Chapter 21
Evolution Education in the Philippines: A Preliminary Investigation

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Abstract Although the literature on evolutionary theory points to its central role in biology, conversations regarding its place in the curriculum remain scanty and vague in terms of content and pedagogy, particularly in the Philippines. In fact, research on evolutionary theory mainly reports on students' beliefs and concepts including their conceptual understanding. Whether evolutionary theory is getting the attention it deserves is uncertain, even to these days. It is thus relevant and timely to determine the place of evolutionary theory in the curriculum in the context of the Philippines. This paper aims to answer the following questions: 1. What specific legal provisions refer to the inclusion of evolution in the curriculum? 2. In terms of content, what concepts of the evolutionary theory are emphasized? 3. In terms of research on evolutionary theory, what has been the focus? The significance of this chapter is two-fold. First, the current literature on evolutionary theory in the Philippines is fragmentary. This chapter aims to address this gap by attempting to corroborate available data. Second, this chapter hopes to serve as a basis for a more focused and streamlined research agenda on teaching and learning evolutionary theory in the Philippines.

Keywords Evolutionary theory · Global evolution education · Science education

21.1 Introduction

> Nothing in Biology Makes Sense Except in the Light of Evolution.
>
> —Theodosius Dobzhansky (1973)

I have come to appreciate the evolutionary theory only in recent years, beginning in 2012 when I was asked to teach evolutionary biology, an elective in the curriculum for Bachelor of Science in Biology. It was then my first time to teach evolution after

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nineteen years of being in the teaching profession. I remember wondering what to teach and how to go about teaching the same to my students. I asked colleagues in my department if they had a syllabus on evolutionary biology. Using one colleague's previously prepared syllabus and another I found in literature elsewhere, I began to write my own.

Since evolutionary biology is a three-unit course in our BS in Biology program, I prepared a syllabus whose focus was three-fold. In terms of content, it centers on basic principles behind evolution and its mechanisms, particularly natural selection and adaptation. As the attempt was integration, key concepts in cell and molecular biology, genetics, ecology, classification and phylogeny were also built-in. In view of developing skills in reading, writing and critical thinking, students were required to turn in article reviews and summaries on key evolutionary issues, in addition to major examinations.

My background in evolution was almost non-existent. It was barely discussed when I was in college. It was taught quite extensively in one of my classes in the graduate school though. Now, I am writing a chapter on global evolution education relative to curriculum, content and research. Initially the intent was to review current curricula from across the country at various levels of education and do a systematic review of literature. Regrettably, these barely were the case. Therefore, it would be presumptuous to say that this narrative is a collective view of the Philippines.

Essentially, this chapter will address aspects of evolution education particularly: public acceptance of evolutionary theory within the social, political, and cultural context of the Philippines, existence and extent of influence of anti-evolution movements in the country, place of evolutionary theory in the curriculum, emphasis given to evolutionary theory in biology teacher education programs, biology teachers' attitudes toward teaching evolutionary theory and suggestions to improve evolution education in the country. Occasional references to my colleagues' experience in teaching and doing research in evolution within the social and cultural context of the Philippines appear in some parts of the chapter as well.

21.2 General Information of Country

As of July 2016, the Philippines' population was estimated to be 102, 624,209, majority of which (36.86%) belong to the 25–54 age group (Philippines Demographics Profile, 2016). In terms of religious affiliations, the Philippines is mainly Catholic (82.9%) followed by Islam (5%), Evangelical (2.8%) and Iglesia ni Kristo (2.3%). Some 4.5% of the population belong to other Christian denominations, 1.8% to others, 0.6% unspecified, and 0.1% none (2000 census, cited in Philippines Demographics Profile, 2016). Such diversity is further convoluted by ethnicity resulting from a unique geography and rich history of enculturation. Thus, the Philippines has a semblance of its European, American, and Asian colonizers.

Education in the Philippines has been a confluence of influence of its natives, migrants and settlers. Durban and Catalan (2012) describe the evolution of Philippine education in a timeline covering the Spanish, American, and Japanese occupations, through the EDSA revolution, and up to the present. Education during the Spanish Colonial Era (1521–1898) was mainly selective and elitist. Learning was more a privilege than a right. The curriculum heavily focused on the teachings of Christian Doctrines, Spanish, Latin, and the Filipino language. Math and science were either neglected or non-existent especially for girls. During the American occupation (1898–1946), schools were established across the country whose curriculum gave primacy to reading and writing American literature (that is, geography, history, lives of heroes and English). Education became accessible to all during this time. However, the Japanese destroyed the public school system within their three-year occupation (1942–1945). After the war, education in the Philippines underwent transition—from massive rebuilding of infrastructures to restoring Filipino values that were eclipsed by colonial mentality. The ensuing years in the 1950s and 1960s were marked by rapid economic growth and student activism. Even up to these days, education in the Philippines is yet to address issues and concerns both emergent and pressing. One such concern points to '*curriculum as not responsive to the basic needs of the country.*' And the growing demands for globalization of education in view of program alignment to meet international standards. This is utterly overwhelming for a country that has been struggling amid political divide, corruption of sorts, poverty, and a growing indifference among the mass to improve their lot.

21.3 Public Acceptance of Evolutionary Theory Within the Social, Political and Cultural Context of the Country

Where does evolution stand amid a very diverse setting then? Why should evolution deserve attention anyway? Is it generally accepted? To what extent is such acceptance palpable and in what terms? Whether the public accepts the evolutionary theory and its related constructs remains contentious. Despite provisions in the curriculum, conversations about the subject tend to be spurious and divisive. Although there are no known anti-evolutionist movement in the Philippines, the divide between adherents of creationism and evolution is common. The following are a couple of excerpts available online: One said, "I was raised catholic and now an Atheist. I think my Philippine education of the late 80s and 90s did not really do a good job in communicating to me what the 'randomness' in evolution is and what natural selection is all about (gmvancity, 2014)." Amparo (2012) said, "evolution is still treated, even within academic circles, as a scientific principle that can be reasonably doubted. Grossly unscientific ideas like creationism continue to permeate the academic, and that people who are products of our country's so-called 'premiere university' keep on spouting nonsense against evolution, makes me seriously doubt the effectiveness of our system of science education." Interestingly, both excerpts alluded to Philippine science education as ineffective.

Apparently, evolutionary theory has yet to gain public acceptance even to these days. And even in academic discourse, it remains in the peripheries. People tend to overlook it, dismiss it or treat it superficially to the point of furthering deep-seated misconceptions. Survey and case studies about biological evolution among students for example (Clores & Limjap, 2006; Clores & Bernardo, 2007) show that attitudes and beliefs both affect acceptance and understanding of evolutionary theory. Students accept, reject or doubt evolutionary theory in the foregoing survey and ensuing case analyses on beliefs and concepts of evolutionary theory among 37 freshman students in a general college biology class at a Catholic University in Philippines (Clores & Limjap, 2006). Those who accept the theory were further categorized based on their strong scientific inclination, preference for evidence, and misconceptions on evolution. Those who reject evolution remain adherent to creation and refuse to change position, even after four weeks of constructivist-inspired instruction.

Similarly, Yasri and Mancy (2016) surveyed Buddhist and Christian high school students in a course on evolution at a Christian school in Thailand using a tool they developed consisting eight positions and a question as to reasons for change in position. They investigated student changes in position on the relationship between evolution and creation. Several students changed their position towards increasing acceptance of evolution which was noticeable among Christian students. Participants averred that such changes were influenced by their understanding of the evidence for evolution and of ways of relating evolution and their religious belief (Yasri & Mancy, 2016).

Both studies show that faulty prior knowledge, deep-seated beliefs and predispositions often lead to misunderstanding evolution and impede learning. It has been 20 years since studies on conceptual change and movement towards deep understanding in science education became popular following reform movements at all levels and in all disciplines (Tanner & Allen, 2005). This has been the scenario elsewhere in the globe and quite recently in Philippine research on conceptual change across disciplines—biology, mathematics, chemistry and statistics—(Clores & Limjap, 2006; Clores & Bernardo, 2007; Halili & Trillanes, 2012; Jugar, 2013). Sadly, conceptual change studies on evolutionary theory remain scarce.

21.4 Place of Evolutionary Theory in the Curriculum

This lack of research on evolution education possibly stems from a general disinterest on the subject despite the explicit mandate on the inclusion of evolution in the BS Biology core program curriculum along with other basic concepts in biology like structure/function; regulation; growth; and development (Sample Outcomes-Based Curriculum for the Bachelor of Science in Biology as per

Commission en Banc Resolution No. 085-2015). However, there is no reference to evolution in the suggested outcomes-based curriculum for the Bachelor of Secondary Education major in natural sciences or biological sciences. Only one private and Catholic school among 22 schools offering Bachelor in Secondary Education major in Biological Sciences has a 4-unit subject on evolution and genetics combined.

21.5 Emphasis Given to Evolutionary Theory in Biology Teacher Education Programs

For higher education institutions in the Philippines, there is an explicit legal provision for placing evolutionary theory in the curriculum. This, however, is limited to Bachelor of Science in Biology. And both public and private higher education institutions (HEIs) are advised to align their curricula according to the foregoing mandate. Currently, the Philippine Education Reform (Enhanced 12-year curriculum) is in transition following its implementation in 2012. In the revised secondary education curriculum (RSEC), evolution is moved from grade 8 to grade 9. Whereas evolution is taught in primary grades, nothing in the provision points to its inclusion in teacher education program for elementary teachers—a blatant gap that has to be addressed.

Even with the foregoing provisions in the Bachelor of Science in Biology curriculum for evolution, implementation varies from one school to another and from one teacher to another, as evidenced by two biology teachers whose thoughts on evolution are presented in Table 21.1. Both teachers are teaching in their respective Catholic universities. I collaborated with one of these teachers on an educational research project about misconceptions with regard to natural selection and photosynthesis. They are referred to as T1 and T2, respectively, hereafter.

T1 first taught evolution in 2006 and T2 in 2013. Both prepared their own syllabus using existing syllabi, books and online sources as guide. T2 further said that she based her syllabus on the practical application and relevance of evolutionary concepts to taxonomy, genetics and biodiversity.

21.6 Biology Teachers' Attitudes Toward Teaching Evolutionary Theory

Both find the evolutionary theory acceptable. According to T1 there is "growing evidence for evolution in many scientific disciplines and the theory is relevant and an intelligible explanation for many natural phenomena." T2 said something akin relative to studies and experiments supporting evolution. She further commented that "evolution is evidently taking place now as seen in how organisms differ then

Table 21.1 Some thoughts on teaching evolutionary theory in terms of focus

Thoughts on evolution when asked:	Teacher 1	Teacher 2
What are the basic tenets of evolutionary theory?	Referred to Darwin's five major theories related to variational evolution: *Theory of evolution as such* *Theory of common descent* *Theory of multiplication of species* *Theory of gradualism* *Theory of natural selection*	Said that organisms change overtime. And whose changes are shown not only in their morphology, but chemistry and genetic composition as well. "These changes are driven by environmental factors
What concepts of the evolutionary theory have you been emphasizing?	• Darwin's basic ideas on evolution • Evidence for evolution • Misconceptions about evolutionary theory	• Physico-chemical theory • Darwin's theory of evolution • Dobzhansky's modern evolution synthesis
Why do you think these concepts should be emphasized?	"Without clear and accurate understanding of these concepts, students might not be able to understand the theory of evolution in particular and biological issues in general"	The physico-chemical theory answers where and how questions. Darwin's natural selection explains why organisms change and how they do so "Dobzhansky's modern evolutionary synthesis points to the significance of chromosome recombination and gene mutation on the evolution of organisms"

and now; and how individuals differ within the same species." As to how they feel towards teaching evolutionary theory, T2 said she feels fortunate since it makes her cognizant of its concepts and that it helps her in teaching other biology subjects.

As can be gleaned from Table 21.1, the two participants appear to have reasonable parallel focus. For example, both point to the theory of evolution as such (organisms change over time); theory of natural selection (changes driven by environmental forces and hinted on genetic composition as the source of variation); and scientific evidence (morphology, genetics, phylogeny) for evolution. T1 sees the relevance of addressing misconceptions about evolutionary theory as well.

Their rationale for emphasizing the foregoing concepts has to do with either ensuring accurate understanding of evolution, its relationship to biology in general (T1); or showing the connections among concepts like the physico-chemical theory, Darwin's natural selection, and Dobzhansky's modern evolutionary synthesis. Both teachers recognize concept integration as primary in understanding evolution.

21.7 Suggestions to Improve Evolution Education in the Country

When asked how evolution education may be improved in the country, T1 said to "engage teachers in helping students fully understand biological evolution." Ergo, research in teaching and learning evolution must be done vis-à-vis students' prior conceptions and or predispositions. Likewise, T2 said that it is essential to "strengthen evolution education in the country owing to its importance in explaining changes in the ecosystem resulting from climate change, pollution, and other organisms" for example. According to her, the "Philippines' rich plant and animal biodiversity can be used as basis for studying patterns of growth, life cycle and behaviour in response to changing environment"—which actually reflect and form part evolutionary processes. T2 further said that to address this "the Commission on Higher Education (CHED) should provide schools with solid and strong guidelines on what concepts should be taught, focusing on Philippine flora and fauna, and how it should be taught."

21.8 An Attempt to Reconcile Curriculum, Focus, Pedagogy and Research in Evolutionary Theory: Further Suggestions to Improve Evolution Education in the Country

The Enhanced K-12 Basic Education Program which was launched on April 24, 2012 resulted from a long history of studies on the inadequacy of the basic education curriculum and whether adding or restoring 7th grade would assuage this enduring problem (DepED Discussion Paper, 2010). The Enhanced K-12 Basic Education aimed to: enhance the quality of basic education owing to its poor quality as evidenced by low achievement in the National Achievement Test (NAT) for basic education and high school and in Trends in International Mathematics and Science Study (TIMSS) in 2003 and 2008, respectively; decongest the curriculum; better prepare high school graduates either for work or higher education, consequently making them more emotionally prepared for entrepreneurship, employment or higher education—here or abroad (DepEd Discussion, 2010).

The K-12 basic education program consists of kindergarten and the 12 years of elementary (6 years) and secondary education (4 years junior high school and 2 years senior high school). Students in senior high school can choose from among specializations in science and technology, music and arts, agriculture and fisheries, sports, business and entrepreneurship. In a nutshell, the Philippines envisions to produce students and graduates who have sound educational principles, are lifelong learners, are competent and productive, coexist in fruitful harmony with local and global communities, are critical thinkers, and are capable of transforming others and self (DepEd Discussion, 2010).

In view of the foregoing, what then should constitute a science curriculum framework for basic education? Problems on quality of teachers, the teaching-learning process, the school curriculum, and instructional materials and administrative support have been identified in many education and graduate student researches (DOST-SEI, 2006 cited in SEI-DOST & UP-NISMED, 2011; Durban & Catalan, 2012). As part of its threefold function, the University of the Philippines National Institute for Science and Mathematics Education Development directed its efforts at creating a science curriculum aimed at improving the quality of education at the elementary and secondary levels. In consultation with key stakeholders from the industry, university, scientists, parents, teachers, school administrators, community leaders, media and students in 2006, the institution resolved to form a "*coherent, comprehensive science curriculum framework for basic education with development of scientific inquiry as its overarching emphasis and the promotion of core science concepts and skills to enable students to 'learn how to learn'*" (SEI-DOST & UP NISMED, 2011).

The framework gives an overall structure for organizing learning and teaching three interlocking components: inquiry skills, scientific attitudes and content and connections. It is non-prescriptive but should provide a common curriculum direction for educators, curriculum developers, and textbook writers in making learning activities and experiences coherent in view of preparing students to become scientifically literate amid a dynamic, ever changing and increasingly technological society (SEI-DOST & UP NISMED, 2011).

Genetics, evolution and biodiversity (under life science) are offered in grades 9 and 10 (Junior High School) whose focus questions are outlined in Table 21.2 (excerpt).

Table 21.2 Grades 9 and 10 focus questions and science ideas for evolution and biodiversity

Focus	Science ideas
Why are there different kinds of organisms? How did each kind come to be?	When changes in the genetic material (mutations) result in individuals that can no longer reproduce with members of the original population of organisms, a different kind of organism (species) evolves
Why are there more kinds of organisms in some areas than others?	There are more kinds of organisms in the tropics than in temperate regions. Scientists propose varied reasons for this observation
Why is high biodiversity important?	Biodiversity promotes stability in a constantly changing environment Biodiversity provides a wider range of resources for food, medicine, fuel and other essential needs of human and other living organisms Evolution and biodiversity are the results of genetic changes Extinction of species may occur when the adaptive characteristics of a species are insufficient to permit its survival in a changing environment

Adopted with permission from SEI-DOST & UPNISMED (2011)

In Junior High School, therefore, evolution is taught relative to natural selection as its mechanism, mutations as sources of variation, speciation, environmental pressures and biodiversity. With the science curriculum framework in place, the gap evidently points to non-inclusion of evolution in the elementary and secondary teacher education program. Possibly it is time to rethink our teacher education program and make it more consistent with the signs of the times. Despite suggested revisions for the Bachelor in Elementary Education and Bachelor in Secondary Education programs in the framework for Philippine Science Teacher Education (SEI-DOST & UP NISMED, 2011), these changes are yet to take effect. Again, the framework gives a broad description of science course for general education and specialization in science. The new teacher curriculum sets 12 and 60 units of science subjects for pre-service teachers in the elementary and secondary levels respectively.

In the past, pedagogy mainly involved recall of information and the teacher with the central role in the educative process. Assessment usually meant having to repeat the same information and with little opportunities for cohesion and integration. Recently, studies in constructivism and conceptual change have slowly permeated education in the Philippines. In effect, approaches that promote constructivism and conceptual change like integration, reflection, collaboration, and inquiry-based problem solving are highly advocated in the Enhanced K-12 Basic Education primer.

As described early on in this chapter, research in evolutionary theory in the Philippines is very limited. Two fairly recent works by Clores and Limjap (2006) and Clores and Bernardo (2007) mostly dealt with beliefs about evolution among students in one Catholic school. The most recent dealt with understanding of natural selection among pre-service and in-service secondary biology teachers (Clores et al., 2014). Here teachers from various public and private secondary high schools in Regions V (Bikol) Region IX (Zamboanga City as representative) generally had low understanding of natural selection. Of 20 items in the Conceptual Inventory of Natural Selection questionnaire, concepts like *origin of variation, variation inherited, change in population and limited survival* were especially difficult for several teachers. When asked about their understanding of natural selection, most teachers referred to *survival of the fittest* and *adaptation*, whereas other important concepts like *overpopulation, migration, dominance and reversibility of evolution* were referred to once only. Elsewhere in the world, studies in evolution education dealt with perceptions (Woods & Scharmann, 2001), scientific views and religious beliefs (Dagher & Boujaoude, 1997), and teachers' conceptions and knowledge structures and acceptance (Rutledge & Mitchell, 2002).

21.9 A Synthesis: What Now?

21.9.1 Of Irreconcilable Thoughts or Imagined Divisions

Apparently, whether it is here or abroad, research on evolution education largely points to students and teachers' misconceptions (Clores & Limjap, 2006; Clores & Bernardo, 2007; Yates & Marek, 2014) and opposing views and associated beliefs and attitudes (Dagher & Boujaoude, 1997). And there is growing evidence relating misconceptions with beliefs and a certain predisposition or religious inclinations (Woods & Scharmann, 2001; Yasri & Mancy, 2016). Interestingly, misconceptions cut across students and teachers irrespective of position (for or against) evolution. What is the root cause of such confusion? Perhaps, the growing dissent even among evolutionists themselves contributes to the furtherance of misconceptions and ill-constructed understandings. The divide among researchers as to which processes should be considered vital is discussed in the paper of Laland et al. (2014). In a nutshell, proponents of the extended evolutionary synthesis (EES) aver that processes like *phenotypic plasticity, niche construction, inclusive (extragenetic) inheritance and developmental bias* control evolution and not solely by genes, as opposed to the "gene-centric" view among advocates of the standard evolutionary theory (SET). According to advocates of the SET, the said processes are add-ons and have long been integrated in discussions of evolutionary theory and the goal has always been towards a more collective, cohesive theory (Laland et al., 2014). The SET asserts that both groups recognize the foregoing processes; yet the genes remain central along with natural selection, drift, mutation, recombination, and gene flow. So, how then do we address misconceptions in the classroom? Or how do we ensure that students are getting the right information? It is unlikely that anything will ever be removed from bias.

21.9.2 Problematic Science Education

Science education in the Philippines has yet to gain momentum and become globally competitive. The implementation of the enhanced K-12 basic education in 2012 was a huge step towards the said direction. The teacher education program though has yet to align with the science framework for basic education chiefly on the inclusion of evolution which is lacking in the current teacher education program. In terms of explicit focus on natural selection and mutations as sources of variation; speciation; and environmental pressures; teacher education program has yet to work on mastery of content to preclude them from spreading ill-constructed concepts in the future. As advanced in the science framework, the skills and attitudes like *critical thinking, curiosity, creativity, intellectual honesty, accuracy, objectivity, independent thinking, active listening, assuming responsibility, taking initiative and perseverance* must be developed and strengthened in science classrooms. Therefore, the learning opportunities must be one where students discuss issues, postpone judgement pending availability of acceptable data, and maintain a tolerant disposition towards diverse ideas, opinions including belief systems. As neatly offered by one teacher in evolution, the Philippines being one of the biodiversity hotspots is a potential material for discussion in science classes—an excellent platform to discuss a frequently undermined concept like evolution.

21.9.3 Research and Teaching Must Inform Each Other

There is no denying the role of research in the classroom. While research is supposed to inform teaching, issues surrounding the teaching and learning process provide a plethora of impetus for research. Much has to be done in the areas on misconceptions; research along this line must be long term and extensive. It is one thing to identify the misconceptions; the work has to move towards correcting those misconceptions (conceptual change studies). Local studies involving intervention are usually short term and for an effect to be truly attributed to the intervention, they require longer exposure and practice. Research on the effects of belief systems on students' acceptance or rejection of evolution inarguably remains challenging. As a science educator, the goal is not to annihilate those belief systems; rather focus on redirecting students' attention to recognizing the relevance of other perspectives, such as those offered by science. I think the gap lies in habitually presenting science and religion as opposing views relative to life, its various forms, and origin, with hardly an opportunity for interaction or connection. Teachers often approach science in a fragmented, disparate and absolute fashion, losing sight of its revisionary nature. Whereas science is essentially systematic, rigorous, controlled, empirical, critical, valid and verifiable, it is never absolute. This paradigm shift in thinking was championed in Kuhn's The Structure of Scientific Revolutions (1970). The history of science is proof of the temporal and revisionary nature of science. Kuhn (1970) referred to critical points in scientific development like those of Copernicus, Newton, Lavoisier, and Einstein. Revolutionary means having to reject one time-honored scientific theory in favor of another incongruous to it. The new paradigm stems from an apparent '*malfunction*' (Roberts, 2000) in the existing paradigm as it ceases to address problems, thereby creating a *crisis* and ensuing revolution. The new paradigm then takes on one of three ways: the community manages the crisis and keeps its paradigm; or on occasions, the community relegates the paradigm for future query; or usually, the new paradigm emerges and the community struggles with its acceptance. Eventually, the new supersedes the old in overall perspective, methods, and goals (Roberts, 2000). Again, our roles as science educators is neither to present science in absolute terms nor simply present it as a collection of facts which is often fragmentary and incoherent. Although there is no undermining the importance of facts, we will do well with integrating the nature of science in class. McComas (2004) describes nine keys to teaching the nature of science in attempts to assuage the problems in science education. The core NOS ideas are:

science demands and relies on empirical evidence; knowledge production in science includes many common features and shared habits of mind – there is no single step-by-step scientific method though by which all science is done; scientific knowledge is tentative but durable; laws and theories are related but distinct kinds of scientific knowledge; science is a highly creative endeavour; science has a subjective element; there are historical, cultural and social influences on science; science and technology impact each other, but they are not the same; and science and its methods cannot answer all questions. (McComas, 2004, pp. 24-27)

Integrating the core NOS ideas in the Philippines basic education and considering its long term effects are rich potential research areas as well. Another area of research that is worth exploring is the teachers' attitude towards teaching evolutionary theory. If teachers were to successfully integrate the core NOS in science teaching, it is imperative that they keep an impartial and clear perspective about what they are getting into. Finally, the absence of evolution in the teacher education program is a huge gap in the science curriculum. Clearly, in terms of emphasis given to teaching evolutionary theory, this is an opportunity for extensive research yet in the Philippines. Elsewhere, Yates and Marek (2014) surveyed 35 students and their respective 536 students in one of 32 public high schools in Oklahoma. They identified types and prevalence of biological evolution-related misconceptions held by high school biology teachers and their students. Furthermore, they identified factors that contribute to the acquisition of misconceptions among students, particularly emphasizing the teachers' role. One factor they explored was number of hours spent in teaching evolution. In the survey they used, teachers were selected from among teachers who spent 0, 1–5, 6–10, 11–15 and >15 h on teaching evolution. Accordingly, the significant difference ($p < 0.01$) in the mean difference between students' numbers of pre-and-post-instruction misconceptions were related to the number of hours teachers spent in teaching biological evolution concepts (Yates & Marek, 2014). Additionally, the optimum duration is 6–10 h. This number of hours (6–10) though neither reduced the occurrence of misconceptions nor added to the existing ones. Possibly, a similar and more extensive study is needed for the Philippines.

21.9.4 Challenges, Issues and Concerns

It would be a misnomer to end this chapter with a conclusion. Since this is a preliminary look at the Philippine scenario, I believe it is fitting to end by recalling the challenges, issues and concerns that continue to haunt and daunt science education in the Philippines.

Overall the problem with ill-equipped classrooms, inadequate equipment, facilities and even infrastructures continue to overwhelm our teachers and administrators across all levels from basic education to higher education particularly in public schools. Equally pressing and dismal is the lack of competent teachers both in science content and process and pedagogy, particularly those in basic education and even secondary education, mostly in the outskirts. This is further convoluted by a growing number of teachers who are inarticulate either in the oral or written forms. Sadly, the better teachers are either abroad or are not evenly distributed. In the Philippines, English is one of the media of instructions. Even with the recent move to use the mother tongue in basic education, language facility remains challenging.

The inclusion of evolution in the curriculum much less its acceptability is no longer an issue at least as evidenced in the new science framework previously discussed. However, evolution must be part of the teacher education programs for both our elementary and secondary teachers. At present, it is only in the Bachelor of Science in Biology that evolution is offered as an elective. The concern, therefore, is one of aligning teacher education programs with the Enhanced K-12 Basic Education. There are opposing views; again, these are mainly spurious and divisive, though such debates have not led to any known anti-evolution movement. Filipinos tend to be dismissive and frequently choose to be tolerant of others' views. Others would rather stay silent about the topic many times either for lack of familiarity or understanding. Still others are more vocal and aggressive in their belief in evolution. Yet again both sides of the fence are marked with bias and prejudice stemming from a stiff outlook or rigid view of evolutionary theory. Perhaps we will never be impartial as everybody is situated in particular contexts, culture, experiences and belief systems that serve as our filters and lenses. The history of science is replete with stories of disunity within the church, within the scientific community and between church and science. Even to these days such disunity is palpable in various forms and shapes.

So how then do we envision science education classrooms to be? Research on evolution-related misconceptions shows that the way out is to focus on conceptual change. Conceptual change studies in the Philippines continue to be sparse and fragmented though. Moreover, attitudes and beliefs of teachers and students regarding evolution are yet to be extensively explored. Specifically, research that attempts to show how attitudes and beliefs interconnect with students' understanding and emphasis (time spent) on teaching evolution are critical. Because attitudes and beliefs are often ingrained in students, a call for integration of the nature of science (NOS) in science education can potentially appease a long-standing divide between those who subscribe to creation theory and evolutionary theory.

Science has thrived because of faith as well—faith in its assumptions, theories, and laws in view of attempts to explain the world and how it works. Again, history is replete with stories of discoveries and scientific breakthroughs championed by Catholic scientists. The list includes Rene Descartes, who came up with analytic geometry and the laws of refraction; Blaise Pascal, who invented the adding machine, hydraulic press, including the mathematical theory of probabilities; Augustinian priest Gregor Mendel, father of modern genetics; Louis Pasteur, for microbiology and inventor of the first vaccine for rabies and anthrax; and Nicolaus Copernicus, for the heliocentric model of the solar system (Kaczor, 2012). Additionally, the "Big Bang Theory" was proposed by Georges Lemaitre, a Belgian physicist and Roman Catholic priest; and there are several Nobel Laureates in Physics, medicine, and physiology who are Catholics, such as Erwin Schrodinger, John Eccles and Alexis Carrel, to name a few (Kaczor, 2012).

Our inclinations and all of our faculties—mental, physical and spiritual—should not be divisive. They are meant to be integrated, complementing and supplementing each other. In ending, I would like to reiterate Kaczor (2012) quoting Pope John Paul II in his 1988 letter addressing the Director of the Vatican Astronomical Observatory saying "*Science can purify religion from error and superstition; religion can purity science from idolatry and false absolutes.*"

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