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Focusing on the big ideas: Learning experiences of non-biology science teachers in biological evolution

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ABSTRACT

Recognizing the ways teachers develop conceptual understanding of biological concepts bridges the gap between misconception and instruction. This descriptive phenomenology explored the learning experiences of eight non-Biology major science teachers on evolution. Thematic analysis revealed six emergent themes: (a) First exposure is faulty and insufficient; (b) Lack of content knowledge leads to advanced studies; (c) Technology-supported learning resources facilitate learning process; (d) Rationalization of both old and new conceptions; (e) Application of concepts in different fields; and (f) Focusing on the big ideas. Overall, themes revealed that teachers developed a conceptual understanding of biological evolution through time and various means. Their adherence to the teleological beliefs led them to experience confusion and misconceptions; however, as science teachers, they resolved the conflict to learning through content enrichment and professional development. Some NOS concepts such as scientific knowledge is based on empirical evidence, open to revision in light of new evidence, and scientific models, laws, mechanisms, and theories explain natural phenomena must be strongly and consistently emphasized not only within the scope of Biology but across other scientific domains and across grade level. Teachers can enhance their conceptual understanding and teaching efficacy through continuous learning and professional development.

Keywords: science teachers, learning experience, conceptual understanding, biological evolution learning, phenomenology

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INTRODUCTION

Effective and efficient biology instruction requires that science teachers must be able to diagnose their students' understanding and the underlying misconceptions in the students' answers (Fischer et al., (2021). Some studies purported that the teachers content understanding is closely correlated with their education particularly their bachelor's degree (Hoy et al. 2006 and Yates & Marek, 2014). However, Nehm et al., (2009) refuted that the biology teachers' extensive backgrounds in evolutionary biology, as a subject matter in Biology, is not an absolute guarantee that they have an accurate working knowledge of evolution, natural selection, or the nature of science. Furthermore, years of studying and teaching biology have not had a transformative effect on the teachers and professors about evolution (BouJaoude, et al., 2011) as teachers undeniably identified as one of the source and propagators of evolution-related misconceptions (Yates and Marek, 2014). Scientifically accurate understanding of this theory is a vital aspect of scientific literacy as teachers are the most essential element in the attainment of effective instructional and curricular decisions (Borgerding et al., 2015; Glaze & Goldston, 2019). Scientific publications showed a dismal portrait of evolution, as a subject matter of biology, often characterized by culturally ingrained misconceptions, faulty prior knowledge, deep-seated intuitive beliefs, and resistance. The common misconceptions in

understanding evolution are attributed to two main points: (a) the content understanding, beliefs and attitude of teachers (Clores & Limjap, 2006; Andrews et al., 2012) and (b) pedagogy used to teach the students (Frasier & Roderick, 2011; Tidon & Lewontin, 2004; Fail, 2008).

The science education community continuously seek for ways forward for effective instruction of nature of science and related concepts such as evolution with respect to the preparation of science teachers (Nouri, et al., 2021). A recent probability survey conducted by Plutzer et al., (2021) among American high school Biology teachers on the quality of teaching on evolution topic reported significant improvement. They reported a substantial reduction of Creationist-based and mixed approach (Creationism as a valid scientific explanation to biological evolution). Furthermore, more Biology teachers allotted more time teaching human evolution and general evolutionary processes. This significant improvement according to the authors reflected generational replacement and teacher training and professional development reforms. This notable observation may indicate increased confidence of teachers to teach the concepts as they have gained conceptual understanding on evolutionary science.

In the Philippine education system, one of the challenges that flagged effective science education is the issue on mismatched science teachers. The present teacher education curriculum is designed to prepare prospective science teachers with specialization (e.g., biology, chemistry, physics, and integrated science). In the actual field of teaching in the K-12 curriculum, they have to teach these four science areas in a spiral progression approach (Orbe et al., 2018). This concern is further aggravated by the fact that there are teachers teaching science subjects who are not education graduates and are not science major hence called as out-of-field teachers. These are teachers whose scholastic preparations are from allied courses such as nursing, chemical engineering and took up diploma for professional education, passed the teachers' licensure exam, and hired to teach in both private and public school system (Macugay & Bernardo, 2013). Local studies have unveiled the struggles and challenges of mismatched teacher and out-of-field teachers teaching science subjects (particularly in teaching biological evolution (Picardal, 2019; Florungco & Caballes, 2021). Some reported challenges were mistrust and refusal of students to learn these contentious scientific ideas and their capabilities to understand the abstract concepts and terminologies it contains and their religious beliefs. Another barrier to effective instruction is the lack of depth in the instruction due to the lack of content knowledge and skills and appropriate materials to deliver properly the lessons. These obstacles oftentimes lead teachers to teach the lesson in a traditional lecture manner. It is in this premise that this study aims to investigate non-Biology major science teachers learning experiences journey in understanding the concepts and nature of evolutionary biology. These are the teachers who have had science courses as cognate or those whose undergraduate degree is from other allied courses and earned units in professional education courses. Exploring how teachers developed conceptual understanding of the highly contentious science concept such as evolution against the background of varied scholastic training and religious and cultural orientations is an attempt to address research gap in science education as well as basis for the learning and development needs of teachers for their professional learning interventions.

In relation to the evolution instruction in the context of study, the Philippines has a very dynamic social, political, and cultural context brought about by the influence of different colonizers and existence of varied religious denominations. The inclusion of evolution theory in the curriculum has been institutionalized but the breadth and depth of instruction of this subject remain discordant among schools in general and among teachers in particular (Partosa, 2018). There is an apparent division between creationism advocates and evolution adherents. On a larger context, majority of the teachers still reject evolution because it often conflicts with their worldview and cultural upbringing particularly on their religious orientation and low levels of acceptance caused by resistance to change, regardless of increase in knowledge (Cofre, Cuevas, & Becerra, 2017; Coleman et al., 2015; Schröder (2013). Concepts like the elements and actions of natural selection and the definition of the phrase "survival of the fittest" were prominent evolution concepts that elicit major disagreement and confusion. Clores and Limjap (2006) and Clores and Bernardo (2007) revealed that college students in a catholic school in the country had various beliefs about evolution where religious and cultural background had a strong influence on these beliefs. The Philippines presents a suitable context for this research because of the recent

changes in the curriculum underscores the shortage of vertically specialized teacher to teach specific discipline in science and may be reflective of the global educational setting. The teaching of evolution is pervasively challenged by opposing ideologies, principles, and previous learning experiences of science teachers. The lack of teachers' content and pedagogical knowledge is detrimental to the goal of scientific literacy. The results of this study can provide insights on how in-service teachers develop a conceptual understanding of evolution. By taking into account the conceptual change process that they underwent to resolve the misconceptions (e.g., evolution as a theory is not valid; organisms evolve depending on what specific trait is needed for survival) that they have learned from their early education until they become science teachers teaching the concepts. Their experiences can provide instructional support to non-Biology science teachers and those out-of-field teachers. Enough evidence are reported on how Biology teachers do not have full conceptual understanding of biological evolution and are reported by students to be one of the sources of misconceptions, more so with non-Biology major teachers (Cotner et al., 2017; Yates and Marek, 2014). Evolution takes place at ecological and geological time scales, involving developmental, ecological, and molecular processes that interact with different levels of biological organization (Araujo, 2022), yet secondary teachers in the Philippines introduced this topic with an understatement "evolution as changes through time". This manner of teaching consequently contribute to the likelihood of committing serious errors in instruction and delivery of content. The worst of possible consequences would be the complete removal of the topic in the curriculum brought about by difficulty in instructional delivery (Picardal, 2019). The prevailing predicament is happening especially with the constant revision of the tertiary education program for Bachelor of Science in Education major in Science programs where the number of core Biology subjects is reduced. This reduction may have minimized the possibility that evolution will be covered in detail, thereby rendering inadequate content knowledge in the subject matter among prospective teachers. Since this curriculum transition is regarded as an essential development towards attaining a well-rounded Science teacher who can teach both life and physical sciences, future policies may be tailored-fit such that these future teachers may not lose the essential preparatory knowledge and skills in the teaching of hardcore science concepts such as evolution. This realization can only be attained if there is an adequate conceptual understanding of the topic, regardless of the curriculum background, scholastic preparation as well as personal and cultural orientations of the teacher. This study delved on the central question "How do non-Biology major science teachers develop conceptual understanding about biological evolution?"

METHOD

This study utilized a qualitative research design, specifically descriptive phenomenological analysis. Phenomenology in education is important not only as a theoretical tradition but also as a research method in exploring the experiential, relational, and intersubjective dimensions of pedagogy, teaching, and learning (Brinkmann & Friesen, 2018). Hence, this phenomenological analysis aimed to describe the lived experiences of science teachers in their journey to an understanding of evolution and does not attempt to explain causes and effects. An in-depth semi-structured interview of participants' experiences was the primary data-gathering technique. The purposefully chosen science teachers were interviewed individually to obtain a more detailed examination of their learning experiences. Interview transcripts served as the unit of data in this study. From individual case analyses, subthemes were constructed to build overarching themes that explained the meaning of participants' experiences.

Participants of this study were public secondary school teachers in the southern part of the Philippines. They were all high school science teachers (n=8), teaching Biology under the revised K to 12 science curriculum. The level of complexity of this lesson is introduced in a spiral progression as grade level increases. This means that "concepts and skills in Life Sciences, Physics, Chemistry, and Earth Sciences are presented with increasing levels of complexity from one grade level to another paving the way to a deeper understanding of core concepts" (K to 12 Science Curriculum Guide, August 2016). Changes in the curriculum prompted prospective science teachers to take up all four areas in Science (e.g., biology, chemistry, physics, and earth science) to cater to

the K to 12 curriculum framework instead of the discipline-based. Among the participants, three were BSEd Physical Science majors and three Nursing graduates, with a diploma in Professional Teacher Education. These teachers have varied religious backgrounds. They have received evolution education only during their graduate studies, while others learned it informally during teaching. Lastly, all of them are currently teaching high school Science subjects.

In terms of the data collection, qualitative data were gained from 30–45 minutes of semi-structured individual interviews with the teachers by using an interview guide as the instrument. The interview guide is composed of six main questions focused on their learning experiences on evolution with probing questions as a follow-up. It was content validated by three experts (two content experts and one methodology expert). To ensure consistency of semi-structured questions, qualified science teachers, who were not part of the actual participants, agreed for the pilot interview. The pilot interview refined and clarified some questions contained in the interview guide and included additional relevant probing questions . All participants consented to a voluntary audiotaped interview session. Interview protocol (Creswell, 2009; Jacob & Furgerson, 2012) was adhered to asking questions and recording answers during the interview. The interview focused on the narrative accounts of teacher's experiences in learning evolution, particularly their perceptions of the concept of evolution, experiences, difficulties, struggles of learning as they developed their conceptual understanding of the topic.

To ensure validity and trustworthiness of data analysis and findings, the researchers observed consistency of answers by the participants in three similar but paraphrased questions, member checking, and substantial description (Cresswell & Poth, 2016). Member checking ensured that what participants said in interviews was accurately captured during the coding processes (Cresswell, 2009). Hence, the interpretation of participant's responses corroborated with the meaning and intent of what they recounted as experiences. There were two rounds of how the interview was conducted. The first round was the proper interview, and the second shorter round was for any questions or clarifications which were missed during the initial interview process (Jacob & Furgerson, 2012).

In the data analysis, verbatim transcripts collected through the semi-structured interview with the participants, were served as the dataset. Participants responded to the individual interview either in (*Bisaya*) vernacular or in English language. Data collection and analysis happened consequently, anchored on the analytic process of Colaizzi (1978) for descriptive phenomenological analysis. The seven steps were as follows: 1. The three authors independently read participant's transcript several times to make sense of it. 2. Phrases that directly relate to the phenomenon under investigation were extracted, such as teacher's specific learning experiences. The text data obtained from the interviews were coded using both descriptive coding and *in vivo* coding methods and were analyzed manually for themes for a more intimate and detailed exploration of the response. 3. Formulated meanings of each significant statement were created. 4. The three researchers repeated these steps for each transcript and then aggregated formulated meanings into clusters of themes. 5. Six themes were identified, and an exhaustive description was developed. 6. The essential structure of the description of the experience was identified. The teachers' learning experiences were analyzed based on their process of learning evolution from the first exposure of the concept up to the present time. The three authors met regularly to discuss and verify the accuracy of the emerging themes and the meaning of each theme. The three authors had to agree 100% and accept the emergent theme. In the event that there is disagreement in the analysis, intercoder consistency was observed then met as a group to decide and applied intercoder agreement (O'Connor & Joffe, 2020). Researchers sent back the results to the participants via email for verification of the interpretation. All participants agreed with the results and interpretation.

FINDING AND DISCUSSION

There were eight teacher-participants comprised of four males and four females with an age range of 25 – 35 years old. They were non-Biology majors teaching evolution and other Biology domains. This scenario reflects the current educational set-up under the basic K to 12-education system in which some science-teaching load is assigned even to the out-of-field

teachers, due to the lack of teachers especially those who are vertically aligned. These participants are those with degrees in science-related professions (e.g., engineers, pharmacists, nutritionists, and nurses) who opted to go into teaching at the basic education level, took 18 units of professional education subjects, and passed the licensure examination for teachers. They are also those whose specialization is different from what they teach. For instance, they are bachelor in secondary education in Science education specializing in Physics, Chemistry, or General Science but not Biology. In the old curriculum for the BSED degree program, those taking up Biology as their field of specialization have a separate intensive course for Evolution class for a semester. This phenomenological investigation aimed to describe the science teachers' experiences in learning evolution using Colaizzi's method of data analysis.

Table 1 shows how the themes emerged from the significant statements extracted from the interview transcript. It revealed six themes that described how they develop conceptual understanding of evolutionary concepts through time. The emergent themes here are defined contextually in this study as a significant experience that helped them attain a partial, if not sophisticated, understanding of evolutionary concepts.

Table 1. Examples of data analysis for the development of themes from significant statements

Participant	Statement	Formulated Meanings	Theme Cluster	Theme
P1, P4, P8	‘Way back high school, it’s always an example about the morphological characteristics of giraffe that they had to adapt to their environment, so they had to develop long neck'.	long/short neck of giraffe as a common example	scarcity of example	First exposure was faulty and insufficient
P2, P6, P1	‘The teacher first asked whether we believe that we came from apes to introduce the lesson'.	'Man came from apes' is the catchy phrase for evolution	limited elaboration and exemplification	
P2, P3, P5, P7	'Our teacher in high school and college discussed less about it. Sometimes they skip it at all.	Omission of evolution topic	null curriculum	
P2, P3, P5, P6, P8	'Evolution is about which species is fit enough to survive in the environment by having favorable traits that make them adaptable'	Association of terminology to layman’s term and daily use	ambiguous meaning-making	
P1, P5, P7	'I was interested in learning about evolution because we had our activity on breeding animals then the teacher associated it to Pokémon character when they had to transform'.	Evolution is the transformation of physical features	incorrect analogy	
P2, P4, P5, P8	‘Whenever our teacher discusses evolution, she always states a disclaimer that this is just a theory and it is still our Creator who is the source of all life.	Give freedom to students to choose what to believe, either creationism or the evolutionary theory	faith-based teaching	

Note: P represents the codename of the teacher participant

Theme 1. The first exposure was faulty and insufficient

All participant’s (8/8) revealed that their exposure to evolution concepts started from their childhood experience (i.e. watching animated videos related to evolution and science documentaries) and early formal education (i.e. input from the teachers) shaped their interest and

initial conceptions towards the theory of evolution. The quality and source of information, childhood activities, experiences, questions asked, examples, and representations were instrumental in introducing evolutionary concepts to the learners' mental schema. When asked about the time they first heard and encountered evolution explicitly, all of them reported that it was during their elementary years that highlighted only the big ideas through a catchy phrase "evolution as descent with modification". There was no elaborate explanation of what the phrase means. Some of them expressed that they had no plausible conception of this science domain because their teachers skipped it deliberately as it is usually at the last part in the curriculum guide. Another explanation of this malpractice is the teacher is not confident to teach the concepts elaborately due to personal biases, lack of pedagogical training, the need for content enrichment, among others. These nuances supported the findings of Hermann (2018) that the amount of evolution courses received by children and the quality of input is an impetus for learning. Donnelly & Akerson (2008) explained that there is a negative repercussion in a person's mental representation of science concept if lessons, which by standard, must be introduced to the learner, is being marginalized, skipped, or inaccurately given. These consistent reports may explain why misconceptions even among teachers are prevalent and persistent when the unifying theme in Biology is not covered.

There was a considerable convergence of responses among participants as to their experiences as a child helped them become interested in the science concept, albeit initial experiences were more of misrepresentation and misconceptions. Two participants who are Nurse by profession and are currently teaching evolution in Senior High School had no formal evolution education in their undergraduate degree, but they were inclined to learning evolution because they had meaningful childhood experiences associated with the concept. *P2* was into animal breeding and fond of watching animal documentaries. *P8* was into playing computer games, wherein he associated the word "evolution" with the character in the game he was playing because it involved transformation.

"*I had no formal education on evolution. The last thing I can remember about it during high school was it was taught superficially and embedded in other subjects like social studies. The idea was simple, Darwin's theory of evolution, natural selection, survival of the fittest, only those simple ideas that I can remember. I love playing computer games, so when I hear the word evolution, I immediately think of Pokémon because Pokémon changes forms, transforms, and evolves. So that is what I associate Pokémon to evolution because it also evolves*." (*P8*)

P2 had a different childhood experience from that of *P8*, which contributed to their existing knowledge. Consequently, knowledge construction develops relatively stable patterns of belief that they perceived as coherent and functional (i.e., rapid transformation of an organism). Exposure of young children to these elements (e.g., media, family members) are critical in facilitating the development of students' views on evolution (Donnelly & Akerson, 2008). The quality of questions, examples, and representations made a lasting impression in their minds. They unanimously shared that the question framed by their teacher upon introducing the topic on evolution centered on "Do you believe that we came from apes?" The way the question was structured and used created a commotion among students, as there is strong resistance to the idea of descent from apes. It was a powerful question enough to cause disequilibrium and dissatisfaction in their mind and is being carried on even until adulthood. Hence, this powerful question embedded some emotional dilemmas and affected students' achievement (Adedoyin, 2010). Textbooks used in schools, which are laden with misconceptions alongside inappropriate pedagogy (Clores and Limjap, 2006) may explain the faulty understanding of teachers. A disclaimer statement about Creationist versus Evolution can foster naïve belief of the origin of human beings through creation story as opposed to the counterintuitive naturalistic explanation. The question "Do you believe we came from apes?", the stimuli which is the question itself acknowledges controversy of the lesson. This observation agrees with the findings of Clores & Bernardo (2007) that students' cognitive structure may not be accommodating to evolutionary concepts because they are inconsistent with their cultural and religious beliefs. Buckberry & da Silva (2012) revealed that conflict is due to the dissonance between new and old ideas that made

an individual doubtful of counterintuitive notions such as evolutionary theory. Such predicament is what compromises the quality of science education (Kosasia & Sikolia, 2015). How the teacher introduced the concept of evolution through examples and analogy to contextualize the lesson significantly affected the learning outcome negatively. These stimuli created a lasting effect on the learners that they persisted until their teaching practice. The incorrect mechanism of evolution proposed by Lamarck seemed to have a plausible reception among these participants, particularly on the *inheritance of acquired characteristics* and *use and disuse of organs*.

Theme 2. Lack of content knowledge leads to advanced study

At the early stage of education, the learning experience was more of an introductory phase. The basic concepts that learners claimed to acquire and understand were deemed insufficient and laden with misconceptions. The majority of the participants expressed that the deepening of content by their graduate school professor enabled them to appreciate more the concept of evolution. The comprehensive discussion and explicit instruction in the graduate studies developed their conceptual understanding of evolution. This finding supported the conclusion of Holt et al. (2018) on the impact of role models to foster the learning of evolution.

Additionally, the common attribute among the participants was educational attainment. All of them pursued advanced studies related to their field of specialization. The feeling of inefficiency in terms of the pedagogical content knowledge on evolution compelled their professional advancement. For instance, *P7* had an awakening moment of realizing the misconceptions she held long enough after the explicit instruction and engaging exercises.

"When I took up Master's degree, I was close-minded about Biology topics, but I conditioned myself and got interested in studying it by watching videos particularly on the criticisms of Darwin. I started to appreciate it. The reading materials and the phylogenetic tree example shown to us by our professor were engaging. The activity requires us to choose an organism and familiarize its taxonomic classification (i.e., the family it belonged to), and find other species under the same family. Then, we have to look into its DNA sequence and analyze how distant or related they are to each other and how each species evolves into its present structure. It helped a lot in my understanding of the lesson." P7

Other participants expressed similar utterances. This account suggests that comprehensive discussion, hands-on and engaging tasks during their advanced studies facilitated the shift in their conceptual understanding. Teachers and instructors have a significant influence on the progression in the knowledge structure of the learners from high school up to the graduate degree programs. In the early years of learning, teachers simply stated that "evolution is a change with modification", sometimes accompanied by a picture of the progressive development of man from apes. There is no substantial explanation on how the mechanism of natural selection can produce the diversity of species nowadays and the underlying principles of evolution that makes it a cornerstone of Biology in the context of the nature of science. Pedagogical approaches also matter how these teachers, regardless of their specialization, learn (Scharmann, 2018). If inadequate and flawed instruction continues to be employed using conventional approaches, science education remains less effective and full of biases favoring only for a particular group (Alters & Nelson, 2002). Teaching on evolution topic requires a high level of competence in both the content and pedagogy through appropriate instructional materials and activities (Fischer et al., 2021). In this study, the instructors that these participants have in their advanced studies exhibited enough credence towards the lesson that it influenced them as a learner to appreciate and find the essence of learning evolution.

Theme 3. Technology-supported learning resources facilitated their learning process

The information acquired from formal school and their actual and empirical observations lead them to extend their learning through the evidence available to support the theory. The most convenient way for learners to validate counterintuitive ideas and clear out confusion is to access various sources of information such as books, documentaries, and other learning materials. P3 utilized technology in learning about evolution, particularly those concepts that are very technical. The videos

presented more concrete examples and situations and were very helpful in facilitating understanding. The majority of the participants shared the same experience because they are also visual learners.

"I tried to understand it [evolution] by reading books and watching documentary films on YouTube. Somehow, it substantiated my understanding of this topic before I teach it to my students." P3

Participants underscored the importance of learning resources in making sense of evolution theory. However, they also warned to be judicious in using materials as these can inflate misconceptions or confusions on evolution theory and its mechanism. False information about evolution is spread online by anti-evolutionist to discredit the validity of evolution and create resistance among readers. Teachers reported having felt a sense of fulfillment and self-efficacy as a learner when they can explain effectively evolutionary processes. They extended effort and time to read more and understand the concept, and it helped them gained the confidence to teach it to their students. There is a synergistic effect between the rich and quality input from the instructors and the metacognition of the information gained through personal reading. The amount of effort and means of learning varies from one participant to another. Some participants found convenience in reading materials, others watched videos and documentaries, and some combined both. Either way, it helped them understand the concept. The majority said that their intrinsic motivation substantiated their understanding of evolution by gathering more solid evidence to support the theory. They were self-motivated to learn by actively seeking information and resources to corroborate their current knowledge structure and position of accepting, rejecting, or merging two ideas. Such experiences from these teachers support Hermann's (2018) findings that the willingness of the teacher to learn and accept evolution is one of the enabling conditions for conceptual understanding.

Theme 4. Rationalization of both old and new conceptions

The participants went through a level of discernment and careful rationalization of the old conception and the new information to their stance and values. Rationalization in this situation is in terms of acceptance or rejection of evolution theory. In learning evolution, cultural preconceptions have been the most important considerations than these scientific objections. Darwinian evolution is incompatible with a literal interpretation of the Bible. The utterances of participants like *P5* strongly underscored the importance of religious points of view in learning evolution.

"I had no limit at all to what I want to read about evolution. However, I did not reach yet the point of internalizing it and then believing in it. I am more on a knowledge base or scientific base, but as a person, I still believe that solely it is God who created us. I did not completely adhere to this scientific fact. Perhaps I was so young when I learned about it in high school, so I just accepted without contemplating the knowledge based on what the teacher said. Eventually, as I grow older, I read many things. I fathom the possibility that it truly happened based on scientifically correct evidence like DNA sequence. Nevertheless, the bottom line of it is there is still God. Maybe there is something greater above in the universe that right now we cannot yet explain. Yes, it [evolution] is scientifically correct. However, as a person, I am not convinced of the mechanism and process of how life came to be and how it leads to diversity because I still believe that there is a greater force behind it all.

Religious orientation and affinity somehow matter towards the understanding as well as the acceptance of evolution. This learning pattern of the participants strongly supports the findings of Manwaring et al. (2019) that religiosity makes an individual more inclined to accept creationist views than evolutionary theory. The majority of the participants are devout Christians. Although they are very objective in their learning approach, they still insisted that they only adhere strongly to their religious beliefs. They implied that evolution is just another set of beliefs opposite to creation by rationalizing the resemblance of creation story with science. This observation validates Clores and Bernardo's (2007) observation that Filipino learners adhered to their tenacious Creationist perspective. Some participants had different means of facilitating their learning of evolution without succumbing

to emotional and psychological conflict. They rationalize the relationship by merging positive attitudes towards religion and evolution. Some of these teachers are deeply rooted in their religious belief that despite the plausibility of evolutionary evidence, they express resistance or rejection of the scientific concepts *with the strong claim "I still believe in God*." Most of them argued that the set of evidence provided by scientists is still insufficient and therefore downplayed the theory as valid and acceptable and often mentioned the misnomer 'man came from apes' and 'missing link' as a way to reject the theory of evolution, thereby discrediting its validity. Few teachers learned about evolution by coalescing or complementing scientific works as support of God's wonders. Those learners whose cultural and religious worldviews are entrenched deeply approached learning by either compartmentalizing or contrasting science or religion as separate entities. Although it is not part of this study to correlate religion with their learning process, the tendency is still evident. They adopted the dual framework of learning called cognitive flexibility (Vosniadou, 2001) or coalesce approach (Yasri & Mancy, 2016) to accommodate information and avoid conflict in learning new concepts.

Theme 5. Application of concepts in different fields

These teachers considered the usefulness of the science concept in real life through direct observation and empirical evidence. There is an observed pattern of the learning process among the participants. They isolated the practicality of conceptual applications in real life for both scientific and religious aspects so that studying evolution can proceed without experiencing conflict, moral dilemma, and resistance. For instance, *P7* denied conflict in learning by citing the application of natural selection in real life by relating it to current issues of climate change such that if habitat loss continues, organisms can no longer adapt to the environment.

"I understood more my function as a human because I realized that those smallest organisms are usually the most susceptible to environmental changes. Their adaptive mechanism will be affected, making living things like us casualties of this effect. So, I can say that being a human as the highest form of an animal, I have a big responsibility towards the preservation of all life forms on earth." P7

Another mean of finding the essence of learning the concept is by complementing ideas together (i.e., seeing science as a mean to confirm and support the existence and power of the Supreme Being). Teachers understood the concept in the context of relevance to their everyday life. In the case of evolution, it allowed them to provide the scientific lens through empirical evidence based on observations in the environment particularly, various applications of the evolution concepts in different fields (i.e., biodiversity conservation, genetics, area of biomedical sciences). By so doing, learners attempted to refine the evolutionary evidence that they have directly observed and deemed applicable in real life as a way of making sense of their learning experience. However, the learning process they went through tends to be selective only to those that are consistent with their observations (Madaiton et al., 2022). Narrative accounts revealed that teachers as learners made sense of learning evolution in terms of its significance by reviewing the historical aspect of the organism (i.e., tracing the descendant and ancestor relationship) and by emphasizing the explanatory power to the present situation. Both approaches helped them arrived at the conceptual understanding of evolution and resolved the conflict between religious beliefs and evolution. This finding confirms Brem et al. (2004) and Chuang's (2003) findings that the perception of the impact of evolutionary theory may influence students' acceptance.

Theme 6. Focusing on the big ideas

The participants reported having developed conceptual understanding when they finally realized the essence and value of the evolutionary concepts to one's life. Participant shared this insight by saying:

"The theory gave me the heart to appreciate life and how each organism contributes a big impact to the environment because everything has a purpose. I have this thing in mind that what about million years from now? What kind of organism are we going to evolve? There is the idea

of dynamism of the concept which fascinates me particularly on how we came from and how we came to be today and how we will be in the future." P1

There was a sense of gratification in learning about evolution when learners see the application of the concept in real life rather than just accumulating knowledge without direct application. There was a positive shift in their perspective in life by becoming conscious of the directionality of evolution in terms of preservation of life and developmental changes that all life forms will possibly undergo. They became more concerned with the implications of anthropogenic activities towards the environment that will contribute to the future direction and impact of evolution. Participants also realized the importance of every organism that resulted in complex developmental processes. They attributed to the unifying explanation of biological evolution on the distribution of species across the geographical landscape that contributed to the diversity of species and mechanism of survival.

"I find it very important to learn about evolution because it is interdisciplinary as it involves many fields (e.g., geographical distribution like Pangea), and it all directs to evolution. I find it interesting to learn because of what will happen in the future given an environmental condition. For the scientist and biologist, if they have that working understanding, then they can predict the future of the human race as time goes by given the pressure of the environment and limited resources." P8

As they ventured into formal and adult education, teachers established connections and relevance of underlying ideas to their belief constructs leading to conceptual understanding. They perceived the real-life application of evolution concepts towards environmental protection and conservation of the diversity of organisms. They also advocated the perpetuation of life and the importance of adaptation and survival of species. A noteworthy observation is that although their response on why evolution occurs had a plausible explanation of the evolutionary mechanism, there remains an implicit association to the creation and supernatural being as the reason for such phenomenon. This pattern of evolution thought maybe because of the socio-cultural orientations of teachers. Most importantly, these non-Biology science teachers' initiatives to open their conceptual space for this central theme in Biology are crucial for scientific literacy.

CONCLUSION

This study unveiled the glaring reality of non-specialized science teachers' conceptual development of complex concepts such as the theory of evolution. The need for content enrichment of science teachers teaching K-12 learners is the strong point elucidated in this research. Teachers need all forms of support to equip them with pedagogical content knowledge to deliver confidently and correctly essential learning competencies. As such, administrative support to these teachers should go beyond weeklong and topic-loaded in-service training and seminars. Instead, a more practical initiative that teachers can practice within their school system is a collaborative learning action focusing on the least competencies not learned by the students but by the teachers. Not all teachers have opportunities to pursue advanced studies or attend content-based seminars. This study suggests that teachers can maximize a wide array of learning resources to enrich their content knowledge. This paper calls for intensive education on evolution through integration of all science teacher education programs and related fields via a complex system approach.

All the themes generated for the learning experiences of these science teachers pointed out the ways teachers as learners develop conceptual understanding about the theory of evolution. The initial knowledge structure of the learners was too limited and clouded with alternative and fragmentary conceptions. They were open-minded to accommodate the evidence presented and available to them. Some participants who were deeply rooted in their religious orientation remained resistant to accept the theory as valid. Others arrived at the middle ground by reconciling two ideas together to avoid conflict in learning. Their varied experience and continuous learning process facilitated the reorganization of their conceptual structure.

Although this study is limited to the experiences of eight science teachers, their narrative accounts were able to illustrate various means to enrich one's understanding of complex scientific concepts. This study supports the need for teachers to pursue content enrichment to enhance their pedagogical content knowledge and self-efficacy in teaching. Future research directions may investigate the effect of standalone classes in evolution among preservice teachers and in-service out-of-field teachers on their acceptance and conceptual ecology. Another promising area to look into is to examine the examples, analogies, and other teaching tools that these teachers utilize to present evolution topics to students, as these may be one of the sources and propagators of misconceptions among students.

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