



Abstract. *One of the main objectives of scientific literacy is the development of rational skills and critical thinking in citizens. This is a central goal for teachers. However, beliefs that lack rational foundation and supporting evidence, named “epistemically unwarranted beliefs” (EUB), spread rapidly among the population. If teachers had some of these EUB, their work could be compromised. The aim of this research was to determine the level of acceptance of different EUB in Spanish pre-service primary school teachers and to analyze the influence of their cognitive style, gender, and academic level. Two hundred and fifty undergraduate students of Bachelor’s Degree in Primary Education participated in this study. Two questionnaires were used to collect data. ANOVA, ANCOVA, correlations, and linear regression analysis were used to quantify that influence. Results showed high levels of acceptance of some EUB in future teachers, with significant influences of gender and academic level, and a mediating role of cognitive styles. Experiential and rational cognitive styles, and academic level were significant predictors of EUB, being experiential thinking the most powerful one. Thus, pre-service teacher education should have an epistemological vigilance on future teachers’ scientific literacy and increase the presence of rational style among teachers.*

Keywords: *cognitive style, epistemically unwarranted beliefs, gender influence, knowledge level, pre-service teachers, primary education*

Pedro D. Cadena-Nogales
Regional College Amazon Ikiam, Ecuador
Joan J. Solaz-Portolés,
Yolanda Echegoyen-Sanz,
Vicente Sanjosé-López
University of Valencia, Spain



LEVEL OF ACCEPTANCE OF EPISTEMICALLY UNWARRANTED BELIEFS IN PRE-SERVICE PRIMARY SCHOOL TEACHERS: INFLUENCE OF COGNITIVE STYLE, ACADEMIC LEVEL AND GENDER

**Pedro D. Cadena-Nogales,
Joan J. Solaz-Portolés,
Yolanda Echegoyen-Sanz,
Vicente Sanjosé-López**

Introduction

It is a fact that a large part of society does not have an acceptable level of scientific literacy. In recent years it has been observed that a prominent part of the citizenry holds beliefs linked to pseudoscience, paranormal phenomena, and conspiracy theories (Bensley et al., 2020). Research by Lobato et al. (2014), Pennycook et al. (2015), Čavojevová et al. (2019), and Bensley et al. (2020), showed that beliefs in pseudoscience, paranormal phenomena and conspiracy theories have a statistically significant association with each other. They can be considered as part of a generic construct that Lobato et al. (2014) called epistemically unwarranted beliefs, Čavojevová et al. (2019) epistemically suspect beliefs and Adam-Troian et al. (2019) epistemically unfounded beliefs.

Pseudoscience includes a whole set of studies (e.g., astrology, reincarnation, spiritual energy, UFO) that, although their followers defend as having a scientific character, use processes of a non-scientific nature to prove claims that include the principle of authority, anecdotes, or unprocessed natural causes (Losh et al., 2003). According to Preece and Baxter (2000, p. 1148) pseudoscience is “a set of ideas or theories that are defended as scientific but are contrary to standard science and have failed empirical tests or cannot in principle be proven”. There is great concern among scientists and educators about the growing and unstoppable popularity of pseudoscience in our society. It even generates health problems when pseudoscience can lead some patients, attracted by illusory promises and virtues, to abandon their conventional medical treatment (Cortiñas-Rovira et al., 2015).

Some studies showed that science education does not ensure the ability to challenge pseudoscience. The studies by Johnson (2003) and Lundström and Jakobsson (2009), did not find a significant relation between the level of scientific knowledge and beliefs in pseudoscience. In addition, Good (2012)

demonstrated that a science education program with special emphasis on the nature of science did not guarantee more skepticism towards pseudoscience. It is striking that neither high school students (Preece & Baxter, 2000) nor university students (Sugarman et al., 2011) have been found to correctly delimit science and pseudoscience. It is not surprising, therefore, that Mugaloglu (2014) advocated for the inclusion of elements, resources and strategies in science and science education curricula that allow the recognition of pseudoscience.

Paranormal phenomena are events or processes that, from a scientific point of view, are unfeasible because they would violate the basic limiting principles of science (Tobacyk & Milford, 1983). These paranormal phenomena are quite accepted among Westerners (Garrett & Cutting, 2017). Some examples are telepathy, divination, extrasensory perception, and ghosts. Like pseudoscience, they are not supported by empirical evidence under controlled conditions (Wilson, 2018). The prevalence of beliefs in paranormal phenomena in society is associated with a general bias towards the perception of causal links where there is no hard evidence, which Blanco et al. (2015) called illusion of causality. Aarnio and Lindeman (2005) showed that as the educational level increases these paranormal beliefs decrease. Shein et al. (2014) obtained negative, although not significant, correlation coefficients between the level of scientific knowledge and beliefs in fortune-telling, and also between the level of expertise in scientific methodology and these beliefs. However, Goode (2002) did not find a consistent relation between scientific knowledge of college students and their beliefs in paranormal phenomena.

Explanations for events that have been relevant involving secret plots of powerful and malevolent groups are often called conspiracy theories (Douglas et al., 2017). These explanations have not been verified, are implausible, and of little epistemological consistency (Brotherton, 2013). An example of a conspiracy theory could be that the murder of John F. Kennedy involved not only Lee H. Oswald but a whole mafia network. Throughout history, conspiracy theories have been present in social and political discourse, have been responsible for genocides and revolutions, and are currently leading many people to reject conventional medicine and anthropogenic climate change (Douglas et al., 2019). Not surprisingly, the work of Lewandowsky et al. (2013) has showed that those who defend conspiracy theories have a strong rejection of science and its methodology. According to the studies of Georgiou et al. (2019) and van Prooijen (2017) having a higher educational level decreases the probability of believing in conspiracy theories.

Gender is a factor that has been studied in relation to pseudoscience, paranormal phenomena, and conspiracy theories. The results of different studies on the levels of acceptance of these beliefs according to gender are contradictory. On the one hand, Johnson and Pigliucci (2004) did not find significant differences in pseudoscience beliefs based on gender in university students of Biology and Philosophy; Lundström and Jakobsson (2009) also did not find differences in upper secondary students. Nor did Spinelli et al. (2002) who studied the association between gender and beliefs in paranormal phenomena. On the other hand, both Preece and Baxter (2000) with upper secondary students and Wilson (2018) with university students, showed a significant effect of gender on beliefs in pseudoscience and paranormal phenomena. In both cases, women were less skeptical than men about such beliefs. As for conspiracy theories, studies by Cassese et al. (2020) and Galliford and Furnham (2017) revealed that men were more likely to believe in conspiracy theories than women. However, in the research of Parsons et al. (1999) gender was not significant for explaining beliefs in conspiracy theories.

According to Garrett and Weeks (2017), cognitive styles affect epistemological beliefs. One of the best known and most widely used models of thinking or cognitive styles is that of Epstein (2003). This researcher proposes a dual-process model of cognition which suggests that human behavior is controlled by two distinct and parallel information-processing systems: the rational or analytical system, which operates using rules of logic and evidence, coding reality in symbols, words and numbers that are culturally transmitted (for example, through education); and the experiential or intuitive system, which is innate and adaptive, allows learning from experience, and regulates behavior by coding emotion-related outcomes.

Relations between beliefs in pseudoscience, paranormal phenomena and conspiracy theories and analytical and intuitive cognitive styles have been analyzed in several papers. Some of these studies showed that intuitive cognitive style is positively related to beliefs in paranormal phenomena (Aarnio & Lindeman, 2005; Sadler-Smith, 2011) and analytical cognitive style is negatively related to such beliefs (Lindeman & Svedholm, 2012; Pennycook et al., 2012). Similarly, research by Georgiou et al. (2019) and Mikušková (2018) revealed that a higher degree of analytical thinking leads to a lower level of belief in conspiracy theories. Majima (2015) found, through a multiple regression analysis, that beliefs in pseudoscience can be predicted by the analytical style, and not by the intuitive style.

If citizens are to be scientifically literate, one aspect that must undoubtedly be addressed from the early stages of the educational system is to encourage epistemologically grounded beliefs. Primary school teachers



can be the first link in the scientific literacy chain. However, it has been found that a good part of primary school teachers in training have great difficulty in distinguishing between science and pseudoscience (Jones et al., 2011), and they believe in the principles of astrology (Oztuna, 2014), accept creationist, magical or fantastic ideas (Losh & Nzekwe, 2011), have faith in superstitions and pseudoscience (Fuertes-Prieto et al., 2020), and have a high level of acceptance (101.10 points on a scale with a maximum of 180 points) of conspiracy theories (Mikušková, 2018).

Thus, previous research indicated that primary school teachers may have a high level of acceptance of epistemically unwarranted beliefs (EUB), regardless of their country of origin. This may influence their science literacy work. Consequently, it is necessary to know the level of acceptance of EUB by pre-service primary school teachers, as well as the influence of some variables on this level of acceptance.

Research Aim and Research Questions

Considering the above, the purpose of this study is to investigate EUB of a specific population, pre-service primary school teachers (who are supposed to teach scientific literacy to their future students) and the influence of some variables on these EUB. Specifically, this study attempts to analyze the influence of cognitive style, scientific training (academic level) and gender on EUB. To this end, the following research questions were formulated:

- What is the level of acceptance of EUB (pseudoscience, paranormal phenomena, and conspiracy theories) in pre-service primary school teachers?
- Is there a significant influence of cognitive styles (experiential or rational), gender and academic level on EUB?
- What is the relative contribution of cognitive style, gender, and academic level to EUB variability?

Research Methodology

General Background

Quantitative research was carried out. In particular, this study used an ex post facto, cross-sectional, descriptive research to analyze the data of the level of acceptance of EUB in pre-service primary school teachers and the relative contribution of cognitive style, academic level and gender to EUB variability. The data for the analyses were collected in the first four months of the 2020-2021 academic year.

Participants

Participants were 250 undergraduate students (of whom 74% were women) pertaining to 6 intact classroom groups (out of a total of 22 existing groups at the chosen levels) currently enrolled in the Bachelor's Degree in Primary Education at a public university located in Valencia, Spain (Universitat de València). Among them, 109 were first-year students (average age 18.9 years) and 141 were final-year students (average age 22.9 years). First-year students had not yet studied any science subjects or science education subjects during their undergraduate studies. Final-year students had studied both science and science education subjects, which include scientific conceptual knowledge, science process skills, and knowledge of the nature of science. There were not random sampling procedures, so the participants formed a convenience sample because of their easy accessibility. However, they did not present, a priori, any special characteristic that could differentiate them from other groups in the same population (Spanish pre-service primary school teachers).

Students' participation was completely voluntary, i.e., no coercion was exerted on them to participate in the study. However, they were warned that research findings could help to improve teacher training. They were also told that they could identify themselves with a pseudonym and were assured of the confidentiality of the information provided in their responses.

Instruments and Procedures

EUB were measured with Lobato et al. (2014) 37-item questionnaire (hereafter, Belief Questionnaire). All items were a priori defined as paranormal, conspiracy, and pseudoscientific. Five items of the questionnaire (items belong-



ing to the subscale of conspiracy theories) that could be poorly understood by Spanish students were substituted by other ones with similar purpose, as shown in Table 1. These new items contain ideas that have either been widely commented on in the Spanish social media or are widespread in Spanish society.

Table 1*Statements of Replaced Items and New Items Regarding Conspiracy Theories*

Original item	New item
7. Members of the US government were involved in the planning and execution of the events that happened on 11 September 2001	7. Pharmaceutical companies release certain types of viruses to improve drug sales
8. President John F. Kennedy was assassinated by Lee Harvey Oswald, who acted alone.	8. Hitler survived and fled to Latin America
21. President Barack H. Obama is a native-born US citizen.	21. The onset of AIDS was the result of testing of drugs in Africa funded by the CIA
32. The rappers Tupac Shakur and Biggie Smalls were victims of assassination conspiracies, which were covered up.	32. The UK's Secret Intelligence Service murdered Princess Diana.
33. The singer Kurt Cobain was murdered by his wife, singer Courtney Love.	33. There was, and probably still is, a secret coalition between Jews, Freemasonry and the communists who pretended to dominate the world.

A 5-point Likert scale for each item was used (1 = strongly disagree and 5 = strongly agree). For analyses, scores were recoded such that the higher the score, the greater rejection of the epistemically unwarranted belief. Some items had a reverse scale, and this was taken into account in the process to keep coherence. An example item of the subscale of beliefs in pseudoscience is "The variety of Species of life that exist today is best explained by the scientific theory of evolution" (value 5: strong rejection of the associated EUB, creationism), and an example of the subscale of beliefs in paranormal phenomena is "Extraterrestrial life forms have visited Earth and abducted human beings" (value 5: strong belief in aliens' paranormal phenomena). The questionnaire reached a reliability of .82 (Cronbach's α).

Individual differences in cognitive styles were assessed by the Rational-Experiential Inventory (Pacini & Epstein, 1999). The scales for rational and experiential thinking both consist of 20 items and are measured with five-point scales (1 = strongly disagree, 5 = strongly agree). In both scales there are negative items that require reverse scoring. Example items measuring rational and experiential thinking, respectively, are "I enjoy solving problems that require hard thinking" and "Intuition can be a very useful way to solve problems". The reliabilities were .83 (rational thinking scale) and .84 (experiential thinking scale).

Only one session was needed to collect the data, and it was carried out in the respective classrooms. In this session, participants were asked to complete the Rational-Experiential Inventory and the Belief Survey. The session lasted approximately 90 min. When the participants finished, they were thanked for their participation.

Data Analysis

Kolmogorov-Smirnov test was used to check the normality of the distribution. One-way analyses of variance (ANOVA), univariate analyses of covariance (ANCOVA), and correlation and multiple regression analyses were carried out. The Cronbach's α values were calculated for internal consistency. The data were analyzed using SPSS 24.0 statistical package program.

Research Results

Means and standard deviations for the Belief Questionnaire and its scales, and for the analytic and the intuitive scales scores are presented in Table 2. The score for each scale was obtained by adding the corresponding item scores.



Table 2
Descriptive Results of Relevant Variables in the Present Study

Variable	Study Year	Gender	<i>M</i>	<i>SD</i>
Pseudoscience Beliefs (maximum score 65)	First-year	Male	47.87	5.50
		Female	47.76	5.12
	Final-year	Male	49.84	6.01
		Female	49.07	4.34
Paranormal Beliefs (maximum score 70)	First-year	Male	52.53	5.44
		Female	49.16	10.17
	Final-year	Male	56.12	9.07
		Female	52.02	9.18
Conspiracy Beliefs (maximum score 50)	First-year	Male	32.73	4.33
		Female	33.28	3.49
	Final-year	Male	33.51	5.10
		Female	33.26	3.38
EUB (maximum score 185)	First-year	Male	133.13	12.33
		Female	130.19	14.74
	Final-year	Male	139.70	17.34
		Female	134.34	12.81
Rational Thinking (maximum score 100)	First-year	Male	68.53	11.96
		Female	67.05	9.58
	Final-year	Male	71.72	8.23
		Female	67.29	10.70
Experiential Thinking (maximum score 100)	First-year	Male	64.27	7.97
		Female	68.40	8.83
	Final-year	Male	63.86	9.67
		Female	67.92	10.21

Pearson product-moment correlations showed that beliefs in paranormal phenomena, conspiracy theories, and pseudoscience all were significantly positively correlated, as shown in Table 3. Therefore, it seems that those participants having one type of belief tend to have the other two types.

Table 3
Pearson Product-Moment Correlation Coefficients Between the Different Types of Beliefs

	Pseudoscience	Paranormal	Conspiracy
Pseudoscience	1	.54*	.29*
Paranormal		1	.28*

Notes: $N = 250$. * $p < .001$

Then, the Kolmogorov-Smirnov normality test was applied to the scores of Belief Questionnaire in each academic level and gender. As the null hypothesis could be rejected in all cases ($p > .05$), the scores in each academic level and gender were considered as normally distributed. Effects of gender and academic level on overall EUB were analyzed in separate one-way analyses of variance (ANOVA). Female students scored significantly lower than male students in the Beliefs Questionnaire and, therefore, they had significantly more EUB than men, although the effect was of very small size, $F(1,246) = 8.99$, $p < .01$, $\eta^2 = .032$. First-year students had more EUB than final-year students (the latter scored significantly higher than the former in the Belief Questionnaire), but again the effect size was very small, $F(1,246) = 9.30$, $p < .01$, $\eta^2 = .044$.

Firstly, it was tested whether cognitive styles were associated with EUB, on the one hand, and with gender and academic level on the other hand, with the aim of investigating the possible influence of the cognitive styles on the



previous results. Pearson product-moment correlations between variables are shown in Table 4. The results showed that EUB correlated significantly and negatively with experiential thinking, $r = -.37, p < .001$, and significantly and positively with rational thinking, $r = .21, p < .001$. On the other hand, rational thinking correlated positively with gender (i.e., male students showed more analytical thinking than female students), $r = .17, p < .01$; and experiential thinking correlated negatively with gender (i.e., female students reported a higher level of intuitive thinking than male students), $r = -.19, p < .01$. No correlation between cognitive styles and academic level was obtained.

Table 4

Pearson Product-Moment Correlation Coefficients Between Variables

	EUB	Rational	Experiential	Academic l.	Gender
EUB	1	.21**	-.37**	.19*	.18*
Rational		1	.00	.08	.17*
Experiential			1	-.07	-.19*
Academic level				1	.25**

Notes: $N = 250$. Gender coded such that female students = 0, male students = 1. Academic level coded such that first-year = 0, final-year = 1. * $p < .01$, ** $p < .001$

The results of univariate analyses of covariance (ANCOVA) showed that rational and experiential thinking mediated the differences according to gender in EUB. When rational thinking was partialled out, $F(1,247) = 5.43, p < .05, \eta^2 = .018$, gender had a slightly reduced although still significant effect on EUB, $F(1,247) = 7.01, p < .05, \eta^2 = .023$. However, when experiential thinking was partialled out, $F(1,247) = 3.29, p = .07$, gender no longer had a significant effect on EUB, $F(1,247) = 6.01, p < .05, \eta^2 = .011$. Thus, the elimination of the influence of experiential thinking caused gender to be a non-significant variable on EUB.

Rational and experiential thinking also mediated the academic level difference on EUB. The results indicated that when both rational thinking was partialled out, $F(1,247) = 7.98, p < .01, \eta^2 = .033$, and experiential thinking was partialled out, $F(1,247) = 7.90, p < .01, \eta^2 = .031$, first-year and final-year students differed a little less although still significantly from each other, $F(1,247) = 8.51, p < .01, \eta^2 = .039$, and $F(1,247) = 8.48, p < .01, \eta^2 = .037$, respectively.

Further, a regression analysis was performed to determine the contribution of rational thinking, experiential thinking, academic level, and gender to EUB. The backward stepwise regression analysis was considered the most suitable method since this method allows to determine the non-significant and redundant predictors. Table 5 shows the corresponding data.

Table 5

Summary of Backward Stepwise Regression Analysis for Variables Predicting Total Score of EUB

Stage	Independent Variables	R ²	Adjusted R ²	ΔR^2	F-value	β -value	p	VIF*
1		.206	.196	.196	19.98			
	Experiential					-.354	<.001	1.040
	Rational					.189	<.01	1.032
	Academic level					.138	<.05	1.066
	Gender					.042	.485	1.128
2		.203	.194	-.002	20.93			
	Experiential					-.362	<.001	1.005
	Rational					.195	<.001	1.006
	Academic level					.142	.01	1.011

Notes: $N = 250$. Gender coded such that female students = 0, male students = 1. Academic level coded such that first-year = 0, final-year = 1. *Variance Inflation Factor.



In step 1, $F(4,245) = 19.98, p < .001$, all independent variables predicted 19.6% of the variation in EUB, and experiential thinking, rational thinking and academic level were significant predictors, but gender was not. There was no evidence of collinearity (all Variance Inflation Factors < 1.5). In step 2 gender was eliminated, $F(3,246) = 20.93, p < .001$, and the remaining variables reduced prediction of EUB by only 0.3 percentage points

Subsequently, a forward stepwise regression analysis predicting EUB, was carried out. Experiential thinking was selected first ($F(1,248) = 39.97, p < .001$) and accounted for 13.5% (adjusted $R^2 = .135$) of the variance in EUB. Introducing rational thinking explained an additional 4 percentage points of the variation in the EUB ($F(2,247) = 27.41, p < .001$). Adding the academic level increased prediction of EUB by 1.9 percentage points ($F(3,246) = 20.93, p < .001$).

Discussion

Firstly, the significantly positive correlations obtained in this research between the three types of beliefs included in the Belief Questionnaire (pseudoscience, paranormal and conspiracy) can be considered quite similar to those obtained by Lobato et al. (2014) with US Psychology students. In the present study, using the same questionnaire (except for 5 items), two correlations were slightly lower (between paranormal and conspiracy, and between pseudoscience and conspiracy) and one slightly higher (between paranormal and pseudoscience). In other subsequent studies these correlations have reappeared (Bensley et al., 2020; Čavojská et al. 2019; Pennycook et al., 2015), even with higher correlation coefficients, although the instruments used have not been the same. Thus, preservice teachers who participated in the present study who give support for one type of belief tend to give support for the other two. It seems, therefore, that our results again provide converging evidence of the existence of a generic construct that can be called EUB. This construct would be made up of different components (beliefs) related to each other, linked to higher hierarchical cognitive structures and variables that we have to unravel.

It seems relevant to know whether the level of adherence to EUB of the pre-service primary school teachers who participated in this research can be considered normal among university students. The only reference we have is the study conducted with North American Psychology students by Lobato et al. (2014). The calculation of the mean scores per item in each of the three beliefs (between 3.67 and 3.83 in pseudoscience, between 3.51 and 4.01 in paranormal phenomena, and between 3.27 and 3.33 in conspiracy theories) allows us to compare both studies. The scores obtained by the participating preservice primary teachers were slightly higher in pseudoscience and paranormal phenomena, and practically equal in conspiracy theories. Thus, the epistemologically unwarranted beliefs of the Spanish teachers in training do not seem to differ substantially from those of the North American psychologists in training. It even appears that Spanish preservice teachers' level of adherence to EUB seems to be somewhat lower. Also, in both cases, beliefs in conspiracy theories are the most widely accepted.

The importance of cognition styles on EUB has been highlighted in the present work, in which we should remember that a higher score in the EUB measure meant a greater rejection of EUB. First, a significant and positive correlation has been found between the rational thinking style and EUB (i.e., the higher the rational thinking the less acceptance of EUB), and a significant and negative correlation between the experiential thinking style and EUB (i.e., the higher experiential thinking the more acceptance of EUB). These expected results are in full agreement with the positive association between paranormal beliefs and the experiential cognitive style found by Aarnio and Lindeman (2005), and Sadler-Smith (2011), and with the negative association between the rational cognitive style and paranormal beliefs found by Lindeman and Svedholm (2012) and Pennycook et al., (2012). The results are also congruent with the findings of Georgiu et al. (2019) who found a negative association between rational thinking and beliefs in conspiracy theories, and a positive association between experiential thinking and beliefs in conspiracy theories. On the other hand, the multiple regression analysis conducted in this study has revealed that cognitive styles are powerful predictors of EUB, and that the most powerful one is experiential thinking, having a negative contribution to the variability of the EUB.

As can be seen in Table 2, gender seems to have a significant influence on EUB in the present study. At first glance, female students seemed to show more EUB than male students. This is aligned with the work of Wilson (2018). However, the ANCOVA performed with rational thinking or experiential thinking as covariates showed that rational and experiential thinking mediated the gender difference in EUB. This result is consistent with the one obtained by Aarnio and Lindeman (2005) regarding beliefs in paranormal phenomena. Specifically, when men and women were statistically matched on experiential thinking, there were no longer differences between them in their EUB. In addition, gender was not a significant predictor of EUB beliefs in the regression analysis performed.



In the present study, a higher academic level implies a higher level of knowledge in science and science education, according to the syllabus of the corresponding university degree. The results concerning this variable (scores in Table 2, ANOVA and ANCOVA, and regression analysis) have shown that the participants with higher academic level were significantly more disbelieving of EUB. Consequently, it seems that their education along the university degree has had a positive effect on their EUB. This decay of EUB as education progresses has also been observed in other studies. Preece and Baxter (2000) observed a decrease in beliefs in pseudoscience as students progressed through secondary education. In the same line, Aarnio and Lindeman (2005) observed an increase of the likelihood of having fewer paranormal beliefs as the educational level increased. Georgiu et al. (2019) and van Prooijen (2017) also showed increasing skepticism towards conspiracy theories with the level of studies completed.

Finally, the limitations of this study should be noted. It was not based on a representative sample and therefore has limited external validity. The sample is made up of citizens with a high level of education (pre-service primary school teachers) who were motivated to participate in the study. Moreover, these participants were predominantly women (the percentage of women almost triples that of men) and were in only two academic levels (at the beginning and at the end of a university degree), particularities that restrict to some extent the extrapolation of our results. Moreover, the results of this study relied exclusively on self-reports that are subject to biases and limitations. Thus, all the conclusions that follow are only valid, strictly speaking, for the students who took part in this study and for the instruments that were used.

Conclusions and Implications

This research shows that Spanish pre-service primary school teachers in general have a level of EUB very poorly suited to the task of making children scientifically literate. The cognitive style of these teachers plays an important role in their EUB: prospective teachers who have a rational style tend to reject EUB compared to those with an experiential style, who tend to accept EUB to a greater extent. In fact, this study reveals that experiential thinking (or experiential style) is the best predictor of EUB. There is also evidence that higher academic level (i.e., more scientific training) significantly reduces their EUB, and that gender affects EUB.

This research also demonstrates a mediating role of cognitive styles on epistemically unwarranted beliefs. The influence of gender on EUB is ostensibly lessened when the effect of cognitive style is discounted (especially in the case of experiential cognitive style). Regarding academic level, differences between prospective teachers with weak scientific background and prospective teachers with strong scientific backgrounds diminish due to the mediating role of both rational and experiential styles, although these differences remain significant.

Based on the above, it seems that a possible way to reduce EUB of prospective teachers could be to shift the dual experiential-rational cognitive system of these teachers towards reducing the experiential style and increasing the rational one through specific programs. Moreover, the level of scientific literacy of these teachers should be improved with contents including elements, resources, procedures, and strategies that help to delimit scientific knowledge from other ideas and processes of a non-scientific nature or of little epistemological consistency.

Declaration of Interest

Authors declare no competing interest.

References

- Aarnio, K., & Lindeman, M. (2005). Paranormal beliefs, education, and thinking styles. *Personality and Individual Differences*, 39(7), 1227-1236. <https://doi.org/10.1016/j.paid.2005.04.009>
- Adam-Troian, J., Caroti, D., Arciszewski, T., & Ståhl, T. (2019). Unfounded beliefs among teachers: The interactive role of rationality priming and cognitive ability. *Applied Cognitive Psychology*, 33(4), 720-727. <https://doi.org/10.1002/acp.3547>
- Bensley, D. A., Lilienfeld, S. O., Rowan, K.A., Masciocchi, C. M., & Grain, F. (2020). The generality of belief in unsubstantiated claims. *Applied Cognitive Psychology*, 34(1), 16-28. <https://doi.org/10.1002/acp.3581>
- Blanco, F., Barberia, I., & Matute, H. (2015). Individuals who believe in the paranormal expose themselves to biased information and develop more causal illusions than non believers in the laboratory. *PLoS one*, 10(7), Article e0131378. <https://doi.org/10.1371/journal.pone.0131378>
- Brotherton, R. (2013). Towards a definition of "conspiracy theory". *PsyPAG Quarterly*, 88(3), 9-14.
- Cassese, E. C., Farhart, C. E., & Miller, J. M. (2020). Gender differences in COVID-19 conspiracy theory beliefs. *Politics & Gender*, 16(4), 1009-1018. <https://doi.org/10.1017/S1743923X20000409>



- Čavojová, V., Secarä, E.C., Jurkovič, M., & Šrol, J. (2019). Reception and willingness to share pseudo-profound bullshit and their relation to other epistemically suspect beliefs and cognitive ability in Slovakia and Romania. *Applied Cognitive Psychology*, 33(2), 299-311. <https://doi.org/10.1002/acp.3486>
- Cortiñas-Rovira, S., Alonso-Marcos, F., Pont-Sorribes, C., & Escribà-Sales, E. (2015). Science journalists' perceptions and attitudes to pseudoscience in Spain. *Public Understanding of Science*, 24(4), 450-465. <https://doi.org/10.1177/0963662514558991>
- Douglas, K. M., Sutton, R. M., & Cichocka, A. (2017). The psychology of conspiracy theories. *Current Directions in Psychological Science*, 26(6), 538-542. <https://doi.org/10.1177/0963721417718261>
- Douglas, K. M., Uscinski, J. E., Sutton, R. M., Cichocka, A., Nefes, T., Ang, C. S., & Deravi, F. (2019). Understanding conspiracy theories. *Political Psychology*, 40(1), 3-35. <https://doi.org/10.1111/pops.12568>
- Epstein, S. (2003). Cognitive-experiential self-theory of personality. In T. Millon, & M. J. Lerner (Eds.), *Handbook of Psychology: Vol. 5. Personality and Social Psychology* (pp. 159-184). Wiley. <https://doi.org/10.1002/0471264385.wei0507>
- Fuertes-Prieto, M. A., Andrés-Sánchez, S., Corrochano-Fernández, D., Urones-Jambrina, C., Delgado-Martín, M. L., Herrero-Teijón, P., & Ruiz, C. (2020). Pre-service teachers' false beliefs in superstitions and pseudosciences in relation to science and technology. *Science & Education*, 29(5), 1235-1254. <https://doi.org/10.1007/s11191-020-00140-8>
- Galliford, N., & Furnham, A. (2017). Individual difference factors and beliefs in medical and political conspiracy theories. *Scandinavian Journal of Psychology*, 58(5), 422-428. <https://doi.org/10.1111/sjop.12382>
- Garrett, B. M., & Cutting, R. L. (2017). Magical beliefs and discriminating science from pseudoscience in undergraduate professional students. *Heliyon*, 3(11), Article e00433. <https://doi.org/10.1016/j.heliyon.2017.e00433>
- Garrett, R. K., & Weeks, B. E. (2017). Epistemic beliefs' role in promoting misperceptions and conspiracist ideation. *PLoS one*, 12(9), Article e0184733. <https://doi.org/10.1371/journal.pone.0184733>
- Georgiou, N., Delfabbro, P., & Balzan, R. (2019). Conspiracy beliefs in the general population: The importance of psychopathology, cognitive style and educational attainment. *Personality and Individual Differences*, 151, 109521. <https://doi.org/10.1016/j.paid.2019.109521>
- Good, R. (2012). Why the study of pseudoscience should be included in nature of science studies. In M. S. Khine (Ed.), *Advances in nature of science research* (pp. 97-106). Springer.
- Goode, E. (2002). Education, scientific knowledge, and belief in the paranormal. *Skeptical Inquirer*, 26(1), 24-27.
- Johnson, R. M. (2003). *Is knowledge of science associated with higher skepticism of pseudoscientific claim?* (Doctoral thesis, University of Tennessee). https://trace.tennessee.edu/utk_chanhonoproj/659
- Johnson, M., & Pigliucci, M. (2004). Is knowledge of science associated with higher skepticism of pseudoscientific claims? *The American Biology Teacher*, 66(8), 536-548. <https://doi.org/10.2307/4451737>
- Jones, L. L., MacArthur, J. R., & Akaygün, S. (2011). Using technology to engage preservice elementary teachers in learning about scientific inquiry. *CEPS Journal*, 1(1), 113-131.
- Lewandowsky, S., Gignac, G. E., & Oberauer, K. (2013). The role of conspiracist ideation and worldviews in predicting rejection of science. *PLoS one*, 8(10), Article e75637. <https://doi.org/10.1371/journal.pone.0075637>
- Lindeman M., & Svedholm A. M. (2012). What's in a term? Paranormal, superstitious, magical and supernatural beliefs by any other name would mean the same. *Review of General Psychology*, 16(3), 241-255. <https://doi.org/10.1037/a0027158>
- Lobato, E., Mendoza, J., Sims, V., & Chin, M. (2014). Examining the relationship between conspiracy theories, paranormal beliefs, and pseudoscience acceptance among a university population. *Applied Cognitive Psychology*, 28(5), 617-625. <https://doi.org/10.1002/acp.3042>
- Losh, S. C., & Nzekwe, B. (2011). Creatures in the classroom: Preservice teacher beliefs about fantastic beasts, magic, extraterrestrials, evolution and creationism. *Science & Education*, 20(5-6), 473-489. <https://doi.org/10.1007/s11191-010-9268-5>
- Losh S. C., Tavani C. M., Njoroge R., Wilke R., & McAuley M. (2003). What does education really do? Educational dimensions and pseudoscience support in the American general public, 1979-2001. *Skeptical Inquirer*, 27(5), 30-35.
- Lundström, M., & Jakobsson, A. (2009). Students' ideas regarding science and pseudo-science in relation to the human body and health. *Nordic Studies in Science Education*, 5(1), 3-17. <https://doi.org/10.5617/nordina.279>
- Majima, Y. (2015). Belief in pseudoscience, cognitive style and science literacy. *Applied Cognitive Psychology*, 29(4), 552-559. <https://doi.org/10.1002/acp.3136>
- Mikušková, E. B. (2018). Conspiracy beliefs of future teachers. *Current Psychology*, 37(3), 692-701. <https://doi.org/10.1007/s12144-017-9561-4>
- Mugaloglu, E. Z. (2014). The problem of pseudoscience in science education and implications of constructivist pedagogy. *Science & Education*, 23(4), 829-842. <https://doi.org/10.1007/s11191-013-9670-x>
- Oztuna, A. (2014). Research on the pseudo-scientific beliefs of pre-service science teachers: A sample from astronomy-astrology. *Journal of Baltic Science Education*, 13(3), 381-393. <https://dx.doi.org/10.33225/jbse/14.13.381>
- Pacini, R., & Epstein, S. (1999). The relation of rational and experiential information processing styles to personality, basic beliefs and the ratio-bias phenomenon. *Journal of Personality and Social Psychology*, 76(6), 972-987. <https://doi.org/10.1037/0022-3514.76.6.972>
- Parsons, S., Simmons, W., Shinhoster, F., & Kilburn, J. (1999). A test of the grapevine: An empirical examination of conspiracy theories among African Americans. *Sociological Spectrum*, 19(2), 201-222. <https://doi.org/10.1080/027321799280235>
- Pennycook G., Cheyne J. A., Seli P., Koehler D. J., & Fugelsang J. A. (2012). Analytic cognitive style predicts religious and paranormal belief. *Cognition*, 123(3), 335-346. <https://doi.org/10.1016/j.cognition.2012.03.003>
- Pennycook, G., Cheyne, J.A., Barr, N., Koehler, D. J., & Fugelsang, J. A. (2015). On the reception and detection of pseudo-profound bullshit. *Judgment and Decision Making*, 10(6), 549-563.



- Preece, P. F., & Baxter, J. H. (2000). Skepticism and gullibility: the superstitious and pseudoscientific beliefs of secondary school students. *International Journal of Science Education*, 22(11), 1147-1156. <https://doi.org/10.1080/09500690050166724>
- Sadler-Smith E. (2011). The intuitive style: Relationships with local/global and verbal/visual styles, gender, and superstitious reasoning. *Learning and Individual Differences*, 21(3), 263-270. <https://doi.org/10.1016/j.lindif.2010.11.013>
- Shein, P.P., Li, Y.Y., & Huang, T.C. (2014). Relationship between scientific knowledge and fortune-telling. *Public Understanding of Science*, 23(7), 780-796. <https://doi.org/10.1177/0963662514522169>
- Spinelli, S. N., Reid, H. M., & Norvilitis, J. M. (2002). Belief in and experience with the paranormal: Relations between personality boundaries, executive functioning, gender role, and academic variables. *Imagination, Cognition and Personality*, 21(4), 333-346. <https://doi.org/10.2190/G54A-7VFM-MLMR-8J2G>
- Sugarman, H., Impey, C., Buxner, S., & Antonellis, J. (2011). Astrology beliefs among undergraduate students. *Astronomy Education Review*, 10(1), Article 010101-1. <https://doi.org/10.3847/AER2010040>
- Tobacyk, J., & Milford, G. (1983). Belief in paranormal phenomena: Assessment instrument development and implications for personality functioning. *Journal of Personality and Social Psychology*, 44(5), 1029-1037. <https://doi.org/10.1037/0022-3514.44.5.1029>
- van Prooijen, J.W. (2017). Why education predicts decreased belief in conspiracy theories. *Applied Cognitive Psychology*, 31(1), 50-58. <https://doi.org/10.1002/acp.3301>

Received: January 03, 2022

Revised: February 22, 2022

Accepted: April 08, 2022

Cite as: Cadena-Nogales, P. D., Solaz-Portolés, J. J., Echegoyen-Sanz, Y., & Sanjosé-López, V. (2022). Level of acceptance of epistemically unwarranted beliefs in pre-service primary school teachers: Influence of cognitive style, academic level and gender. *Journal of Baltic Science Education*, 21(3), 398-407. <https://doi.org/10.33225/jbse/22.21.398>

**Pedro D.
Cadena-Nogales**

Master's Degree (MSc) in Research in Science Education, Assistant Professor at Regional College Amazon Ikiam (Universidad Regional Amazónica-Ikiam), Parroquia Muyuna Km.7, Tena, EC150101, Ecuador.
E-mail: pedro.cadena@ikiam.edu.ec
ORCID: <http://orcid.org/0000-0002-9726-8972>

**Joan J.
Solaz-Portolés**
(Corresponding author)

PhD in Chemistry, Associate Professor at the Department of Experimental and Social Sciences Education of the University of Valencia (Universitat of València), Avgda Tarongers, 4, 46022 València, Spain.
E-mail: Joan.Solaz@uv.es
ORCID: <http://orcid.org/0000-0003-4690-6556>

**Yolanda
Echegoyen-Sanz**

PhD in Chemistry, Associate Professor at the Department of Experimental and Social Sciences Education of the University of Valencia (Universitat of València), Avgda Tarongers, 4, 46022 València, Spain.
E-mail: Yolanda.Echegoyen@uv.es
ORCID: <http://orcid.org/0000-0002-3729-460X>

**Vicente
Sanjosé-López**

PhD in Physics, Full Professor at the Department of Experimental and Social Sciences Education of the University of Valencia (Universitat of València), Avgda Tarongers, 4, 46022 València, Spain.
E-mail: Vicente.Sanjose@uv.es
ORCID: <http://orcid.org/0000-0003-3806-1717>

