



## The Perceptions of Incoming College Students from One of the Universities of the South on the Use of Biomimicry as a Method in the Field of Engineering

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**Abstract:** Biomimicry is a growing concept in science. Technologies that are developed nowadays are influenced by thorough studies on the structure and function of plants and animals. To bring innovative ideas that came from nature's own adaptation and apply this to the principles of engineering, the study aimed to gauge and understand the level of perception of incoming Engineering students towards the process and engineering of biomimetics technologies. It determined the level of knowledge of the respondents with regards to the utilization of biomimicry in the modern setting. The researchers used a descriptive quantitative survey research design to measure the awareness or perception of the respondents. The researchers also made use of a researcher-made questionnaire for the collection of data and applied the 4-point Likert scale. The respondents of this study are the Grade 12 STEM students of the University of Perpetual Help System DALTA. The study utilized the statistical tools of frequency, percentage, and weighted mean in interpreting the perception of the respondents. The results of the study showed that majority of the respondents are aware to more famous inventions/concepts inspired by biomimicry such as the Bullet Train and photosynthetic ability of plants. After analyzing the results, the researchers conclude that the respondents are aware of the modern the designs and concepts of biomimicry making way for professionals to apply biomimicry in the future. In addition, the results of this study provided the researchers insights for future reference and engineering designs.

**Key Words:** biomimetics, biomimicry, engineering methodology, perceptions, sustainability

### 1. INTRODUCTION

Biomimicry is the term to describe the design process of Biomimetics, the study that deals with observing and examining the functions of living organisms as models for creating products and inventions to benefit human society. The term 'biomimetics' was coined by Dr. Otto Herbert Schmitt, an American biophysicist, in 1957 after developing a device that mimicked the electrical reactions of human nerves. The field is focused on understanding and application of biological functions of living organisms to be used with engineering to develop commercial devices (Bhushan, 2009). Biomimetics comes from the Latin words: *bios*, meaning "life," and *mimesis* meaning "to imitate" (2020). Biomimetics is similar to Bionics, (Muderis & Ridgewell, 2016). Glaser et al., (2013) illustrates that biomimicry is not the literal replicating of these functions as there are limitations and consequences, rather it is a process of selective learning

Benyus (1997) popularized the term "biomimicry" with her book, "*Biomimicry: Innovation Inspired by Nature*". Benyus discussed nature as

having three importance to the method of biomimicry, these being: (1) Nature as a Model; (2) a Measure; and (3) a Mentor.

These signify the inspiration of man to replicate nature's biological processes and incorporate it to society. Biomimicry is seen in the world of architecture and engineering as it functions as a methodology in the field when creating infrastructures to suit society's needs. One example is the Japanese Bullet Train in 1964. The bullet train took inspiration from the kingfisher's pointed narrow beak which allows it to gracefully dive into the water without much disruption. The bullet trains achieved this structure through creating a smoother and "pointed" design for its front to reduce the sonic boom it causes when going through tunnels. A historical instance were the sketches created by Italian polymath, Leonardo da Vinci. His sketches of the Ornithopter took innovation from the flapping motion of a bird's wings which allowed them to lift from the ground with their hollow skeletal structures.

Sustainable usages of biomimicry were adapted to counteract the adverse effects of the industrial age. The use of the humpback whales'



tubercles reduces stall caused by underwater movement to increase speed when travelling through fluids. When employed in wind turbines, the same effect is found. A study conducted by Fish et al. (2011) explored the usage of tubercles in wind turbines and found the use of tubercle-lead blades produced higher performance in generating electricity while maintaining stability as opposed to smooth-lead blades.

There is Philippines has less utilization of biomimetics, causing a need for sustainability. Romolo Nati, CEO of Italpinas, pointed out that there is a great imbalance in the use of resources as many have the misconception that natural resources are infinite and continue to abuse these (2014). Similarly, Nati (2013) emphasized the need to switch to an eco-friendlier method of infrastructure by applying biomimetics methods. Stating that cities occupy 2% of landmass, but produce 70% of green-gas-emissions, he asserted that there is need to have a sustainable solution by employing sustainable development tools through biomimicry and performance-based strategies.

This study aimed to know the perceptions of incoming engineering students towards biomimicry. The study sought to determine the knowledge regarding biomimicry in products for improvement in a person's lifestyle through use of a survey questionnaire to obtain fixed responses from the respondents.

The study determined the perceptions of incoming Engineering students on the use of biomimicry as a methodology. Specifically, the study obtained the following details through the questions: First, the respondents' profile: age, sex, and previous academic performance. Second, the respondents' level of perception to biomimicry designs as to structure and biological function of plants and animals. Third, the level of perception of respondents as to the inventions using biomimetics. Lastly, insights to be drawn by the researchers from the results.

## 2. METHODOLOGY

### 2.1. Data Gathering Tool

The study made use of the research-made questionnaire for data-gathering. The research questionnaire was floated to the respondents, Grade 12 STEM Students, who will be taking engineering courses, through an online setting.

The researcher-made questionnaire was in two parts. The first part presented the profile data of the respondents, their age, sex, and previous academic performance. The second part of the questionnaire determined the perception of respondents as to biomimicry designs.

It determined the level of perception of the respondents to the structure and biological function of plants and animals and inventions that used biomimicry designs.

Table 1. Interpretation Scale

Scale	Limits	Verbal Interpretation	Word Description
4	3.50-4.00	Strongly Aware	The respondents are fully aware and are familiar on the use of Biomimicry as a methodology in the field of engineering as well as the functionality it has on everyday technology
3	2.50-3.49	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.
2	1.50-2.49	Unaware	The respondents have little knowledge on the use of biomimicry as a method in the field of engineering.
1	1.00-1.49	Strongly Unaware	The respondents have no knowledge or have only known of biomimicry as a method in the field of engineering

Table 1, shows the interpretation scale. It used a statistical trait using Microsoft Excel-generated interval of 3.5-4, which has the highest scale of 4, and has a verbal interpretation of "Strongly Aware". Followed is the interval of 2.5-3.49, with a rating scale of 3, and a verbal interpretation of "aware". The statistical trait of 1.5-2.49, follows with an equivalent scale rate of 2, and a verbal interpretation of "Unaware". Last is the statistical trait of 1-1.49, with the lowest scale of 1, and a verbal interpretation of "strongly unaware".

### 2.2. Population and Sampling Design

The study solicited data from Grade 12 students enrolled in the STEM strand focused in the engineering course of the University. There are nine (9) sections comprising the STEM strand composed of forty (40) students each. Five (5) of those sections are composed of students who will be taking Engineering programs. Four (4) of these sections were the sources of the respondents.

Purposive sampling was utilized as it was deemed appropriate by the researchers to have respondents who may be familiar with a topic of biomimetics in engineering. Purposive sampling is a non-probability method of gathering a sample which, according to Black, K. (2010), occurs when "*elements selected for the sample are chosen by the judgment of the researchers*". The selection of respondents is based on their knowledge and expertise towards a certain topic, or concept (Robina, 2014). This form of sampling is accomplished through logical assumptions and expert knowledge of a given population, elements are selected nonrandomly from the population (Lavrakas, 2008).

For the population, the study utilized selected Grade 12 students from the University of Perpetual Help System-DALTA, Las Piñas Campus currently in the STEM strand focused on engineering. It included respondents who were willing to participate in the study.



### 2.3. Data Gathering Procedure

The study utilized a descriptive quantitative design, the Descriptive Survey research design. A descriptive quantitative research measures the subjects in question and finds the association between the chosen independent and dependent variables (Hopkins, 2000). This is due to the study gathering data from the perceptions of respondents towards biomimicry as a methodology in engineering. Creswell (2003) states that quantitative research design “*employs strategies of inquiry such as experiments and surveys, and collect data on predetermined instruments that yield statistics data*”.

The Descriptive Research design is used when researchers’ goal is to measure the behavior and characteristics of a sample (Dudovskiy, 2011). This research design answers what, where, when, and how (McCombes, 2020) through observation and descriptive analysis with instruments such as surveys (Koh & Owen, 2000).

Uses of descriptive-surveys are to find the “*range and distribution*” of the demographic or psychographics of individuals to see if there is any relation of it to behavior patterns and/or attitudes (Zurmuehlen, 1981). The Descriptive Survey Research design was utilized in the study to investigate the awareness of the respondents towards biomimicry as an engineering methodology.

The first phase was the formulation and validation of research made questionnaire. The researchers formulated the research questionnaire and have it verified through experts. Second, writing a letter to the administrators of the Senior High School Department to ask for permission and approval to conduct a study. Lastly, distribution of the questionnaire, wherein the researchers sought the consent of the respondents before distributing the questionnaire. The respondents were given one week to answer the distributed questionnaire. The researchers collected the questionnaire and interpreted the data through 4-point Likert scale.

### 2.4. Data Analysis Plan

The researchers analyzed and interpreted the data after collation. In analyzing the data, the researchers used statistical treatment. They used statistical tools of percentage, frequency and weighted mean. After getting the weighted mean, the researchers analyzed the data based on the Likert scale formulated by the researchers. The last part was the interpretation of the data.

## 3. RESULTS AND DISCUSSION

Table 2. Profile of respondents as to Age

Corresponding Age	Frequency (f)	Percentage (%)
17	21	20.6
18	67	65.7
19	11	10.8
20 and above	3	2.9
Total	102	100

From Table 2, it could be gleaned that majority of the respondents, sixty-seven (67) or sixty-five and seven tenths (65.7 %) are aged eighteen (18).

It can be said that most of the respondents falls on the age of eighteen as this is the typical age of Filipinos who are enrolled in the grade 12 program.

Table 3. Profile of respondents as to Sex

Sex	Frequency (f)	Percentage (%)
Male	63	61.8
Female	39	38.2
Total	102	100

From Table 3 it can be derived that more than half of the respondents’ sex is male with a frequency of sixty-three (63) or a percentage of sixty-one and eight tenths (61.8 %).

This is due to the preference of male students to enroll in engineering programs. As the chosen locale of the study is in the engineering STEM strand, this has been the case.

Table 4. Profile of respondents as to Previous Academic Performance

Grade	Frequency (f)	Percentage (%)
93-95	20	20
90-92	29	28
87-89	31	30
84-86	15	15
81-83	6	6
75-77	1	1
Total	102	100

From Table 4, it can be extracted that majority of the respondents, thirty-one (31) respondents, a percentage of thirty (30%), have their previous academic performance to be in the range of 87-89.

It is inferred that majority of the respondents have above average academic performance in the sciences and mathematics.



Table 5.  
 Perception of respondents as to biomimicry designs as to structure of plants and animals.

Indicator	Weighted mean	Verbal interpretation	Word Description
1. I am aware that the improved blades of wind turbines are based on the fin structure of humpback whales	2.37	Unaware	The respondents have little knowledge on the use of biomimicry as a method in the field of engineering.
2. I am aware that the modern Japanese bullet train's front nose design to the beak of a Kingfisher bird.	2.64	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.
3. I am aware that a commercial building in Melbourne, Australia, Council House 2, utilizes design strategies of termite mounds for natural cooling	2.36	Unaware	The respondents have little knowledge on the use of biomimicry as a method in the field of engineering.
4. I am aware that inspiration for Velcro were burdock burrs hooked-spikes that are able to latch onto objects	2.30	Unaware	The respondents have little knowledge on the use of biomimicry as a method in the field of engineering.
5. I am aware that the spandex swim suits are inspired on the hydrophobic nature of shark skins.	2.62	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.
<b>Average</b>	2.46	Unaware	The respondents have little knowledge on the use of biomimicry as a method in the field of engineering.

Table 5 presented the perception of respondents as to biomimicry designs on the structure of plants and animals. Indicator 2 has the highest weighted mean of two and sixty-four hundredths (2.64) with a verbal interpretation of "Aware". While Indicator 4 has the lowest weighted mean of two and three tenths (2.3) with a verbal interpretation of "unaware". Results of table 5 show the respondents' weighted average is two and forty-six hundredths (2.46) with a verbal interpretation of "Unaware".

Table 5.1.  
 Perception of respondents as to biomimicry designs as to biological function of plants and animals

Indicator	Weighted mean	Verbal interpretation	Word Description
1. I am aware that the solar cells were inspired by the process of photosynthesis by the leaves.	3.29	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.
2. I am aware that the bird wing inspired aircraft to aid in aerodynamics.	3.19	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.
3. I am aware that the biological function and structure of a firefly's bulb is the inspiration for the efficiency found in LED Light Bulbs	2.79	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.
4. I am aware that tubercle-lead blades produced higher performance in generating electricity for wind turbines	2.62	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.
5. I am aware that the flapping motion of birds to gather lift is inspiration for how helicopters increase lift	2.74	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.
<b>Average</b>	2.93	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.

Table 5.1 presented the perception of the respondents towards biomimicry designs as to the

biological function of plants and animals. Indicator 1 having the highest weighted mean of three and twenty-nine hundredths (3.29) with a verbal interpretation of "Aware". While

Indicator 4 has the lowest weighted mean of two and sixty-two hundredths (2.62) with a verbal interpretation of "Aware". Results of table 2.3 show the respondents' weighted average of two and ninety-three hundredths (2.93) with a verbal interpretation of "Aware".

Table 6. Perception of respondents as to inventions using biomimicry designs

Indicator	Weighted mean	Verbal interpretation	Word Description
1. I am aware that the Japanese bullet train's front nose is based on the narrow beak of the kingfisher bird to maximize speed and lessen noise pollution.	2.73	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.
2. I am aware that the solar cells are based on the photosynthetic ability of plants in producing energy from light-energy sources	3.08	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.
3. I am aware that the second council house in Melbourne, Australia was based on termite mounds for temperature regulation	2.25	Unaware	The respondents have little knowledge on the use of biomimicry as a method in the field of engineering.
4. I am aware that the improvement of structure in wind turbines increases efficiency in generating electricity	2.88	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.
5. I am aware that the American B2 Spirit Bomber was based on the ability of hawks to maintain aerodynamic speed and mobility through having a packed body.	2.3	Unaware	The respondents have little knowledge on the use of biomimicry as a method in the field of engineering.
<b>Average</b>	2.66	Aware	The respondents are aware and are somewhat familiar with the use of biomimicry as a method in engineering and its use on some devices.

As seen on Table 6, Indicator 2 has the highest weighted mean of three and eight hundredths (3.08) with a verbal interpretation of "Aware". While Indicator 3 has the lowest weighted mean of two and twenty-five hundredths (2.25) with a verbal interpretation of "unaware". Results of table 6, the respondent's weighted average is two and sixty-six hundredths (2.66) with a verbal interpretation of "Aware".

#### 4. INSIGHTS DRAWN BY THE RESEARCHERS

According to the data, the respondents of the study were most aware of the designs inspired by the biological functions of nature. This may be due to the curriculum of the respondents surveyed, as students who took science classes with biological concepts. Results show that the students were more aware of the design, function, and inspiration which created



the Bullet Train and Council House 2 from Melbourne, Australia.

The biomimetic technologies with the highest weighted mean are what the respondents are most aware of due to the commonality of these inventions in their life to counteract effects of industrial-based technologies.

Likewise, the researchers are able to gauge the level of perception the respondents have regarding the topic of Biomimicry. The results gave insights towards the things that should be implemented to suffice the lack of knowledge that is essential in pursuing engineering. It signifies the pursuit of the implementation of biomimetics research in the future engineering programs the researchers will be enrolling in. Some of these inventions are not widely used in modern homes. Factors to consider are previous academic experiences regarding the topics such as photosynthesis and aerodynamics.

#### *4.1. Summary of the Findings*

Majority of the respondents of the study are within the age range of 17 to 18 years of age. Most of them are males and their previous academic performance, above average. As to perception to the structure of biomimicry inventions, majority of the respondents are aware that the Bullet Train was inspired by the kingfisher bird, which has the highest weighted mean. As to the biological function as to plants and animals, majority of the respondents are aware that the photosynthetic ability of leaves became the inspiration in the creation of solar cells. As to the perception as to inventions using biomimicry designs, majority of the respondents are aware of solar cells inspired from the photosynthetic ability of plants to create energy from solar-light. The researchers were able to come up with the insights based on the results of the study. These insights include the importance on the use of biomimicry design and how it will play in pursuing future careers.

#### *4.2. Conclusions of the Study*

Based on the findings of the study, the following conclusions are drawn:

Most of the respondents are within the age range of 17 – 18 years of age. Majority who are taking Engineering focus stem strand are males and have grades of above average and excelled in the fields of Science and Mathematics. Most of the respondents are aware on the existence of the bullet train and solar cells. Since these technologies are well-marketed and being used for convenience in transportation and electricity-generation. Majority of the respondents are aware of photosynthesis being the inspiration for the invention of solar cells to generate electricity from the

sun's solar-light. From the increase of efficient and sustainable power-generating from the use of solar cells, most of the respondents are familiar of the existence of these technologies. The researchers adhere to the conclusion that most of the respondents are aware that some modern technologies are products of biomimicry design and concept. These insights gleaned by the researchers from the study provide a wider perspective in designing future technologies by studying the structure and function of plants and animals. Furthermore, through the data gathered, these inspired the researchers to make more in-depth studies about biomimicry.

#### *4.3. Recommendations*

Based on the findings and conclusions drawn from the study, the following recommendations are hereby made:

There should be a follow-up study on biomimetics for efficiency in household chores. Future studies must involve a larger range of respondents of a specific engineering field that may utilize biomimetics in the future. The Department of Science and Technology (DOST) must allocate funding for researches for biomimicry designs. Likewise, the Commission-on-Higher Education (CHED) and Department of Education (DepEd) must include in the STEM and Engineering curriculum the designing of technologies using biomimetics. Engineering companies should invest on biomimetics research, through the study of the structure and biological function of organisms to mitigate pollutants produced by modern machinery. Engineering schools may consider in creating or drafting a curriculum prioritizing technologies that follow biomimicry designs that would be sustainable. The study made use of respondents from the engineering-focused field of the STEM Strand. Future studies may include biology-based fields in order to increase depth of the study on the perception of respondents towards biomimetics.

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