

A REVIEW OF SUSTAINABLE DESIGN IN THE AUTOMOTIVE INDUSTRY

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ABSTRACT

To date, much research on the sustainability of the automotive industry has been published. The classification analysis method has been used to describe the relationship between sustainable design categories and the automotive industry. More than 50 articles related to sustainability towards the automotive industry were found from a search through a database on sustainability and automotive published between 2000 and 2018. This paper attempts to direct attention towards the user and responding to his needs when designing automobiles to help avoid overconsumption. The findings show that the past articles discussed 1) improvement and actions taken; 2) the impact of fulfilling the users' aesthetic and emotional needs; and 3) categories in sustainable products related to the automotive industry including green initiatives to sustainability, Malaysian industry and green initiatives, environmental aspects, sustainability in product life cycle, sustainable consumption, aesthetics and sustainability, end-life-remanufacturing, and product aesthetics, longevity, and user interaction. The study also found that sustainable design is considered less in meeting consumers' emotional and aesthetic needs. This study could benefit from making early decisions during the automotive design and development process to avoid the costs and time used through later redesign, especially in Malaysia. As a whole, this paper contributes to encouraging manufacturers to adopt new thinking to support the environment by considering the influence of users' aesthetic and emotional needs to improve the quality of the automotive industry.

Keywords: Sustainability, Aesthetic, Automotive, Green Product, User.

INTRODUCTION

Today, the automotive industry plays an important role in developing the economy by creating jobs, enhancing research, developing capacity, and strengthening production and parts assembly. Healthy growth courses have played a part in the significant growth of automotive demand (Wei et al., 2008). Recently, there is increasing concern from governments, consumers, and the public about the depletion of natural resources and increased pollution. The automotive industry has been identified as one of the highest discarders of commercial waste that damage the environment (Zailani et al., 2015). In general, the Malaysian automotive industry has been able to apply eco-product innovation which will lead to economic, environmental, and social development sustainability (Rashid & Shami, 2018). On the other hand, the Malaysian automotive industry has ignored the users and their needs (Escobar-Tello, 2016). As well as meeting the users' demands to contribute to reaching the aim of sustainability with fewer efforts, less time, and less money, categorizing the main themes related to sustainable products identified in the literature could also help to resolve this issue. Rather than claim to have the exact solutions to issues of environmental harm, this paper considers some aspects that have been less studied and that may be effective in addressing sustainability by focusing on the roots of the issue. In this paper, literature studies regarding sustainable products are included due to their strong links to the automotive industry. Furthermore, in some aspects, the Malaysian automotive industry is presented as an example to give a clearer explanation.

METHOD

The analysis classification technique is crucial to discovering knowledge in the process of skimming through databases (Fayyad, U., Piatetsky-Shapiro, G. and Smyth, 1994; Yamini and Ramakrishna, 2015). For this reason, this technique was used to assign categories to a collection of data provided by the online database to describe the relationship between sustainable design categories and the sustainable automotive industry that were published between 2000 and 2018. This technique was also used to answer the key questions of this paper: Is the automotive industry paying attention to users' emotional and aesthetic needs in designing sustainable automobiles? Does the design of automobiles encourage users to limit overconsumption through repair and reuse?

To provide a comprehensive review of the literature on sustainable automotive design, we first searched sustainable automotive design over the time span of 2000 to 2018. However, most publications focus on sustainable product design in general as related to the automotive industry. We retrieved papers that were published in this category from the online database with titles, abstracts, or keywords containing the expression 'sustainable product design and sustainable automotive design,' which yielded an initial set of more than 43 articles.

We did not include some articles that contained the words 'sustainable product design and sustainable automotive design' because their publication time is not within the chosen period of 2000 to 2018, or because their publication emphasized other sub-topics such as sustainability in technology or sustainable social innovation.

Next, we skimmed through the references of these articles in search of articles that were related to our topic but not found in the first search round. This added 13 articles. The final selection included more than 50 articles.

FINDINGS

The literature provides some subjects of sustainable products which were classified into three themes: 1) improvement and actions taken; 2) the impact of fulfilling the users' aesthetic and emotional needs; and 3) categories in sustainable products related to the automotive industry including. The third theme is comprised of eight categories which were identified as a) green initiatives to sustainability, b) Malaysian industry and green initiatives, c) environmental aspects, d) sustainability in product life cycle, e) sustainable consumption, f) aesthetics and sustainability, g) end-life-remanufacturing, and h) product aesthetics, longevity, and user interaction. In this study, the discussion on the third topic theme — categories of sustainable products related to the automotive industry — will be focused on due to the need for a better solution for automotive sustainability design.

The literature outlines some categories of sustainable products. Some of these categories have been studied quite often, such as green initiatives to sustainability, Malaysian industry and green initiatives, environment aspects, and sustainability in product life cycle, while other categories have not been studied as frequently. Although existing classifications provide good suggestions for reduction of environmental harm, they do not focus on the direct reasons for environmental conflicts. Unfortunately, this slows the progress towards sustainability.

1. Improvement and Actions Taken Related to Sustainability in the Automotive Industry

A sustainable product provides more consumer-helping solutions and improvements in social and environmental operations during the entire life cycle of the product compared to ordinary products (Dangelico, 2010). It is very challenging to design a fully sustainable product. Still, many associations are trying to further improve the sustainability of their products to keep up with their customers' rising demand for healthy, safe, and eco-friendly products (Sally, 2009). These sustainable industrialized products that, when designed, did not keep in mind the needs of future generations (Dangelico, 2010). Sustainable products also decrease their effects on the environment and decrease costs during the product's lifecycle while still trying to stay economically strong (Sally E, 2009).

For example, the Malaysian automotive industry considerably enhances the commitment of suppliers to environmental validation (Haines-Gadd et al., 2018). To influence commercial sustainability, companies must adopt an eco-culture. Products are modernized as the Malaysian automotive industry focuses on both energy and pollution during the production and discarding phases of the new product development process (Rashid and Shami, 2018).

However, the Malaysian automobile economy is focusing on these points rather than focusing on the users and their emotional and aesthetic needs which could affect the sustainability of the products (Trathen, 2000; Escobar-tello, 2016).

Unfortunately, if given a choice, most Malaysians prefer not to buy national marks, and those who do usually buy them due to their low price. Malaysian consumers tend to view international automobiles as desirable and will switch to these products as soon as possible (Baharom, Zolkifly and Tan, 2014).

The Malaysian automotive industry is one of the world's industries that are promoting the green eco-friendly product (Shatouri *et al.*, 2013; Rashid and Shami, 2018). However, this industry is not focusing on a product that fulfills the user's aesthetic and emotional needs. In other words, the Malaysian automotive industry replaces those needs with green products in an attempt to attain sustainability. The Malaysian automotive industry has been able to change its supply and production from traditional to eco-friendly (Haines-Gadd et al., 2018) by using product modernization, limiting both energy and pollution during production, and discarding phases of a new product (Rashid and Shami, 2018). According to the Malaysian Automotive Association (MAA) (2019), in January 2019 the market performance increased by nine per cent or approximately 3,890 units higher than January of 2018, sales had increased due to the clearance of stock and festive holidays, not for the preference of automotive design. In other words, if the emotional design had been better, then sales would have been even higher (Baharom, Zolkifly and Tan, 2014) Therefore, reach sustainability, companies must keep in mind users' aesthetic and emotional needs.

2. The Impact of Fulfilling Users' Aesthetic and Emotional Needs in Sustainable Design for the Automotive Industry

Harper (2018) and Zafarmand et al. (2009) indicate that product aesthetics might emotionally affect consumers' behaviour and interaction with the products. This, in turn, may indirectly affect sustainability in consumers' actions.

A sustainable product can be influenced by different themes and materials for its design, creation, and processing (Cucuzzella, 2009a, 2009b).

Moreover, aesthetics comprise an important part of a product’s sustainable improvement (Zafarmand, Sugiyama and Watanabe, 2003) Attractiveness should be considered to address the emotional, aesthetic, and functional requirements of society and users (Sevener, 2003). Aesthetic durability is an important part of a product’s sustainability because the product should be aesthetically sustainable during the user’s usage (Zafarmand & Ono, 2003). Sustainability diversity helps the user to create a good emotional relationship with the product on a psychological level to attain (Zafarmand and Sugiyama, 2002).

Products are usually not attractive, which is a reflection of the lifestyles and wants of the user. Aesthetics are an important aspect of product sustainable development. Design can help in increasing the sustainability of a local automotive.

To conclude, attractiveness should be considered in addressing the emotional, aesthetic, and functional requirements of users when designing an automobile. These elements are crucial for automotive sustainability and aesthetics during product usage.

3. Categories of Sustainable Products Related to the Automotive Industry

The findings show the following eight categories of main themes related to sustainable products:

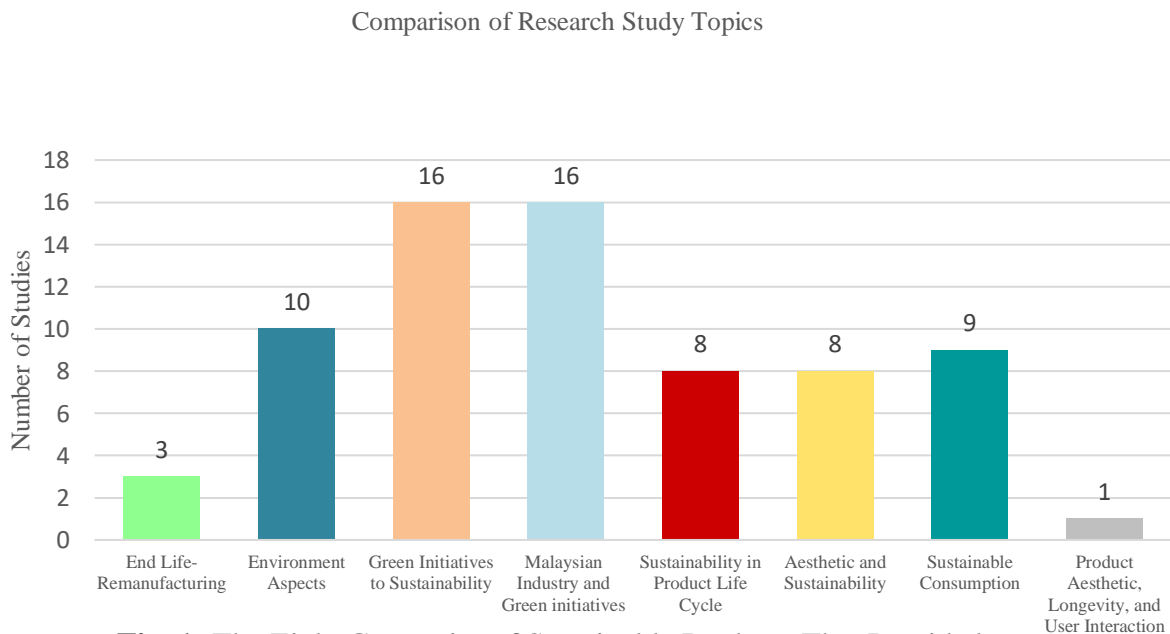


Fig. 1: The Eight Categories of Sustainable Products That Provide by Literature

Environmental aspects

According to Amli et al. (2014), environmental issues are human-caused. These behaviors require sustainable and strict actions which are important to the consumption future of consumers.

Environmental consciousness helps decrease pollution and waste during the production, use, and end-life of automobiles. This awareness can be raised by legislating strict and important rules and regulations due to rising ownership (Rothenberg, 2000; Zailani et al., 2015). Before, abidance with environmental regulations was perceived by most automobile industries as an extra cost rather than a very important process to stop environmental harm. As a result, firm environmental regulations and ecologists' supervision have altered the competitive rules in the market (Zailani et al., 2015). Thus, environmental aspects need to be kept in mind to help attain sustainability.

End-life and remanufacturing

The government of Malaysia has been trying different ways to tackle the problem of the end-life of vehicles. One of their regulations as a solution to this problem is to create easily disintegrated, reusable, and recyclable vehicle components and materials. Factors related to effective end-life automotive recovery should be studied in depth because they are correlated and connected. The causes and effects of these practices differ depending on the situation. For example, other regulations can lead to different results. In other words different investors have unlike aims. (Ali and Stephenie, 2017).

Remanufacturing generally means changing a used dead product of acceptable quality in the customers' viewpoint and giving it a warranty that is the same as other products of its type (Charter, 2007; Yusop, Wahab and Saibani, 2012).

The creation of green automotive was initiated because of global marketing development. Remanufacturing can help companies gain more and reduce the environmental damage of automotive death. The main point of remanufacturing is to lengthen the life of product parts; however, remanufacturing can affect the quality of the parts (Yusop, Wahab and Saibani, 2012). Thus, industries have poorly understood remanufacturing and confused this other 're' elements such as recycling, repair, and reconditioning. Therefore, an accurate understanding of remanufacturing needs to be ensured to encourage its usage.

Green initiatives to sustainability

Ineffective use of natural resources by automobile producers can result in pollution; in contrast, productivity can be increased through green innovation (Chen, Lai and Wen, 2006; Zailani *et al.*, 2015). Companies which initiate green innovation first have an advantage by charging higher prices for their green products. They can creatively include the green concept in their products to make them stand out from the competition (Chen, Lai and Wen, 2006; Zailani *et al.*, 2015). However, Harper (2018) indicates that sustainable products do not have the attractiveness that can motivate users to keep reusing and repairing them. Moreover, they usually do not have a suitable design to meet their customers' aspirations (Escobar-tello, 2016).

Also, for the most part the vast growth of technical improvements in products (Cucuzzella, 2011; Bijan, 2013) damages the environment. The consumer's role is to be an active part of sustainability resolution for the design of the product (Manzini, Milano and Jonas, 2006). As users, we must change our way of life to reach this degree of involvement (Parent, Cucuzzella, & Revéret, 2013).

It is important for environmental activists to see other projects as competition in a company. Public and legislation pressure along with any available cost reduction can reduce environmental damage (Nunes & Bennett, 2010) and may lead to sustainability.

Malaysian industry and green initiatives

Green innovation, as defined by Zailani et al. (2015), is producing and assimilating a product, service, or management methods that are new to an industry and that lessen environmental damage and pollution through the product's life cycle. Also, Wong and Mo (2013) believe that green innovation makes it easier to reduce the product's impact on the environment. Green innovation, which tries to follow this strategy through a product's lifestyle, leads to sustainable consumption (Zailani et al., 2015).

In the Malaysian automotive industry, there is much waste produced even at research and development stages, for example clay modelling and fabric which actually have a very high cost. To reduce their effect on the environment, manufacturers recycle these materials through reuse or by sending them to other institutions for other purposes. Consequently, if this happens in the early automotive development stage, we can expect increased waste which will be produced in the actual automotive manufacturing process. This scenario needs further investigation.

Finally, to help achieve Malaysia's goal of reducing 40 per cent of carbon intensity by 2020, the safety, security, and environmental movement will help by minimizing carbon emissions, increasing fuel efficiency, conserving the environment, and preserving natural resources (NAP, 2014).

Sustainability in product's life cycle

According to The Lowell Center Framework for Sustainable Products, a sustainable product is sustainable throughout its life cycle and considers its effects on its production and disintegration system (Sally, 2009). A product designer can benefit from using sustainable designs and utilizing methods that sustain a product's duty during its life cycle (Charter, 2007). Also, design methods do not always reflect the operability and aesthetics of the product, nor its environmental impact from the early design stages and improvements. Some products have short lives, but long technological lives (Li, Yu and Gao, 2014). However, focusing on disintegrating technologies and controlling pollution must be maintained to advance recycling networks (Ali and Stephenie, 2017) and reduce environmental harm.

Aesthetics and sustainability

Emotional values that attract the user aesthetically can create sustainability, but this is a fact designers so often ignore (Harper, 2018). According to Hogg & Alba (2011), a product's aesthetic design can describe its quality and functionality and thus increase its probability of being purchased (Luchs, Brower and Chitturi, 2012; Magnier and Schoormans, 2015). Therefore, a product with excellent aesthetic design can signify excellent quality to consumers. Thus, to conclude, this indication of quality will support its sustainability because aesthetics is an important aspect of a product's sustainable development, as referred to in the literature.

Sustainable consumption

To effectively move toward sustainable consumption concept, consumers, especially in developed countries, must sufficiently consume less to also make this concept more efficient. To achieve sustainable consumption, there must be sustainable policies. These policies should focus on lessening environmental harm by using fewer materials, especially toxic and harmful ones (Boulanger and Mainguy, 2018). Also, a user should be involved in finding a sustainable solution for the designing of products (Manzini, Milano and Jonas, 2006). To conclude, we must change our ways of production and our lifestyle to reach this level of involvement (Cucuzzella, 2013).

Product Aesthetic, Longevity, and User Interaction

To lengthen a product's life, aesthetic durability is one of the key factors when designing and improving a sustainable product. On the other hand, aesthetic discontinuation makes a product unsustainable (Zafarmand and Ono, 2003). To further define sustainability, durability must first be defined:

- Durability is related to sustainable ideas and progression.
- Durability is the use of recyclable, easy-to-fix sustainable materials that do not wear out quickly.
- Durability can also mean easy utility and resilience.

Simplicity is a must for durability because the human eye can analyze a product quickly. Finally, aesthetic appeal is important to aesthetic durability. Users will only want to reuse a product if it is aesthetically sustainable (Harper, 2018). Dullness may be regarded as a negative effect to aesthetic durability. Concludingly, lessening the dullness of a product increases its aesthetic sustainability and product life (Zafarmand and Ono, 2003).

DISCUSSION

Past research on sustainability has confirmed that a sustainable product gives solutions in its whole lifecycle that can help consumers and social-environmental operations in contrast to ordinary products. These matters beg the question of what is the sustainable design ability to achieve this purpose, and to what extent? Research has begun to highlight the importance of designing sustainability in product life cycle, but it has been found that it is challenging to completely design a sustainable product as referred by Ali and Stephenie (2017). Ignoring the aesthetic and emotional demands of users could be the reason, possibly because the automotive industry is focusing more on disintegrating technologies, controlling pollution, and advancing recycling networks besides the green initiatives to sustainability. Moreover, additional work is needed to enrich this view.

The review that we created shows that any organization has the goal of attending to the primary desires of users while protecting the environment from any further crisis that can arise from human use and automotive industrial waste through sustainability in product life cycle and green initiatives to sustainability. This goal can aid coming generations to live in a clean environment and have access to a small supply of natural resources to help keep them alive. However, these attempts have not yet reached an effective solution. Public and legislation pressure along with any available cost reduction could reduce environmental damage. Malaysia is working on reducing 40 per cent of carbon intensity by 2020.

Since sustainability is essential in the current century, specifically with the development of the industrial automotive economy, new solutions should be found by designers and companies concerning sustainable methods in the automotive production economy. As well as aiding designers in contributing to finding solutions to environmental and social problems, sustainable automotive design does not lessen the creativity of a designer despite what some claim.

Sustainable design should try to create products that are strong and can be repaired and reused easily (Harper, 2018). Although research has praised superior green design capabilities such as green initiatives to sustainability, these designs concentrate solely on environmental aspects and the human-caused damage that is sustained while trying to convince clients to purchase a green vehicle. Enabling consumers to settle on aesthetic and ethical decisions in automotive includes aesthetics and sustainability to diminish overconsumption which is the main target of sustainable product design. This must be the focus rather than focusing on sustainable consumption because

controlling pollution and trying to lessen it are not sufficient according to the literature. The method of controlling and reducing pollution cannot decrease natural harm since it has focused on the impacts and not genuine reasons for this pollution. This paper strongly supports what was shown by Cucuzzella (2009a) and Rashid and Shami (2018) that the leading cause of pollution is overconsumption, which is why sustainability is needed in this method. This paper attempts to directly consider the user by responding to his needs when designing automobiles, because users live in sustainable ways only for a benefit they are trying to attain as shown in the study by Marchand and Walker (2008). Consequently, the design of automobiles has to provide the aesthetic and emotional pleasure expected by the user in order to encourage his sustainable behavior. As well, an excellent aesthetically designed sustainable product gives it preference in the likelihood of being purchased. Superior aesthetic design empowers sustainable products that lack confidence, as indicated by the literature. This paper agrees that developing aesthetic design in automobiles will strengthen manufacturers and augment their competitive power.

Concerning the product's end-of-life, a better understanding of this term may lead to the sustainability of creating easily disintegrated, reusable, and recyclable designs to reduce the impact of automotive manufacturing on the environment. The term end-of-life indicates that a product is made obsolete and does not receive continuing support, manufacturing, improvement, repair, or maintenance because existing marketing, support, and other processes are terminated. This is the end of its useful life. As mentioned previously, the causes and effects of these practices differ depending on the situation. A deeper investigation may be needed to understand the relationships and identify the difference between the terms remanufacturing and end-of-life as well as 're' elements such as recycling, repair, and reconditioning.

The important question is, can the sustainability concept support the capabilities of the product and manage it in terms of end-of-life by remanufacturing to lengthen the life of the product's parts and to maintain its quality? Working within the other categories such as product aesthetics, user interaction, and longevity could support the automotive industry and make it environmentally friendly. Based on the findings from this review, aesthetics should be included in designing automobiles and avoiding dullness to encourage users to reuse and maintain products, as well as support the products under the remanufacturing concept.

There is a relationship between some interrelated components that the literature did not highlight. However, these components play a positive role in designing sustainable automobiles, such as product aesthetics, longevity, and user needs. If we look at these components under the sustainable automotive concept, the links between them are apparent through considering how user needs and product aesthetics lead to an emotional interaction between user and product. This emotional interaction could positively affect the sustainable consumption by the user (see Fig. 2). As a result, all of these elements drive automotive aesthetic sustainability, and at the same time support the environment through longevity. Together, these elements may lead the way to achieve sustainable design in the automotive industry.

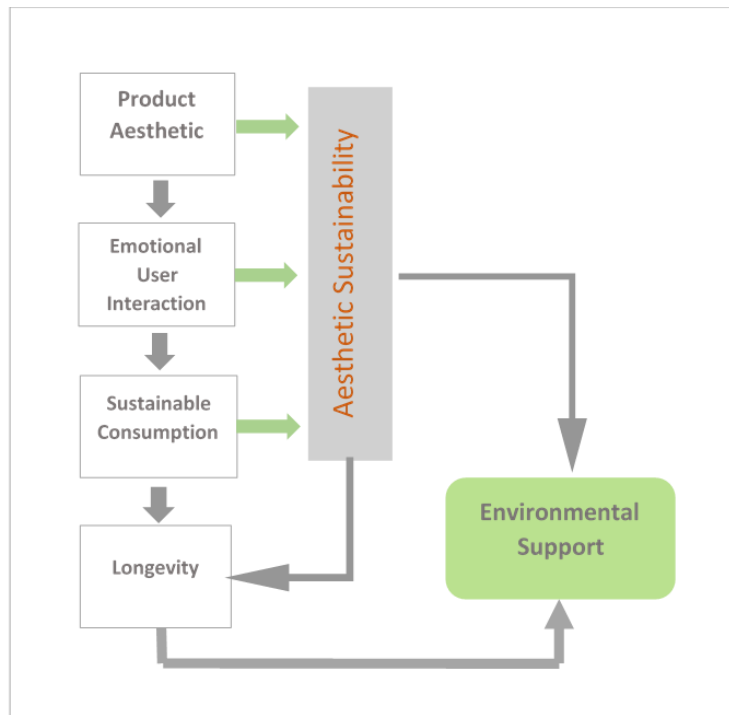


Fig. 2: The Relationship between The Sustainable Products Categories

CONCLUSION AND RECOMMENDATIONS

There is a need to consider users' emotional and aesthetic demands in design within the Malaysian automotive industry. This consideration could help inform decisions at the early stage of the automotive design and development process to avoid the costs and time used through later redesign. This paper suggests adopting new concepts that depend on sustainable design application to improve the quality of the automotive industry by looking at the users' aesthetic and emotional demands while at the same time solving the existing design problems that face the Malaysian automotive industry when resolving environmental issues. Based on a review of the literature, this paper identifies eight themes: green initiatives to sustainability, Malaysian industry and green initiatives, environment aspects, sustainability in product life cycle, sustainable consumption, aesthetics and sustainability, end-life-remufacturing, and product aesthetics, longevity, and user interaction. This paper reveals that sustainable design gives less value to users' emotional and aesthetic needs. As well, product aesthetics, longevity, user needs, and end-life and remanufacturing were only briefly considered in the literature. Thus, this paper recommends focusing more on these categories in future studies. Also, this paper recommends that manufacturers consider users' emotional and aesthetic needs to achieve sustainable design and cooperation in the growth of the economy to support the environment.

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