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Navigating between faith and science: Acceptance of cosmological and evolutionary theories among Greek pre-service teachers

Georgios Stylos [1]*, Georgia Vakarou [1], Elli Gkaltemi [1], Konstantinos T. Kotsis [1]

[1]University of Ioannina, Ioannina, GREECE
***Corresponding Author:** gstylos@uoi.gr

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ABSTRACT

Acceptance of the big bang theory and evolutionary theory often intersects with learners' religiosity, particularly in culturally religious contexts such as Greece. Pre-service teachers' acceptance of these theories is critical, as their beliefs may shape future science instruction. This study investigates the extent to which religiosity is associated with Greek pre-service primary teachers' acceptance of the said theories, while examining variations by gender, year of study, and high school specialization. A quantitative survey design was implemented with 486 pre-service teachers using the MATE, MABBT, and centrality of religiosity scale. Data were analyzed through exploratory factor analysis, internal consistency testing, non-parametric comparisons, and correlation analysis. Participants demonstrated moderate acceptance of both theories and moderate religiosity. Acceptance was higher among later-year students, whereas religiosity was lower in later-year cohorts. Religiosity was negatively correlated with acceptance of both theories. No gender differences emerged, but science-track students showed higher acceptance. Teacher education should address epistemic tensions between science and religion to foster informed scientific acceptance.

Keywords: acceptance, evolution, big bang theory, MATE, pre-service teachers

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INTRODUCTION

Understanding acceptance of scientific explanations about the origin and development of the universe requires more than recounting discoveries; it involves exploring how learners revise or resist deeply rooted beliefs. The big bang theory (BBT) and evolutionary theory (ET) offer naturalistic explanations of cosmology and life but accepting them often entails conceptual change–restructuring prior conceptions rather than simply adding new facts. Conceptual-change research indicates that learners adopt new ideas when they become dissatisfied with existing explanations and view the new theory as intelligible, plausible, and fruitful (Posner et al., 1982; Sinatra et al., 2008). However, those whose understanding is grounded in religious narratives may not experience such dissatisfaction. Narratives strongly shape beliefs by offering coherent, emotionally resonant accounts that reduce counterargument and discourage replacing familiar explanations with scientific ones (Braddock & Dillard, 2016; Sinatra et al., 2008).

Recent studies underscore the role of religiosity in shaping acceptance of scientific theories. Strong religious convictions are associated with lower acceptance of evolution and cosmological models (Aini et al., 2024; Betti et al., 2020; Gutowski et al., 2023; Kuschmierz et al., 2020; Manwaring et al., 2018). Such findings suggest that religiously grounded worldviews can act as barriers to acceptance because they conflict with the conditions for conceptual change. Understanding these dynamics is therefore essential for science educators seeking to support learners in reconciling scientific explanations with their belief systems. However, existing studies have predominantly focused on evolution (Aini et al., 2024; Betti et al., 2020; Gutowski et al., 2023; Kuschmierz et al., 2020; Manwaring et al., 2018), while comparatively fewer investigations examine acceptance of the BBT (Christonasis et al., 2023).

This study examines Greek pre-service elementary teachers, a group whose beliefs are still developing and thus open to change (Sheridan, 2016). As their views influence both their own understanding and future teaching, it is

essential to explore how religiosity affects their acceptance of cosmological and evolutionary theories. Greece's predominantly Orthodox Christian context offers a unique setting to investigate how a specific religious tradition intersects with conceptual change. Therefore, this study investigates pre-service primary teachers' acceptance of both BBT and ET and explores how religiosity and demographic characteristics (gender, year of study, and high school specialization) are associated with theory acceptance. This dual focus contributes to a more comprehensive understanding of how different domains of origin-related science interact with religious conceptual frameworks during teacher education.

THEORETICAL FRAMEWORK

Conceptual Change Theory

Conceptual change theory posits that the acceptance of scientific explanations requires not just cognitive acquisition of knowledge but the restructuring of prior belief systems (Posner et al., 1982; Sinatra & Pintrich, 2003). For this restructuring to occur, learners must perceive their current explanations as insufficient and view the alternative theory as intelligible, plausible, and fruitful (Posner et al., 1982). However, belief change is influenced by the learner's conceptual ecology–their prior knowledge, epistemological views, and worldview (Sinatra & Pintrich, 2003; Strike & Posner, 1992). In the case of evolution, this ecology may include scientific understanding, religious beliefs, and social influences (Athanasiou et al., 2012; Demastes et al., 1995), meaning that rejection or partial acceptance of scientific explanations may not stem from a lack of understanding but from resistance to belief change driven by religious meaning-making systems.

Understanding vs. Accepting

This epistemic tension highlights the critical distinction between understanding and accepting scientific theories in science education (Bilen & Ercan, 2016; Lombrozo et al., 2008), particularly for controversial topics such as Cosmology and evolution. Individuals may comprehend scientific explanations yet reject them due to conflicts with personal belief systems (Lewandowsky & Oberauer, 2016). Therefore, acceptance involves not only understanding but also viewing the explanation as valid and trustworthy (Lombrozo et al., 2008). For prospective teachers, whose professional identities are still developing, such tensions are especially influential (Flores, 2020). Teachers' personal convictions–including values, emotions, cultural affiliations, and knowledge–shape how they interpret and teach scientific concepts (Bryan & Atwater, 2002), and when these beliefs conflict with curriculum goals, they may lead to misrepresentation, marginalization, or omission of certain topics (Tekkaya et al., 2012).

Thus, pre-service teachers play a central role in attempting to reform science education (Barnes & Brownell, 2017). Teachers' attitudes toward scientific and socio-scientific concepts are shaped by the sociocultural contexts in which they are embedded, their epistemological perspectives, and their prior learning experiences (Mansour, 2013). Exploring these dimensions is vital for designing undergraduate programs that cultivate both epistemic openness and scientific literacy (Lederman et al., 2013). Accordingly, the present study focuses on acceptance of evolution and cosmology, and interpretations are framed in terms of endorsement of the scientific account rather than conceptual understanding.

Science, Religion, and the Greek Educational Settings

In culturally heterogeneous societies, religious affiliation continues to affect attitudes toward science, especially concepts related to cosmic and human origins. In Greece, Orthodox Christianity is the dominant faith, and a key institutional element embedded in public education. Although lower acceptance of cosmology and evolution has been repeatedly linked to religiosity (Betti et al., 2020), it is important to address the interpretational differences of biblical texts across different Christian traditions.

Unlike many Protestant doctrines, the Greek Orthodox Church officially promotes symbolic readings of the book of Genesis, conveying the message that scripture provides not scientific claims but rather theological truths (Allert, 2021). This doctrinal orientation provides a space where personal religious stances and scientific theories do not collide but rather have a potentially greater compatibility. Empirical studies in Greece, however, found that many teachers are still resistant or ambivalent toward the BBT (Christonasis et al., 2023). Yet, little is known about how this ecclesiastical viewpoint is internalized or perceived by Greek pre-service elementary teachers–a research gap that the present work aspires to explore.

Empirical Studies Exploring BBT and ET

Religious beliefs about creation are a prime example of entrenched conceptions that can compete with scientific theories of origins. A substantial body of international research on pre-service teachers indicates that higher religiosity is associated with lower acceptance of evolution and cosmology across different educational levels (Aini et al., 2024; Barnes et al., 2021; Gutowski et al., 2023; Hill, 2014; Kuschmierz et al., 2020; Manwaring et al., 2018). Objection to this concept is often based on a literal interpretation of scripture, individualistic sense of conflict regarding Darwinian existential implications, or institutional teachings (Deniz et al., 2007; Gutowski et al., 2023; Lombrozo et al., 2008; Mantelas & Mavrikaki, 2020; Manwaring et al., 2018). As a result, religiosity consistently emerges as one of the strongest negative predictors of accepting evolution (Ferguson et al., 2024).

While the BBT has received less educational research attention, prior literature suggests that this concept, also, falls under religious inspection and further resistance. For instance, Aretz et al. (2016) investigated pre-instructional concepts upper high school students hold toward BBT without examining any religious influence. On the contrary,

Christonasis et al. (2023) found that Greek in-service elementary teachers are ambivalent toward the said theory when their religiosity level rises. However, the observed lack of relevant studies underpins the need for further investigation of the matter.

Demographic Factors

Demographic factors such as gender, year of study, and academic specialization can influence acceptance of scientific theories. Gender has been examined as a predictor, but findings are inconsistent, with effects often small or context-dependent (Großschedl et al., 2014; Miller et al., 2016) and interpreted within broader sociocultural patterns of gendered engagement in science (Archer et al., 2017).

Year of study may influence acceptance, as increased exposure to scientific reasoning during higher education can enhance acceptance of theories like BBT and ET (Southcott & Downie, 2012). Academic specialization also matters as students from science-oriented tracks tend to show higher acceptance due to engagement with empirical reasoning (Deniz & Sahin, 2016), whereas those in humanities or social sciences often report lower acceptance (Glaze & Goldston, 2015).

In line with previous research that emphasizes the influence of religiosity, gender, and educational background, the present study examines pre-service teachers' acceptance of the BBT and ET, explores the impact of religiosity, and investigates potential differences based on gender, year of undergraduate study, and high school specialization. To address these objectives, the following research questions were formulated:

1. What are the levels of pre-service teachers' acceptance of the BBT and ET?
2. What are the levels of religiosity among pre-service teachers?
3. How does religiosity correlate with acceptance of the BBT and ET?
4. Are there statistically significant differences in acceptance of these theories and in religiosity with respect to gender, year of study, and high school specialization?

METHODS

Research Design

This study uses a quantitative, cross-sectional survey design to investigate how religiosity relates to acceptance of the BBT and ET among Greek pre-service teachers. This design enables examination of multiple variables (e.g., acceptance, religiosity, gender, and educational background) at a single point in time (Creswell & Creswell, 2017).

Sample

The sample comprised 486 pre-service primary teachers from the University of Ioannina, Greece, selected through convenience sampling. The majority were women (80.7%). Most had completed a humanities or social sciences high school track (71.8%), followed by natural sciences (16.9%) and technology (7.4%). Participants were distributed across all years of study: 23.7% first-year, 22.6% second-year, 19.5% third-year, and 32.1% fourth-year. Data were collected via a questionnaire administered either in person or online, depending on availability.

Research Instrument

To address the study aims, participants completed a structured questionnaire covering demographics, acceptance of ET, acceptance of the BBT, and religiosity. The first section collected demographic information, including gender, high school specialization, undergraduate year of study, and religious affiliation.

The second section employed the measurement of acceptance of the theory of evolution (MATE) questionnaire (Rutledge & Warden, 1999), which assesses individuals' acceptance of ET. The instrument consists of 20 items rated on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), evaluating perceptions related to the process of evolution, the scientific validity of the theory, and related constructs (Rutledge & Sadler, 2007).

The third section included a modified version of the MATE, adapted for the context of cosmology. In this customized instrument–termed the measurement of acceptance of the big bang theory (MABBT)–all references to "evolutionary theory" were replaced with "big bang theory." Four items explicitly referring to biological evolution and human origins were excluded a priori, as they were not conceptually applicable to a cosmological framework. This adaptation resulted in a 16-item scale rated on the same five-point Likert format (1 = strongly disagree, 5 = strongly agree). These four items were excluded a priori on conceptual grounds during instrument adaptation, whereas any subsequent item removal reported in the Results reflects empirical decisions based on the exploratory factor analysis (EFA). MATE and the adapted MABBT were used to assess acceptance (rather than conceptual understanding) of the respective theories; therefore, interpretations are limited to acceptance.

The fourth section comprised the centrality of religiosity scale (CRS) (Huber & Huber, 2012), complemented by five additional items adapted from Mantelas and Mavrikaki (2020) to enhance contextual relevance. Previous research in Greek samples has reported supportive psychometric evidence for the MATE and for the CRS (Athanasiou et al., 2016; Mantelas & Mavrikaki, 2020). A comparable MATE-based adaptation to assess acceptance of the BBT has also been implemented in the Greek context (Christonasis et al., 2020). **Table 1** provides a brief content mapping of the main item themes covered by each instrument. In the present study, the internal consistency and factorial structure of the

Table 1. Item-domain overview for the MABBT, MATE, and religiosity items

Acceptance of BBT	Acceptance of ET	Religiosity scale
Process of big bang	Process of evolution	Public practice
Scientific validity of BBT	Scientific validity of ET	Private practice
Evidence of big bang	Evolution of humans	Ideology
Scientific community's view of BBT	Evidence of evolution	Intellectual
	Scientific community's view of evolution	
	Age of earth	

Table 2. Categories of acceptance and religiosity scores

Acceptance of ET (%)	Acceptance of BBT (%)	Religiosity scale (%)
Very low acceptance: 18-47	Very low acceptance: 15-39	Not religious: 20-40
Low acceptance: 48-58	Low acceptance: 40-48	Religious: 41-79
Medium acceptance: 59-68	Medium acceptance: 49-57	Very religious: 80-100
High acceptance: 69-79	High acceptance: 58-66	
Very high acceptance: 80-90	Very high acceptance: 67-75	

study scales were examined to provide evidence of construct validity in the current sample (see the results).

Finally, the questionnaire underwent a translation and back-translation procedure to ensure linguistic and conceptual equivalence. The instrument was first translated into Greek by two bilingual translators and subsequently back-translated into English by two additional bilingual translators. Minor discrepancies were resolved by consensus to ensure semantic and conceptual equivalence across items (Beaton et al., 2000).

Data Analysis

As shown in **Table 2**, all participants completed a structured questionnaire consisting of four sections. Participants were classified according to their acceptance of the BBT, acceptance of the ET, and their level of religiosity.

Data were analyzed using IBM SPSS Statistics 28.0. Factorial validity was examined using EFA with principal axis factoring as the extraction method and Varimax rotation; negatively worded MATE and MABBT items were reverse-coded, and items with rotated loadings ≥ .40 were retained. Sampling adequacy was evaluated using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity. Internal consistency was assessed using Cronbach's alpha for the MATE, MABBT, and religiosity scales. Non-parametric tests were used to examine differences across demographic groups. Scale scores were computed from the retained items and rescaled to a 0-100 metric for descriptive categorization using the cut-offs reported in **Table 2**. No missing responses were observed; therefore, all analyses were conducted with complete data (N = 486).

RESULTS

To provide evidence of construct validity within the present sample, we examined factorial validity through exploratory factor analyses procedures and internal consistency through Cronbach's alpha. An initial dimensionality assessment was conducted on the 56 items using a component/factor-analytic approach with Varimax rotation. The data were adequate for factor analysis (KMO = 0.945; Bartlett's χ^2 (1,596) = 14,981.560, $p < .001$). Seven components had eigenvalues > 1.00; however, the scree plot showed a clear inflection after the third factor, supporting a three-factor solution. Accordingly, an EFA was performed using principal axis factoring with Varimax rotation, specifying a three-factor solution, showing similarly strong adequacy (KMO = .932; Bartlett's χ^2 (1,456) = 12,547.254, $p < .001$). Three items were excluded from the final solution because their rotated factor loadings were below .40 (MABBT: Much of the scientific community doubts if universe changes occurs; MATE: The theory of evolution provides explanations for the diverse characteristics and behaviors observed in living organisms; MATE: The age of the earth is estimated to be at least 4 billion years). The final three-factor structure explained 45.572% of the variance: religiosity (29.358%), Acceptance of the BBT (11.439%), and Acceptance of ET (4.775%). This estimate is reported as a descriptive index of the factor solution rather than as evidence of practical impact. Rotated factor loadings are presented in **Table 3**. **Table 3** also provides the full final item set retained for scoring each scale (religiosity: 20 items; BBT acceptance: 15 items; ET acceptance: 18 items).

Reliability Analysis

Cronbach's alpha coefficients were calculated to assess the internal consistency of the overall instrument and each subscale independently. The results indicated satisfactory to excellent reliability across all factors, confirming that the instrument demonstrates strong internal consistency (**Table 4**).

Together with the factor-analytic results, these findings provide supportive evidence for the construct validity and reliability of the study scales in the present sample.

Following the EFA, three variables were computed representing the factors of big bang acceptance, evolution acceptance, and religiosity. **Table 5** presents the descriptive statistics for each factor score. Overall, participants reported moderately high acceptance of both BBT (mean [M] = 68.00) and ET (M = 72.22), whereas religiosity levels were comparatively lower (M = 56.00).

Table 3. Summary of questionnaire items and their factor loadings

Items	FL		
	R	BB	E
1. How important is personal prayer for you?	.843		
2. To what extent do you believe that God or something divine exists?	.837		
3. How often do you pray?	.819		
4. How important is it to take part in religious services?	.818		
5. How often do you experience situations in which you have the feeling that God or something divine intervenes in your life?	.808		
6. Based on your personal perception of religious belief, how religious would you describe yourself?	.804		
7. How often do you pray spontaneously when inspired by daily situations?	.792		
8. How important is it for you to be connected to a religious community?	.785		
9. In your opinion, how probable is it that a higher power really exists?	.771		
10. How interested are you in learning more about religious topics?	.760		
11. How often do you experience situations in which you have the feeling that God or something divine is present?	.755		
12. How often do you take part in religious services?	.744		
13. How often do you think about religious issues?	.708		
14. To what extent do you believe in an afterlife – e.g., immortality of the soul, resurrection of the dead or reincarnation?	.659		
15. How often do you experience situations in which you have the feeling that God or something divine wants to communicate or to reveal something to you?	.656		
16. Religion can provide answers to all the questions and problems of our time.	.615		
17. How often, on average, do you practice religious practices (prayer, church attendance, confession, sacrament, etc.)?	.607		
18. How often do you keep yourself informed about religious questions through radio, television, internet, newspapers, or books?	.539		
19. "Historical", factual elements of the Old Testament (mostly chronologies, the way that earth, plants, animals, humans were created, cataclysm, etc.) are mostly realistic and not symbolic.	.499		
20. I grew up in an environment intensely religious.	.472		
1. The BBT is the result of sound scientific research and methodologies.		.791	
2. BBT is scientifically valid.		.731	
3. BBT is not scientifically valid.		.658	
4. BBT is based on real, historical and laboratory data.		.654	
5. BBT yields testable predictions about the characteristics of the universe.		.636	
6. The Universe is the result of the big bang.		.587	
7. There is a significant amount of data supporting the BBT.		.569	
8. The current form of the universe is the same as it has always been.		.567	
9. Most scientists accept that the BBT is scientifically valid.		.562	
10. BBT is based on assumptions and not on valid scientific observations and tests.		.552	
11.BBT cannot be correct since it disagrees with the biblical account of creation.		.534	
12. BBT explains the variety of features observed in the universe.		.497	
13. The available data are inconclusive as to whether the big bang has occurred		.448	
14. BBT is impossible to prove scientifically.		.438	
15. With few exceptions, all the celestial bodies in the universe came into existence at about the same time.		.423	
1. Organisms exist today in essentially the same form in which they always have.			.719
2. Evolution is a scientifically valid theory.			.664
3. ET is the result of sound scientific research and methodology.			.633
4. Humans exist today in essentially the same form in which they always have.			.625
5. Organisms existing today are the result of evolutionary processes that have occurred over millions of years.			.586
6. ET is supported by factual, historical, and laboratory data.			.574
7. ET cannot be correct since it disagrees with the Biblical account of creation.			.573
8. With few exceptions, organisms on earth came into existence at about the same time.			.567
9. ET generates testable predictions with respect to the characteristics of life.			.548
10. The age of the earth is less than 20,000 years.			.534
11. Much of the scientific community doubts if evolution occurs.			.499
12. ET is incapable of being scientifically tested.			.482
13. Most scientists accept ET to be a scientifically valid theory.			.479
14. Modern humans are the product of evolutionary processes which have occurred over millions of years.			.442
15. Evolution is not a scientifically valid theory.			.424
16. ET is based on speculation and not valid scientific observation and testing.			.415
17. The available data are ambiguous as to whether evolution occurs.			.412
18. There is a significant body of data that supports the ET.			.404

Note. FL: factor loadings; R: Religion; BB: Big bang; E: Evolution; & Only loadings ≥ .40 are displayed; all other loadings (including cross-loadings) were < .40

Acceptance of ET

Figure 1 presents the distribution of participants according to their acceptance levels of the theory of evolution. Most pre-service teachers demonstrated a medium level of acceptance (39.83%), followed by those with low (26.12%) and high acceptance (24.20%). A smaller proportion reported very high acceptance (8.14%), while only 1.71% fell into the very low acceptance category.

As illustrated in **Figure 2**, most participants also exhibited a medium level of acceptance of the BBT (46.23%),

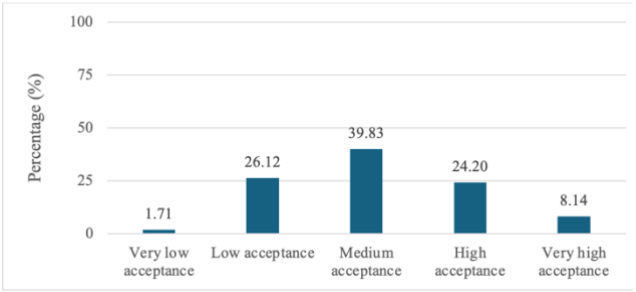

Figure 1. Distribution of pre-service teachers' acceptance levels of the ET (Source: Authors' analysis of study data (SPSS); figure created using Microsoft Excel)

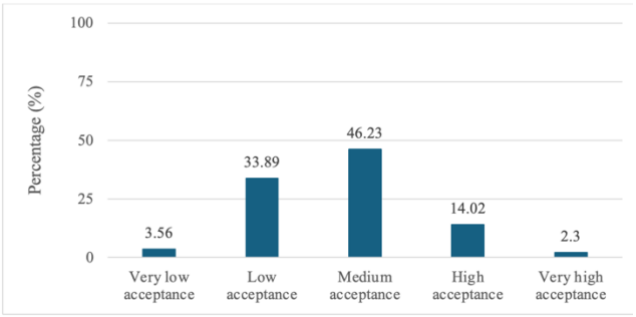

Figure 2. Distribution of pre-service teachers' acceptance levels of the BBT (Source: Authors' analysis of study data (SPSS); figure created using Microsoft Excel)

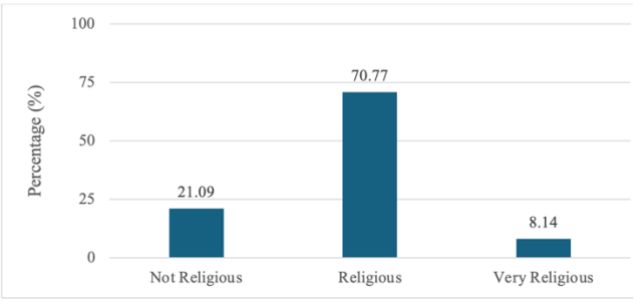

Figure 3. Distribution of pre-service teachers' religiosity levels (Source: Authors' analysis of study data (SPSS); figure created using Microsoft Excel)

followed by low acceptance (33.89%) and high acceptance (14.02%). Only a small proportion indicated very high acceptance (2.30%), while 3.56% were categorized as having very low acceptance.

Figure 3 displays the distribution of participants according to their religiosity levels. The majority of pre-service teachers were categorized as religious (70.77%), followed by non-religious (21.09%). A smaller proportion of the sample identified as very religious (8.14%), indicating that while most participants reported moderate levels of religiosity, highly religious individuals represented a relatively small segment of the sample.

Table 4. Number of items, Cronbach's alpha coefficients, and total explained variance per factor

Factors	N (items)	Cronbach's alpha	Total variance (%)
Acceptance of BBT	15	.85	11.439
Acceptance of ET	18	.91	4.775
Religiosity scale	20	.96	29.358
Total	53	.85	45.572

Table 5. Descriptive statistics of the three factor scores

Factor	Mean	Standard error	Standard deviation
Big bang	68.00	.41	9.05
Evolution	72.22	.50	10.83
Religiosity	56.00	.79	17.50

Differences in Acceptance and Religiosity by Gender

A Mann-Whitney U test was conducted to examine potential differences between male and female pre-service teachers in acceptance of the BBT, acceptance of the ET, and levels of religiosity. As shown in **Table 6**, no statistically significant gender differences were observed for any of the examined variables. Specifically, acceptance scores did not differ significantly between men and women for the BBT ($U = 16{,}270.000$, $Z = -1.131$, $p = .258$, $r = .051$) or the ET ($U = 15{,}556.500$, $Z = -1.125$, $p = .220$, $r = .051$). Religiosity also showed no significant variation by gender ($U = 17{,}312.500$, $Z = -0.325$, $p = .745$, $r = .015$). In all cases, effect sizes were trivial, indicating negligible practical differences between male and female participants in this sample. For Mann-Whitney U tests, effect size was computed as $r = |Z|/N$, where Z is the standardized test statistic and N is the total sample size.

Differences in Acceptance and Religiosity by Year of Study

A Kruskal-Wallis H test was conducted to assess differences in acceptance of the BBT, acceptance of the ET, and religiosity across students' year of undergraduate study. Statistically significant differences were observed for all three variables (**Table 7**). Acceptance of the BBT differed across year groups (χ^2 [3] = 14.742, $p = .002$, $\eta^2\_H = .024$), with fourth-year students showing the highest mean acceptance ($M = 70.30$, standard deviation [SD] = 9.53). Acceptance of the ET also varied by year of study (χ^2 [3] = 19.142, $p = .001$, $\eta^2\_H = .033$), again with the highest mean scores among fourth-year students ($M = 75.30$, $SD = 11.90$). Religiosity differed significantly across year groups (χ^2 [3] = 10.527, $p = .015$, $\eta^2\_H = .016$), with first-year students reporting the highest mean religiosity and fourth-year students the lowest ($M = 52.66$, $SD = 18.07$). Across

Table 6. Mann-Whitney U test results for gender differences across big bang, evolution, and religion components

Components	Men (M-SD) (%)		Women (M-SD) (%)		U	Z	p	Effect size
Big bang	66.62	11.17	68.32	8.46	16,270.000	-1.131	.258	.051
Evolution	70.67	12.33	72.59	10.43	15,556.500	-1.125	.220	.051
Religion	55.21	19.82	56.19	16.93	17,312.500	-.325	.745	.015

Table 7. Kruskal-Wallis H test results for year of study differences across big bang, evolution, and religion components

Components	1st year (M-SD) (%)		2nd year (M-SD) (%)		3rd year (M-SD) (%)		4th year (M-SD) (%)		χ^2	df	p	Effect size
Big bang	67.09	9.54	66.28	7.74	66.78	7.64	70.30	9.53	14.742	3	.002	0.024
Evolution	70.18	8.63	70.25	9.23	70.56	10.08	75.30	11.90	19.142	3	.001	0.033
Religion	59.58	14.49	56.41	16.97	58.85	18.10	52.66	18.07	10.527	3	.015	0.016

Table 8. Mann-Whitney U test results for differences in acceptance and religiosity by high school specialization

Components	Social sciences/humanities (M-SD) (%)		Positive/technological (M-SD) (%)		U	Z	p	Effect size
Big bang	66.98	8.36	70.67	10.10	6,891.000	-4.078	< .001	.185
Evolution	70.55	9.87	76.54	12.10	15,092.500	-4.896	< .001	.222
Religion	58.65	16.64	49.08	17.62	15,289.000	-5.351	< .001	.243

Table 9. Correlations between acceptance of BBT, acceptance of ET, and religiosity

Variables	Evolution	Religion
Big bang	.683*	-.338*
Evolution		-.419*

Note. *Correlation is significant at the 0.01 level (2-tailed)

outcomes, effect sizes were small, indicating that year-of-study differences, while statistically detectable, were modest in magnitude. Effect sizes were calculated using the bias-corrected eta-squared estimate for the Kruskal-Wallis test (Tomczak & Tomczak, 2014).

Differences in Acceptance and Religiosity by High School Specialization

A Mann-Whitney U test was conducted to examine differences in acceptance scores and religiosity according to participants' high school specialization (social sciences/humanities vs. positive/technological track). As shown in **Table 8**, statistically significant differences were observed across all examined variables. Participants from the positive/technological track reported higher acceptance of both the BBT ($U = 6{,}891.000$, $Z = -4.078$, $p < .001$, $r = .185$) and the ET ($U = 15{,}092.500$, $Z = -4.896$, $p < .001$, $r = .222$) than those from the social sciences/humanities track. In contrast, participants from the social sciences/humanities track reported higher religiosity scores ($U = 15{,}289.000$, $Z = -5.351$, $p < .001$, $r = .243$). Effect sizes ranged from small to approaching moderate, indicating meaningful differences associated with prior academic specialization within this sample.

Correlations among Acceptance of Scientific Theories and Religiosity

Correlation analysis revealed a strong positive relationship between acceptance of the BBT and acceptance of the ET ($r = .683$, $p < .01$, **Table 9**), indicating that participants who were more accepting of one theory tended to co-occur with higher acceptance of the other. In contrast, religiosity was negatively correlated with both acceptance of the BBT ($r = -.338$, $p < .01$) and acceptance of the ET ($r = -.419$, $p < .01$). These findings suggest that higher levels of religiosity are associated with lower acceptance of both cosmological and evolutionary explanations. Given the cross-sectional design, these correlations should be interpreted as associations and do not imply causal relations.

Overall, the results show differences in acceptance and religiosity across year groups and high school specialization, whereas gender differences were not evident. In addition, acceptance of the two theories was positively associated, while religiosity was negatively associated with both forms of scientific acceptance.

DISCUSSION

The present study examined pre-service teachers' acceptance of the BBT and ET and the extent to which religiosity and demographic variables such as gender, academic year, and high school specialization influenced this acceptance. Overall, the findings revealed moderate levels of acceptance for both theories, with acceptance increasing across academic years and being more pronounced among students with a science-oriented educational background. In contrast, religiosity scores differed by year of study, with lower mean religiosity reported among fourth-year students compared to earlier-year groups; this pattern is best interpreted as associative in nature given the cross-sectional design (Manwaring et al., 2018). No significant gender differences were observed, indicating that acceptance and religiosity were not strongly gender-dependent within this sample. The strong positive correlation between acceptance of the two theories further suggests conceptual alignment in the way pre-service teachers engage with scientific narratives of universal and biological development. These findings underscore the complex interplay between educational exposure, religious orientations, and epistemic acceptance of scientific knowledge within teacher education contexts.

The moderate acceptance levels of both the BBT and ET observed in this study are consistent with international findings among pre-service teachers and university students (Betti et al., 2020; Deniz & Sahin, 2016), as well as with Greek data indicating neither strong rejection nor full endorsement of such theories (Athanasiou et al., 2016). Similarly, the moderate religiosity levels accord with previous Greek studies showing that pre-service teachers often maintain a balanced engagement with religious identity alongside scientific learning (Mantelas & Mavrikaki, 2020). This pattern suggests a state of cognitive coexistence rather than explicit conflict or full integration between religious and scientific worldviews (Sinatra et al., 2014),

providing a meaningful baseline for understanding future instructional impact.

The Role of Educational Progression and Specialization

The increase in acceptance of both theories across academic years suggests that sustained exposure to scientific discourse and university-level instruction strengthens alignment with scientific explanations, consistent with prior findings on the positive impact of higher education on scientific literacy and theory acceptance (Betti et al., 2020; Sinatra et al., 2014). The higher acceptance levels among fourth-year students may reflect enhanced critical engagement with scientific epistemology and evidence-based reasoning through coursework, while the lower religiosity scores observed among later-year groups may reflect differences between cohorts and/or cumulative educational experiences; however, given the cross-sectional design, these differences should be interpreted as associations rather than within-person developmental change (Akyol et al., 2012; Mantelas & Mavrikaki, 2020).

Additionally, students from science-oriented high school tracks exhibited significantly higher acceptance of both theories than those from humanities and social science backgrounds, aligning with research demonstrating the influence of disciplinary exposure on scientific reasoning (Deniz & Sahin, 2016; Glaze & Goldston, 2015). These findings highlight the formative role of both early academic specialization and continued scientific engagement in promoting conceptual openness toward evolution and cosmology.

The Influence of Religiosity on Acceptance of Scientific Theories

The negative correlations between religiosity and acceptance of both the BBT and ET suggest that stronger religious commitment is linked to lower acceptance of scientific explanations, echoing findings from previous studies (Aini et al., 2024; Athanasiou et al., 2016; Barnes et al., 2021; Deniz & Sahin, 2016; Gutowski et al., 2023; Hill, 2014; Kuschmierz et al., 2020; Manwaring et al., 2018; Stylos et al., 2026). From a conceptual change perspective, religious narratives may provide coherent, deeply internalized explanatory frameworks that reduce dissatisfaction with prior beliefs, limiting openness to scientific alternatives (Posner et al., 1982; Sinatra et al., 2014). Motivated reasoning may further lead individuals to reinterpret or reject scientific information to preserve identity-related beliefs (Kahan, 2013). The moderate levels of both religiosity and acceptance observed may thus reflect cognitive coexistence rather than complete conflict or integration, underscoring the need for teacher education to address epistemological distinctions between religious and scientific ways of knowing (Bertka et al., 2019).

Gender and Acceptance of Scientific Theories

The absence of significant gender differences in acceptance of the said theories, as well as in religiosity levels, suggests that gender was not a determining factor in shaping scientific acceptance within this sample. This finding aligns with studies reporting minimal or non-significant gender effects in science-related attitudes when educational exposure is comparable (Betti et al., 2020). However, it contrasts with research indicating that male students may sometimes exhibit slightly higher acceptance or confidence in science, potentially due to sociocultural expectations and gendered participation patterns in STEM fields (Archer et al., 2017; Großschedl et al., 2014). The lack of gender divergence in this cohort may reflect a more equitable academic environment in teacher education, where both male and female students are equally engaged with scientific content. Consequently, gender alone does not appear to be a major driver of variation in acceptance or religiosity among pre-service teachers, suggesting that factors such as educational experience and epistemic orientation play a more prominent role.

Implications for Teacher Education

The findings highlight the need for teacher education programs to explicitly address the epistemological foundations of scientific theories such as Evolution and the Big Bang. From a teacher education perspective, it may be useful to address not only evidence and explanatory models in origins-related sciences but also how scientific consensus is formed and communicated, as this dimension can shape acceptance-related judgments (Korfmacher et al., 2024; Kotsis, 2026). This consideration may be especially pertinent for prospective primary teachers, given evidence that pre-service kindergarten and primary teachers can display comparatively weak evolution knowledge while still reporting high acceptance, highlighting a potential mismatch that initial teacher education should explicitly target (Lanka et al., 2024). Beyond treating these topics as peripheral content, programs can embed dedicated instructional time that supports pre-service teachers in engaging with scientifically established explanations while maintaining a respectful stance toward personal beliefs (Barnes & Brownell, 2017; De Carvalho, 2013). A practical step is to incorporate explicit-reflective teaching about what counts as scientific evidence and explanation in evolution and cosmology, using concrete examples that illustrate how scientific claims are evaluated and justified in each domain (Abd-El-Khalick, 2013; Bartos & Lederman, 2014; Lederman et al., 2012; Stylos, 2026). In parallel, teacher preparation can include guided reflection activities (e.g., brief reflective prompts or learning journals) that enable pre-service teachers to articulate uncertainties, questions, or perceived tensions in a structured and non-confrontational manner (Sinatra et al., 2014). Furthermore, instructional designs grounded in conceptual change theory–particularly those that foster cognitive conflict and offer plausible, intelligible scientific alternatives–may help students move beyond mere coexistence of conflicting views toward greater epistemic alignment (Posner et al., 1982). Consistent with practice-based approaches to teacher education, programs can strengthen classroom

readiness by incorporating structured approximations of practice (e.g., microteaching and rehearsals) in which pre-service teachers practice short lessons on conceptually demanding topics such as evolution and the big bang and receive targeted feedback (Davis et al., 2017; Long et al., 2019). Such rehearsals create supported opportunities to refine instructional moves and discourse facilitation, while microteaching cycles paired with feedback and reflection can help address issues of scientific accuracy and explanatory clarity and promote classroom talk conditions that support broad student participation (Davis et al., 2017; Long et al., 2019). Finally, scenario-based tasks can be used to develop instructional decision-making, for instance by asking pre-service teachers to plan responses to religion-based objections or common misconceptions in ways that preserve a supportive classroom climate while keeping instruction aligned with the scientific account (Barnes & Brownell, 2017; Bertka et al., 2019; Klassen et al., 2021). Given their future role as mediators of scientific knowledge in school settings, supporting pre-service teachers in developing informed acceptance is essential for fostering scientifically literate classrooms (National Research Council [NRC], 2012). Additionally, embedding such elements within teacher education can strengthen pre-service teachers' capacity to teach these topics confidently and responsibly and may reduce the likelihood that origins-related science is avoided or presented ambiguously in future classrooms (Davis et al., 2017).

LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

A primary limitation is the use of a convenience sample from a single teacher education department, which may limit the generalizability of the findings to other pre-service teachers in Greece or internationally. Future research should use multi-institutional or nationally representative samples to strengthen external validity and examine potential regional or institutional variation.

The study also did not examine possible mediating variables, such as epistemic beliefs or prior exposure to explicit instruction about the nature of scientific inquiry, which may shape acceptance of scientific theories (Akyol et al., 2012; Sinatra et al., 2014). Future studies could include such mediators to clarify how acceptance and religiosity relate. In addition, intervention studies across different stages of teacher education could test whether targeted instruction is associated with changes in acceptance over time, particularly in relation to conceptual change and epistemic development.

CONCLUSION

This study examined how Greek pre-service teachers engage with scientific explanations of cosmological and biological origins by focusing on acceptance of the BBT and ET in relation to religiosity and demographic factors. Overall, participants reported moderate levels of acceptance and religiosity, with higher acceptance among later-year students and those with science-oriented academic backgrounds. Religiosity was negatively associated with acceptance, highlighting the importance of addressing potential tensions in teacher education. Gender differences were not evident, suggesting that variation in acceptance is more closely associated with educational background than with gender.

Taken together, the findings underscore the role of teacher education in supporting engagement with scientifically grounded theories, particularly through approaches that explicitly address the nature of scientific inquiry and conceptual change. Strengthening pre-service teachers' acceptance of foundational scientific theories matters because their future teaching will shape how pupils encounter and interpret scientific knowledge. Further research examining religiosity alongside epistemic beliefs and instructional experiences can inform teacher education practices that support scientifically literate and reflective educators.

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