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Exploring Students' Mental Constructs on Evolution towards Proposed Pedagogical Interventions

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Abstract: ***The purpose of this study is to be able to know the ideas, thoughts, and understanding of the selected respondents to certain topics about evolution. The subject tries to challenge the stored knowledge of our students, as they manage to recall former lessons and interconnect them with recent findings or updates, which can enable them to value their existence as living organisms, interacting with other living forms together with the abiotic factors. A quantitative method was used in order to define and support the objective of the study, where one section of Psychology students enrolled in Biology with evolution for the first semester were chosen as the key respondents for this study. The basis of their selection was to evaluate what they have formally learned in their former studies of evolution and how it coincides with the things that they firmly believe in, so that the appropriate pedagogical intervention can be cited accordingly. The Likert Scale Method was used, with the 5 - point range, in order to determine the level of agreement of the students. The results were collated and analysed. The findings as supported by the results clearly specified the type of pedagogical interventions that should be suggested for the students in order to understand and appreciate evolution more effectively. This includes the application of the quality typelecture - discussion method, the inclusion of picture analysis and trivias, book reviews, enhancement of reports, and the making of infomercials. On the other hand, the ideas and thoughts of students constituted their mental constructs or understanding about evolution. This included their idea about mutation, the theory of creationism, Darwin's theory of evolution, the onset of natural selection, the study about fossils, DNA and genetic traits, and the similarities in physical features of some organisms. At the end, it was firmly noted that the study of evolutionary biology should be given enough consideration in our everyday lives as this constitutes a remarkable part in our existence.***

Keywords: Science Education, Evolutionary Biology, College students, Pedagogical Intervention, Online learning

1. Introduction

Mental constructs are simply the set of ideas and beliefs that we hold and this mental constructs literally form the structure of our world. This is because they orient ourattention, and therefore actions in the world. They give meaning to our experiences.

Helping students understand evolution is not simply a matter of adding to their existing knowledge, but rather, it means helping them to see the world in new and different ways. According to Brem, SK, Evans, EM, &Sinatra, GM (2008), the theoretical perspectives on creating change in students' conceptions have implications for teaching about biological evolution. To be able to recognize connections between scientific advances and pressing societal needs, it was noted by Meagher, TR (1999) that it is critical that evolutionary biologists communicate important scientific advances, ongoing research, and the nature of scientific enterprise to the public as well as to the scientists outside of their immediate discipline. In so doing, the foundations are laid for better public understanding of science, as well as a stronger policy base for support of science itself.

It was pointed out by Bertka, CM, et al (2019) that the religious or cultural objections by many people to the teaching of evolution can impact both students' willingness to explore a scientific understanding of evolutionary theory and teachers' willingness to provide sound instruction on the topic

The word evolution is being analyzed and understood by a number of people in different ways. It can depend on their basic observation of the environment, coupled with the interactions of living species with one another, or it could also be an interaction between living things and the non - living forms, that can substantiate the word ecosystem as well.

Networks of ecological interactions define the way that ecosystems function, this is according to Science Direct, Journals and Books (2020) that network assembly and temporal persistence can be thought of as contemporary ecological functions but shaped by historical evolutionary processes. Increasingly, researchers study networks within a phylogenetic comparative context, acknowledging that networks are sensitive to evolutionary constraints operating at regional or local scales. Methodological progress in population genomics and molecular detection, combined with theoretical developments, can now permit investigation of ecoevolutionary feedback loops.

It was even stressed further by Science Direct, Journals and Books (2020), that evolution is not a phenomenon of the past. It is an active process occurring even now. The emergence of new strains of influenza, drug - resistant cancer cells, and pesticide - resistant insects demonstrate

that the genetic make - up of populations changes over time by the process of natural selection. Within the population of influenza viruses, for example, some viruses are naturally resistant to the drugs that are used to treat them. As a result, the resistant viruses survive and reproduce, so new influenza vaccines must be created to treat the newly evolved strain. Laboratory experiments also demonstrate evolution in action. Using rapidly reproducing species such as bacteria, yeast, and fruit flies, scientists have shown that altering the environmental conditions in which these organisms exist can induce genetic changes within the population. The scientific evidence showing that evolution has happened and continues to happen is overwhelming.

Thus, the primary aim of this study is to be able to explore the mental constructs on evolution of selected students of San Sebastian College - Recoletos, Manila towards proposed pedagogical interventions.

This study would like to clarify or intervene in some of the misconceptions pertaining to evolution, that can make our students truly understand and appreciate its existence.

Specifically, the study aims to:
a) Strengthen the theories and concepts about evolution
b) Enlighten our students to appreciate the processes involve in the existence of life.
c) Encourage / Motivate our students to do more research works in order to be more updated about recent information in ecoevolution

The study wishes to answer also the following questions:
a) What were the key sources of the students' mental constructs?
b) Were the students keen on their understanding, beliefs, and ideas about evolution?
c) How can they be motivated to increase their knowledge/learning about the existence of living organisms from the past to the present time?

2. Literature Review

The process of evolution involves a series of natural changes that cause species (populations of different organisms) to arise, adapt to the environment, and become extinct. According to the Smithsonian National Museum of Natural History (2020), all species or organisms have originated through the process of biological evolution. In animals that reproduce sexually, including humans, the term species refers to a group whose adult members regularly interbreed, resulting in fertile offspring. Scientists classify each species with a unique, two - part scientific name. In this system, modern humans are classified as Homo sapiens.

It was cited in an article, Relevance of Evolution: Medicine, that understanding evolution help us solve biological problems that impact our lives. There are excellent examples of this in the field of medicine. To stay one step ahead of pathogenic diseases, researchers must understand the evolutionary patterns of disease - causing organisms. To control hereditary diseases in people, researchers study the evolutionary histories of the disease - causing genes. In these ways, a knowledge of evolution can improve the quality of human life.

In an article, Why is it important to teach evolution?, it was clearly mentioned that teaching and learning about evolution have immense practical value that extends beyond understanding our world. The principles of evolution underlies improvement in crops, livestock, and farming methods. Natural selection accounts for the rise in pesticide resistance among agricultural pests and informs the design of new technologies to protect crops from insects and disease. Scientists are applying lessons from evolutionary biology to environmental conservation. Species from microbes to mammals adapt to climate change; studying the mechanism and rate of these changes can help conservation experts formulate appropriate measures to protest species facing extinction.

Students' perceptions on evolution should also be taken into consideration. According to Bertka, et. al (2019), students may choose not to accept evolution, but to be scientifically literate, they should understand how and why scientists consider it as a core unifying theme of biology. Teachers must be willing to teach the topic, and students must be willing to try and understand the material. The reality for both teachers and students is that they are being asked to engage in a topic that conflicts with their worldview. Simply stated, "a worldview provides a person with presuppositions about what the world is really like and what constitutes valid and important knowledge about the world" (Cobern 1996). For many people, their religious worldview is a significant component of their social identity. People are unlikely to embrace a topic that is seen as likely to threaten significant social connections and relationships.

An interesting topic in evolution would be about Darwin's theory of evolution. This is clearly emphasize in an article on **evolution and natural selection (**2010), where Darwin's theory of evolution fundamentally changed the direction of future scientific thought. The core of Darwin's theory is natural selection, a process that occurs over successive generations and is defined as the differential reproduction of genotypes. Natural selection requires heritable variation in a given trait, and differential survival and reproduction associated with possession of that trait. Examples of natural selection are well documented, both by observation and fossil record.

It was mentioned by Lehnardt (2017), that evolution rarely follows a straight line from species to species. Instead, it is more like a tree with many branches. Some branches lead to new branches, while others become dead ends.

Bickerton, P. (2019), made mention of an interesting fact, and that is about genetic drift, which is the randomness that we see from generation to generation. Its effects become stronger in small population, which tend to lose genetic variation as different versions of genes are lost. This often happens when populations often go to a bottleneck, which sees their numbers drastically reduced. When this happens, some versions of a gene can be lost, by chance, and the remaining ones become the prevalent version.

3. Methods

Research Design
This research employed a quantitative method in defining the objectives of this study, which is to explore the mental constructs on evolution towards proposed pedagogical interventions. The researcher made use of the survey questionnaire as the main source for the data collection.

Sample
The respondents of this study are the incoming 3rd yr. Psychology students who would be taking up Biology subject during this 1st semester of 2021. Survey questionnaires were sent to the 20 officially enrolled Psychology students of San Sebastian College - Recoletos, Manila. They will all attend online classes at present.

Sampling technique
The purposive sampling technique was used for the respondents, since they have the major course who can respond well to the inquiries about exploring students' mental constructs on evolution towards proposed pedagogical interventions.

Data Collection and Data Analysis techniques
The incoming 3rd year Psychology students were chosen as the key respondents for this study. They have enrolled the subject Biology for this 1st semester of 2021, where evolution will be tackled. Survey questionnaire were sent to them online, using the google forms. Among the 20 students enrolled, only 10 among them submitted their responses. This is due to the pandemic period where students are having problems with their connectivity at home, the absence of good laptops and cell phones, power interruption and the presence of inclement weather at times. These reasons were quite understandable. It also happened that the construction of this research work was conducted during the summer period, where majority of our students are on vacation, thereby giving the authors a hard time in retrieving their answers, since most of them have decided to relax for a while and enjoy the summer break with their families.

Their responses were collated and analyzed as to what statistical treatment should be applied, in order to come up with the correct results that can give good discussion, conclusion, and recommendations.

4. Results and Discussion

This part of the study exhibits the data accumulated by the researchers. The results of the data gathering procedure were organized, presented, analyzed and interpreted by the researcher in order to arrive at a better understanding of the information gathered.

Table 1.1 to 5 - point Likert Rating Interpretation of Range

	Value	Range
Strongly Disagree	1	1.00 - 1.80
Disagree	2	1.81 - 2.60
Neither / Nor Agree	3	2.62 - 3.40
Agree	4	3.41 - 4.20
Strongly Agree	5	4.21 - 5.00

Source: Sozen & Guven (2019)

TheLikert Scale is an ordered scale from which respondents choose one option that best aligns with their view. It is often used to measure respondents' attitudes by asking the extent to which they agree or disagree with a particular question or statement.

Table 2: Mean Analysis for Science 102 with Questions 1 - 10 (Sci 102)

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Mean	3.7000	2.4000	3.7000	3.7000	3.3000	3.5000	3.0000	3.5000	4.2000	3.6000
N	10	10	10	10	10	10	10	10	10	10
Std. Deviation	1.33749	1.07497	1.25167	1.41814	1.41814	1.26930	1.56347	1.50923	.63246	1.17379

The table showed the highest mean in Q9 which generated an average mean of 4.2. The question in number 9 stated that Can mutation be beneficial, neutral, or harmful to the organism? Most of the students agreed with this question, since this topic was taken up already during their former years of study and was easily recalled by them.

Table 3: Mean Analysis for Science 102 with Questions 11 - 20 (Sci 102)

	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
Mean	3.8000	4.0000	4.0000	4.0000	3.8000	3.4000	4.4000	4.1000	4.0000	4.3000
N	10	10	10	10	10	10	10	10	10	10
Std. Deviation	.63246	1.24722	1.63299	1.15470	1.47573	1.50555	.51640	1.28668	1.63299	1.25167

The table showed the highest mean in Q17 which generated an average mean of 4.4 The question in number 17 stated that Should there be an enhancement of report about natural selection. ? It was clearly agreed by the students that they would like to learn more about natural selection, its significance, and more updated information about the said topic.

Shown also on this tabulation are the following high average means, which can serve as a basis for the proposed pedagogical interventions. The questions asked were the following:
Q12 - Can looks be deceiving in some animals ?
Q13 - Can a tour in the national museum enhanced the students' understanding about evolution?
Q14 - Will a good lecture - discussion increased the students' understanding about ecological evolution?
Q18 - Should students be introduced to several book reviews or articles pertaining to the historical structure of evolution ?
Q19 - Is it really necessary to have a lively class interaction ?

Q20 - Would students be informed well about the patterns of evolution, if they would be able to create infomercials?

These questions were given a rating of 4.0 for Q12, 13, 14, and Q19. The average mean for Q18 was 4.1, and for Q20 was 4.3. It was reflected then from the results that these students are in search of updating themselves more with new trends and strategies of further understanding the remarkable things or information about evolution.

5. Discussion

The results showed certain realizations on the understanding of students about evolution. It clearly indicated that not all students who took up the subject way back in their high school years, and some partial components of it during their freshmen and sophomore years can easily recall learning inputs by their teachers. This can be brought about by factors such as uninterested attitudes of students to the subject matter, short attention span, lack of quality lecture - discussions, that should had been supported by good power point presentations, no report enhancements, lack of interconnection on the patterns of evolution to the present day scenario, and thus not all of them have been motivated and engaged on the subject itself.

The use of the Likert scale served as a good measurement of the thoughts and ideas of students who are about to take the subject, since the results gathered can help the researchers determine the appropriate pedagogical approach in order to correct some misconceptions about the study on evolution, and help the students to appreciate the subject. Therefore, the existing thoughts and ideas of students who answered the questionnaire, are the key sources of their mental constructs.

Table 2 showed the highest average mean of 4.2 from Q9, which was focused on the understanding about mutation, where most of the students agreed that it can either be beneficial, neutral, or harmful. According to the National Human Genome Research Institute, a mutation is a change in the DNA sequence. It can result from DNA copying mistakes made during cell division, exposure to ionizing radiation, exposure to chemicals called mutagens, or infection by viruses. Therefore, the answers of the students is their clear, honest understanding of the possible effects of mutation as observed in living organisms.

Table 3 showed the high average means gathered ranging from 4.0, 4.1, 4.3, and 4.4, where the summation of the results would tell about the possible pedagogical interventions for the students to understand thoroughly and appreciate better the teachings in evolution.

The pedagogical interventions to be proposed for this study are the correct or appropriate teaching methods/strategies that are necessary to awaken the senses of our students in learning the principal components of evolution. A good lecture - discussion should allow the sincere participation of students in order to come up with a lively and informative discussion. A picture analysis information about a specific topic concerned can be combined with some trivias to make the discussion more relax, yet invigorating. Requiring the students to do some book reviews or article reviews and be able to share it in class, would be another big step in convincing them to learn more. On the other hand, a creative activity can also be done in order to set a different mood that can also lead to accumulation of knowledge. This will be the introduction of science infomercials, which will be about creating advertisements, just like in television, which concerns a product, service, or idea. Students will try to find a way on how to convince the audience about for example an updated information about fossils. They will try to find a way on how to sell the information by thinking logically and creatively. Class debates can still be encouraged even in an online class. There will be set of guidelines to be followed. The enhancement of reports should also be given time and space, for this activity can boost the confidence among students, and can also enhance their communication skills. Seeing the evidences on the history of evolution can really perk the imagination and analytical prowess of our students, and one better way of doing it will be a tour in the national museum. Unfortunately, we are still in a pandemic period, so the best way will be the incorporation of an online historical tour to this museum, where the students can be given the chance to have a glimpse of the past evolution, its connections to the present time, and its implications to the future setting. With all of these suggested or proposed pedagogical interventions, we could have high hopes for evolution through our students.

6. Conclusion

Learning new topics or lessons in science should be look forward by students, most especially if these topics seem to be interesting, well - updated, and is worth their time. Evolution matters poses a great challenge on the part of the teachers, since they have to think of possible and effective ways on how to teach evolution to their students, in such a way that these students will be able to learn the basics of the subject, ascending to the next higher level of understanding. According to Johnson, WR & Lark, A. (2018), they said that current reform efforts at all levels of biology education advocate for the integration of science content and practices and emphasize the importance of phenomena - driven inquiry. They have describe an instructional sequence for teaching evolution by natural selection that addresses the goals by engaging students in parallel selection experiments with biological and digital model organisms. These activities address multiple learning objectives in the Biology Curriculum Framework and the Next Generation Science Standards while engaging students in authentic science practices to learn about natural selection. They also report results from pre and post assessments in a biology class which demonstrate students' learning gains and increased acceptance of evolution.

While there could be other means or methods on how to challenge students in becoming knowledgeable about evolution, we should also presume then that there could also be worries in teaching evolution. According to Richards, RA, these worries of people about evolution and the teaching of evolution are not always and only based on a commitment on creationism and biblical literalism. Evolution challenges some of our most deeply entrenched philosophical commitments about human nature. It challenges a widespread belief that humans are somehow

exempt from the laws of nature. This challenge in turn naturally raises questions about justification not raised by other less philosophically significant scientific theories. If we want to fully understand the opposition to evolution and its teachings, we need to understand the philosophical challenges posed by evolution.

We also tend to think of our everyday dealings with life, and we want to know how evolution can be of help to the present day scenario. It was then mentioned in an article of SCooke (2017), that the synthetic theory of evolution is essentially a combination of Charles Darwin's concept of natural selection, Gregor Mendel's basic understanding of genetic inheritance, along with evolutionary theories developed since the early 20th century by field biologists, population geneticists, and more recently by molecular biologists. The hottest area of research concerning the mechanisms of evolution today is in evolutionary developmental biology (commonly known as evo - devo). It focuses on discovering and understanding genetic changes that alter embryonic development and lead to new features in species lines.

How do we sum up then the reasons on why we really need to teach evolution? In an article, "*Why Teach Evolution?"* (1998), it was stated that biological evolution accounts for the similarities among living things, the diversity of life, and the many features of the world that we inhabit. Explanations of these phenomena in terms of evolution draw on results from physics, chemistry, geology, many areas of biology, and other sciences. Thus, evolution is the central guiding principle that biologists used to understand the world. This has been clearly emphasized in the presence of human pathogens, advances in agriculture, finding and using natural resources, and other important matters that deeply concerns evolutionary biology. Therefore, to teach biology without explaining evolution deprives students of a powerful concept that brings great order and coherence to our understanding of life. This would then be the guiding principle on why we have to enhanced our ways of teaching evolution to our students with the help of the proposed pedagogical interventions cited earlier on the results and discussion part of the paper. It will always be an evident truth that the study of evolution will always play a significant and remarkable part in our everyday existence.

7. Recommendations

Students should have a concrete understanding of the general components of evolution, as this could greatly affect their encounter with the other science subjects that would need supplemental facts in line with evolution.

Science teachers should be able to explain well to their students that there should be no conflicting issues regarding religion and evolution.

That each student in the class, including the teachers concerned should be respectful of one's mental constructs regarding the study of evolution.

There should be more substantial and valuable research works to be accomplished by the students, in line with the topics discussed.

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