Journal of Creative Practices in Language Learning and Teaching (CPLT)
Volume 9, Number 2, 2021

Biomimicry Approach Adapted From The Fundamentals Of Design Development Process

Azharı Md Hashim*
azhari033@uitm.edu.my
Industrial Design Department, Faculty of Art & Design
Universiti Teknologi MARA, Kedah Branch Campus, Malaysia

Muhammad Faiq Hilmi bin Mohamad Zamberi
faiq@rtm.gov.my
Department of News
Radio Televisyen Malaysia, Malaysia

Corresponding author*

Received: 29 June 2021
Accepted: 15 September 2021
Published: 15 October 2021

ABSTRACT
Transport design inspiration form that requires the observation from the surrounding environment derived from the attribute and imitating inspiration between nature and transportation. The designer was inspired by the potential form obtained from the physically or philosophically aspect underneath nature's living organisms during the early phases of transport design development, particularly during the conceptual and proposal phases. As a result, researchers and designers began to aspire to nature as a problem solver in their conceptual design. This study aims to investigate natural characteristics that can be incorporated into transportation design projects through the design learning process, as well as obtaining an understanding of the users' perceptions of the suggested design. In this project, the learning process comprises of evaluating the design influence, system, and technology that emphasizes on the attributes of nature. As an outcome, a survey involving potential users was conducted by utilising questionnaires and distributed to the respondents. Finally, the findings demonstrated how nature may be used as a tool of research to break down barriers between natural science and engineering disciplines, notably in the domain of design. Furthermore, the responses revealed the respondents' views on the design as references in academic and industry practises.

Keywords: Biomimicry attribute, design development, natural characteristic

INTRODUCTION

The interaction and connection between transportation and nature are one area where designers have encountered a number of unexpected situations. At that moment, there is a distinctive approach to design that is established a long time ago and enables designers to observe and seek inspiration from natural processes. These techniques have been around for decades, but they have only lately been uncovered and disclosed. Would we be able to harness the logic or terms behind nature's living organisms to assist us in the growth of humanity? Janine M. Benyus (JM, 1997) coined the term Biomimicry or biomimetic to describe a branch of study that combines engineering and biology and encourages humans to look to nature for solutions. The word biomimicry is composed of two words: 'bios,' which means life, and 'mimesis,' which means to emulate or imitate. It will be easier to comprehend the concept and procedures if users understand the meaning of the word.

The term "bionic" established in 1960 as "the science of systems with functions copied from nature" (Harkness, 2004). This strategy emphasises what can be learned from nature rather than what can be extracted from it (McGregor, 2013). The fundamental idea is that engineers and designers should focus on the features and designs of natural systems, using them as inspiration for effective, self-sustaining, renewable, and permanent solutions to challenges that threaten environmental sustainability. According to Zhang (2012), biomimicry can be accomplished at three levels: 1) imitating the form or function of nature, 2) imitating natural processes, and 3) imitating natural systems, with the first being the most common.

This study looks into imitating the form or function of nature by inherent qualities of hummingbirds and how they might be incorporated to a three-wheeled scooter design. The findings will be used to influence design, system, and technology that emphasises the hummingbird's unique qualities. Hummingbirds are little, colourful birds with iridescent feathers. Their name comes from the humming sound they create when they flap their wings so quickly (about 80 times per second). Hummingbirds can fly in all directions: right, left, up, down, backward, and even upside down. They can also hover by flapping their wings in a figure-8 pattern. They have a long, tapering bill that they use to get food (Croskery, 2016). The feet of a hummingbird are primarily for perching rather than hopping or walking. In addition, the prospective qualities are highlighted, as well as how to use it. A hummingbird fluttering its wings, the only form of bird that relies completely on its own strength to hover in the air, necessitates more mass-based mechanical power production than any other type of locomotion (Tobalske BW et al., 2007). Furthermore, researchers discovered that the colourful feathered creature's efficiency is determined by the length-to-width ratio of its wings. Hummingbird wings' aerodynamic performance is "amazingly similar" to sophisticated micro helicopter rotors, according to the study (Mayntz, 2017).

Figure 1 illustrates the broad tailed Hummingbird in its nature. Hummingbirds have a special avoidance system built into their brains that allows them to do quick aerobatics while being safe. Until recently, the way they manage to avoid potentially fatal collisions has still been a mystery (Warrick, Tobalske, & Powers, 2005).

Figure 1. Broad tailed hummingbird (Selasphorus platycercus)

In addition, a propose conceptual three-wheeler is a motorbike scooter with an advanced step through-frame and a hummingbird-inspired platform for the rider's feet. Three-wheelers are a fantastic alternative for metropolitan commuters or young professionals since they offer superior manoeuvrability. Following that, this study will look on how biomimicry can be utilised as a tool for breaking down barriers between natural science and engineering in the design learning process as a pilot survey. The final composition will depict the feasibility of merging nature and transportation design segments in order to achieve transportation that is completely integrated between the vehicle, the user, and the environment before the actual survey and complete designing process can be conducted.

Implementation of nature's biomimicry in Transport Design

The applications of nature, its models, systems, processes, and elements to imitate or take inspiration from in order to address human issues are known as biomimicry or biomimetic. Biomimicry and biomimetic are terms derived from the Greek words bios, which means life, and mimesis, which means to imitate. Bionics, bio-inspiration, and bio gnosis are all phrases that are frequently used. It is also a method leads to innovation and looks for long-term answers to human problems by replicating nature's attempted patterns and strategies. The term "biomimicry" was coined in 1982. Janine Benyus, a scientist and author, coined the word biomimicry in her 1997 book Biomimicry: Innovation Inspired by Nature. Figure 2 illustrates the design form imitate from nature surroundings as inspiration.

Nature has inspired transportation solutions and design concepts, whether for cargo or passengers (Boaretto et al., 2021). Examples of nature-inspired problem-solving approaches rely on the bullet train case derived from kingfisher which reflects in the high level of noise inferred to the train when it enters a tunnel due to a turbulent flow that also causes structural damage from air shock waves. The engineers observed how kingfisher birds can slice through the air and dive into water to catch prey while barely making a splash. The redesigned of the train's front end to resemble the shape of a kingfisher's beak help to reduce noise and tunnel booms, but it also allowed the train to travel 10% faster while using 15% less electricity (JR, 2021).

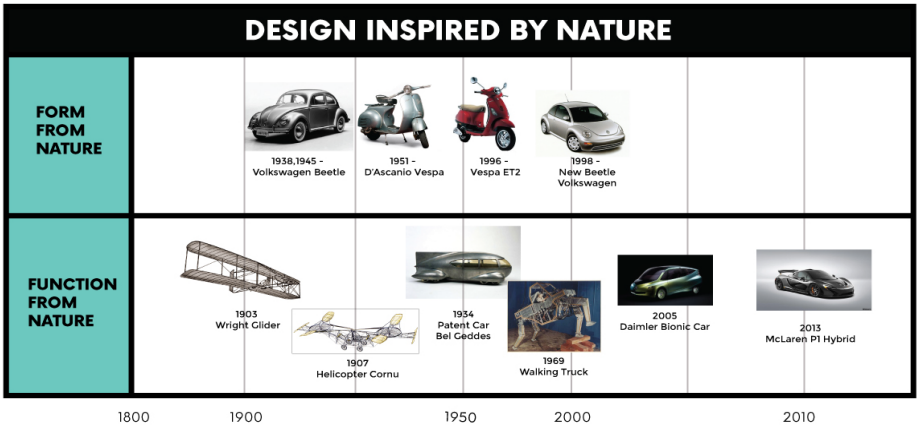

Figure 2. Design forms imitated from nature

Related to this, Volvo presented a very daring concept, the Volvo Ants, based on actual ants (Formicaridae family), inspired to reduce energy consumption for cooling the electric energy storage system (battery packs), multiload capacity, and most importantly, an "intertruck" communication network that allows combinations to form trains and seek route optimization, a skill widely used by ant species. Volvo invested a lot in raising environmental awareness through the use of biomimicry as a tool for approaching innovation, which seeks long-term solutions to human obstacles by replicating nature's moment models and frameworks (Almaraz, 2019).

Refering to figure 3 in aerial section, Galantai et al. (2012) were inspired by the flight of birds and adapted the concept of wing morphing (i.e., the potential of the wings to deform to adjust to various phases of flight) to unmanned aerial vehicles (UAVs). The shape of the airfoil determines the lift and drag forces experienced by the vehicle, and the main goal was to provide a solution that allows for dynamic adaptation of the wing profile during flight rather than the current wings, which relying on complex hydraulics and servo motors (inferring a weight penalty to the structure) (Galantai et al., 2012).

Added to this, Rashidi et al. (2019) effectively illustrated how a structure produced with a composite material using additive manufacturing and inspired by the carapace of an armadillo (order Cingulata) permits the creation of high strain articulating cylindrical shells for aircraft applications. The composite material simulates the interplay of soft collagen and stiff bone structure in alternating portions using two 3D printing materials with Young moduli and Poisson ratios of 1 MPa and 0.48 and 2 GPa and 0.35, respectively (Rashidi et al., 2019).

Despite the fact that these techniques are distinctive subjects of biomimicry inspired by nature for transportation, it is necessary to highlight their limitations. As for example, the use of biomimetics may be expanded to a variety of disciplines of research that are not connected to structural engineering only (Boaretto et al., 2021). The feasibility of natures will depend on how user react and perceive the final design and the aesthetics value towards the inspirations (Lurie-Luke, 2014).

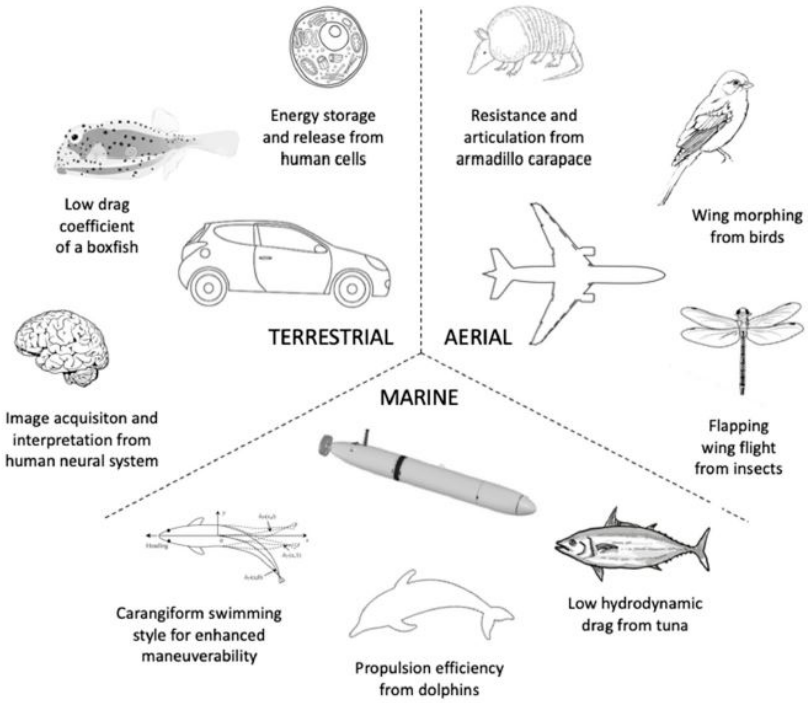

Figure 3. Bio inspiration works imitated from nature in transport (Boaretto et al., 2021)

Study Approach

It is concluded that a biomimicry approach to transportation design incorporates an understanding of nature and ecosystems could incline into a tool for creating a transport design that goes beyond current conditions. It also can sustain current conditions to a restorative practise where the characteristics and principles become crucial in the integration process. The importance of ecosystem biomimicry is highlighted as it has broad concepts and traits. Problem-Based Approach and Solution-Based Approach are the two most prevalent approaches to be dealing with biomimicry as a design process. Thi is thoroughly explained in the following section.

Problem-Based Approach

Designers use this strategy to look for solutions in ecosystems and applied to analyse concerns and problems. Then biologists must combine these into species with similar difficulties and appropriate traits. This process is impressively guided by designers who recognise the design's basic goals and scope. The pattern of problem-driven biologically inspired design involves a series of processes that are non-linear and dynamic in nature, with output from later stages commonly influencing earlier stages, giving iterative feedback and refinement loops (Vattam, Helms, & Goel, 2021).

Figure 4 demonstrates a top down approach.

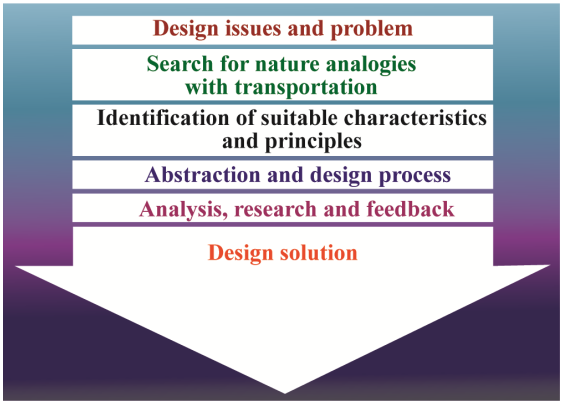

Figure 4. Top down approach

Daimler Chrysler's Bionic Car is one of the samples which employs boxfish (ostraceon malagris) as a reference, is an example of this method illustrated in figure 5 (Pedersen Zari & Storey, 2007). The boxfish, which may be found in coral reefs, has incredible structural strength but little bulk. Despite the fish's unusual look, it also has an impressively low flow resistance, with a drag coefficient of 0.06. The car's skeleton and structure have also been built using a computer modelling process based on how trees are able to grow in a way that minimises stress concentrations. The resulting structure is practically skeletal, as material is only assigned to the areas where it is most needed.

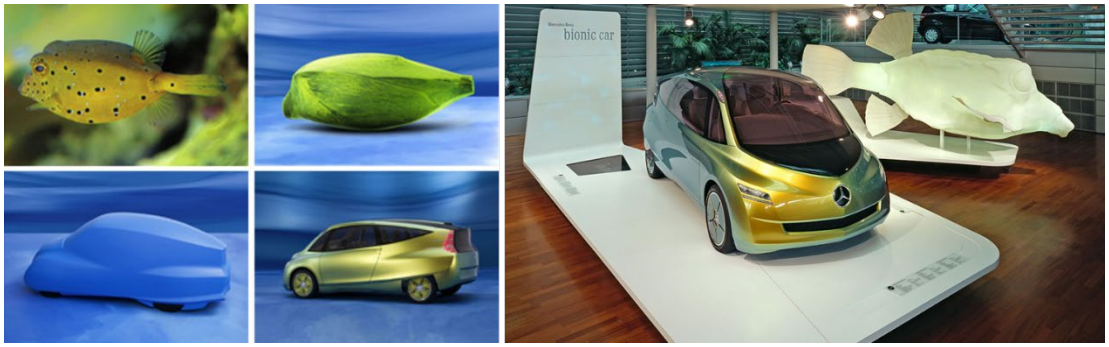

Figure 5. Daimler's Bionic Car (Daimler Global Media Site, 2021)

Another sample of natures inspired design for transportation is the new concept vehicle introduced by Isuzu named FL IR that used bio-design techniques to enhance aerodynamic performance and route. Physically, the machine would resemble a "mighty shark" (Carcharodon carcharias), and the designers focused on the behaviour of marine species that interacts underwater via ultrasonic sound waves. The new FL IR vehicles have been shown to be capable of forming a platoon while travelling autonomously. The automobile at the front of the caravan may interact with each successive truck and convey all essential information to the convoy members (Kharitonova, 2019). Figure 6 illustrates the Isuzu FL IR inspired from the nature of

marine species.

Figure 6. FL IR from Isuzu resembles a "mighty shark" (Kharitonova, 2019)

Solution-Based Approach

When biological knowledge influences human design, the collaborative design process is initially reliant on people understanding about relevant biological research rather than specific human design concerns. As a result of this approach, biology may impact humans in ways that are not related to a planned design problem, leading in previously unimaginable technologies, systems, or even design approaches. With a biomimetic design approach, the possibility for true transformations in the way humans design and what is focused on as a solution to a problem exists (Vincent, Bogatyreva, Bogatyrev, Bowyer, & Pahl, 2006). Figure 7 demonstrates a button up approach.

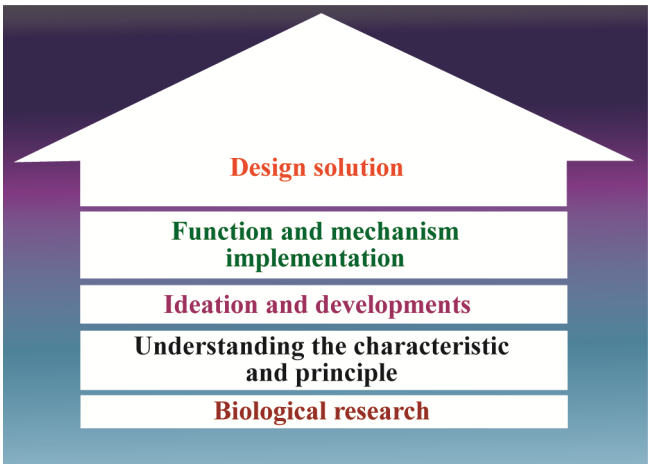

Figure 7. Button up approach

As a result of this approach, biology may impact humans in ways that are not related to a planned design problem, leading to previously unimagined technologies, systems, or even design solutions. With a biomimetic design approach, the possibility for true transformations in the way

humans design and what is focused on as a solution to a problem exists (Vincent et al., 2006). This approach has the limitation on requiring biological research to be undertaken before it can be selected as relevant to a design context. As a result, biologists and ecologists must be able to identify the potential of their findings in establishing novel applications (Vattam et al., 2021).

THE STUDY'S OBJECTIVES

The majority of designers may be unaware of or fail to notice that design is attempting to imitate nature. Although biomimicry is not generally utilised in transportation design, it has been employed as part of alternative methodologies that are commonly used in product design. aerodynamics, materials, mechanics, safety, and other aspects of transportation designs.

Furthermore, in order for biomimicry to become a viable solution to transportation issues, more exploration and testing need be conducted, as well as the adoption of inspired ideas to improve the area. Information and data generated about the process of adopting biomimicry for design and how it might be useful to design should be made publicized so that others can be influenced and encouraged to think about its uses further.

The major goal of this research is to investigate the feasibility of interaction between transportation and nature through the development of a concept scooter that uses the characteristics of hummingbirds as a biomimicry idea. This study also means to investigate the potential of biomimicry in transportation design. Hence the objectives of the study are:

i. To explore the potential of biomimicry (broad tailed hummingbird) in conceptual three-wheeled scooter design;
ii. To establish a theoretical feasibility for preliminary case-studies of biomimicry;
iii. To verify the possibility of implementing and integrating selected biological principles with conceptual three-wheeled scooter design.

The study is considered a pilot and meant to be conducted to explore the feasibility of the biomimetic design approach during conceptual designing process of class project and not involving the final product. The final result obtained from this study is considered the fundamental aspect of design direction which would be benefit to construct the actual survey.

METHODOLOGY

Twenty-questions questionnaires were given via Google Docs to thirty respondents (N=30) via social media. Given the facts that this small sampling size was due to the needs of a pilot survey and conducted during conceptual designing process of class project. The primary goal of this pilot study is to assess the viability of a method that will eventually be employed in a larger size study. However, if the sample sizes larger than 30 and less than 500 are appropriate for most research and consisting of subsamples male/females and juniors/ seniors, then the minimum sample size of 30 for each category is necessary (Sekaran, 2003). Supporting to this, successful study may be conducted with samples as small as 10 to 20 in size for simple experimental

research with tight experimental controls (matched pairs, etc.) (Saunders, 2007). Since this study was a pilot survey, this sample size was deemed adequate for this study (Carter, 2004).

Considering it is well recognised that background characteristics such as age, education, and socioeconomic position may impact product evaluation, respondents were chosen to form a relatively homogeneous group (Babbie, 1990). Respondents were chosen from various background so that past knowledge of comparable research would have no bearing on their response (Wilson & Mackenzie, 2000). It was thought that by having a group of respondents that were similar, the survey findings would be easier to understand.

The first section of the twenty questions was aimed to acquire demographic information from respondents, such as age groups, genders, races, marital status, academic qualifications, and monthly income salary. The second section aims to determine respondents' requirements for a three-wheeler conceptual scooter based on imitation qualities.

RESULT AND ANALYSIS

The survey has been put together to illustrate the findings, and the data analysis summarises the collected data via pie charts. The chart results are also accompanied by a detailed explanation. The demographics of the survey respondents are summarised in Table 1. This table illustrates the respondents' demography components of age groups, gender, races, marital status, academic qualification and basic monthly salary.

Table 1
Respondents' background and characteristics

	Questions	Percentage	Result
1	Age groups	60%	21-30 years
		33.3%	30-40 years
2	Gender	63.3%	Male
		36.7%	Female
3	Races	96.7%	Malay
		others	Other races
4	Marital status	70%	Single
		30%	Married
5	Academic qualification	60%	Degree
		33.3%	Diploma
6	Basic monthly salary	10%	RM3000-5000k
		40%	RM1000k-3000k
		26.7%	<RM1000k

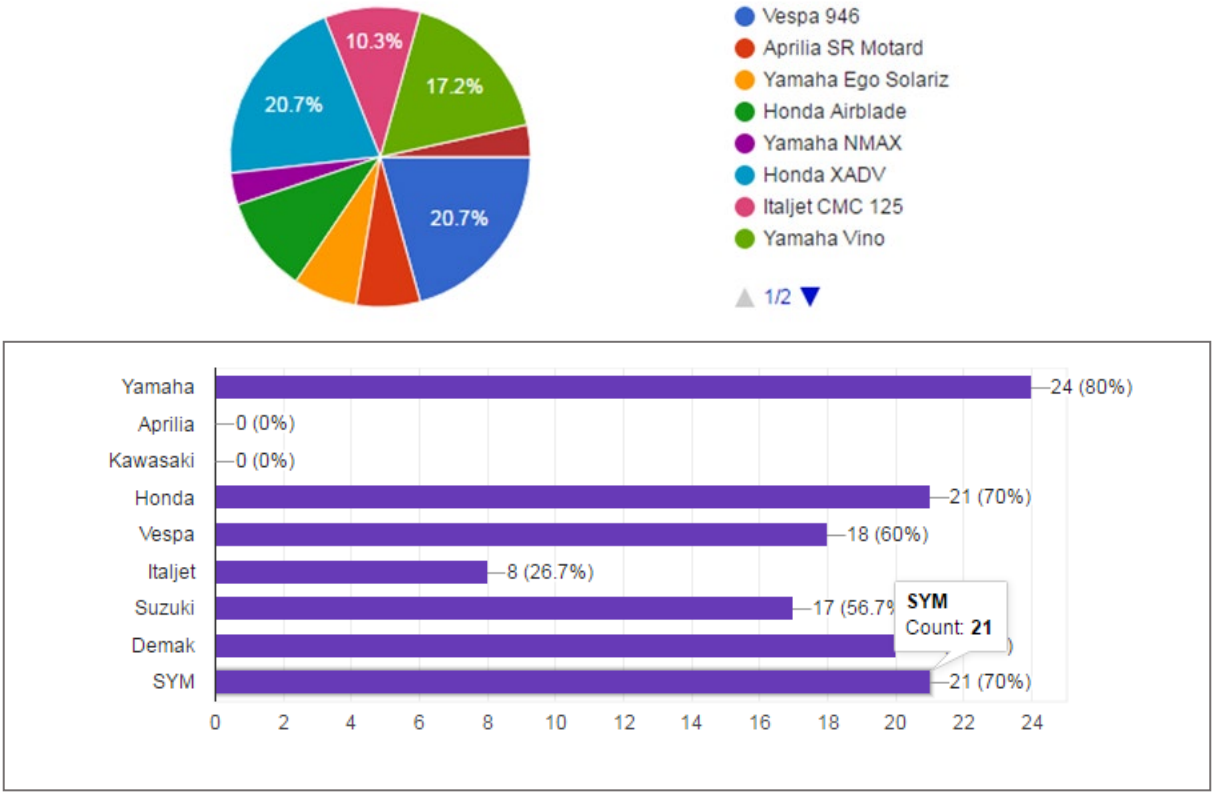

Chart 1. Most familiar scooter brand

Referring to bar chart 1, there is a little difference in the percentage of respondents who are aware of scooter brands, with the exception of Italjet, which has the lowest percentage of 26.7%. Yamaha has the biggest share of 80%, followed by Honda and SYM with both 70%, Demak, Vespa, Suzuki, and Italjet. As to summarise, Yamaha is the most chosen brand over other brands. With 20.7 percent of the vote, the Vespa 946 and Honda XADV were voted the most appealing existing scooter designs. The Yamaha Vino is the second highest at 17.2%, followed by Italjet, Honda Airblade, Yamaha Ego Solariz, Aprilia SR Motard, and Yamaha NMAX.

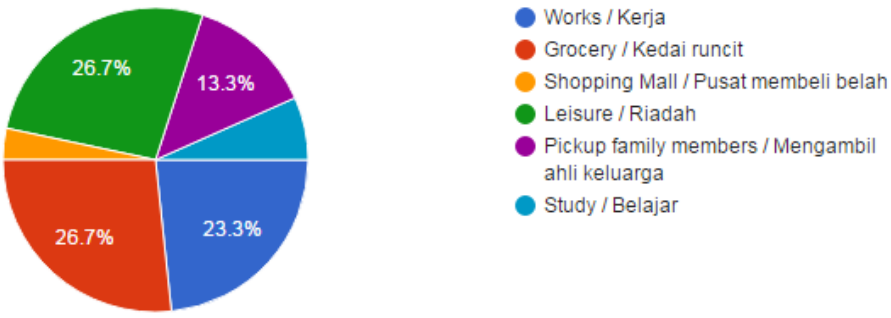

Figure 8. Destination with scooter

Figure 8 shows that the largest number is 26.7 percent, which is split evenly between leisure and groceries. Pickup family members, study, and going to shopping mall come in second

and third, with 23.3 percent, 23.3 percent, and 23.3 percent, respectively.

Based on the respondents' preference of 24.1 percent, respondents selected Design 6 as the most appealing of the seven designs shown in Figure 9. There is a small difference between the highest design, which is 20.7 percent, and the third, which is design 4, followed by the least, which is design 1.

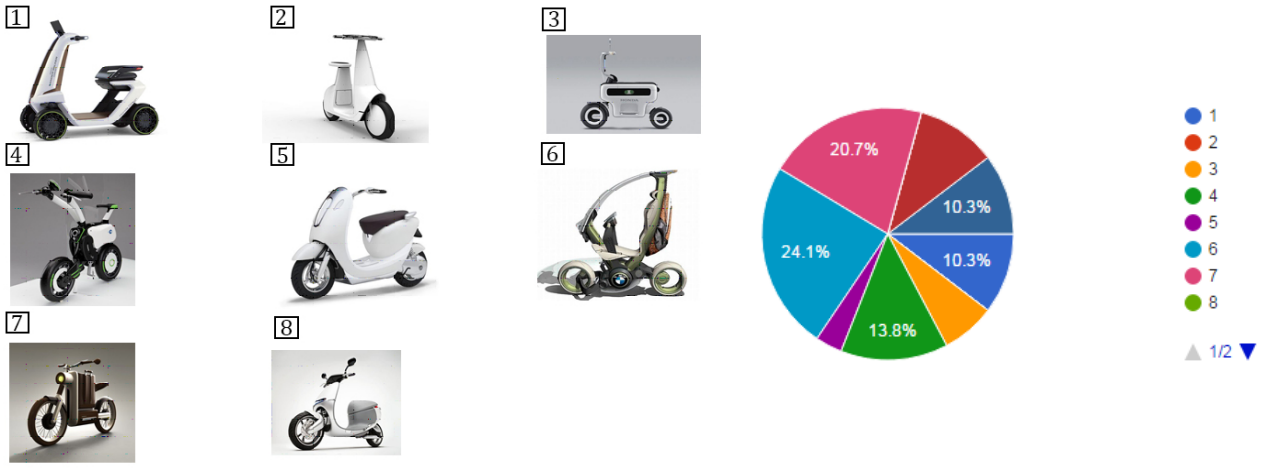

Figure 9. Proposed reference of scooter designs

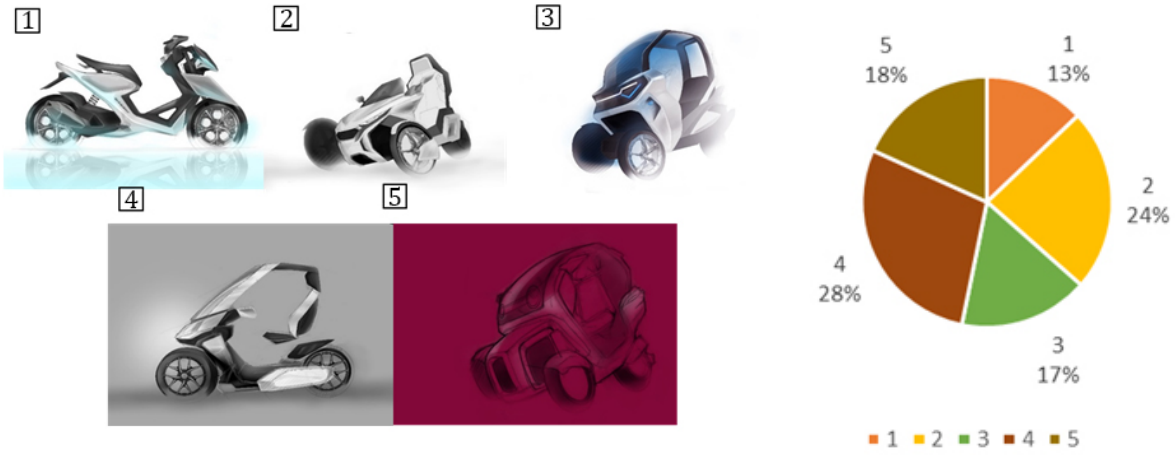

Figure 10. Proposed conceptual three-wheeler scooter designs

The respondents selected Design 4 as the most desired with 28%, as shown in Figure 10. Other designs, on the other hand, have a very minor percentage change. According to the results of the survey, respondents are more inclined to choose a concept scooter with a rooftop, which will allow them to ride in all weather. Eventhough the possible explanation for respondents to prefer Design 4 as their conceptual three-wheeler scooter design, the fact that this design appears more appealing with slimmer form resemble to humming bird form of characteristics. As compared to other design proposed, the side perspective of this design would be a possible way

to explain why the respondents prefer this design as compared to others which portray in three quarter front perspectives.

Special capability of the flying or hovering technique. It can fly right, left, up, down, backwards, and even upside down
Have a unique collision avoidance system built into their brains that allows them to perform high-speed aerobatics in safety
Feathers with structural colour reflect, scatter or absorb different wave lengths in different ways, resulting in changing colours
Can see ultraviolet light

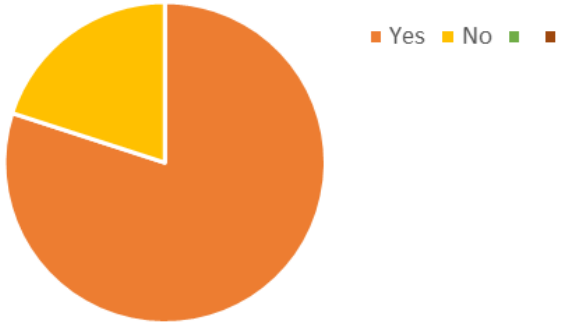

Figure 11. Suitability on humming bird characteristics for conceptual three-wheeler scooter design

The final questions accompanied by the characteristics statements on the humming birds were asked on the respondents' opinion on these advantages and look on the suitability to be applied to conceptual three-wheeler scooter design. From the fig. 11 above, it is clear that most of the respondents (80%) agreed that hummingbirds characteristics are suitable to be applied to conceptual three-wheeler scooter design.

DISCUSSION AND CONCLUSION

This study looks at biomimicry which is the study of the interaction and connection between transportation and nature. Biomimicry is a type of analysis that uses nature as inspiration. The development of a design process based on biological principles is then presented, which is then applied and associated to transportation design. Furthermore, it begins by investigating the use of biomimicry in existing transportation design, resulting in a series of design techniques and stages.

The characteristics of hummingbirds are translated into the technology of proposed conceptual three-wheeler scooter design. Hence, the proposed conceptual three-wheeler scooter design would consider the characteristics of hummingbird rather than its form or shape as external or exterior form or surfaces. The proposed concept imitating the function of nature by

transferring and suggesting the first level of biomimicry as posit by Zhang (2012). Fig. 12 illustrates the characteristics of hummingbird which is possible to be translated into the technology of proposed conceptual three-wheeler scooter design.

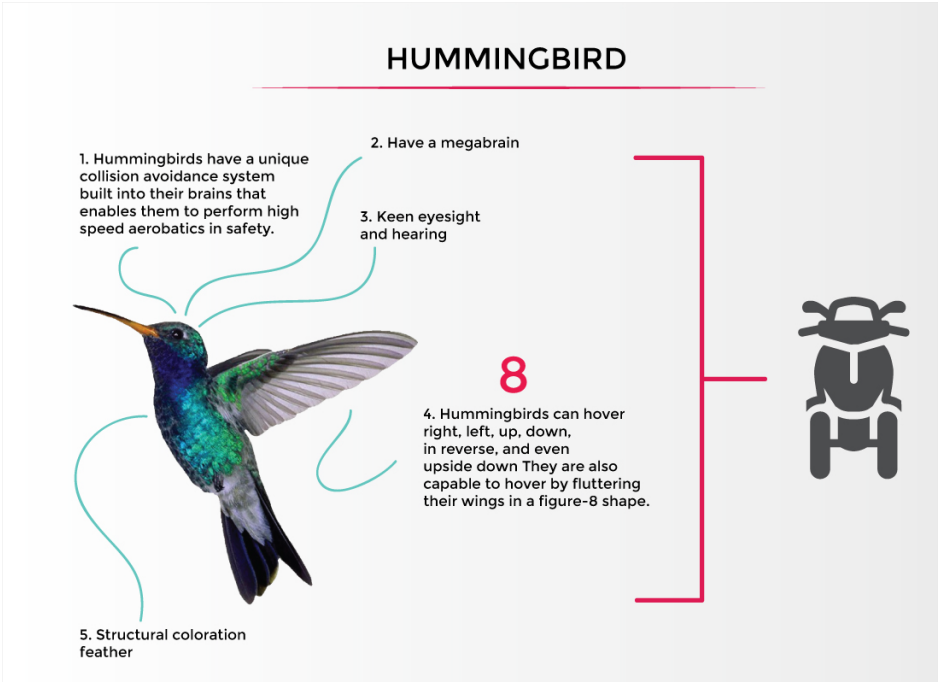

Figure 12. Proposed transferred biomimicry

The proposed technology were then summarized in Table 2 for further exploration of the development of this technique. The suitability of natures itself depends on the characteristics and the inspiration of the choosen type of transport.

Table 2
Characteristics and technology

Characteristics of hummingbird	**Technology propose for conceptual three-wheeler scooter**
Unique collision avoidance system and sharp sense	Ultrasonic sensors: Intelligent observation and gesture recognition
Mega brains	LIDAR or laser guided mapping
Flying technique	Magnetic levitation wheel

However, because of the methodologies and data analysis, this study was conducted as a basic of academic practice by design project and may need to be improved further. An actual survey consists of larger sample would determine the possibility of this technique into conceptual three-wheeler scooter design. In addition to this, a systematic analysis of data should be further utilized to determine the factor related to this technique. Furthermore, biomimicry has become a common consideration for many vehicle designers, who are looking for natural tactics that can outperform their own ideas. Biomimicry provides designers with practical, efficient, and

cost-effective solutions that nature has evolved over millions of years. As to summarise, nature without a doubt is the best engineer and most ingenious designer of all.

ACKNOWLEDGEMENTS

The authors are grateful to acknowledge Universiti Teknologi MARA (UiTM), Technology, Sciences, Social Sciences and Humanities International Conference 2021: The Virtual Series (TeSShi) and The Journal of Creative Practices in language Learning and Teaching (CPLT) of UiTM Kedah for providing the precious opportunity to publish this paper. The authors also would like to thank everyone who have helped in constructing this paper.

About the Authors

Associate Professor Ts. Dr. Azhari Md Hashim holds a Bachelor of Design in Industrial Design from Universiti Teknologi MARA, Malaysia, a Master Degree in Automotive Design from the Coventry University, United Kingdom and Doctor Philosophy in Design from Swinburne University of Technology, Melbourne, Australia. His expertise is specialized in emotion and perception on design aesthetics, automotive design and industrial design and has experiences in industrial collaboration with industry as well as consultancy with several public and private universities at local and international level. Currently, he serves as a Deputy Rector of Research and Industrial Linkages, Universiti Teknologi MARA (UiTM), Kedah branch campus.

Muhammad Faiq Hilmi bin Mohamad Zamberi holds a Bachelor of Design in Industrial Design from Universiti Teknologi MARA, Kedah, Malaysia, and Master holder in Industrial Design from Universiti Teknologi MARA, Shah Alam, Malaysia. His specializes in transport design and currently serves as Producer at Department of News, Radio Televisyen Malaysia RTM.

REFERENCES

Almaraz, I. P. (2019). *New dynamic pallet for Volvo trucks based in Biomimicry: New support modular and adaptable to different geometries, based in the structures of the radiolarian microorganisms and honeycomb.* (Bachelor's), University of Skövde, Skövde, Sweden.

Babbie, E. (1990). *Survey research methods* (2nd ed.). Belmont, California: Wadsworth Publishing Company.

Boaretto, J., Fotouhi, M., Tende, E., Francisco Aver, G., Ritzel Marcon, V. R., Luís Cordeiro, G., . . . Vannucchi de Camargo, F. (2021). Biomimetics and composite materials toward efficient mobility: A review. *Journal of Composites Science, 5*(22), 1-16.

Carter, D. (2004). *Quantitative psychological research: a student's handbook*. New York: Psychology Press.

Croskery, C. (2016). Hummingbirds' Unique Way Of Seeing Prevents Them From Crashing. Retrieved from https://www.newscientist.com/article/2097846-hummingbirds-unique-way-of-seeing-prevents-them-from-crashing/

Daimler Global Media Site. (2021). Taking its clues from nature – Mercedes-Benz bionic car. Retrieved from https://media.daimler.com/marsMediaSite/en/instance/ko/Taking-its-clues-from-nature--Mercedes-Benz-bionic-car.xhtml?oid=9361190

Galantai, V. P., Sofla, A. Y. N., Meguid, S. A., Tan, K. T., & Yeo, W. K. (2012). Bio-inspired wing morphing for unmanned aerial vehicles using intelligent materials. *International Journal Mechanical Material Design 8*, 71-79.

Harkness, J. M. (2004). An ideas man. *IEEE Engineering Medicine Biology, 23*, 20-41.

JM, B. (1997). *Biomimicry – Innovation Inspired by Nature* NY, USA: HarperCollins Publishing New York.

JR, W. (2021). High speed train inspired by the Kingfisher. Retrieved from https://asknature.org/innovation/high-speed-train-inspired-by-the-kingfisher/

Kharitonova, O. (2019). Isuzu announces bio truck design. Retrieved from https://auto.mail.ru/article/74820-isuzu_anonsirovala_gruzovik_s_bio-dizainom_foto/

Lurie-Luke, E. (2014). Product and technology innovation: What can biomimicry inspire? *Biotechnology Advances, 32*, 1494-1505.

Mayntz, M. (2017). How Hummingbirds Fly? What Makes Hummingbird Flights Unique? Retrieved from https://www.thespruce.com/g00/how-hummingbirds-fly-386446?i10c.referrer=https%3A%2F%2Fwww.google.com%2

McGregor, S. L. (2013). Transdisciplinarity and biomimicry. *Transdisciplinary Journal Engineering Science, 4*, 57-65.

Pedersen Zari, M., & Storey, J. (2007). *An ecosystem based biomimetic theory for a regenerative built environment*.

Rashidi, M. R. W., Frank, G., Seifert, R., Chapkin, W., Baur, J., & Walgren, P. (2019). *Biomimicry of the armadillo carapace for the design of bending cylinders for aerospace applications*. Paper presented at the AIAA Scitech 2019 Forum, San Diego, CA, USA,.

Saunders, M. N. (2007). *Research methods for business students* (5th ed.). India: Pearson Education India.

Sekaran, U. (2003). *Research methods for business: A skill building approach*: John Wiley & Sons.

Tobalske BW, Warrick DR, Clark CJ, Powers DR, Hedrick TL, Hyder GA, & AA., B. (2007).

Three-dimensional kinematics of hummingbird flight. *Journal of Exploratory of Biology, 13*, 2368-2382.

Vattam, S., Helms, M., & Goel, A. (2021). Biologically Inspired Design: A Macrocognitive Account. *Proceedings of the ASME Design Engineering Technical Conference, 5*. doi:10.1115/DETC2010-28567

Vincent, J., Bogatyreva, O., Bogatyrev, N., Bowyer, A., & Pahl, A.-K. (2006). Biomimetics: Its Practice and Theory. *Journal of the Royal Society, Interface / the Royal Society, 3*, 471-482. doi:10.1098/rsif.2006.0127

Warrick, D. R., Tobalske, B. W., & Powers, D. R. (2005). Aerodynamics of the hovering hummingbird. *Nature, 435*(7045), 1094-1097. doi:10.1038/nature03647

Wilson, M., & Mackenzie, N. (2000). Social attributions based on domestic interiors. *Journal of Environmental Psychology, 20*(4), 343-354.

Zhang, G. (2012). Biomimicry in biomedical research. *Organogenesis, 8*, 101-102.