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Research Article

Confidence in science among pre-service primary teachers: Pedagogical implications

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ABSTRACT

The way in which science and technology are shown and perceived by society—and by teachers in training—can influence attitudes that emerge towards science and technology subjects in the classroom. This study examines attitudes, primarily confidence, towards science and technology in general, and considers how this would influence attitudes towards science subjects. To do so, we administered a survey on perceptions of science and technology to a sample of 452 prospective primary school teachers and performed a descriptive and multivariate analysis of the data. The results show that pre-service teachers have less interest in science, are less informed, and show less confidence than their age cohort. This should encourage institutions to reflect on their selection and hiring processes for teaching careers. It seems that recruiting future teachers with a spontaneous interest, trust in scientific matters and a greater level of basic scientific knowledge would provide a sample of teachers closer to the different attitudes to science that exist in society. The findings also suggest that knowledge about social perception of science impacts the classroom. Therefore, it should be included in the training of future teachers and be a component of pedagogical content knowledge.

Keywords: attitudes about science, confidence in science, pedagogical content knowledge, pre-service teacher training, teacher education

INTRODUCTION

Attitudes towards science, whether positive or negative, is a complex issue that is often considered as composed of elements such as level of knowledge, spontaneous interest, and confidence among others (Jho et al., 2014; Olsen & Lie, 2011; Riegle-Crumb et al., 2015). These elements mutually influence one another.

Thus, scientific knowledge and educational level can affect spontaneous interest in science also influences increasing knowledge in science (Allum et al., 2008; Cortassa, 2016; Roduta Roberts et al., 2013; Sturgis & Allum, 2004). But, social groups with less education may show more blind confidence, while more educated groups may show a more ambivalent and reserved confidence. On the other hand, people who show a greater spontaneous interest in science tend to have greater confidence in it. However, these tendencies related to knowledge, interest, and trust in science are mediated by other factors, including social and cultural group affiliation, personal beliefs (scientific, political, religious), and gender (DeBacker & Nelson, 2000; Guo et al., 2024). Therefore, interest in understanding trust in science and scientists has grown significantly, especially in the aftermath of the pandemic, as evidenced by the emergence of large-scale studies (Cologna et al., 2024).

Sociological studies on public attitudes towards science, conducted within the framework of public understanding of science (PUS), analyze the science-public relationship from a broad perspective, considering factors such as affiliation, beliefs, gender, and economic level (Bauer & Falade, 2021; Metcalfe & Riedlinger, 2019). Several approaches emerge from these studies.

The first, known as the deficit model, argues that positive public attitudes towards science are dependent on the level of knowledge people have about it (Cortassa, 2016). This model has been criticized for its inability to explain why certain groups, such as women (Allum et al., 2008) or African Americans in the United States (Gauchat, 2008), consistently show lower interest and less favorable attitudes towards science, regardless of their education.

More nuanced approaches acknowledge that scientific knowledge can influence attitudes towards science, but they also consider the social context in which attitudes vary according to social, economic, and cultural groups (Bruckermann et al., 2021; Diamond et al., 2020; Roduta Roberts et al., 2013). This approach emphasizes greater public engagement in science, bidirectional communication between scientists and the public, and the need for scientists to better understand the characteristics and concerns of the audiences they interact with. This paradigm shift has coincided with the rise of the internet and social media, which facilitate more horizontal and multidirectional participation in scientific communication.

On the other hand, science education research has considered factors directly related to each individual's contacts with science or to specific dynamics of classroom interactions, such as previous educational experiences (Lovelace & Brickman, 2013; Potvin & Hasni, 2014), exposure to scientific communication (Gustafson & Rice, 2020), and encounters with socio-scientific conflicts (e.g., climate change, vaccines, or biotechnology), which have been observed to shape and challenge initial attitudes (Osborne et al., 2003; Reis & Galvão, 2004).

Focusing on pre-service teachers, the existing literature on their attitudes towards science predominantly concentrates on subject-related aspects (Asma et al., 2011; Kaya et al., 2009) and their teaching (Abramzon et al., 2017; Sears & Sorenson, 2000; Tosun, 2000), in addition to attitudes in class, and memories of their own education (Wendt & Rockinson-Szapkiw, 2018) and its relationship to pedagogical content knowledge (PCK) (Johnston & Ahtee, 2006).

In this context, Asma et al. (2011) and Simon and Osborne (2010) distinguish between the attitude towards studying science and the attitude towards science itself (what they refer to as "science in general"). They also describe the increasing tendency to reject science subjects in developed societies because of a profound cultural shift regarding science. According to these studies, pre-service primary teachers may express interest in science as presented in television documentaries or YouTube videos on astronautics ("show science"), while still rejecting formal science subjects.

Some authors suggest that this divide is due to the way school science is presented as a value-free, detached activity, disconnected from any societal context that would give it meaning or relevance, which seems to lead to the notion that "science is important, but not for me" (Ebenezer & Zoller, 1993; Lyons, 2006; Simon & Osborne, 2010).

In this regard, Smith (2010) provides reasons why science should be taught in school, why students develop a more positive attitude towards science, and how educators may influence this. In this sense, it is assumed that teachers' attitudes influence students' attitudes (Kazempour, 2014; Maier et al., 2013; Smith, 2010). In the words of Barker (2000), "the most important factor influencing students' attitudes towards science is their teachers". This same idea is discussed by van Aalderen-Smeets et al. (2012), who emphasizes teacher training "(...) to achieve sustainable improvements in science education in primary school, it is crucial that primary school teachers develop their own positive attitudes towards science". Both focus their concern exclusively on attitudes towards teaching and find the origin of negative attitudes to negative experiences in the science classroom during their own schooling.

Considering this background, it seems relevant to explore the attitudes of pre-service teachers towards science, particularly their confidence in it. As Smith (2010) points out, we assume that this personal attitude will influence their classroom practice. To this end, we conducted a study on attitudes towards science among pre-service teachers, focusing on their confidence in science rather than on the perceived difficulty or general attitude they may have during their initial training. For this purpose, we followed the same approach as the questionnaires used in major national and international surveys on public attitudes towards science (Allum et al., 2008; Wynne, 1995, among others). It would be expected that the trust in science among pre-service primary school teachers will be slightly higher than that of their age cohort, since they are a somewhat better trained population, belonging to a slightly higher social class and with a vocation for teaching.

In previous works, we have analyzed how pre-service teachers inform themselves about science (Fernández-Carro et al., 2024), as well as their beliefs in superstitions and pseudo-sciences (Fernández-Carro et al., 2023), or how they incorporate science in social context in the classroom (Vílchez et al., 2025). At this stage, by focusing on confidence in science, we complement the overall view of pre-service teachers' perception of science and its potential impact on their teaching performance.

The research problem in this study is to examine the level of confidence that pre-service teachers have in science, to identify the factors that may influence this confidence, and to investigate potential explanatory models that account for its development and implications for future teaching practice

METHODS

The design of this research is framed as an ex post facto, quantitative, and multivariate study. The survey technique is used, with the questionnaire serving as the instrument. The methodology is articulated in successive phases (**Figure 1**):

(1) construction of dependent variables through principal component analysis (PCA) with varimax rotation,

(2) descriptive analysis with a comparative strategy, and

(3) explanatory analysis, utilizing ordinary least squares (OLS) regression models.

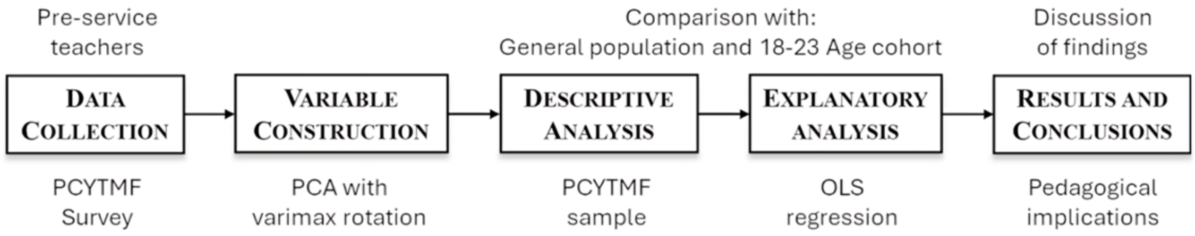

Figure 1. Research design flowchart (Source: Authors' own elaboration)

These issues are detailed below.

Instrument and Data Analysis

The data was gathered using survey perception of science and technology among pre-service teachers (PCYTMF), an almost exact replica of the social perception of science and technology survey of 2016 (EPSCYT16) by the Spanish Foundation for Science and Technology (2017, 2019). The Survey EPSCYT16 draws on the universe of residents in Spain over the age of 15 years, and its representative sample is of 6357 interviews (Spanish Foundation for Science and Technology, 2017, 2019).

The comparison has been made between the pre-service teachers who responded to the PCYTMF with:

(1) their age group in the sub-sample of EPSCYT16, the cohorts between 18 and 23 years, since this cohort matches the age of our pre-service teachers and

(2) the population of all ages in the same survey EPSCYT16.

We have based our explanatory analysis on regression models of OLS of PCYTMF and EPSCYT16. The instruments used allow us to analyze possible differences in the social perception of science among pre-service teachers, the general population, and sub-sample of 18-23-year-old, as well as verify whether the training and sociocultural level of future teachers have impact on the way they perceive science.

Participants and Context

The sample to whom PCYTMF has been administered consists of 452 pre-service teachers, degree students aged 17-43 (mean = 20.67, mode = 19, and standard deviation = 3.396), 84 from the early childhood education degree, 306 from the primary education degree, 61 from the double degree early childhood-primary education, and 1 from the double degree in primary-pedagogy. The survey was administered at five Spanish universities in different cities: Madrid, Seville, Granada, Valladolid, and Cuenca. Although it is a convenience sample, it includes representative socio-economic differences: different regions, cities of a different size and different university types—public and private.

The similarities and differences between the samples are:

- The PCYTMF sample is only made up of education degree students in Spain. They are all university students, and their educational level is, therefore, higher than that of their counterparts. The sub-sample EPSCYT16_18-23 (N = 639) represents young people residing in Spain aged 18-23 where only one third of them are university students.
- The PCYTMF sample includes a larger proportion of women (77%) than that in EPSCYT16_all (the entire EPSCYT16 sample, N = 6,357), which is nearer to the distribution of the population. The ages of the young participants in this survey are evenly distributed, while in PCYTMF, the mode is 19 years.
- Political ideology is quite similar among the youths in both surveys, skewed slightly to the left (where left is 1 and right 10): the average is 4.8 in PCYTMF and 4.7 in EPSCYT16_18-23.
- The family income level of pre-service teachers (PCYTMF) is slightly higher, "from €1,801 to €2,400", while in the sub-sample of youths from 18 to 23 years (EPSCYT16_18-23) it is "from €1,201 to €1,800".

To sum up, teachers in initial training are a population chosen from the general population, mainly women, with a greater presence of those 19 years old, with somewhat higher family income and a greater level of studies than the general population for their age, although with the same ideological postures.

Description of the Variables

In order to construct the variables, we used some items exactly as provided in the surveys, while others were derived from the batteries of questions grouped through PCA with varimax rotation and the regression method. This orthogonal rotation was selected to simplify the structure and facilitate interpretation, as the extracted factors did not exhibit strong correlations. The regression method for computing factor scores maximizes the correlation between the factors and the underlying latent dimensions and better represents individual participation in each factor. The factor analysis here is a way to produce the dependent variables and not the final analysis—which is done with OLS regressions.

For more details on the wording of these items, the basis of our variables, you can consult the PCYTMF survey[1].

Independent variables

Aspects that may influence the object of study have been considered:

Some socio-demographic factors such as *gender* (D1), *age* (D2), *ideological self-positioning* (D5), *university education* (D7), *religious beliefs* (D8), or *income level* (D9).

Interest or being *informed about science and technology*, which are presented in PCYTMF as an item in batteries P1 and P2, respectively.

The level of general scientific knowledge is measured through the variable *knowledge 8*, summation of the points in an Oxford type questionnaire. This instrument is frequently used to measure this type of knowledge

[1] To consult the PCYTMF survey: https://hdl.handle.net/10481/77352

by their efficiency and comparability. This is presented in battery P14, constituted by 8 items. The respondent must choose from paired statements the one he or she considers correct. The topics included are the rotation of the Earth relative to the Sun, antibiotics to cure viruses, movement of the continents, laser beams, coexistence of humans and dinosaurs, genetically modified foods, ozone and climate change, and the meaning of the number π.

Dependent variables

The dependent variables are derived from batteries of questions P7, P8, P10, P11, and P12 in the PCYTMF survey, which seek to identify factors influencing confidence in science and technology. These batteries measure varied attitudes, such as the general balance of benefits and harms (P7), association with terms (P10), and the degree of agreement with sentences regarding caution or security (P12):

Battery P7 directly asks for a balance between positive and negative aspects. Possible answers are "the benefits of science and technology are greater than its harms" (1), "the benefits and harms of science and technology are balanced" (2), and "the harms of science and technology are greater than its benefits" (3).

Battery P8 offers different items to respond to the question: "P8. If you had to make a […] balance regarding some aspects of science and technology, which of the following options would best show your opinion?" The options include items related to economic development, improving quality of life, environmental conservation, fighting disease, food and agriculture, privacy and data protection. The replies suggested are: "the benefits exceed the harm" (encoded as 1), "benefits and harm are balanced" (2) and "the harm exceeds the benefits" (3). Note that the scale is reverse encoded, assigning fewer points for benefits and more for harm.

Battery P10: "We shall now show you some terms. How would you associate each of these with science and technology, totally fairly, little or absolutely nothing?" The terms are: "progress", "dehumanization", "wealth", "inequality", "wellbeing", "risks", "opportunities", and "threats". The items are summarized by two factors which we have called ***negative*** ("threats", "inequality", "dehumanization", and "risks") and ***positive*** (the others). Again, the scale is in reverse encoded (the higher the figure, the less association).

P12 asks the degree of agreement with a series of sentences. These questions raise issues such as the veracity of scientists, the influence of their sources of funding, restrictions on new technologies, laws and regulations on scientific knowledge, the role of citizens and experts in decision-making, and science and technology as a source of risk or prosperity and technology.

After analyzing the responses to P12 in PCYTMF, three variables can be identified. The first of which shows a positive but cautious attitude to science (we have called it ***caution***); the second, an attitude of rejection or distance (***suspicion***); and the third, believer's uncritical confidence (***security***). In EPSCYT16, there are only two factors: the first summarizes both rejection as well as cautious attitudes (***critical***); the second, the same uncritical attitude security (and which we have called ***uncritical trust***).

Question P11 asks whether there is agreement or disagreement with the following sentences (shown in the order in which they contribute to the factorial points): "Science and technology make our life more healthy, easy and comfortable", "the majority of environmental issues may be resolved using technology", "science and technology may resolve nearly every problem", "I would support the government investing more in scientific and technological research", "science and technology have an important role in economic and industrial", and "it is better for decisions in scientific and technological policy to be made by experts instead of the public". It is included to measure trust in science as is typically done in international surveys (Roduta Roberts et al., 2013, p. 631), summarizes 36.8% of the variance. The items combined to form a sole factor interpreted as ***confidence in science***. However, as P11 does not appear in the general population survey (EPSCYT), it is not utilized in our comparative strategy.

RESULTS

Confidence in Science and Among Pre-Service Teachers: Descriptive Analysis

Table 1 shows the descriptive results of some variables that describe attitudes to science and technology in both surveys, comparing the group of pre-service teachers (PCYTMF) with the population at large (EPSCYT16

Table 1. Attitudes to science and technology among pre-service teachers: Descriptive study

Item	Item	PCYTMF	Item	EPSCYT16 all	EPSCYT16 18-23
Spontaneous interest in S&T	P1.2	78.3%	P2	70.2%	76.7%
("Very interested")		11.8%		-	17.3%
Informed about science	P2.2	65.0%	P3	60.9%	69.6%
Balance of benefits of science	P7	61.7%	P12	63.4%	60.8%
Agreement: "Reduction of differences between rich and poor families"	P8.9	26.0%	P13.9	36.1%	33.9%
"Economic development"	P8.1	39.0%	P13.1	61.0%	58.8%
Benefits of: "Mobile telephone"	P9.6	52.7%	P14.7	67.0%	67.8%
"Fracking"	P9.5	4.5%	P14.5	16.7%	17.1%
Associating S&T with terms: Wellbeing	P10.5	85.1%	P17.5	80.1%	80.6%
Associating S&T with terms: Threats	P10.8	67.9%	P17.8	60.0%	60.3%
Agreement: "Science and technology are the maximum expression of prosperity in our society"	P12.9	47.1%	P18.3	53.4%	52.2%
"If the consequences of a new technology are unknown, one should act cautiously and control their use to protect health or the environment"	P12.4	71.6%	P18.6	72.5%	63.2%

all) and their age cohort (EPSCYT16 18-23). The names of the items in **Table 1**, such as 'P1.2' and 'P7,' correspond to the question numbers in the original questionnaire.

Pre-service teachers show approximately the same spontaneous interest in science (P1.2 in PCYTMF) as their age cohort: 78.3% declare they are "somewhat interested", "fairly interested", or "very interested", compared with 76.7% in EPSCYT16_18-23. On the contrary, that spontaneous interest is lower among the population at large (EPSCYT16_all), although it is high (70.2%). That may mean that interest in science has grown since the older generations, but we do not know what their interest level was when they were that age; we could also attribute it to the major difference in the level of studies between that age group and their elders.

In any event, that factor of spontaneous interest in science influences confidence in science with a certain independence as it is prior—spontaneous—to other elements. Thus, that factor—spontaneous interest—increases exposure to scientific content from different sources and, thus, a multi-faceted vision of science. This leads to higher, more complete levels of knowledge that are acquired previously, or in parallel to standard education. This usually provides greater trust in science. To examine this item in greater depth, we focus on those who said they are "very interested", amounting to just 11.8% among pre-service teachers, while it reaches 17.3% among youths in general (EPSCYT16_18-23). That is, although teachers appear to share the same average level of interest in science and technology as people their age, we do not find so many enthusiasts among them. Pre-service teachers declare they are somewhat less informed about science (P2.2; 65.0% declare they are "somewhat", "fairly", or "very informed") than the members of their cohort in (69.6% of whom declare this). Spaniards in general appear to be less informed than the youths 60.9%.

Question P7 asks for a general balance. Optimists, who reply that "the benefits are greater than the harm", amount to 61.7% among pre-service teachers (PCYTMF), practically the same as youths in EPSCYT16_18-23, 60.8% (question P12 of that survey). The figures are similar among the population at large (EPSCYT16_all), in that case slightly higher: 63.4%.

P8, as we saw, it is a battery that extends that balance to specific matters. Among pre-service teachers (PCYTMF), 26% believe that the "benefits are greater than the harm", compared with 33.9% in their age group (P8.9, "reduction of differences between rich and poor families"). Future teachers appear to be more skeptical. That difference is increased in item P8.1 ("economic development"): pre-service teachers only agree by 39% that "the benefits exceed the harm" while 58.8% of youths (EPSCYT16_18-23) in their cohort agree (P13.1). The results of the total population (EPSCYT16_all) are similar to those of young people in this item. One would have to ask what factors make future teachers appreciably skeptical, compared with relative general agreement.

P9 is a battery that asks for the same balance, regarding specific technological applications. In this case, the factor analysis has distinguished two obvious groups, daily applications and the controversial ones. As a representative of the former, we take question 9.6, "mobile telephone", and to represent the latter, P9.5, "fracking". Thus, 52.7% of pre-service teachers (PCYTMF) considered that mobile phones are more beneficial than harmful, compared with 67.8% of their cohort (EPSCYT16_18-23 and 67% among the population at large (EPSCYT16_all). That pattern of skepticism is repeated in the following item: only 4.5% of education students accept fracking compared with 17.1% of their age group (16.7% of the population of all ages). That unexpected skepticism is the first notable result. Pre-service teachers tend to be more skeptical regarding some technological applications than their age group, although they were not so pessimistic in the general balance. A reason that we shall discuss later is that people educated in environments with a higher level of studies tend to have a more skeptical confidence in science, which is less naive.

With regard to battery P10, 85.1% of pre-service teachers (PCYTMF) associates science and technology with "wellbeing" (the item that contributes most to the factor positive), compared with 80.6% of youths their age (EPSCYT16_18-23), and 80.1% of all ages (EPSCYT16_all). On the other hand, 67.9% of pre-service teachers associates science with "threats" (the item that most contributes to the factor negative), compared with 60.3% in their age group and 60% of the general sample. Along with a slightly positive valuation, we find the skepticism mentioned again.

Regarding the P12 battery (attitudes of caution, suspicious and security), we concentrate on some items that are repeated in both surveys. For example, item P12.9, which is usual to measure confidence: "Science and technology are the maximum expression of prosperity in our society", the proportion of pre-service teachers who respond, "fairly agree" or "totally agree", is 47.1%, less than that for youths of their age, 52.2%, and that of the general population, 53.4%. The relative skepticism we find among education students may be considered informed caution. This is checked with the following item, P12.4 of PCYTMF: "If the consequences of a new technology are unknown, one should act cautiously and control their use to protect health or the environment". Among pre-service teachers, 71.6% say they "fairly agree" or "totally agree", while the sample between 18 and 23 years in EPSCYT16 only reaches 63.2%; curiously, the general population in this survey is more cautious: 72.5% (EPSCYT16_all).

Confidence in Science Among Pre-Service Teachers: Explanatory Analysis

In this section, we analyze the factors that may be assigned to the attitude of trust towards science of pre-service teachers. To prepare each model, we tested all the variables recommended by the theoretical elaboration and then removed those that had insufficient significance; the best specified model is that presented. We have not used the SPSS StepWise procedure or any other similar one. The dependent variables are successively those we have discussed: different aspects related to attitudes of confidence in science and technology. **Table 2** shows the explanatory models of the PCYTMF survey.

Thus, model 1 (***positive***) appears to convey a spontaneous form of confidence. The scale is reversed, thus the relationship is interpreted as negative (we have marked it with [-]). The model indicates that positive associations with science depend on *spontaneous interest in science and technology* (P1.2), but not on how *informed* the respondent considers themselves (P2.2). It is associated more with a lower *age*, although weakly and directly with *university education* and general scientific knowledge—measured by the Oxford questionnaire (*knowledge 8*)—. Other expectable variables, such as gender, ideological self-positioning, religious belief or income ranges, do not intervene—perhaps because the variability in this sample is small, as we have discussed. The graphic analysis—not presented—suggests that the model 1 is well specified, as also suggested by the ANOVA, in spite of the small determination coefficient (R^2).

Model 2 (***caution***), derived from battery P12, explains cautious confidence (**Table 2**). Again, it is influenced by *spontaneous interest in science and technology* (P1.2). This time, *gender* acts as a factor that explains that attitude. According to the terms found in the literature, women appear more cautious regarding science and tend less to be naively confident (Allum et al., 2008; Trankina, 1993). *Age* influences this, but little; that influence is surprising, in any case, because due to its nature our sample does not have a large range. Apart from that, we do not find influence from other variables.

Table 2. PCYTMF models

		1 (-)	2	3	4 (-)
(Constant)		0.611	-1.314	-0.162	1.432
Sig.		0.098	0.000	0.094	0.000
(P1.2) Interest in science and technology		-0.213	0.108		-0.122
Sig.		0.000	0.023		0.006
(P2.2) Informed about science and technology					
Sig.					
(D1) Gender (woman, 1)			0.348		0.292
Sig.			0.003		0.006
(D2) Age		0.042	0.030		-0.029
Sig.		0.007	0.039		0.029
(D6) Ideological self-positioning 1-10				0.046	
Sig.				0.010	
(D8) Religion, non-believer, believer, indifferent					
Sig.					
(D9.5-7) Intermediate income range €901-€2,400					0.220
Sig.					0.013
(D9.8-11) Upper income range > €2,401					
Sig.					
(D7) Education, university students		-0.808			
Sig.		0.003			
Knowledge 8 (P14; Oxford questionnaire)		-0.114			-0.106
Sig.		0.001			0.003
ANOVA	F	11.073	5.580	6,690	10.306
	Sig.	0.000	0.001	0.010	0.000
	R^2	9.3%	3.7%	1.5%	10.7%
	N	435	442	439	438

Notes. 1: "Positive", positive terms associated with science (-); 2: "Caution", agrees with sentences suggested; 3: "Security", agrees with sentences suggested; 4: "Confidence in science" (-)

Model 3 (***security***) refers to the degree of perceived confidence in science and technology (**Table 2**) and indicates that it depends solely on *ideological self-positioning*, in particular on whether one declares oneself right-wing. Although the equation is well specified, the R^2 limits the scope of that result.

The explanations of model 4 (***confidence in science***), whose dependent variable is obtained from P11, are the most consistent (**Table 2**). This variable measures trust in the way it is usually done in international surveys and is reverse encoded. Confidence depends directly on *interest in science and technology* (P1.2). As suggested by the literature, women have less confidence than men, one third less. *Age* has a certain influence, a surprising one as in model 2. The intermediate income ranges are those that show greater reluctance when compared with the others; that variable may possibly be concealing the education effect. Lastly, confidence depends directly on the respondent's scientific knowledge (*knowledge 8*; P14), which may be expected due to that link to interest which we previously mentioned. Surprisingly, there is no effect of *self-reported degree of information* (P2.2). Nor have we found a *political ideology, religious beliefs*, or *university studies* effect either. The scarce variation in the sample and its specific nature, due to being formed by the social origin of education students, could be part of the cause.

Model 2 and model 3 are more doubtful than 1 and 4, so they provide little explanation of the variance. In spite of them not appearing to be badly specified (as shown by the ANOVA), small R^2 values are usual and suggest that the respondents do not have a genuine interest in those matters, which produces an opinion based on true grounds. In any case, it is interesting to consider that the attitudes to science and technology that we may find in the classroom are dependent on sociological factors. That should allow us to understand the different positions such as from caution to complete security.

DISCUSSION

Comparison With the Samples of the General Population

As mentioned, similar analyses to this one (PCYTMF) have also been carried out with the sample of young people aged 18 to 23 (EPSCYT16_18-23) and the general population (EPSCYT16_all). The main similarities and differences found are discussed below.

Model 1, which explains the variable on ***positive*** terms towards science, shows a clear correspondence in the samples of young people and the general population. In the three samples, it depends on the *spontaneous interest in science and technology* and on having good general knowledge of science (assessed in the *knowledge 8* battery). Another important coincidence is that *gender*, *perceived information on science* and *ideological positioning* do not seem to have an influence in any of the samples, to explain this positive position towards science. Unlike what happens with pre-service teachers, having a good *income level* (> €2,400) is an influential factor in the other samples (EPSCYT16_18-23 and EPSCYT16_all). On the other hand, *age*, which has a favorable effect on pre-service teachers, does not seem to influence young people from their same cohort or in the general population.

The variables that reflect critical aspects of science in the sample and subsample of the general population are not directly comparable with model 2 (***caution***) in pre-service teachers. However, in the case of young people in the general population (EPSCYT16_18-23), this critical attitude, as it occurs with pre-service teachers, also depends on *spontaneous interest in science and technology* and *gender* (women are more critical). No influence on age is detected.

On the other hand, the complete sample of the general population (EPSCYT16_all) deviates from this behavior of young people. *Gender* has no influence, but the following variables do: the degree to which the subject is considered scarcely *informed* about science and technology, their *age*—those who are older show slight distrust—, the fact of self-reporting *non-believers* and belonging to the upper *income* ranges.

Finally, the last two models considered in PCYTMF explain the ***security*** and ***confidence* in science** (model 3 and model 4). In the sample and sub-sample of the general population (EPSCYT16_18-23 and EPSCYT16_all) variables are detected to explain an uncritical confidence in science. The *ideological self-positioning* (further to the right causes more uncritical confidence) is an important factor, as it occurs with the pre-service teachers to explain the security in science. On the other hand, this uncritical position also seems to be based, in EPSCYT16_18-23 and EPSCYT16_all, on *information about science and technology*, unlike what occurs in the PCYTMF sample. Other factors that support the uncritical trust in science and technology in the general population and that are not shared by pre-service teachers are: low scientific knowledge (*knowledge 8*) in young people (EPSCYT16_18-23), and low *interest in science and technology*, *age*, few religious *beliefs*, having high *incomes* and low *educational level* in the population as a whole (EPSCYT16_all).

Results in Context

These results provide relevant information that can be contextualized in light of the existing literature. To this end, we will contrast the models we have identified with similar ones described in studies of this type. The interest of the data obtained allows for analysis at different levels. Thus, it is possible to consider differences in attitudes towards science among our prospective teachers, young people in their age group, and society as a whole. To this end, we focus particularly on the implications these differences have for teacher education.

In this regard study reveals that pre-service teachers in Spain generally feel uninformed about scientific topics, lack spontaneous interest in science, and do not exhibit higher confidence in science compared to their peers or the general population. Actually, they have a slightly less positive attitude. Informed skepticism is also missing among these education students, that is, ambivalent confidence that is present in educated populations as described in the literature (Bromme et al., 2022).

All of this is surprising because pre-service teachers have a slightly higher educational level than the general population and are from a relatively higher income range. These aspects are pointed out in the literature as precursors to a nearer attitude to science (Allum et al., 2008; Cortassa, 2016; Roduta Roberts et al., 2013; Sturgis & Allum, 2004; Sturgis et al., 2021). Thus, we expected the opposite difference to that found.

Moreover, we suppose that pre-service teachers have a vocation to teach, and we assume that they also have one to learn.

According to the literature on PUS (Allum et al., 2008; Cortassa, 2016; Roduta Roberts et al., 2013; Sturgis & Allum, 2004), scientific knowledge, independent of the level of studies, causes trust in science and technology. We have confirmed this by analyzing the ***positive*** and ***confidence*** variables (**Table 2**). The same is the case with spontaneous interest in science and technology. It produces greater scientific knowledge regardless of educational levels, and also greater confidence in science. However, in our sample, that spontaneous interest is not greater than among the population of the same age, and our students consider themselves to be less informed regarding science than them; due to this, we may suppose that this influential factor does not compensate the weight of the socio-economic or socio-demographic composition.

A first explanation would state that the over-representation of women in education studies (in our sample women reach 77.2%), could bias the results towards more extreme skepticism. Both in the literature as well as in our results, gender (being female) is one of the first predictors of a lack of interest and confidence in science (Allum et al., 2008; Trankina, 1993) and also of sceptic confidence when it arises (**Table 2**).

Interpretation of the small R^2 values of many of our regression models is that the largest part of the respondents does not have a specific attitude, and that they may perhaps decide it at the moment of responding. The ANOVA values and graphic analysis, which we have not presented, suggest that the responses are not given at random and that there is coherence between what they would have responded if science were a usual subject in their thought, although perhaps a certain social desirability factor may weigh this. Overall, it suggests that science is not a matter that greatly concerns society, nor prospective teachers.

CONCLUSIONS AND IMPLICATIONS

A general recommendation arises from our work, if confidence in science among future teachers (influenced by knowledge and interest) affects the quality of the science that will be taught in schools in the future, it appears to be necessary for the educational system to encourage that appreciation among women, at least if the majority of education students are going to continue to come from that gender group. That is in line with policies that aim to encourage women's interest in STEM subjects, but it will not be of much use if the women who develop that interest decide to take up STEM careers instead of those related to education. That recommendation would go hand in hand with encouraging shared participation in education among men. Encouraging the recruitment of future teachers (both women and men) with a spontaneous interest, confidence in scientific matters and a greater level of basic scientific knowledge, would provide primary school students a more realistic sample, nearer to the reality, of different attitudes to science that exist in society. That should make the institutions reflect on the process of getting young people to opt for teaching careers. This is something we perhaps have no possibility of influencing directly.

Some limitations of this study are related to the lack of data on the educational background of both parents and students (whether they come from the humanities or the experimental sciences). In addition, the samples are still relatively small and refer to narrow cohorts; moreover, they do not exactly match the surveys compared here, although the differences are minor. We also cannot ensure that the sample can be extrapolated to other periods or societies, despite our effort to include different types of universities in various settings—public and private universities, located in different sized cities and in both urban and rural environments, given that it is a non-representative sampling. There is no gender bias in this sample, since Spanish preservice teachers are predominantly women: our sample reflects the current gender distribution within this population of preservice teachers.

With regard to the pedagogical implications arising from these results, we think that knowledge of the social perception of science must form part of training for pre-service teachers. Below we provide three reasons to reflect on this, and on how it can ultimately have an impact on teaching practice in real science classes.

- Firstly, such knowledge would allow one to understand the different social perceptions of science and technology one cohabits with, to understand the vary role played by science in our society (Lederman, 1999), to know the many sensibilities to the different socio-scientific issues, the ways of showing the image of science in the social media (Anderson et al., 2021; Klosterman et al., 2012; Lundgren et al., 2022; Perales-Palacios et al., 2005; Peters et al., 2008) or how it is used in advertising (Campanario et al., 2001; Ezquerra & Fernández-Sánchez, 2014).

- Secondly, because inquiry into such knowledge would make it possible for pre-service teachers to express their self-perception regarding science (García-Carmona & Acevedo Díaz, 2016) and contrast this with the different social profiles that exist. Such metacognition would allow future teachers to progress from their initial position regarding science and learn about other options. Thus, those with clearly positive or trusting attitudes could anticipate the existence of more cautious positions. It would also be interesting for future teachers with critical positions to become familiar with more favorable attitudes in the environment of their students or schools (**Table 2**).
- Thirdly, because that knowledge would allow them to develop and adjust their pedagogical approaches to each student profile. For example, to identify perception of science among students (Christidou, 2011; Lewis & Leach, 2006), to identify the socio-scientific issues that are most relevant for the students at each educational level (Albe, 2008; Kokolaki & Stavrou, 2023; Kolstø, 2006), or even for students to develop skills to participate in reasoned discussions and make decisions (Cebesoy, 2021; Levinson, 2006).

Therefore, we should think about how future teacher who incorporate this knowledge in designing activities. To do this, various elements in which science is present in society can be used, such as advertising, social networks, news, etc. Assuming that children can start from positions of total uncritical trust in science to others that are more distrustful, depending on the topic, the teacher can make some decisions. For example, he can anticipate and take them into account by encouraging constructive debate among the diverse students' positions. Also, by promoting an adequate image of science based on the generation of knowledge through rigorous data collection, formulation of explanations and provisional models that must be contrasted with reality.

We must not forget that primary school teachers' confidence and attitudes towards science and technology significantly impact on their classroom practices and students' learning outcomes, as those with lower confidence may employ limiting strategies that negatively affect children's learning (Harlen & Holroyd, 1997). Consequently, improving teachers' confidence in science and technology can lead to more effective classroom practices and better outcomes for students (Oppong et al., 2023).

Based on the findings of this study, we propose that teacher training programs should:

- Select candidates who show a genuine interest in science and technology. This is consistent with research emphasizing the importance of intrinsic motivation in teaching science (Antink-Meyer et al., 2023).
- Ensure that selection processes adequately reflect societal diversity, particularly in relation to gender and attitudes towards science. Increasing gender diversity in science education helps reduce stereotypes and promotes equitable learning environments (Miller et al., 2015).
- Integrate knowledge about the social perception of science into the curriculum. Understanding how science is viewed within society supports future teachers in contextualizing their practice and recognizing external factors that shape students' engagement with science (Vílchez et al., 2025).
- Incorporate activities that enable student teachers to identify scientific phenomena in everyday contexts. Contextualized learning tasks have been shown to strengthen scientific literacy and foster sustained engagement with science (Lundgren et al., 2022; Perales-Palacios et al., 2005; Ezquerra et al., 2022).
- Implement practical strategies explicitly aimed at fostering scientific trust, such as collaborative problem-solving tasks, structured inquiry activities, and opportunities for evidence-based argumentation. These practices contribute to developing teachers' self-efficacy and their trust in teaching science (Toma et al., 2024).

Definitively, all these matters should form part of the PCK (Fernández-Carro et al., 2023; Vílchez et al., 2025; Han-Tosunoglu & Lederman, 2021; Hartelt et al., 2022; Kaya & Nafiz Kaya, 2022). It is important that educational research continues to address how society perceives science, since the influence that this factor has on the teaching-learning process is obvious, conditioning the attitude of both students and teachers.

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