, the acquisition of new knowledge, skills and competencies; and they contribute to their personal development, social inclusion and active citizenship, thereby improving their employability (Council of Europe, 2006). Consequently, the European states are invited to promote formal and informal activities and to recognize the competencies and knowledge acquired by young people through non-formal and informal education.

The design of curricula and school practices that compensate for potential initial inequality is a necessary condition for building a school that is more inclusive in science and technology, especially for female students. This is in line with the proposed target of the European Council of Education for the year 2010, namely:

> Increase by at least 15% the total number of college graduates in mathematics, science and technology, reducing, during the same period, the imbalance in the representation of men and women. (UNESCO-OCDE-Eurostat questionnaire, quoted in Council of Europe, 2003).

In summary, schools should give priority to innovations for achieving a more equitable curriculum (Vázquez, Acevedo and Manassero, 2005) and, in particular, for achieving true gender equity in the sciences, as one aspect of a real contribution to the building of a more inclusive general education, for science and technology as well.

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