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ESTUDIOS / *RESEARCH STUDIES*

Public Perception of Citizen Science in Spain: Sociodemographic Analysis

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Abstract: This study analyzes the public's view of citizen science based on survey respondents' expressed knowledge, attitudes, and motivations. The questionnaire was answered by 1,002 residents of 48 Spanish cities. The study population was 50% female and spanned various age groups, occupations, and levels of education. The results indicate that although the population has a quite favorable opinion of citizen science, people feel underinformed about it. Very few respondents consider it to be negative and many expect it to have a positive impact over the coming decade. While both men and women exhibit intrinsic motivations to participate in citizen science, women specifically exhibit social motives for contributing. The data reveal differences in respondents' attitude to citizen science depending on gender, age, level of education, and occupation. The data suggest that incorporating a balanced and representative sample of the public into scientific endeavor will require greater institutional intervention in coming years.

Keywords: citizen science, open science, public participation, knowledge, attitudes, motivation.

Percepción pública de la ciencia ciudadana en España: Análisis sociodemográfico.

Resumen: Este estudio analiza la visión del público general sobre la ciencia ciudadana basándose en los conocimientos, actitudes y motivaciones expresados por los encuestados. Un cuestionario específico fue respondido por 1.002 residentes de 48 ciudades españolas. La población de estudio, 50% mujeres, abarcó varios grupos de edad, ocupaciones y niveles de educación. Los resultados indican que los ciudadanos se sienten desinformados aunque tienen una opinión bastante favorable sobre la ciencia ciudadana; muy pocos encuentran aspectos negativos y muchos esperan un impacto positivo de la ciencia ciudadana. Si bien tanto hombres como mujeres informan motivaciones intrínsecas para participar en proyectos científicos, las mujeres añaden motivaciones sociales. Los datos revelan diferencias en la visión de los encuestados hacia la ciencia ciudadana según el género, la edad, el nivel educativo y la ocupación. Los datos sugieren que incorporar una muestra equilibrada y representativa de ciudadanos a proyectos científicos requiere una mayor intervención institucional.

Palabras clave: ciencia ciudadana, ciencia abierta, participación ciudadana, conocimiento, actitudes, motivación.

1. INTRODUCTION

In today's complex world, policy decisions increasingly depend on the knowledge generated by a highly specialized science and technology elite whose expertise is beyond the comprehension of the general public. In democratic societies this can create problems of legitimacy between voters and their elected representatives if the former do not understand the reasoning behind the decisions made. To resolve this contradiction between democratic participation and specialized expert knowledge, citizen engagement with science is sought through public involvement in its production (Weingart et al., 2021). Accordingly, public participation in science, or *citizen science*, is growing rapidly and is being recognized by governments and science funding agencies as a promising potential solution to issues affecting the relationship between science and society. Firstly, it can advance science by accelerating research and data collection in processes requiring high volumes of observations. Secondly, by educating the public and shaping its perception of science it improves society's scientific knowledge and, through greater involvement in the research process, promotes trust in and engagement with science. Finally, its democratizes science, since involving society in the process better reflects the population's diversity and interests regarding the matters addressed (Strasser and Haklay, 2018).

To foster public engagement with science it is necessary to understand the psychosocial processes —the knowledge, attitudes, and motivations— that drive voluntary public participation in science. Identifying these processes would make it possible to promote the necessary public participation in the entire research process, thus fulfilling one of the fundamental purposes of open science as recommended by UNESCO (2021). No studies are available analyzing how citizens address this issue of citizen science in Spain. The closest precedent is the two-yearly report published by the FECYT (Fundacion Española de Ciencia y Tecnología) science and technology foundation tracking Spaniards' science-related knowledge, attitudes, and conduct, but which does not specifically address the topic of citizen science. To advance understanding in this field and drive its development, it is therefore considered relevant to ask the public specifically about their knowledge of and attitudes to citizen science. The FECYT reports have thus provided a point of reference for this research, given that in the absence of specific studies on the factors that may influence Spaniards' view of citizen science, the data obtained in the 2022 survey —such as the scant interest in science in general, the negligible appreciation of it, and the general unwillingness to participate in science projects— form the basis of some of the hypotheses put forward in this paper regarding citizen science.

Regarding public motivation to participate in science programs, most research has focused on analyzing the motivation of those who volunteer to contribute to research projects. This field of research on the experience of participants in research projects is relatively new and not very developed. It is usually based on studies, conducted in other disciplines within the social and health sciences, on the characteristics of volunteers. These studies therefore use methods pertaining to these social sciences, such as surveys or in-depth interviews, where respondents are asked to express their level of agreement with a list of statements about their motivation and to indicate which ones are most important for them (Land-Zandstra et al., 2021). West and Pateman (2016) proposed combining these questions with various motivation categories such as those defined by Finkelstien (2009), who distinguished between volunteers' intrinsic motivations (e.g., for personal fulfillment) and extrinsic ones (e.g., seeking to achieve another objective through participation, for example, finding another job).

Looking beyond motivation, several studies show that an interest in science and a willingness to contribute to the production of knowledge are two important factors for participation (Everett and Geoghegan, 2016). Other aspects are also mentioned, such as personal fulfillment or motivation due to the specific characteristics of the project they are participating in, especially in the health and environment areas (Chia-Hsuan and TeEn, 2021; Lehman et al., 2020). Other studies examine sociodemographic variables and the interaction between them to determine the probability of participating in research projects or of repeating the experience (Pateman et al., 2021; Asingizwe et al., 2020).

While the studies reviewed refer mainly to volunteers who have participated in science initiatives, little is known about how the general public —not only members who have participated in specific projects— perceive and value citizen science, or about their possible motivations for contributing to it. The authors of this paper therefore consider that the data and the findings it sets out may also make an important contribution to understanding the development and implementation of citizen science in Spain.

2. OBJECTIVES

As already mentioned, and given the prospect of members of the public becoming increasingly important contributors within the research ecosys-

tem —as envisaged by both European and Spanish legislation— the general objective of this study is to analyze the Spanish public's view of citizen science based on the information that survey respondents provide regarding their knowledge, attitudes, motivations, and personal experience in relation to science. The specific objectives (SOs) and the hypotheses associated with them are briefly detailed below.

SO1: To identify the extent of public knowledge about citizen science. Hypothesis: Since citizen science is a recent label, especially in nonacademic contexts, the public has little knowledge of it.

SO2: To analyze respondents' opinion of citizen science and their assessment of it and its consequences. Hypothesis: The assessment will be positive, as it is considered a form of science.

SO3: To identify the degree of participation in citizen science projects. Hypothesis: A small percentage of citizens will have personal experience of this type of project. Additionally, and to expand knowledge on the topic, respondents will be asked if they would be willing to participate, if they know others who have participated, if they perceive participating in this type of project in a negative light, and if they intend to donate money to science programs.

SO4: To analyze the motivational factors associated with potential participation in citizen science projects. Hypothesis: Intrinsic motivation will be a more salient factor than extrinsic motivation in explaining participation.

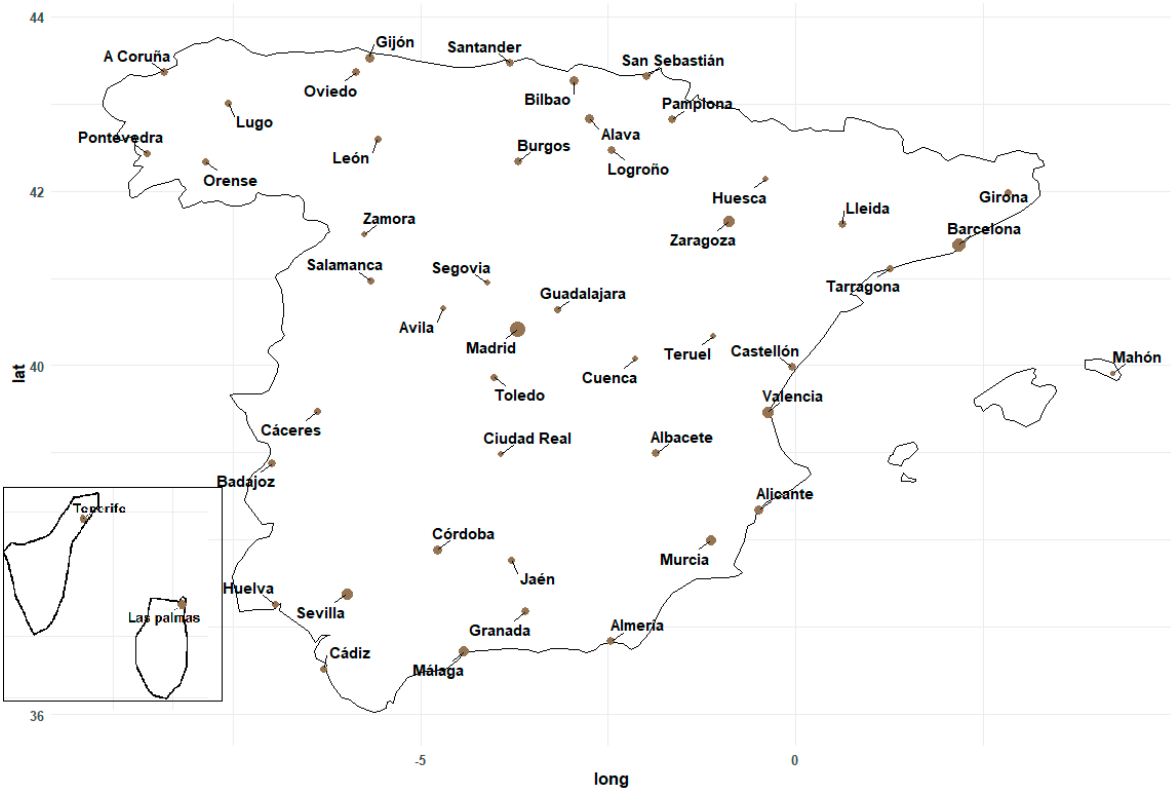
SO5: To analyze the public's assessment of the impact of citizen science. Hypothesis: The assessment of the impact will be positive, given that it can be considered a type of science.

SO6: To analyze the public's knowledge of and interest in science in general and their opinion of the investment made in science and its dissemination. Hypothesis: The evaluations will be positive.

SO7: To analyze the variables studied, considering the sociodemographic profiles of the respondents (gender, age, level of education, occupation, and place of residence) to identify possible differences based on these sociodemographic variables.

This article seeks to analyze these objectives through the opinions collected from a large sample of Spaniards drawn from across Spain and from all social strata.

Figure 1. Map indicating the cities where the survey was conducted.



3. MATERIALS AND METHODS

3.1. Sample

The sample comprised 1002 subjects, 50% of whom were female. Average female age was 39 and average male age was 53. By level of education, 53% of females and 45% of males held university-level qualifications. Study respondents were drawn from 48 cities located throughout Spain's 17 autonomous communities. A map indicating the cities where the survey was conducted is attached.

3.2. Data Collection Procedure and Instrument Employed

To obtain a representative sample of the population, Netquest was commissioned to identify and select men and women from various cities throughout Spain. Selection criteria included age and gender quotas and considered size of city of residence to ensure proper representation of these percentages in our sample. Respondents were assigned to one of 5 preestablished age groups and completed a questionnaire (see in https://doi.org/10.5281/zenodo.6509944) drawn up specifically for this study and made available via the SIDE platform.

The questionnaire was designed to collect information about the general public's knowledge, attitudes, and motivation relating to citizen science and to examine their perceptions of science and technology in general. The questionnaire was divided into 3 parts: part one provides information about the project encompassing the questionnaire and explains the scope of the collaboration requested, part two comprises a series of questions on respondents' sociodemographic variables (gender, age, level of education, current employment, occupation, and region and province of residence), and part three comprises 36 questions relating to the variables analyzed in the study (knowledge and opinion of citizen science, motivation to participate in citizen science projects, estimated impact of citizen science, and negative elements perceived about citizen science). The questionnaire also assessed respondents' willingness to participate in citizen science projects, to make financial contributions to science initiatives, their prior experience in this type of project, and their opinion of science in general. The questionnaire was administered online and analyzed throughout 2022.

3.3. Data Analysis

To address the objectives and hypotheses of this research, the dimensionality of the questionnaire was first analyzed using the Mplus 8.0 software (Muthén & Muthén, 1998-2017). KMO statistics were extracted and Bartlett's test was performed to assess the compatibility of the scales and the factor analysis technique. Given that the variables collected in the questionnaire are categorical and the sample broad enough, the weighted least square mean and variance adjusted method (WLSMV) was employed. The number of factors was determined by parallel analysis using principal component analysis and the psych library for the R programming language (Revelle, 2022).

Absolute fit indices χ^2 and SRMR, the RMSEA parsimony-adjusted index, and the CFI and TLI comparative fit indices were employed. To assess the model's fit quality, the criteria established by Hu and Bentler (1998) and Brown (2015) were adopted, according to which RMSEA indicates a model is a good fit for the data when RMSEA ≤ 0.06, CFI and TLI ≥ 0.95, and SRMR ≤ 0.08. The reliability was estimated with Cronbach's alpha coefficient. T-tests and ANOVA were used to compare population means, and proportions were compared with statistical test χ^2. To address the objectives, the data from the 1002 responses were analyzed descriptively and inferentially using the IBM SPSS v26 software when comparing populations (i.e., the sociodemographic profile of gender, level of education, age, etc.).

4. RESULTS

SO1–SO2. Knowledge, Opinion

In line with Hypothesis 1, respondents feel underinformed about citizen science (mean = 1.85, SD = 0.903). The most frequent categories on how informed they feel are *Not at all* and *Very little* (77.5% of all respondents). Only 5% (*Quite* + *Very*) feel they are informed about citizen science.

Hypothesis 2, which anticipates a positive opinion of citizen science, is supported by the data (mean = 3.55, SD = 0.762). Very few people have a negative opinion of citizen science (only 5.4% perceive it either very negatively or negatively), 55.0% perceive it favorably and almost 40% are indifferent. Additionally, the majority (80.9%) do not perceive any potential negative aspects derived from citizen science.

SO3. Participation

Table I shows the results of Hypothesis 3. The vast majority of respondents have never participated in science projects (85.2%) nor know anyone who has (91.5%). The distribution of cases is much more uniform when asked if they are willing to

voluntarily participate in a citizen science project. A total of 309 respondents would be *Quite* or *Very willing* to participate (30.9%) while 306 respondents would be *Not at all willing* or *Largely unwilling* (30.6%). In relation to the willingness to make selfless donations, more respondents were *Not at all willing* and *Largely unwilling* (n = 501; 50.0%) than *Quite* or *Very* (n = 169; 16.9%) willing.

S04. Motivation to Participate

Exploratory factor analysis was conducted on the 6 questions on the reasons that would lead respondents to participate in a citizen science project (scale from 1 to 5). The data suggest a common structure (KMO = 0.796; Barlett χ^2 (15), $p < 0.001$). The results suggest the existence of two factors: χ^2 (4) = 22,660, p = 0.0001; RMSEA = 0.068 CI 95% [0.043–0.114]; CFI = 0.998; TLI = 0.992; SRMR = 0.014. Parallel analysis also suggests the existence of two factors that, given the nature of the factor loadings and the question contents, may be termed *intrinsic motivation* and *extrinsic motivation*. The correlation between the two factors was 0.371 ($p < 0.001$), indicating a moderate and positive relationship between the two motivations. Factor loadings and estimated internal consistency reliability are shown in Table II.

The mean and standard deviation of the two types of motivation were also calculated. In line with Hypothesis 4, intrinsic motivation showed a clearly higher mean than extrinsic motivation (t (1001) = 32.326, $p < 0.001$, d = 1.021) with a large effect size. In absolute scale terms, while extrinsic motivation had a mean of 2.638 (CI 95% [2.584–2.692]) versus the theoretical mean of 3, intrinsic motivation had a mean of 3.619 (CI 95% [3.559–3.679]).

SO5. Impact of Citizen Science

Exploratory factor analysis was conducted on the 12 questions related to the positive current or future impact of citizen science (scale from 1 to 5). The data suggest a common structure (KMO = 0.967; Barlett χ^2 (66), $p < 0.001$). While parallel analysis suggests the existence of two factors,

Table I. Participation on citizen science.

		Yes		No	
Participation in science projects		150 (15%)		852 (85%)	
I know people (relatives, friends, acquaintances) who have participated		85 (8.5%)		917 (91.5%)	
	Not at all Willing	Largely unwilling	Somewhat	Quite	Very Willing
Willing to voluntarily and altruistically participate in a science project	115 (11.5%)	191 (19.1%)	387 (38.6%)	218 (21.8%)	91 (9.1%)
Willing to include science among my selfless money donations	222 (22.2%)	279 (27.8%)	332 (33.1%)	122 (12.2%)	47 (4.7%)

Table II. Factorial loadings for the two-factor solution for motivation variables.

	Intrinsic motivation	**Extrinsic motivation**
Material or monetary incentives	0.290**	0.423**
Public recognition (e.g. being mentioned in the project)	-0.003	0.956**
Having people I know also participating in the project	0.229**	0.463**
Believing my contribution will help society	0.894**	-0.089**
Finding the study subject matter of interest	0.865**	0.010
The project's objective is to solve specific problems that affect my community	0.905**	0.003
Cronbach's alpha	0.889	0.667

Note: *== $p < 0.05$; ** = $p < 0.01$

the factor solution shows a correlation of 0.885 between them, which is excessive in terms of discriminant validity (it is difficult to distinguish between the two factors). The three-factor solution shows that the high loadings of the questions are concentrated on a single factor. The one-factor solution appears to be the most appropriate and has reasonable fit indices, although it is somewhat modest for RMSEA: χ^2 (54) = 468.537, $p < 0.001$; RMSEA = 0.088 CI 95% [0.080–0.095]; CFI = 0.982; TLI = 0.978; SRMR = 0.027. The scale has an internal consistency of 0.945. The factor loadings and the internal consistency of the scale are shown in Table III. It is evident that the observed indicators (questions) are reliable measures of the construct given that the loadings are all above 0.70. The internal consistency of the scale is also very high. The data also support Hypothesis 5 and show that respondents have a positive view of the impact of citizen science over the coming years (mean = 3.42, SD = 0.81).

Table III. Factor loadings for the one-factor solution for the impact variables relating to citizen science over the next 10 years

	Impact
Public interest in science and technology	0.847**
Public participation in science and technology activities	0.818**
Public knowledge of science and technology matters	0.830**
Social pressure on public authorities to increase funding of science and technology	0.774**
Social prestige of scientists and technologists	0.751**
People's capacity to set science and technology policy objectives	0.786**
Social impact of science and technology	0.826**
Increase in financial profitability of science and technology developments	0.807**
Increase in jobs as a result of more efficient science and technology policy	0.800**
Improvement in assessment methods of science and technology projects	0.806**
Welfare and happiness of society as a whole	0.807**
Advances in science and technology knowledge	0.823**
Cronbach's alpha	0.945

Note: * = $p < 0.05$; ** = $p < 0.01$

SO6. Opinion of Science and Technology

The dimensionality of the 7 questions related to science and technology was analyzed. Parallel analysis suggests the existence of two factors. The fit indices for this solution showed acceptable values: χ^2 (8) = 29.330, $p < 0.001$; RMSEA = 0.052 CI 95% [0.032– 0.072]; CFI = 0.993; TLI = 0.982; SRMR = 0.019. The factors were termed *Knowledge of and interest in science and technology* and *Opinion of the investment in and dissemination of science and technology* (the question measures whether public and private investment in science and technology receive sufficient acknowledgement). The internal consistency of both scales showed values of 0.687 and 0.768, respectively. The factor loadings and estimated internal consistency reliability are shown in Table IV.

The means and standard deviations of the three dimensions analyzed in Tables I and II were also calculated. The opinion of the impact of citizen science (M = 3.42, SD = 0.81) is the dimension with the highest mean ($p < 0.001$), far above respondents' knowledge of and interest in science and technology (M = 2.90, SD = 0.85) and their opinion of public and private investment in science and technology and the dissemination of science (M = 1.84, SD = 0.86). These data partially support the proposed hypothesis.

The correlation analysis (Table V) shows there are significant relationships between almost all the variables that assess respondents' opinion regarding citizen science: knowledgeableness, opinion, willingness to participate, motivations to participate, and view of impact in coming years. As for respondents' opinion on science and technology in general, there are statistically significant but low relationships between knowledge of and interest in science and technology and opinion of public and private investment in science and technology and their dissemination. While the first of these variables (11) appears significantly related to most of those determining respondents' opinion regarding citizen science, this is not the case with the second one (12), which has a not very significant relationship with the remaining variables and dimensions.

SO7. Analysis of the Respondents' Sociodemographic Profile: Gender, Age, Level of Education, Occupation, and Place of Residence

The analysis comparing the scores by **gender** in Table VI shows the means in the questionnaire variables for men and women. There are only two differences worthy of note (statistically significant, $p < 0.01$). The most important difference, with an effect size of 0.271, is the participation varia-

Table IV. Factor loadings for the two-factor solution for knowledge and social acknowledgement. *of science variables*.

	Knowledge and Interest	**Investment evaluation**
Science and technology are part of my everyday life	0.665**	0.009
I participate in science and technology projects	0.538**	0.274**
The dissemination of advances in science and technology is sufficient	0.087**	0.707**
The dissemination of advances in science and technology has increased my knowledge.	0.821**	-0.001
Social development is impossible without advances in science and technology	0.625**	-0.318**
Public investment in science and technology is sufficient	-0.101**	0.938**
Private investment in science and technology is sufficient	0.015	0.771**
Cronbach's alpha	0.687	0.768

Note: * = $p < 0.05$; ** = $p < 0.01$

Table V. Pearson's correlation between the analyzed dimensions and variables.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
(1) Knowledgeableness											
(2) Opinion of CS	.219**										
(3) Participation	.294**	.142**									
(4) Willingness to participate	.258**	.401**	.197**								
(5) Willingness to donate	.304**	.279**	.154**	.504**							
(6) Negative aspects of CS	.240**	.117**	.485**	.196**	.146**						
(7) Acquaintances	.073*	.090**	.117**	.094**	.064*	.117**					
(8) Intrinsic M.	.178**	.441**	.100**	.657**	.412**	.176**	.112**				
(9) Extrinsic M.	.178**	.181**	.051	.357**	.243**	.017	.026	.457**			
(10) Impact of CS	.181**	.494**	.085**	.393**	.294**	.056	.034	.435**	.242**		
(11) Knowledge/Interest of science and technology	.356**	.359**	.267**	.441**	.352**	.300**	.168**	.439**	.225**	.377**	
(12) Opinion of investment and dissemination of science and technology	.188**	-.080*	.055	-.021	.013	.030	-.052	-.113**	.170**	.017	.186**

Note: (1) Knowledge of citizen science; (2) Opinion of citizen science; (3) I have participated in science projects; (4) Willing to voluntarily and altruistically participate in a science project; (5) Willing to incorporate science into my donations; (6) Negative aspects of citizen science; (7) I know people (relatives and friends) who have participated in science projects; (8) Intrinsic motivation; (9) Extrinsic motivation; (10) Impact of citizen science in the next 10 years; (11) Knowledge of and interest in science and technology; (12) Opinion of public and private investment in science and technology and their dissemination.

ble, in which women report greater participation in citizen science projects than men. In particular, the proportion of women almost doubles that of men (when adjusted by age and motivation, the differences are even more evident in favor of women, with participation being 50% higher than that of men). There are also significant differences between men and women in the willingness to donate selflessly to projects (women are more willing to donate, although in this case the effect size is small, d = 0.187).

Table VI also reports the *F* statistic and the effect size (partial eta squared) comparing differences by **age groups**. As these analyses have a merely descriptive value and high sample sizes, only the results where it appears age shows greater differences in the analyzed dimensions and variables are highlighted. The result with the most evident differences, with a medium–large effect size (eta = 0.081), is for extrinsic motivation. The data show a negative linear relationship between age and extrinsic motivation (r = -0.246, p < 0.001). There are also differences with a medium–small effect size in participation, where the results show much greater participation before the age of 30 (where the participation proportion is 0.31) than after the age of 30 (where participation is 0.11 and barely changes as age increases). The final notable result is the dimension on the opinion of investment in science and technology and its dissemination. Here, the youngest respondents (those under 25) show a significantly higher mean (i.e., they believe to a greater extent that public and private investment in science and technology is sufficient) than all the other age groups except those over the age of 80, who also score significantly higher on this dimension.

Table VI shows that the higher the **level of education**, the better informed respondents feel about citizen science, the better their opinion is about it, the more willing they are to participate in citizen science projects, the more willing they are to donate money to science projects, the more they have participated in science projects, the more

Table VI. Differences by gender (men and women), by age groups and by level of educations in the analyzed dimensions and variables.

	Gender differences			**Age group differences**			**Education group differences**		
	Men	**F**	**p**	**eta**	**Women**	**Cohen's d**	**F**	**p**	**eta**
Knowledgeableness	*1,898*	2,061	0,014	0.026	*1,810*	*0,097*	9,916	<0,001	0,047
Opinion of CS	*3,569*	0,887	0,566	0,012	*3,541*	*0,037*	3,583	0,003	0,018
Participation	*0,102*	4,462	<0,001	0,055	*0,198*	*0,271*	10,165	<0,001	0,049
Willingness to participate	*2,982*	2,026	0,016	0.026	*2,976*	*0,005*	9,633	<0,001	0,046
Willingness to donate	*2,391*	2,659	0,001	0,034	*2,597*	*0,187*	10,004	<0,001	0,048
Acquaintances	*0,068*	1,773	0,043	0,023	*0,102*	*0,122*	12,868	<0,001	0,061
Negative aspects of CS	*0,180*	1,661	0,064	0,021	*0,202*	*0,056*	5,729	<0,001	0,028
Intrinsic M.	*3,621*	2,059	0,014	0,026	*3,616*	*0,006*	7,995	<0,001	0,039
Extrinsic M.	*2,589*	6,730	<0,001	0,081	*2,687*	*0,113*	1,093	0,369	0,005
Impact of CS	*3,411*	1,322	0,194	0,017	*3,436*	*0,031*	1,795	0,111	0,009
Knowledge/Interest of science and technology	*2,929*	2,040	0,015	0,026	*2,866*	*0,074*	16,844	<0,001	0,078
Opinion of investment and dissemination of science and technology	*1,817*	3,669	<0,001	0,046	*1,857*	*0,047*	1,204	0,305	0,006

their acquaintances have participated in science projects, and the higher they score for intrinsic (but not extrinsic) motivation to participate in science projects. In addition, they score higher for knowledge of and interest in science and technology. There are no differences regarding respondents' perception of the impact of citizen science, nor regarding their opinion on the investment in science and technology and its dissemination.

As regards **occupation** (Table VII), statistically significant differences were detected among occupations in the scores for knowledgeableness about open science (with students showing a higher mean than the unemployed, workers, and retirees and pensioners; and with workers showing a higher mean than retirees and pensioners) and for intrinsic and extrinsic motivation (especially extrinsic motivation, where students and the unemployed have higher mean scores than workers and retirees and pensioners). Students show a greater willingness to participate altruistically in science projects (with students having a higher mean than retirees and pensioners and the unemployed) and a higher knowledge of and interest in science and technology (with students presenting higher scores than retirees and pensioners, the unemployed, workers, and household employees; retirees have a lower score than workers).

Students and the unemployed also have a more critical opinion of the investment in science and technology and its dissemination.

As regards respondents' **autonomous community** of residence (Table VII), there are no substantial differences in any of the 12 analyzed dimensions and variables. The only two significant differences are found in participation (where the region with the highest participation is Cantabria, reaching a proportion of 0.4; those with the lowest proportions are Islas Baleares and La Rioja with 0.0) and in extrinsic motivation (where on a scale of 1–5 the differences in the means are no more than 0.5 between the two regions with the highest and the lowest scores: Islas Canarias and Asturias, respectively). There are small significant differences in mean willingness to donate, with the trend being that regions such as Madrid, Galicia, Murcia, and La Rioja are more inclined to donate than

Table VII. Differences in occupation and Spain's autonomous communities in the analyzed dimensions and variables.

	Spain's autonomous communities			**Occupation group differences**		
	F	**p**	**eta**	**F**	**p**	**eta**
Knowledgeableness	1,506	0,090	0,024	2,110	0,050	0,013
Opinion of CS	0,857	0,620	0,014	2,782	0,011	0,016
Participation	1,780	0,029	0,028	7,868	<0,001	0,045
Willingness to participate	1,643	0,052	0,026	2,536	0,019	0,015
Willingness to donate	1,750	0,033	0,028	3,404	0,002	0,020
Acquaintances	1,205	0,257	0,019	1,501	0,174	0,009
Negative aspects of CS	0,723	0,772	0,012	2,593	0,017	0,015
Intrinsic M.	0,913	0,553	0,015	2,132	0,047	0,013
Extrinsic. M.	1,825	0,024	0,029	8,391	<0,001	0,048
Impact of CS	0,799	0,688	0,013	1,454	0,191	0,009
Knowledge/Interest of science and technology	1,909	0,017	0,030	5,953	<0,001	0,035
Opinion of investment and dissemination of science and technology	1,300	0,189	0,021	4,164	<0,001	0,024

others like the Islas Baleares or Aragón. Lastly, there are significant differences in knowledge of and interest in science and technology, as reflected in the higher means for Madrid and Murcia versus Navarra, Islas Canarias, and Islas Baleares.

5. DISCUSSION AND CONCLUSIONS

The contributions made by this study include a questionnaire developed specifically for this research and which has facilitated better understanding of public knowledge of and attitudes to citizen science, as well as of the possible motivations that would lead people, in this case a broad sample of the Spanish public, to participate in citizen science projects. The analyses of the questionnaire data show that, overall, the dimensions examined have a high internal consistency as regards measuring the contents of interest.

The data support the hypotheses posited. The descriptive analyses of the data show that the male and female respondents feel underinformed about citizen science (H1), even though their opinion of it is quite favorable (H2). Very few find negative aspects in its implementation and many express a positive view of the impact of citizen science over the next 10 years. Their answers on the motivations that would lead them to participate in citizen science projects primarily indicate intrinsic motivations, such as believing their contribution may help society, that the topic of research is of interest to them (an item that coincides with previous studies, e.g. Chia-Hsuan and Te-En, 2021), or that the project's objectives target specific problems facing the community their belong. Their answers secondarily indicate extrinsic motivations (material or monetary incentives, public recognition, or also participation of people they know), with the two appearing significantly related. These results would support Hypothesis 4.

In line with Hypothesis 3, the data portray a public that participates little in scientific endeavor: only 15% of respondents said they had ever taken part in a science project, a figure that may even be overestimated since the FECYT survey reports that only 11.5% of respondents stated they had taken part in one. These data would indicate a disconnect between citizens and science, which could have a negative impact on its development. In Spain, the legislation set to govern the development of science in coming years assigns the general public an important role in scientific endeavor. On a wider scale, European regulations and UNESCO recommendations likewise require public participation. The reality, however, is that the public is absent from the process of producing science. With the exception of a minority, people do not appear to feel that the development of science concerns them. The low level of public participation in science identified in this study is not an anomaly; rather it is in line with the data collected in the long-running two-yearly FECYT survey, the 2022 edition of which —covering a sample of approximately 6,000 people— evidences the scant interest in science in general (only 12.3% of respondents spontaneously mention it as one of their areas of interest). Furthermore, when respondents are asked directly about science, they only express moderate interest in it (a score of around 3 on a 5-point scale), place little importance on it, and are generally unwilling to participate in science projects. The lack of engagement with science may be related —it is impossible to determine whether it is cause or effect— to the acute lack of information that respondents report receiving about citizen science.

The sociodemographic profile derived from analysis of the perception of citizen science by respondents indicates that the women who participated in the survey are significantly younger than the men (average female age of 40, slightly below the average age of the Spanish female population). In the tranche including this age the percentage of women with university qualifications is significantly higher than that of men, a finding that coincides with the data published in 2022 by the INE (Spain's national statistics institute). In line with this, gender differences had the most significant effect sizes in this study. Twice as many women as men report having participated in citizen science projects. The data show that the archetypal Spanish participant in science is a female university graduate aged between 21 and 40 with a positive attitude to science that similarly translates into a greater willingness to make financial donations to science projects. She shares the same intrinsic motivations to participate as men, such as interest in the area under research and a desire to contribute to solving problems affecting the community and to help society at large, but also exhibits social motivations such as sharing the research experience with people she already knows and earning the social recognition associated with participation. The data suggest that while both men and women have intrinsic motivations for participating, women also find social or recreational incentives for doing so that do not appear to appeal to men. This aspect was not contemplated in Hypothesis 3 but nonetheless provides relevant information that should be taken into account as regards understanding the differing reasons that lead men and women to participate in science projects.

Women's greater willingness to participate in altruistic causes coincides with what has been

observed in the realms of work and volunteering, where women also participate more than men and take on tasks that do not generate personal benefit and may even hinder career advancement. To identify the psychosocial factors that may help explain the difference between men and women as regards participation in science, it would be beneficial to review the related research and experiences reported in the volunteering field. Similarly, it would be necessary to adopt the required measures to balance male and female participation in terms of roles and tasks performed in research processes.

In this sociodemographic profile, the influence of age is seen in a lesser willingness to participate altruistically in citizen science projects, a tendency that increases after the age of 30. Also, the older the respondent, the fewer acquaintances they have who participate in this type of project. Nonetheless, the most evident effect of age appears to be related to extrinsic motivation since, as mentioned, the data indicate a significative negative linear relationship between these two variables. The effect of age was likewise found in the opinion of the investment in science and technology and its dissemination, with those under 25 and those over 80 being most in agreement that it is sufficient. The decline in interest in participating in such projects matches the data in the FECYT survey, which also detects a significant decrease among those aged under 24 and those aged over 64. Notwithstanding, this study reveals that interest in science grows again in the oldest age groups. It appears that after several years of retirement, and once released from work-related tasks and with more free time available, retirees are attracted to participating in science projects that satisfy their desire to serve society and that offer an opportunity to establish social relations that have a positive impact on personal well-being beyond the associated contribution to science and which would constitute an incentive that strengthens participation among these age groups.

Level of education favorably affects the perception of citizen science across all variables and dimensions used to measure it; specifically, a difference was identified between respondents with university/postgraduate/doctorate-level qualifications and those who only completed primary and secondary education in all the variables analyzed. As regards occupation, respondents belonging to the group of high school and university students hold the most positive opinion of citizen science in all the variables analyzed and who are the most critical, together with the unemployed, of the investment in science and technology and its dissemination. The significant relationship between level of education and participation in science projects may be associated with a greater affinity to the culture of science. Finally, the sociodemographic profile outlined by the data is not substantially altered by the respondents' autonomous community of residence, as this item only shows the isolated differences described in the Results section.

A possible reason explaining the discrepancies between the (little) knowledge and experience respondents' admitted having regarding citizen science and their reasonably good opinion of it and its impact can be found in the results: citizens' positive attitudes regarding science and technology could be the background or basis for their positive view of citizen science, a relationship comparable to what some authors have established between the interest in science and the willingness to participate in and contribute to the development of scientific knowledge (Everett and Geoghegan, 2016). The positive attitudes towards science and technology would translate into a readiness to participate in citizen science projects, although only 15% of respondents have actually done so. These same attitudes may likewise be why they are willing to make selfless financial donations to science projects. The positive attitudes that lead to a good opinion of science, and of science and technology in general, in turn explain the critical opinion of the public and private investment in science in Spain and the limited dissemination of scientific knowledge. The relationship between the variables associated with citizen science and science and technology in general is shown in the correlation analysis presented in Table V.

Citizens are currently contributing in many ways to science by mapping land, analyzing waters, identifying mosquitoes, locating birds and plants, scanning stars, or helping locate the mass graves of people missing as a result of armed conflict in Colombia (Tamayo, 2022), among many other examples (see Aliende, Castelló-Cogollos and Llopis, 2022). The complementary analysis conducted on the type of participation has helped to confirm they did so by providing information (contributory projects). The future development of citizen science, however, aims to promote projects with greater citizen involvement (co-created projects), designed jointly by researchers and citizens and in which the latter participate actively in most of the project's activities and not merely as providers of information (see Bonney et al., 2009).

In summary, based on the general data collected in this study it could be said that the citizen science movement that has long been growing in Europe is still in its infancy in Spain as the hypothetical

mainstay, namely the general public, still has very little theoretical or practical knowledge about it. In any case, public ignorance is a further indicator of the slow development of open science in Spain due to the lack of incentives and the barriers hindering its growth (Abadal, 2021; Abad-García et al, 2022; De Filippo, Lascurain and Sánchez, 2023; Sánchez and De Filippo, 2022).

Citizen science is one of the areas of open science and it is also striking to see how little prominence it has in one of the settings most conducive to scientific research, namely universities, where the development of open science has been found to be "in progress/pending", with limited knowledge of it among faculty and limited availability of instruments and strategies to promote it, as confirmed by university administrators themselves (see Casani, 2022; Sánchez and De Filippo, 2022; De Filippo et al. 2023). It is to be expected that this situation will change in coming years, to the extent that the Spanish government, driven by European dynamics pushing towards open science, incorporates the concept of open science and citizen science in the terms and conditions of calls for research grant applications and in the recently passed law on science (2023). At the same time, universities are signing operational protocols such as the one proposed in 2023 by the Coalition for Advancing Research Assessment (CoARA) seeking to change the assessment processes to attain a more open way of producing scientific knowledge that helps solve the social and economic problems of the society in which it takes place.

The main conclusion drawn from the data provided by the study is that in coming years all the institutions involved in Spain's science ecosystem must engage in actions to encourage public involvement in science projects. For such involvement to occur it will be necessary to design proposals capable of changing and improving Spain's culture of science. These proposals must also demonstrate the added value and social significance of involvement in science and of the various roles that members of the public are expected to perform within its development. The evidence to date indicates that the public has delegated the task of producing science to scientists.

Finally, it should be noted that this is a descriptive study that, on the one hand, identifies and highlights a reality but that, on the other, is limited by its scope and demonstrates the need to conduct future explanatory studies on the key variables identified through which to advance the understanding and development of citizen science. Furthermore, consideration must be given to other major public, private, and third-sector stakeholders and institutions within civil society that are conducting valuable participative grassroots science initiatives —sometimes from outside the official science and technology ecosystem— that are fundamental to encouraging bottom-up public participation in science. In future research it would be highly beneficial to examine in depth the role these other stakeholders play in encouraging citizen science.

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7. AUTHORSHIP CONTRIBUTION DECLARATION

Sánchez, Flor: Conceptualization, Funding acquisition, Methodology, Supervision, Visualization, Writing – original draft, Writing – review & editing.

Casani, Fernando: Conceptualization, Investigation, Writing – original draft, Writing – review & editing.

Olmos, Ricardo: Data curation, Formal Analysis, Writing – original draft, Writing – review & editing.

8. CONFLICT OF INTEREST DECLARATION

The authors of this article declare that they have no financial, professional, or personal conflicts of interest that could have inappropriately influenced this work.

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