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Investigating Filipino pre-service science teachers' misconceptions, understanding, and acceptance of evolution

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ABSTRACT
Despite growing research on Evolution education, limited studies explore how misconceptions about Evolution relate to understanding and acceptance, particularly in the Philippine context. This descriptive-correlational study was participated by 114 senior pre-service science teachers enrolled in five teacher education institutions in the province of Nueva Ecija, Philippines. Results revealed that the respondents have a fairly high level of misconceptions regarding Evolution concepts, as reflected by 70.02 (SD = 7.43) BEL-MIS for the 23 BEL Survey statements with an average of 46.65% misconception rate. Moreover, understanding of Evolutionary theory was very low (ECKT: M = 34.25, SD = 13.76), while acceptance was moderate (MATE: M = 68.41, SD = 9.07). Furthermore, the analysis demonstrated an unexpected positive correlation between three out of five parameters of Evolution-related misconceptions and level of acceptance. This finding implies that even though the respondents have a fairly high level of misconceptions regarding Evolution, they still accept the theory. This result encouraged a holistic approach to studying the relationship of Evolution-related misconceptions to other Evolution education constructs in the future. The findings of the study demonstrated that the level of understanding and acceptance of Evolution are highly and positively correlated with one another. Thus, the result of this study supports the growing literature about the positive correlation between these two variables. The study contributes valuable insights to the Philippine context and highlights the importance of targeted interventions to improve Evolution education among pre-service science teachers.

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Introduction

The scientific community considers Evolution an integral part of Biology. "Nothing in Biology makes sense except in the light of Evolution" (Dobzhansky, 1973, p. 125) is a widely cited message in the scientific community from a paper by Theodosius Dobzhansky. Truly, it is the sole theory that serves as a thread that meaningfully 'links' the knowledge related to all domains of Biology. It would be impossible to understand Biology without understanding Evolution. Evolution, as a unifying theory in Biology, explains similarities among organisms, biological diversity, and many physical characteristics that are among the most basic characteristics of the living world, allowing students to understand the biological significance of phenomena such as reproduction, cell division, and how ecosystems function (Banet & Ayuso, 2003). It is considered one of the 'big ideas' in science that students must grasp to

become scientifically literate and make informed decisions about the applications of science (Harlen et al., 2015; Abdullah, 2022). Despite its importance, teaching and learning evolution remain fraught with challenges, particularly in countries where scientific literacy rates are low (Borgerding & Deniz, 2018).

In the Philippines, the K to 12 science curriculum was designed to produce scientifically literate individuals who can make responsible decisions and apply scientific knowledge to solve community problems (K to 12 Science Curriculum Guide, 2016). However, in the latest findings of the Programme for International Student Assessment (PISA) 2022, the Philippines' average score in science dropped by one point from 356 in PISA 2018 to 355, ranking the Philippines third-lowest among 81 countries in science (OECD, 2023). In Biology, understanding Evolution is required for scientific literacy (Bishop & Anderson, 1990). Aberilla et al. (2018) stated that learning Evolution is critical for learners to acquire the process of scientific inquiry, which is necessary for making informed decisions and increasing innovativeness and competitiveness in the 21st century.

Science classrooms continue to be one of the few "arenas" where pupils can learn about Evolution (Nelson, 2008). Within these classrooms, learners are faced with a choice between believing and rejecting science. The former involves grasping the nature of science and recognising the fundamental theoretical underpinnings of science, including Evolution (Glaze, 2018). One of the indispensable components of classrooms is the teacher. Teachers are considered to be the "missing link" between scientists' understanding of Evolution and the public's ignorance of (or resistance to) Evolutionary theory (Nehm & Schonfeld 2007). Therefore, they should be prepared to communicate the ideas of Evolutionary theory to their students without any misinterpretations or misconceptions. Pre-service teachers are in the process of transitioning from students to teachers. Therefore, to build a scientifically literate society, it is also necessary to assess their scientific literacy since they will soon be on the front lines of educating society. Moreover, it is critical to understand their level of acceptance of Evolution since their ideas and beliefs about teaching and learning Evolution will influence the pupils they educate (Glaze, 2018).

Studies about misconception research in Evolution focused primarily on identifying these misconceptions and inquiring about several contributing factors. However, what is overlooked is investigating its relationship with other influential constructs in Evolution education, such as understanding and acceptance of Evolution.

Lastly, research on Evolution education is sparse, with most studies focusing on Western and Middle Eastern contexts. Studies in Asian countries are very limited. In the Philippines, there is limited empirical data on how misconceptions about Evolution relate to understanding and acceptance among pre-service teachers. Studies often overlook the interconnectedness of these constructs, leaving a gap in understanding how these factors influence one another.

Aims of the Study

This study aims to explore the misconceptions, understanding, and acceptance of Evolution among Filipino pre-service science teachers in selected teacher education institutions (TEIs) in Nueva Ecija. By examining the relationships between these variables, this study provides critical insights into the status of Evolution education in the Philippines and identifies areas for improvement in teacher preparation programs.

To achieve this, the study addresses the following research questions:

1. What is the demographic profile of the respondents in terms of sex, age, type of Teacher Education Institution, and self-rated knowledge of Evolution?
2. What misconceptions about Evolution are held by the respondents?
3. What is the level of understanding of Evolution among the respondents?
4. What is the level of acceptance of Evolution among the respondents?
5. Is there a significant relationship between the respondents' Evolution-related misconceptions and their level of acceptance of Evolution?

6. Is there a significant relationship between the respondents' level of understanding and their level of acceptance of Evolution?

Literature Review

Misconception Research about Evolution

Studies on misconceptions about Evolution have been chronicled thus far in different populations such as high school students (Woods & Scharmann, 2001; Yates & Makek, 2015), university students (Archila et al., 2024, Brumby, 1984; Bishop & Anderson, 1990; Wescott & Cunningham, 2005; Robbins & Roy, 2007; Pazza et al., 2010), science/Biology teachers (Yates & Marek, 2013; Yates & Marek, 2014; Yesilyurt et al., 2019), and pre-service teachers (Karataş, 2020).

High School Students' Perception of Evolution: Woods and Scharmann (2001) investigated the perceptions of 518 high school students in the United States about Evolution. The researchers collected data using both quantitative and qualitative methods. A causal-comparative or *ex post facto* design was used to examine quantitative data sources, which consisted of subjects' responses to a questionnaire set, while a short post-questionnaire interview protocol was utilized to obtain qualitative data.

Overall, the researchers revealed that based on their findings, these high school students who participated in the study do not fully comprehend the concepts of the Evolutionary theory. The proof of this statement is that the respondents were harboring misconceptions about Evolution that narrow their understanding of the full scope of what Evolution is. The most notable misconception was, "man evolved from monkey or ape," which sixteen (16) students used this phrase to define Evolution. The researchers also pointed out that high school students tend to use anthropomorphic terms, teleology, and vitalism in their definitions (e.g., Evolution as a conscious process based on the organism's needs). Woods and Scharmann (2001) concluded their paper that there is a need to provide learning opportunities that foster a better grasp of the nature of Evolutionary theory and why biologists regard it as a compelling unifying theme for study in the biological sciences. According to the researchers, failure to do so will result in students memorizing what their teachers want to hear from them about Evolution. Worse, they may be alienated from studying biological sciences in the future. Worst of all, it may contribute to the persistence of popular misconceptions about Evolutionary theory among future adults.

Yates and Marek (2015) utilized their constructed questionnaire called the Biological Evolution Literacy Survey (BEL) to assess quantitatively the prevalence of biological Evolution-related misconceptions held by high school students in Oklahoma. The BEL Survey consists of 23 biological misconception statements grouped into five categories to identify students' misconceptions and calculate conception index scores. Nine hundred ninety-three (993) students enrolled in their initial high school Biology course during the 2010-2011 academic years in one of 42 Oklahoma public high schools served as their respondents. The analysis revealed that student participants produced a mean 39.1% misconception rate for the 23 BEL Survey statements. Participants' mean misconception rates per category were: *Science, Scientific Methodology and Technology*, 35.2%; *Intentionality of Evolution*, 37.5%; *Nature of Evolution*, 43.8%; *Mechanisms of Evolution*, 39.4%; and *Evidence Supporting Evolution*, 39.7%. These results paved the way for the authors to conclude that misconceptions were prevalent within the high school student population.

University Students: The subsequent studies showed that students admitted to the college or university harbor misconceptions, despite taking Biology or science-inclined course or not. A recent study by Archila et al. (2024) examined whether a significant difference existed in the understanding of Evolution between STEM and non-STEM university students in Colombia. Interestingly, misconceptions about Evolution did not vary significantly between STEM and non-STEM students. The researchers highlighted this as an opportunity to leverage the distinction between microEvolution and macroEvolution as a foundation for fostering interdisciplinary skills such as creativity and collaborative work.

Moreover, Brumby (1984) showed misconceptions held by medical students in Australia about natural selection. One hundred and fifty (150) first-year medical students from one university participated in her study. Despite that these students all have a solid scientific background in chemistry, math, and other science and are considered among the most successful science students entering tertiary education due to the intense entrance competition; still, misconceptions about biological reasoning about natural selection were found when they were subjected to several unfamiliar qualitative problems based on the concept of natural selection designed by the researcher and given to the students in three different formats.

Results from the analysis of students' explanations demonstrated that the majority of these medical students still believe in the long disproved Lamarckian view of Evolution (Evolutionary change occurs as a result of need). The researcher noted that this view caused a faulty pattern of reasoning. The researcher thought that this "intuitive Lamarckism" was due to an initial incorrect observation that individuals can change their characteristics during their lifetime and that this acquired change is passed genetically on. Though the concept of genetics was introduced, the students failed to include the critical difference between induced and spontaneous mutations. Moreover, the concept of adaptation was confused with immunity among the students, and other immunological concepts of resistance, tolerance, and antibodies were introduced incorrectly in the students' reasoning. Thus, Brumby (1984) stated that she was surprised not by how little these students knew about natural selection but how much they knew incorrectly, for their answers were given with assurance, not hesitatingly.

University students who are non-Biology majors also held misconceptions about Evolution as reflected in the studies of Bishop and Anderson (1990), Wescott and Cunningham (2005), Robbins and Roy (2007), and Pazza et al. (2009).

Bishop and Anderson (1990) found that 110 college students enrolled during two successive quarters in a one-term to a nonmajors' introductory Biology course possessed a misconception about the three umbrella concepts in Evolution, namely (1) *origin and survival of new traits in the population,* (2) *the role of variation in a population, and* (3) *Evolution as the changing proportion of individuals with discrete traits.* Thus, the students' naive explanations are also implicitly Lamarckian; they do not regard variability as necessary to Evolution, and they attribute gradual progressive quality in Evolutionary change not to the proportion of individuals in the population but to gradual changes in the traits themselves, viewing traits as improving or deteriorating from one generation to the next. Furthermore, Bishop and Anderson (1990) stated that college students also misunderstand or confuse the two often used Evolutionary terms: *adapt/adaptation and fitness,* because their meaning in daily English differs from their definition in an Evolutionary context.

Wescott and Cunningham (2005), Robbins and Roy (2007), and Pazza et al. (2009) utilized a quantitative approach by using a questionnaire as opposed to the research methodology used by Bishop and Anderson, as well as Brumby (1984) in identifying the misconceptions among tertiary students.

Wescott and Cunningham (2005) claimed that though 547 undergraduate participants who are enrolled in *Introduction to Biological Anthropology* class also have many misconceptions, as revealed by their data analysis using a 25-statement questionnaire, they *do not follow the same patterns* in their misconceptions as found by other researchers in the United States, like the study done by Bishop and Anderson (1990) and Wilson (2001). Wescott and Cunningham (2005) explained that while many of these students' misconceptions are shared by students in other regions in the US, the student-participants in their study appear to be *more scientifically educated* about other concepts in Evolution. The researchers were honest in admitting that they do not know what factors influenced this difference; however, they suspected it could be due to educational, religious, generational, and possibly motivational differences between their university respondents and those surveyed by Bishop and Anderson (1990) and Wilson (2001).

Pazza et al. (2009), on the other hand, examined the misconceptions of first-year Brazilian students who are attending different classes such as biological sciences (morning and evening schedule), exact sciences (agronomy, physics, chemistry, and math), and human sciences (history, geography, and pedagogy), using a 10-item questionnaire about Evolution, comprising the vital concepts of

Evolutionary theory in different levels of difficulty. The findings showed that these students have misconceptions about the following chief issues in Evolution: Darwin and Lamarck, Homologies and Analogies, Variation and Natural Selection, Human Evolution, and the Random Effect. In totality, Pazza et al. (2009) concluded that data obtained from their study suggest that these first-year students do not understand how Evolution occurs. Specifically, they do not know about the role of random effects, variation, and natural selection in the Evolutionary process.

Robbins and Roy (2007) not only identified misconceptions about Evolution but also tested several strategies to correct them. These strategies include pre-quiz to identify and respond to common misconceptions, peer instruction, and using Evolution as a lens to examine aspects of other topics (such as natural history, anatomy, and biochemistry) instead of teaching it as a separate unit. Their efforts in using these interventions were not in vain since the researchers reported significant improvements. Students were asked to explain the theory of Evolution in a short paragraph before the unit on Evolution. Only 6% did so correctly, in which the misconception, *"Evolution says that humans came from monkeys,"* was on top of the list, with 42% of 141 students agreeing to this statement. However, by the end of the unit, 92% correctly explained the theory of Evolution. Indeed, a considerable improvement from 6% before instruction.

Science/Biology Teachers: Recent studies about misconception research focusing on teachers were done in the two consecutive studies by Yates and Marek (2013, 2014) and Yesilyurt et al. (2019).

Yates and Marek (2013) did a regional study of the prevalence of biological Evolution-related misconceptions held by introductory Biology teachers. The unit of analysis for this study included 76 teachers who taught at least one part of Biology I in one of 71 Oklahoma public high schools from 2010 to 2011. The Biological Evolution Literacy Survey, which contains 23 biological misconception statements classified into five categories, was used as a study instrument to identify participants' misconceptions and calculate conception index scores. The study's findings revealed that participants' knowledge of biological Evolution concepts is lacking, as shown by a mean 72.9% rate of understanding coupled with a 23.0% misconception rate. Moreover, the researchers were disturbed to find that a minimum of 30.0% ($n \geq 23$) of the teachers did not accept the following Evolution concepts: (1) New traits within a population appear at random, (2) Individual organisms do not adapt to their environments, (3) Evolution is not a totally random process, (4) Survival of the fittest does not mean that 'only the strong survive,' (5) Complex structures such as the eye could have been formed by Evolution, and (6) There exists a large amount of evidence supporting the theory of Evolution.

Yates and Marek (2014) published another study about Evolution education in Oklahoma only a year after. However, this time, the researchers explored the factors contributing to high school Biology students' acquisition of biological Evolution-related misconceptions and the possible transmission of teachers' misconceptions to their students. Thus, to carry out their study, 35 teachers who taught at least one section of Biology I in one of 32 Oklahoma public high schools during the 2010-2011 academic year and their respective 536 students were the study's respondents. The Biological Evolution Literacy Survey is used once more to identify teachers' misconceptions prior to student instruction and students' misconceptions both prior to and following the instruction in biological Evolution concepts and to calculate conception index scores and collect demographic data. Multiple statistical analyses were carried out to find statistically significant (p.05) relationships between variables associated with students' acquisition of biological Evolution-related misconceptions. Results demonstrated significant relationships between student misconception acquisition and teachers' bachelor's degree field, terminal degree, and hours dedicated to Evolution instruction. Furthermore, the study discovered a significant relationship between teachers' levels of misconceptions and student achievement, which may provide further evidence of misconception transmission from teachers to students. The findings indicate an inverse relationship between the number of teachers' misconceptions and the post-instruction BEL Survey index scores of students. Yates and Marek (2014) argue that the transmission of misconceptions from these teachers to their students cannot be ruled out as a causative agent, though several variables may be at work in the decrease in students' post-instruction BEL Survey index scores after instruction by teachers with high levels of misconceptions.

Yesilyurt et al. (2019) investigated science teachers' understanding of micro- and macroEvolutionary processes. Using a case study approach, the researchers compared the Evolutionary conceptions of novice and experienced middle school science teachers. Data were gathered through four Evolutionary scenarios combined with cognitive interviews.

The findings revealed that the novice teacher retained Lamarckian misconceptions, such as the inheritance of acquired traits and a transformational perspective on Evolution. In contrast, while the experienced teacher applied several macroEvolutionary principles to explain Evolutionary changes beyond the species level, her causal explanations were primarily based on natural selection and exhibited cognitive biases regarding Evolution. Notably, both teachers, regardless of experience, demonstrated a tendency toward teleological reasoning when interpreting Evolutionary changes, even though the experienced teacher had a stronger grasp of Evolutionary concepts. Based on these results, the researchers emphasized the need to examine how teachers' cognitive biases influence their instructional practices in the classroom when teaching Evolutionary theory.

Pre-Service Teachers: The study of Karataş (2020) focused solely on identifying the misconceptions harbored by Pre-Service teachers. Participants of the study were 190 pre-service teachers in the Science Education Department in one of the universities in Turkey. Out of 190 participants, 91 were senior pre-service teachers who had already completed an Evolution course, while the remaining 99 were sophomores and juniors who were not yet taking an Evolution course. Karataş (2020) reported that misconceptions were found in 57 of the 190 preservice teachers who took part in the study, accounting for 30% of the students. The vast majority of this rate (43%) was caused by misconceptions in students who had never taken an Evolution course (sophomores and juniors). Meanwhile, 14 of the 91 students who completed the course had misconceptions (seniors). Despite the fact that the number of misconceptions among students who completed the course decreased, the researcher stated that misconceptions were not completely cleared up.

The ranked misconceptions found among the Turkish pre-service teachers were the following: 1) Students explaining Evolution as gaining better characteristics, 2) Students explaining Evolution with a human-related perspective, 3) Students explaining Evolution as a change a living being/organism goes through during life, 4) Students explaining Evolution with metamorphosis, and 5) Students considering Evolution/Creation theories as alternatives to each other.

Literature Synthesis

Studies on misconceptions about Evolution have extensively examined high school and university students, as well as in-service science teachers. Findings consistently reveal deeply rooted misunderstandings, including Lamarckian inheritance, teleological reasoning, and anthropomorphic interpretations of Evolutionary processes (Woods & Scharmann, 2001; Brumby, 1984; Yates & Marek, 2013, 2014, 2015). While educators are expected to address these misconceptions, research suggests that many teachers themselves harbor inaccuracies, which may be inadvertently passed on to their students (Yates & Marek, 2014; Yesilyurt et al., 2019).

Despite extensive research on students and in-service teachers, studies focusing on pre-service teachers remain limited. Karataş (2020) identified Evolutionary misconceptions among Turkish pre-service teachers, highlighting the persistence of misconceptions even after formal instruction. However, little is known about how pre-service teachers in the Philippines conceptualize Evolution, presenting a critical gap in the literature.

This gap in the literature underscores the originality of the present study. While prior research has investigated misconceptions in various academic populations, there is a dearth of studies focusing on the misconceptions, understanding, and acceptance of Evolution specifically among Filipino pre-service teachers. Addressing this gap is crucial, as these individuals will soon become educators responsible for shaping students' scientific literacy. By examining the conceptual barriers faced by future science teachers in the Philippines, this study provides a culturally and contextually relevant contribution to the broader discourse on Evolution education.

Methodology

Research Design

The researcher utilized a descriptive-correlational design for this study. The descriptive design was used to determine the Evolution-related level of understanding, misconceptions, and level of acceptance of pre-service science teachers. The correlational design was used to determine if there is a significant relationship between the Evolution-related misconceptions, level of understanding of Evolution, and level of acceptance of Evolution of Pre-service science teachers.

Respondents

Senior pre-service science teachers in five selected Teacher Education Institutions (TEIs) in the province of Nueva Ecija, Philippines, who are currently enrolled or have enrolled in Teaching Internship or Practicum in Teaching for the academic year 2021-2022 were the respondents of this study. A total of 114 respondents from these five TEIs participated. The researcher employed a purposive sampling method, selecting institutions that were identified as the top producers of licensed teachers in the past five consecutive years in the province, based on consolidated data from the Professional Regulation Commission (PRC). The purpose of choosing senior Pre-Service Science teachers relies on the assumption that these respondents have finished all their science major subjects; thus, they have also finished all their Biology subjects. Therefore, the necessary Evolution concepts are expected for these respondents to have learned.

Research Instruments

The researchers utilized the following survey-questionnaire tools for the study:

Socio-demographic Profile Survey

The demographics survey was used to collect information about respondents' gender, age, type of Teacher Education Institution, and Evolution knowledge self-rating.

Biological Evolution Literacy Survey (BEL)

The Biological Evolution Literacy Survey, which presents 23 biological misconception statements grouped into five categories, served as the research tool for identifying students' misconceptions and calculating conception index scores. This research tool is adopted from Yates and Marek (2015) with Cronbach's alpha of 0.848.

Two methods of scoring responses were used during data analysis. First, the responses "strongly agree" and "somewhat agree" were combined, indicating participant agreement with the statement. Likewise, the responses "strongly disagree" and "somewhat disagree" were combined, indicating participant disagreement with the statement. Second, by means of Likert scaling of responses, a biological Evolution misconception scoring index was calculated. The possible range of BEL Survey index scores was 0 to 115, with a score of 115 representing a lack of associated misconceptions, whereas lower indices represented high levels of biological Evolution-related misconceptions. In addition, a count of the number of misconceptions revealed by responses to the statements was conducted.

Evolution Content Knowledge Test (ECKT)

A 21-item Evolution Content Knowledge Test with one correct answer and four distracters, initially developed by Johnson (1986) and modified by Rutledge and Warden (2000), was used to assess pre-service science teachers' understanding of Evolution. The test covers the following content areas: natural selection, extinction processes, homologous structures, coEvolution, analogous structures, convergent Evolution, intermediate forms, adaptive radiation, speciation, Evolutionary rates, the fossil record, biogeography, environmental change, genetic variability, and reproductive success. A total of 21 points would indicate a perfect understanding of the content, and a score of 0 represents no understanding of the content. The research panel of experts evaluated and accepted the test as valid. Moreover, the internal consistency of the test was measured, and the result was 0.78 (Rutledge & Warden, 2000).

The ECK test scores were reported as the per cent of questions answered correctly with score ranges representing the student's level of understanding: very high (90–100), high (80–89), moderate (70–79), low (60–69) and very low (59 or less).

Measure of Acceptance of the Theory of Evolution (MATE)

The Measure of Acceptance of the Theory of Evolution (MATE) (Rutledge & Warden, 1999) was utilized to assess students' acceptance of the Evolutionary theory. This instrument has 20 statements and was scored using a Likert scale. The response with the highest level of acceptance of Evolution received a score of 5, while the response with the lowest level of acceptance of Evolution received a score of 1. As a result, the total score range was 20-100. Rutledge (1996) developed the following acceptance categories based on the MATE's initial field testing: very high acceptance: 89-100; high acceptance: 77-88; moderate acceptance: 65-76; low acceptance: 53-64; very low acceptance: 20-52.

Data Gathering and Analysis

A letter requesting authorisation to conduct the study was personally delivered or sent online to the different deans of the College of Education or the Campus Director of the five TEIs prior to the start of the study. Once approved, the researcher made a Group Chat (GC) in Facebook Messenger for all the pre-service respondents. The survey questionnaires were created and administered using Google Forms. The link was sent to the GC for easy dissemination and tracking.

The data collected from the socio-demographic profile survey, the scale responses and number of biological Evolution misconceptions from BEL, test scores from ECK, and scale responses from MATE were analysed by descriptive statistical methods including frequency counts, per centages, and means. The statistical technique of Pearson-product-moment correlation was used to explore relationships between the variables.

Results

The Socio-Demographic Profile of the Respondents

The socio-demographic profile of the respondents, such as sex, age, type of Teacher Education Institution affiliated with, and evolution knowledge self-rating, is presented in Table 1.

It can be gleaned from the table that the majority, or 74 per cent of the respondents (64.91%) were female, while 40 per cent or 35.09 per cent were male. This is consistent with the observation by Lacap (2015) that teacher education is primarily a female-focused field of study.

Table 1

Socio-Demographic Profile of the Respondents

Parameters	Frequency N = 114	Per centage
Sex		
Male	40	35
Female	74	65
Age		
21	23	20
22	78	68
23	8	7
24	2	2
25 and above	3	3
Teacher Education Institution		
Public	99	87
Private	15	13
Evolution Knowledge Self-Rating		
Poor	0	0
Fair	1	1
Moderate	66	58
Good	42	37
Excellent	5	4

Table 1 also indicates that the majority of the respondents were 22 years old, with a frequency of 78 or 68.42 per cent. The K-12 curriculum was implemented in the Philippines in 2012, and these senior science pre-service teachers were the first batch of this enhanced curriculum. Therefore, due to the additional two years, the expected college seniors' age before (20 years old) will also be added by two years, which is why most of the respondents are 22 years old.

The table also shows that the majority of 99 respondents (86.84%) were affiliated or enrolled in public Teacher Education Institutions (TEI). Fifteen or 13.16 per cent were affiliated or enrolled in a private TEI. This result implies that pre-service science teachers are primarily produced by public colleges and universities in the province of Nueva Ecija.

Lastly, Table 1 also shows that 66 or more than half of the respondents (58%) rated their knowledge about Evolution as "Moderate." No one rated having a "Poor" knowledge of Evolution. Thus, these pre-service science teachers consider themselves to have neither excellent nor poor knowledge about Evolution.

The Misconceptions Held by Respondents in the Evolution Concepts

The misconceptions held by respondents about Evolution concepts are determined in the following discussions, as shown in Table 2.

Table 2 shows each BEL Survey statement and the per centage of respondents who responded to it. The combined per cent responses of respondents highlighted in orange identify the per centage of respondents who held the associated misconception of the accompanying statement, whereas the combined pair of per cent responses in the adjacent regions highlighted in blue identify the per centage of respondents who held the correct concept as related to the statement (Yates & Marek, 2015). Undecided and No Response were highlighted in grey.

Table 2

BEL Survey Statement Pre-Service Science Teachers' Per cent Responses

#	Category*	Statement	Pre-Service Teachers Response (%)					
			1	2	3	4	5	6
1	SSMT1	A scientific theory that explains a natural phenomenon can be defined as a "best guess" or "hunch."	18.42	50.88	11.40	14.91	4.39	0
2	SSMT2	The scientific methods used to determine the age of fossils and the Earth are reliable.	58.77	37.72	1.75	1.75	0	0
3	SSMT3	According to the second law of thermodynamics, complex life forms cannot evolve from simpler life forms.	17.54	50	14.91	14.91	2.63	0
4	SSMT4	The Earth is old enough for Evolution to have occurred.	23.68	38.60	18.42	11.40	6.14	1.75
5	SSMT5	Evolution cannot be considered a reliable explanation because Evolution is only a theory.	13.16	32.46	33.33	19.30	1.75	0
6	IE1	Evolution always results in improvement.	41.23	41.23	13.16	3.51	0.88	0
7	IE2	Members of a species evolve because of an inner need to evolve.	42.98	47.37	4.39	5.26	0	0
8	IE3	Traits acquired during the lifetime of an organism—such as large muscles produced by body building—will not be passed along to offspring.	38.60	38.60	9.65	13.16	0	0
9	IE4	If webbed feet are being selected for, all individuals in the next generation will have more webbing on their feet than do individuals in their parents' generation.	12.28	55.26	20.18	8.77	2.63	0.88
10	IE5	Evolution cannot cause an organism's traits to change within its lifetime.	8.77	23.68	34.21	28.07	4.39	0.88
11	NE1	New traits within a population appear at random.	24.56	52.63	15.79	5.26	0.88	0.88
12	NE2	By means of Evolution, individual organisms adapt to their environments.	67.54	28.95	2.63	0	0	0.88
13	NE3	Evolution is a totally random process.	21.93	42.98	21.93	7.89	3.51	1.75
14	NE4	The environment determines which traits are best suited for survival.	54.39	41.23	3.51	0	0	0.88
15	ME1	Variation among individuals within a species is important for Evolution to occur.	48.25	41.23	7.89	0	1.75	0.88
16	ME2	"Survival of the fittest" means basically that "only the strong survive."	46.49	31.58	14.91	6.14	0	0.88
17	ME3	The size of the population has no effect on the Evolution of a species.	12.28	23.68	35.09	27.19	0.88	0.88
18	ME4	Complex structures such as the eye could have been formed by Evolution.	23.68	47.37	15.79	11.40	0.88	0.88
19	ME5	Only beneficial traits are passed on from parent to offspring.	12.28	27.19	28.95	29.82	0.88	0.88
Table 2. BEL Survey Statement Pre-Service Science Teachers' Per cent Responses (Continued)								
20	ESE1	There exists a large amount of evidence supporting the theory of Evolution.	36.84	49.12	10.53	2.63	0	0.88
21	ESE2	According to the theory of Evolution, humans evolved from monkeys, gorillas, or apes.	49.12	31.58	9.65	7.89	0.88	0.88
22	ESE3	Scientific evidence indicates that dinosaurs and humans lived at the same time in the past.	19.30	30.70	22.81	21.93	4.39	0.88
23	ESE4	The majority of scientists favor Evolution over other explanations for life's diversity.	32.46	43.86	15.79	3.51	2.63	1.75

Note:

1	Strongly Agree		Misconception
2	Somewhat Agree		
3	Somewhat Disagree		Correct Concept
4	Strongly Disagree		
5	Undecided		Undecided/No Response
6	No Response		

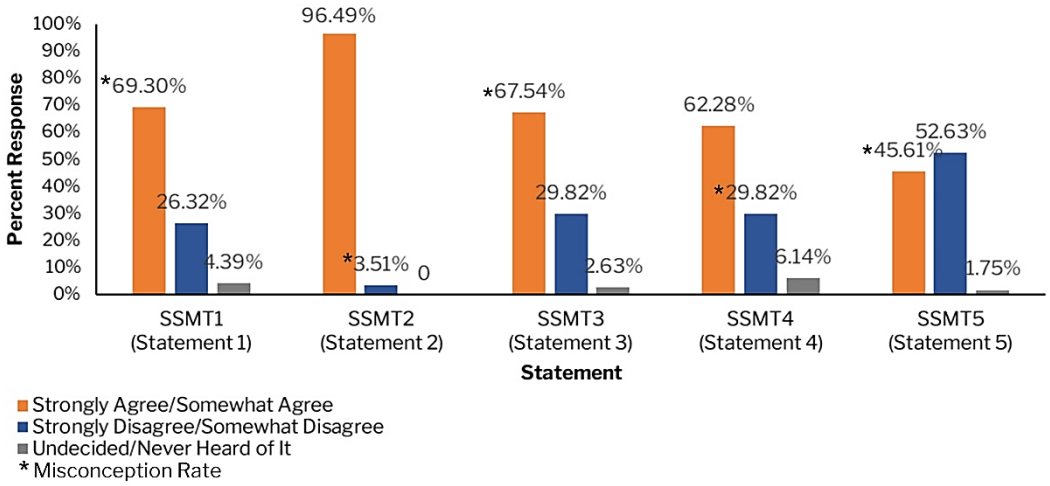
SSMT, Science, scientific methodology, and terminology; IE, intentionality of Evolution; NE, nature of Evolution; ME, mechanisms of Evolution; ESE, evidence supporting Evolution.

Science, Scientific Methodology, and Terminology

Statements 1 through 5 address the general opinions of student respondents concerning Science, scientific methodology, and terminology as they relate to Evolution. The responses to each of these statements are depicted in Figure 1.

Figure 1

Per cent Response to Science, Scientific Methodology and Terminology



It can be gleaned from Figure 1 that responses to statement 1 (*"A scientific theory that explains a natural phenomenon can be defined as a 'best guess' or 'hunch'"*) reveal that 69.30 per cent (n= 79) of the respondents failed to interpret the word "theory" as used by the scientific community and its difference with its word usage in daily communication. Only 26.32 per cent (n=30) correctly interpreted the word theory.

The response performed slightly better for statement 5 (*"Evolution cannot be considered a reliable explanation because Evolution is only a theory"*), with 45.61 per cent (n=52) of the respondents agreeing with this statement, suggesting a misconception. According to Yates and Marek (2015), in common parlance, the terms 'guess' or 'hunch'—implying speculation or conjecture—are synonymous with theory. But "theory" from the scientific point of view is far from speculation or conjecture. When scientists use the term *"theory,"* they mean a logical, tested, and well-supported explanation for a wide range of facts; thus, scientific theories are not mere guesses (Smith & Sullivan, 2007). Students who have misconceptions about scientific theories typically understand theory in the speculative sense, as in *Evolution is just a theory.* This claim is supported by the results of the study of Prinou et al. (2008), in which the researchers reported that when Evolution is referred to as a "theory," students believe it is not supported by evidence. This kind of misconception is called *vernacular misconception,* which results

from the distinction between a word's scientific and common usage and the resulting misunderstanding of the distinction (Alters & Nelson, 2002).

Statement 2 *("The scientific methods used to determine the age of fossils and the earth are reliable")* obtained a relatively high per centage of respondents agreeing with this statement, with 96.49 per cent (n=110) agreeing and only 3.51 per cent (n=4) disagreeing with the statement, thus holding a misconception. A comparative statement, statement 4 (*"The Earth is old enough for Evolution to have occurred")*, received a less favourable response, with 62.28 per cent (n=71) in agreement, while 29.82 per cent (n=34) disagreed. Thus, even though the pre-service science teachers generally recognise the reliability of scientific dating techniques, some still believe that the Earth is not old enough for Evolution to have occurred. The same misconception was reported by Robbins and Roy (2007) when they found out that the students' doubts about Evolution stem from their belief that Evolution occurs over *centuries* rather than tens and hundreds of millennia, indicating the students' difficulty in understanding the basic premise in the theory of Evolution, which is that Evolutionary processes require a long period to occur.

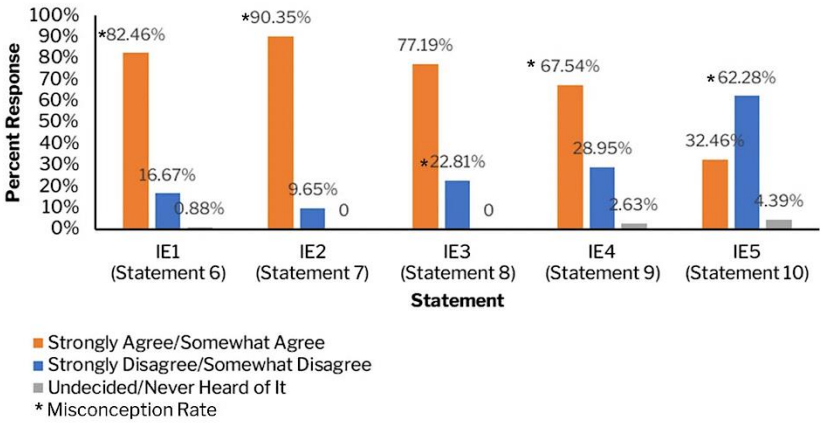
Responses to statement 3 *("According to the second law of thermodynamics, complex life forms cannot evolve from simpler life forms")* revealed that the majority of the respondents have a misconception about this statement, as reflected by 67.54 per cent (n= 77) agreeing to it, while only 29.82 per cent (n=34) of the respondents lacked the associated misconception. According to Schreiber and Gimbel (2010), the anti-Evolutionists' argument that *"Evolution violates the second law of thermodynamics"* is based on a misunderstanding of the second law of thermodynamics, which states that disorder (or entropy) constantly increases, implying that complex organisms could not have evolved from simple organisms because systems become more disordered over time. Schreiber and Gimbel (2010) did, however, explain that the increase in entropy is only to be expected in *thermally isolated systems* (closed systems) or those in which no energy is added or removed. However, organisms do not live in such a system because the Sun constantly adds energy, and they can use it to overcome the increase in entropy. Based on the findings, the majority of Science pre-service teachers failed to understand that life operates within an *open system* with a constant inflow of energy, leading to a misconception that Evolution violates the second law of thermodynamics.

Intentionality of Evolution

The five statements of the BEL Survey Intentionality of Evolution section were designed to determine the respondents' misconceptions about biological Evolution intentionality. Figure 2 depicts the responses to each of these statements.

Figure 2

Per cent Response to Intentionality of Evolution



Responses from statement 6 (“Evolution always results in improvement”) showed that a hefty 82.46 per cent (n=94) agreed with this statement, signifying misconception, while only 16.67 per cent (n=19) understood that Evolution does not always result in improvement. Statement 7 (“Members of a species evolve because of an inner need to evolve”) produced a comparable result in which the majority of the respondents also or 90. Thirty-five per cent (n=103) agreed with this statement, whereas only 9.65 per cent (n=11) disagreed. This finding suggests that these science pre-service teachers perceive Evolutionary processes as deterministic in nature, with improvement as their goal. Furthermore, acceptance of statement 9 (“If webbed feet are being selected for, all individuals in the next generation will have more webbing on their feet than do individuals in their parents’ generation”) also implies a deterministic view of Evolutionary mechanisms. Findings demonstrated that 67.54 per cent (n=77) of the respondents have this misconception, and only 28.95 per cent (n=33) disagreed.

Statement 10 (“Evolution cannot cause an organism’s traits to change within its lifetime”) elicited 32.46 per cent (n = 37) agreement among respondents, with 62.28 per cent (n = 71) disagreeing, indicating that the majority of respondents believe Evolutionary processes can cause a change in individual organisms during their lifetimes. Furthermore, statement 8 (“Traits acquired during the lifetime of an organism--such as large muscles produced by body building—will not be passed along to offspring”) yielded agreement among 77.19 per cent (n=88) of the respondents, as opposed to 22.81 per cent (n=26) who apparently believed in the Lamarckian misconception of inheritance through acquired characteristics. These findings show that, while the majority of respondents correctly understand that acquired traits cannot be passed down to the next generation, the majority of respondents also still believe that characteristics acquired by an organism during its lifetime are produced by Evolutionary processes, as reflected by the responses in statement 8 and 10, respectively.

Surveyed literature done by Yates and Marek (2015) showed that the tendency of students toward biological Evolutionary explanations based on purpose is widespread and consistent in the literature. For example, Alters and Nelson (2002) reported that in a survey of 392 university students, nearly 43 per cent believed that "Evolution involved a purposeful striving toward higher forms (that it is steady progress from microbes to man)." Moreover, Prinou et al. (2008) stated that in their study, the majority of students believed that new features emerged in the organisms out of need since 59.3 per cent agreed that “new features appear in organisms because they need them in order to survive.” Misconceptions regarding the intentionality of Evolution also exist among teachers (Tidon & Lewontin, 2004; Nehm & Schonfeld, 2007).

Nature of Evolution

The Nature of Evolution statements, 11-14, addressed respondents' views on the nature of Evolution, including the roles of randomness, the environment in Evolutionary processes, and adaptation. The responses to each of these statements are depicted in Figure 3.

Figure 3

Per cent Response to Nature of Evolution

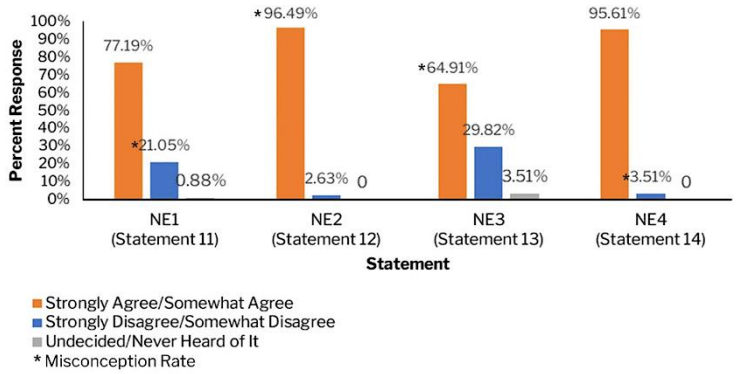


Figure 3 demonstrates that responses for statement 11 *("New traits within a population appear at random")* produced only 21.05 per cent (n=24) disagreement, supporting the misconception, while 77.19 per cent (n=89) agreed. A comparative statement, statement 13 *("Evolution is a totally random process"),* resulted in 64.91 per cent (n = 74) of respondents in agreement, thus having an associated misconception, while 29.82 per cent (n =34) disagreed.

Conversely, although fewer respondents disagreed with statement 11, the majority of them agreed with statement 13, presenting the conflicting misconceptions that Evolution is a totally random process, yet new traits within a population *do not* appear at random. The same result was also found by Yates and Marek (2015). However, it should be pointed out that these rates of misconceptions among respondents about the concept of randomness are concerning, as Isaak (2003) contends that there is no other misconception that is a better indicator of a lack of understanding of Evolution than the misconception that Evolution proceeds by random chance. He argued that while chance certainly plays a role in Evolution, this argument completely ignores natural selection, which is the opposite of chance. Furthermore, Smith and Sullivan (2007) clarified that the simple phrase *"Evolution is random"* is dangerously clumsy since it simply does not acknowledge the complexity of Evolution. The complete diversity of life, including its order, balance, and complexity, is the outcome of a *nonrandom selection of random variations* in living organisms.

Statement 14 *("The environment determines which traits are best suited for survival")* revealed that a large 95.61 per cent (n=109) correctly agreed with the statement, and only 3.51 per cent (n=4) disagreed, thus having a misconception. On the contrary, responses from statement 12 *("Individual organisms adapt to their environments")* found that only 2.63 per cent (n = 3) of respondents disagreed, whereas a hefty 96.49 per cent (n = 110) agreed, claiming the associated misconception.

The relatively high per centage of respondents who held this misconception raised concerns. The same concern was also raised by Yates and Marek (2015) regarding this misconception of this statement. Since Yates and Marek (2015) surveyed high school students, they assumed that this very high misconception rate for statement 12 is because they may have failed to address the term adapt in an Evolutionary context due to their *limited academic exposure* to biological Evolution concepts. However, for this study, the respondents were pre-service teachers who had undergone four years of studying in a teacher education institution, majoring in Science. Therefore, they have had *more exposure* to biological Evolution concepts than the respondents of Yates and Marek (2015). This finding only signifies that these pre-service science teachers still did not fully grasp the word "adaptation" in an Evolutionary context despite their four years of college or university studies. Unfortunately, they failed to understand that the smallest unit that adapts in an Evolutionary context is not an individual but a population.

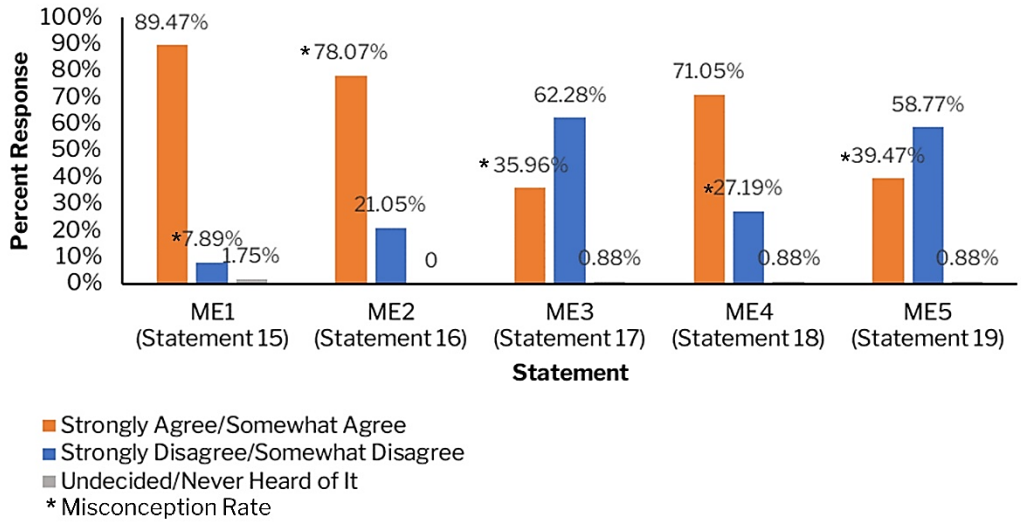
Mechanisms of Evolution

Statements 15 through 19 addressed respondents' perspectives on the mechanisms that lead to Evolutionary change. Figure 4 illustrates the responses to these statements.

Responses from statement 15 *("Variation among individuals within a species is important for Evolution to occur")* show that the majority of respondents (89.47%, n = 102) agreed with statement 15. In comparison, only 7.89 per cent (n = 7) believe that variation among members of a species is not an important contributing factor to Evolutionary processes, adhering to a misconception. This finding is also found by Wescott and Cunningham (2009), in which the majority of university students (83%) also tend to agree that variation matters in Evolution.

Figure 4

Per cent Response to Mechanisms of Evolution



Responses from statement 16 *("Survival of the fittest' means basically that 'only the strong survive")* demonstrated that the majority of students have a misconception since 78.07 per cent (n=89) of the respondents agreed with this statement, while 21.05 per cent (n=24), disagreed. Out of all the misconceptions in this category, statement 16 has the highest rate of misconception among the respondents. Smith and Sullivan (2007) clarified that the word *fitness* in an Evolutionary context pertains to the statistical likelihood that an organism will have offspring. Thus, those respondents who have misconceptions about statement 16 have a faulty understanding of the word "fitness" in an Evolutionary context, another example of vernacular misconception. Like the word "adapt," other researchers reported that the scientific meaning "fitness" has undoubtedly been distorted by its use in common parlance (Alters & Nelson, 2002; Bishop & Anderson, 1990). Based on the surveyed literature, students may associate the meaning of "survival of the fittest" with physical strength, speed, intelligence, longevity, the number of mates possessed, or even physical fighting between different species, with the strongest species winning (Bishop and Anderson,1990; Anderson et al. 2002; Robbins and Roy 2007; Wescott & Cunningham, 2009), indicating how pervasive this misconception is.

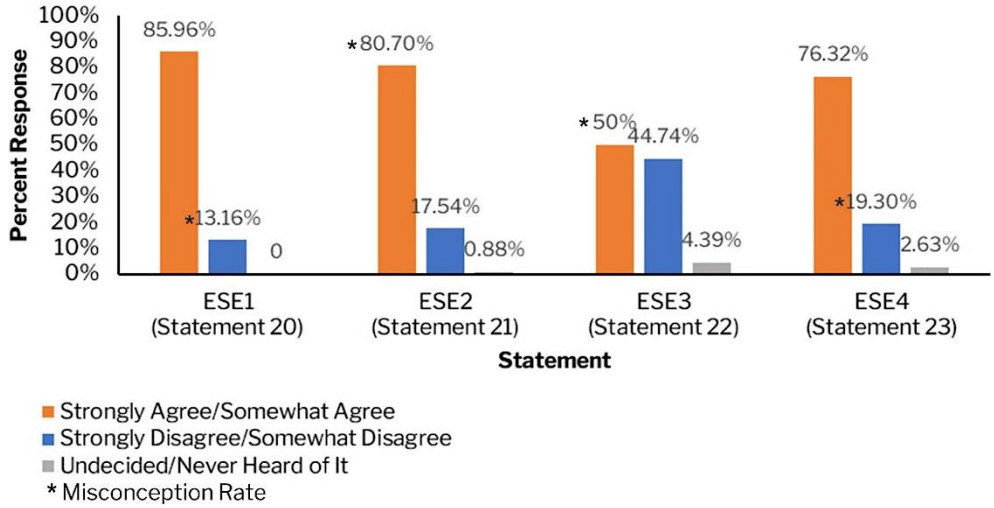
Statement 17 *("The size of the population has no effect on the Evolution of a species")* resulted in disagreement among 62.28 per cent (n = 71) of respondents, while 35.96 per cent (n =41) voiced their agreement with the statement, thus revealing a misconception. Statement 18*("Complex structures such as the eye could have been formed by Evolution")* demonstrated a response, being favored by 71.05 per cent (n = 81) of respondents, whereas 27.19 per cent (n = 31) disagreed, thus having a misconception. Lastly, Statement 19 *("Only beneficial traits are passed on from parent to offspring")* showed that 39.47 per cent (n= 50) affirmed this statement, thus adhering to the misconception that hereditary mechanisms are the reason for passing only *advantageous traits* from generation to generation, while 58.77 per cent (n=70) disagreed, correctly understand that inheritance does not dispense only beneficial traits, *but harmful traits as well*.

Evidence Supporting Evolution

Statements 20 through 23 addressed respondents' opinions on evidence supporting Evolution. The responses to each of these statements are depicted in Figure 5.

Figure 5

Per cent Response to Evidence Supporting Evolution



It can be gleaned from Figure 5 that responses from statement 20 *("There exists a large amount of evidence supporting the theory of Evolution")* revealed that the majority of respondents, or 85.96 per cent (n = 96), agreed, whereas 13.16 per cent (n = 15) revealed the associated misconception that there is not. Thus, the majority of respondents recognize that a large amount of evidence supports Evolution. The fossil record of ancient life, such as plants and animals, can assist scientists in determining the truth about life on Earth. For instance, the fossil record contains over 200,000 examples of extinction (Smith & Sullivan, 2007). That is why, according to Mayr (2001), the discovery of fossils of extinct organisms in older geological strata is the most convincing evidence for the occurrence of Evolution.

However, responses from Statement 22 *("Scientific evidence indicates that dinosaurs and humans lived at the same time in the past")* revealed a *surprising result* in which 50 per cent (n=57) agreed with this statement, indicating a misconception, while 4.39 per cent (n=5) were undecided/never heard of the statement, therefore, despite the fact that the fossil record indicates the two groups are separated by *approximately 65,000,000 years* (Alters & Nelson, 2002), half of the respondents accept the coexistence of humans and dinosaurs. Based on this finding, it is disconcerting to see so many pre-service science teachers having this misconception since adherence to this single misconception alone reveals a *less than adequate understanding* of the evidence supporting Evolution (Yates & Marek, 2013). The misconception rate generated in this statement is notably higher than the misconception rate found by other researchers. In a similar statement, only 27 per cent of Californian college students thought humans and dinosaurs lived at the same time (Wilson, 2001), 11 per cent of university students have this misconception (Wescott & Cunningham, 2009), 33.6 per cent of high school students (Yates & Marek, 2015) and 25 per cent of Biology teachers (Yates & Marek, 2013).

Statement 21 related to human Evolution *("According to the theory of Evolution, humans evolved from monkeys, gorillas, or apes")* garnered a large 80.70 per cent (n=92) of respondents' affirmative responses to this statement, thus holding to one of the most prevalent and persistent misconceptions in Evolution--- humans evolved from monkeys, gorillas or apes. Smith and Sullivan (2007) explained that humans did not evolve from monkeys, gorillas, or apes. Humans *share a common ancestor* with chimps and, before them, with the group that evolved into monkeys. The authors further emphasize that to say humans evolved from monkeys is *simply wrong*, and Evolution has never claimed it. Mayr (2001) pointed out the culprit of this misconception, stating that one of the common misconceptions about macroEvolution held by most students is that Evolution is exclusively a *linear process* in time. As a result, various studies also recorded this misconception among students (Woods, 2001; Robbins & Roy, 2007; Wescott & Cunningham, 2009) and teachers (Yates & Marek, 2013).

Lastly, Statement 23 *("The majority of scientists favor Evolution over other explanations for life's diversity")* yielded 76.32 per cent (n = 87) agreement among respondents, with 19.30 per cent (n = 22) in disagreement, having a misconception. Thus, the majority of respondents recognize that majority of scientists favor Evolution over other explanations for life's diversity.

Summary of BEL Responses

In totality, out of a possible Biological Evolution Literacy Survey Maximum Index Score (BEL-MIS) of 115, pre-service science teachers in this study (N = 114) earned a 70.02 (SD = 7.43) BEL-MIS for the 23 statements with an average of 47 per cent misconception rate, 51 per cent correct concept rate and combined 2 per cent undecided and nonresponse rate. The developers of BEL did not establish a specific scale for verbal interpretation of the possible indices that fall between 0 and 115 for the BEL Survey index scores. However, they recommend converting the BEL-MIS score to a per centage to interpret the data. Thus, following this method, a 70.02 BEL-MIS indicates that the respondents scored 61 per cent of the maximum score of 115 overall, indicating a fairly high level of misconceptions.

The Level of Understanding of the Respondents of Evolution

The respondents' level of understanding of Evolution is presented in Table 3. It can be deduced from the table that almost all of the respondents have a surprisingly "Very Low" understanding of Evolution, as reflected by 95.61 per cent (n=109) of the pre-service science teachers. Only 1.75 per cent (n=2) have "Moderate" and "High" levels of understanding, while only 0.88 per cent (n=1) of the respondents has "Low" level of understanding. No one has a "Very High" level of understanding of Evolution. Overall, the level of understanding of pre-service science teachers is "Very Low" (Mean=34.25; SD=13.76).

Table 3

Level of Understanding of the Respondents to Evolution

Range	Descriptive Rating	Frequency Mean = 34.25 Sd = 13.76	%
59 or less	Very Low	109	95.61
60 – 69	Low	1	0.88
70 – 79	Moderate	2	1.75
80 – 89	High	2	1.75
90 – 100	Very High	0	0.00

This result indicates that there is a problem with how these pre-service science teachers learned the theory of Evolution. Considering that they are currently in their fourth year of studying the course, they are expected to have already learned at least the basic concepts of Evolution in their Biology subjects; however, the results revealed that these were not learned efficiently. Thus, it implies that there is a problem in emphasizing Evolution education in science teacher preparation curriculum in Teacher Education Institutions in the Philippines. This indicates the need for more targeted instructional interventions to address these knowledge gaps.

The finding conforms with the study of Clores et al. (2014), in which they also found that pre-service and in-service secondary Biology teachers in the Philippines, specifically Regions V (Bikol) and IX (Zamboanga City), had a poor understanding of natural selection, one of the essential concepts in Evolution. The result was also generally in line with the published levels of understanding or

knowledge regarding the Evolution of Chinese and Indonesian pre-service teachers, in which they scored low (Ha et al., 2019; Rachmatullah et al., 2018). Moreover, Farenwald (1999), Nehm et al. (2009), and Nunez et al. (2012) reported that public high school teachers in South Dakota, pre-certified Biology and non-Biology teachers in New York, and Belizean Biology teachers also have low levels of understanding of Evolution.

The Level of Acceptance of the Respondents to Evolution

Table 4 reports that pre-service science teachers have "Moderate Acceptance" (Mean=68.41; SD=9.07) of the theory of Evolution. This finding implies that Filipino pre-service science teachers accept the theory of Evolution, but not entirely. The findings show that acceptance of Evolution among respondents is moderate but influenced by their misconceptions and understanding. This suggests that addressing misconceptions and improving understanding could enhance acceptance levels.

Table 4

Level of Acceptance of the Respondents to Evolution

Range	Descriptive Rating	Frequency Mean = 68.41 Sd = 9.07	%
20 – 52	Very Low Acceptance	2	1.75
53 – 64	Low Acceptance	47	41.23
65 – 76	Moderate Acceptance	40	35.09
77 – 88	High Acceptance	24	21.05
89 – 100	Very High Acceptance	1	0.88

This moderate level of acceptance of Evolution by Filipino pre-service science teachers supports Partosa's (2018) description of the status of acceptance of Evolution in the Philippines. She reported that it remains in need of wide public acceptance and is on the periphery even in academic discourse.

This finding is also consistent with the acceptance rates of pre-service teachers of various nationalities reported in various studies. According to Akyol et al. (2010), Turkish pre-service science teachers accept Evolution to a moderate degree. Kim and Nehm (2011) found that the average Measure of Acceptance of the Theory of Evolution (MATE) score of Korean pre-service teachers was 73.79 (SD = 9.2), indicating moderate acceptance of the Evolution. The average MATE score for Indonesian pre-service Biology teachers was 65.06 (SD = 6.76), indicating moderate acceptance of Evolution (Rachmatullah et al., 2018). According to Rutledge and Warden (2000), Indiana public high school Biology teachers accept the Evolutionary theory moderately.

Moreover, it was notable that the respondents' level of acceptance in this study is higher than the reported levels of acceptance by the studies of Nunez et al. (2012) and Peker et al. (2010), which showed low levels of acceptance of Evolution among teachers and students, respectively. Nunez et al. (2012) stated that with an average MATE score of 64.4 and a mean knowledge score of 47.9 per cent, Belizean teachers were classified as having 'Low Acceptance' while Peker et al. (2010) reported that their study results among Biology, Biology education, and science education majors resulted to an overall acceptance rate of Evolution theory was 27.75 per cent.

On the contrary, it was also notable that the respondents' level of acceptance in this study was lower than the reported levels of acceptance by the studies of Trani (2004) and Korte (2003). Analysis of the Oregon Biology teachers' responses to the MATE demonstrated a high acceptance of Evolutionary theory with a mean MATE = 85.9, SD = 17.48 (Trani, 2004). Ohio life science teachers also highly accepted Evolution after analysing their MATE scores revealed a mean MATE = 87, SD = 17.24 (Korte, 2003).

The Relationship between the Respondents' Evolution-related Misconceptions and Level of Acceptance of Evolution

The relationship between the respondents' Evolution-related misconceptions and level of acceptance of Evolution in terms of science, scientific methodology, and terminology, intentionality of Evolution, nature of Evolution, mechanisms of Evolution, and evidence supporting Evolution is determined in the following discussions as shown in Table 5.

The level of acceptance of Evolution is found to have a significant relationship with four out of five categories of Evolution-related misconceptions. Specifically, it has a positive correlation and is highly correlated with science, scientific methodology, terminology ($r = .427$), and mechanism of Evolution ($r= .424$) with p values less than 0.01. The evidence supporting the Evolution category also has a positive correlation ($r=.217$, $p < 0.05$). Seemingly, the higher the misconceptions related to science, scientific methodology, terminology, mechanism of Evolution, and evidence supporting Evolution, the higher the acceptance of Evolution, while the lower the misconceptions in these categories, the lower the acceptance of Evolution.

On the contrary, intentionality of Evolution category has a negative correlation ($r= -.190$, $p < 0.05$). Seemingly, the higher the misconceptions related to the intentionality of Evolution, the lower the acceptance of Evolution, while the lower the misconceptions in these categories, the higher the acceptance of Evolution.

Table 5

Relationship between the Respondents' Evolution-related Misconceptions and Level of Acceptance of Evolution

Evolution-Related Misconceptions	Level of Acceptance of Evolution	
	r	p-value
Science, Scientific Methodology, and Terminology	.427**	.000
Intentionality of Evolution	-.190*	.042
Nature of Evolution	.063	.507
Mechanism of Evolution	.424**	.000
Evidence Supporting Evolution	.217*	.020

Note. * correlation is significant at 0.05 level (2-tailed), ** correlation is significant at 0.01 level (2-tailed)

The findings of this study were unexpected and surprising. The researchers expected that the acceptance of Evolution has a *negative correlation* with Evolution-related misconceptions, but the results reflect that even though the respondents have a fairly high level of misconceptions regarding Evolution, they still accept the Evolution concepts. Thus, an *interesting relationship* has been revealed by this finding. The researchers initially thought that this relationship was unprecedented. However, an extensive literature review revealed that Clores and Limjap (2006) and Clores and Bernardo (n.d.) reported in their *qualitative approach* to investigating the diversity of Filipino Catholic students' beliefs about Evolution that some students accepted the theory of Evolution *based on alternative conceptions or misconceptions.*

These researchers concluded that "acceptance of the theory of Evolution is *not necessarily based on an accurate and sophisticated understanding of the theory.* Many students *submitted to a lot of misconceptions* and used them to *justify their confidence* in the theory. Even after instruction, they held on to these misconceptions and beliefs". These researchers' conclusions confirmed the unexpected and surprising

result of this quantitative study, which investigated the relationship between Evolution-related misconceptions and the level of acceptance among pre-service science teachers.

The Relationship between the Respondents' Level of Understanding and Level of Acceptance of Evolution

The level of understanding of Evolution was found to have a significant relationship with the level of acceptance of Evolution.

Table 6

Relationship between the Respondents' Level of Understanding and Level of Acceptance of Evolution

Level of Understanding of Evolution	Level of Acceptance of Evolution	
	r	p-value
	.264**	.005

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

Table 6 presents that the level of understanding of Evolution has a weak positive correlation and is highly correlated with the level of acceptance of Evolution ($r=.264$, $p < 0.01$). This finding indicates that the lower the understanding of Evolution of pre-service science teachers, the lower their acceptance of Evolution. In the same manner, the higher the level of their understanding of Evolution, the higher the level of their acceptance of Evolution. Thus, the current findings imply that a faulty understanding of the theory could lead to rejecting Evolution. However, improving the pre-service science teachers' understanding of Evolution can lead to an increase in their acceptance of the Evolutionary theory.

Discussion

This study is primarily conducted to determine the misconceptions, level of understanding, and acceptance of Filipino pre-service Science teachers to biological Evolution and to investigate the relationship between these variables. A 70.02 BEL-MIS indicates that the respondents scored 61% of the maximum score of 115, overall indicating a fairly high level of misconceptions. This suggests that despite four years of science education, misconceptions about Evolution remain prevalent, emphasizing gaps in Evolution education within teacher education programs. This suggests that despite four years of science education, misconceptions about Evolution remain prevalent, emphasizing gaps in Evolution education within teacher education programs. This finding coincides with the findings of Yates and Marek (2014) that biological Evolution-related misconceptions were prevalent among Oklahoma's introductory Biology teachers.

Similar findings have been reported in other studies, where persistent misconceptions about Evolution have been observed among pre-service teachers across different educational systems (Akyol et al., 2012a; Athanasiou et al, 2012). These misconceptions often stem from early educational experiences, religious and cultural influences, and inadequate pedagogical approaches to teaching Evolution. These pre-service teachers, soon to become educators themselves, may face challenges in teaching Evolution accurately. Interestingly, most respondents self-rated their knowledge of Evolution as "Average" or "Good," yet their ECKT scores reflected poor understanding. This discrepancy mirrors findings in previous research, where confidence in scientific knowledge does not always correlate with actual understanding (Nehm & Schonfeld, 2007). Such a disparity suggests that pre-service teachers may rely on superficial or misconceived understandings of Evolution, which can be perpetuated in their future classrooms if not addressed effectively.

Notably, the data indicated that misconceptions could positively influence acceptance. This paradox may arise because respondents use their misconceptions to justify their acceptance of Evolution, reflecting a superficial alignment rather than an informed understanding. This finding suggests that traditional teaching methods, which often prioritize content delivery over critical engagement, may inadvertently sustain these misconceptions. Studies have shown that passive learning environments reinforce misconceptions, as students may memorize Evolutionary concepts without critically evaluating them (Sinatra et al., 2003). Thus, shifting towards more inquiry-based and discussion-driven pedagogical strategies is essential to ensure a deeper conceptual grasp of topics in science, such as Evolution (Usman et al., 2023; Liline et al., 2024)

Educators must address this paradox by fostering scientific thinking and critical analysis in classrooms. Nelson (2008) recommends three strategies to challenge misconceptions and enhance understanding: (1) interactive engagement focused on scientific thinking, (2) developing general critical thinking skills, and (3) comparing initial misconceptions with scientific conceptions. Studies have demonstrated that students benefit most when all three strategies are integrated, as this approach helps them restructure their cognitive frameworks and replace misconceptions with accurate scientific explanations (Sinatra et al., 2003; Mufit, F., & Fauzan, 2023; Labak et al., 2024). Therefore, the findings of this study could serve as a basis for much-needed pedagogical retooling in teaching and learning Evolution, ultimately increasing knowledge and fostering greater acceptance of Evolutionary theory.

The very low level of understanding further reinforces the concerns raised by Partosa (2018), highlighting the absence of Evolution as a dedicated subject in the Philippine teacher education curriculum, as noted in CHED Memo No. 75, Series of 2017. Evolution is often taught as a subtopic in courses like Genetics, Cell and Molecular Biology, or Ecology, which are frequently rushed or skipped due to time constraints. This fragmented exposure limits students' ability to develop a cohesive understanding of Evolutionary principles, allowing misconceptions to persist. Partosa (2018) did the sole study investigating the Evolution of education holistically in the country. According to the K to 12 Science Curriculum Guide (2016), the first introduction of Evolution concepts in the Philippine Science curriculum happens in primary grades (before the age of 10), specifically in K-3. However, Partosa (2018) emphasized that in the Philippines, there is an explicit legal provision for including Evolutionary theory in the curriculum, but this is limited to the Bachelor of Science in Biology. Nothing in the provision indicates that it will be included in teacher education programs for elementary teachers, a glaring gap that must be filled given that, according to the current science curriculum, fundamental concepts of Evolution were first introduced in primary grades, as previously stated.

Moreover, the principal concepts of Evolution are taught in Junior High School (Grade 10) in terms of natural selection as its mechanism, mutations as sources of variation, speciation, environmental pressures, and biodiversity. Subsequently, the topics Evolution and Origin of Biodiversity, as well as Systematics Based on Evolutionary Relationships, were integral parts of the content for General Biology 2 in the Science, Technology, Engineering, and Mathematics (STEM) strand in Senior High School. With the science curriculum in place, the gap also clearly indicates the absence of the teaching of Evolution in secondary teacher education programs, as suggested by the currently implemented Policies, Standards, Guidelines for Bachelor of Secondary Education (BSEd) Major in Science by the Commission on Higher Education (CHED Memo No. 75, Series of 2017). Ironically, Evolution is considered by the scientific community as the unifying theme in Biology, but in preparing teachers who will teach Biology at the elementary and secondary levels, Evolution was not included in their curriculum. Thus, Partosa (2018) advocated for a reconsideration of the teacher education curriculum to align it more closely with contemporary educational needs—a call that this study supports.

Lastly, although some studies suggest that the level of understanding of Evolution has no relationship with the level of acceptance (Bishop & Anderson, 1990; Brem et al., 2003; Sinatra et al., 2003; Akyol et al., 2010; Cofré et al., 2016), the present study supports a growing body of literature reporting a positive correlation between these two variables. Research by Deniz et al. (2008) found a low but positive relationship between understanding and acceptance of Evolution among Turkish pre-service biology teachers. Similarly, Kim and Nehm's (2011) analysis revealed a significant but low association

between Evolution content knowledge (ECK) scores and MATE scores ($r = 0.22$, $p < 0.05$), implying a comparable trend among Korean science pre-service teachers. Additional studies, such as those by Fahrenwald (1999), Rutledge and Warden (2000), and Nunez et al. (2012), have also documented a positive relationship between biology teachers' understanding and acceptance of Evolution. Akyol et al. (2012b) and Athanasiou et al. (2012) reported similar findings among pre-service science teachers and pre-service preschool education teachers, respectively.

These results highlight the potential for improved understanding to enhance acceptance, suggesting that targeted interventions in teacher preparation programs could yield meaningful improvements. Incorporating Evolution education into teacher training, coupled with active learning strategies and curriculum reform, could address persistent misconceptions and foster a more scientifically literate teaching workforce. Future research should explore how cultural factors uniquely influence Filipino pre-service teachers' understanding and acceptance of Evolution, contributing further to the discourse on Evolution education in diverse educational contexts.

Conclusion and Implications

Filipino pre-service science teachers exhibited a fairly high level of misconceptions, very low understanding, and moderate acceptance of Evolution. These findings underscore significant gaps in their teacher education programs, which may hinder their ability to effectively teach Evolution and related biological concepts. Misconceptions could lead to misinterpretations of Evolution and perpetuate inaccuracies in their future classrooms. Moreover, the partial acceptance of Evolution raises concerns about their confidence in teaching this foundational theory.

The most significant contribution of this study to the existing literature is its contextualization of Evolution-related misconceptions, understanding, and acceptance within the Philippine pre-service science teacher education landscape. While previous research has explored similar issues in other cultural settings, this study provides the initial empirical evidence for these three variables and their relationship to one another, specific to Filipino pre-service teachers, thereby highlighting unique challenges and areas for intervention. By establishing the relationship between misconceptions, understanding, and acceptance of Evolution, this study informs both curriculum development and instructional strategies aimed at improving Evolution education in teacher preparation programs.

To address these challenges, enhancing Evolution education should be prioritized in teacher preparation programs. This could be achieved through three key approaches: (1) reconsidering the current curriculum to include a dedicated subject on Evolution. This course would focus on Evolutionary theory and evidence-based strategies for teaching it to high school students, and (2) pedagogical retooling to equip educators with methods that emphasize critical thinking and scientific inquiry. Strategies might include presenting compelling evidence for Evolution, engaging them with fieldwork, experiments and observations that allow them to draw conclusions, and challenging them to analyze and validate this evidence independently.

This study supports the reconsideration of the teacher education curriculum to align it more closely with contemporary educational needs. With Evolution concepts now introduced as early as elementary school and reinforced through senior high school under the current Philippine science curriculum, pre-service teacher training must reflect this shift. Teacher preparation programs should place greater emphasis on Evolution education, ideally by introducing a separate course dedicated to the subject. Therefore, pre-service teachers should receive both content enrichment on Evolution and pedagogical training that incorporates instructional methodologies presenting evidence-based Evolutionary concepts. Encouraging them to evaluate and critically engage with these concepts can lead to greater understanding and acceptance of Evolution, thereby ensuring that they enter the teaching profession well-equipped to educate future generations.

Finally, a holistic approach is the third key to addressing Evolution-related misconceptions. Future research should employ both quantitative and qualitative methodologies, including interviews, concept maps, essays, and open-ended questions, to gain a deeper insight into students' knowledge

structures and reasoning processes. Further exploration into effective interventions for correcting misconceptions is also necessary. An essential step is the development of a contextualized and localized instrument aligned with the Philippine curriculum to assess the misconceptions associated with Evolution among Filipino students, pre-service science teachers, and public high school science teachers. A tailored diagnostic tool would enable educators to better identify, address, and mitigate misconceptions that are unique to the local educational context.

By implementing these changes, pre-service science teachers can develop a deeper understanding and full acceptance of Evolution, enabling them to teach it confidently and accurately. These reforms are essential to ensuring that future generations receive an Evolution education rooted in scientific integrity, preparing them for a more comprehensive understanding of Biology as a whole.

Ethical Considerations

Respondents who only agreed to the consent form stated at the beginning of the administered survey were able to proceed to the rest of the questionnaire; thus, they were the only respondents included in the study. Data privacy was diligently maintained throughout the execution of the research. Each response was handled with the utmost discretion and confidentiality.

Declaration of Interests

The authors affirm that this manuscript has not been published previously and is not presently under consideration for publication elsewhere. Furthermore, there are no conflicts of interest to declare.

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