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# EFFECT OF DESIGN THINKING TO DEVELOP MARINE AND COASTAL ENVIRONMENTAL ATTITUDES

CORRIENNA ABDUL TALIB[1]*, FARUKU ALIYU[2], ADI MAIMUN ABDUL MALIK[1], KANG HOOI SIANG[1], CHIN CHEE KEONG[3], MOHD ERFY ISMAIL[4] AND MOHD ALI SAMSUDIN[5]

*[1]Universiti Teknologi Malaysia, Johor, Malaysia. [2]Sokoto State University, Sokoto, Nigeria. [3]Teacher Education Institute Malaysia Tuanku Bainun Campus, Pulau Pinang, Malaysia. [4]Universiti Tun Hussein Onn Malaysia, Johor, Malaysia. [5]Universiti Sains Malaysia, Pulau Pinang, Malaysia*

**Corresponding author: corrienna@utm.my*
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**Abstract:** This paper analysed the effect of the design thinking approach on the student's awareness of marine and coastal environmental sustainability. The paper employed an experimental design and utilised a sample of 35 students using an online questionnaire through a Google form validated by experts in educational research. Based on the analysis of their responses, the findings revealed that the respondents are fully aware of the harmful effects of marine and coastal pollution on human lives. It is imperative to prevent the proliferation of plastic products in the environment, even if it means sacrificing something to slow down marine and coastal pollution. Also, students agreed that there is a need for awareness that despite the continual contamination of rivers and oceans, nature's purifying processes soon return to normal when they have good management. The paper concluded that even with the awareness of marine and coastal pollution, there is still a lack of understanding of the holistic consequences of marine plastic and the resulting impact on ecosystem services, as well as the implications for human health, society, and the economy. It is limited to a small sample size, quantitative data and simple statistical tools of frequency and percentages and recommended that an approach such as design thinking focusing on marine and coastal pollution could be used in schools and the government needs to introduce harsh measures to halt marine and coastal pollution since very few people will regulate themselves.

Keywords: Design thinking, marine coastal, environment, attitudes, pollution.

## Introduction

Marine pollution is a combination of chemicals and debris which mostly comes from land sources and is washed away by some external forces and gradually get into the marine environment. The introduction of substances into the marine environment by humans causes harmful effects that endanger human health, interfere with marine activity, and reduce seawater quality. These effects deny seawater from serving a variety of uses (Verma *et al.,* 2020). This pollution damages the environment, affecting the health of living things and the economic structure of the coastal regions.

Coastal regions and oceans are complicated and fragile environments with many capabilities connected to public fitness, food security, and different financial and social advantages. These also are decisive factors within side the relief of poverty. Healthy estuary, nearshore and oceanic structures offer cultural heritage, meals, constructing materials, conventional livelihoods, tourism opportunities, transportation routes, hurricane protection, organisms for biotechnology and lots of greater advantages which might be regularly not noted or abused.

Although the financial valuation of ecosystems wishes to be dealt with cautiously, it is common that the products and offerings brought through nature are well worth trillions of dollars. Some primary worldwide figures are on the cost of ecosystems and the advantages of sports in those ecosystems (Epps & Benbow, 2007). The value of coastal and marine environments is reflected through

the sports carried out on land. In addition, clearing vegetation, mining, and constructing roads, houses and accommodations can destroy habitats and fill rivers and estuaries with dust and silt. Daily inhabitants produce a large quantity of waste and sewage that poisons groundwater, rivers, lakes, and oceans. Industrial and agricultural manufacturing sent down pollutants to rivers and coastal waters, which could result in algal blooms and infected seafood products.

This primarily generates dangerous influences and collectively affects the fitness of the valuable salt and brackish water ecosystems and those who depend upon them as a supply of wealth, splendour and recreation. It is essential for the general public, and especially young learners, to be aware of the detrimental effects and consequences of polluting the marine and coastal environment since coastal regions are considered part of human settlements due to their productivity, environmental attributes, and cultural offerings. Their awareness of these effects and consequences would no doubt help curb and attain environmental sustainability.

## Conceptualisation

The major concepts considered by the paper were discussed under the following headings:

### *Design Thinking*

Design thinking is often defined as an analytical and creative process that provides the opportunity to experiment, create models and prototypes, solicit feedback, and redesign. Hence, an individual quickly identifies the implication of action regarding the environment. The literature identifies several characteristics that a good design thinker should possess. According to Razzouk & Shute (2012), design thinking also attracts increasing attention in the business environment and many sectors.

This is because the design of products and services is an important component of business competitiveness, so much so that many well-known companies have committed to becoming design leaders. Design thinking has become an integral part of design, engineering, and business, but it can also positively impact education in all 21st century disciplines. Students must read critically, think and reason logically, and solve complex problems in an academic setting. To help students succeed in our interconnected digital world, educators should help students develop and refine 21st century skills (e.g., design thinking, systems thinking, and teamwork) to improve their problem-solving abilities and prepare them for college and careers. These skills are consistent with the theoretical tradition of situated cognition. What is new is that individual and collective success is increasingly seen as dependent on possessing these skills. This kind of ideology brings about awareness among learners.

### *Marine and Coastal Pollutants*

Marine pollutants include tough biological contaminants, endocrine-disrupting chemicals such as mercury, pesticides, pharmaceuticals, waste plastic oils, large quantities of metal compounds and other related chemicals such as phthalates, personal care products, and agricultural and industrial wastewater. The scope and scale of marine and coastal pollution are enormous and difficult to determine fully. Hence, their risks and multiple hazards in ecological contexts are not fully understood.

There are no human health statistics or ecological data for many marine and coastal pollutants, and knowledge of the effects of endocrine disruptors on the reproduction, growth, and general livelihood of aquatic and other marine and coastal organisms is still in its infancy. This is because chemicals enter the marine environment through various pathways, including atmospheric transport, direct disposal, and flux into waterways. It is estimated that 80% of marine and coastal pollution originates from land.

Over time, due to climate change, the coastal and marine environment has experienced an exponential increase in oxygen depletion and harmful chemicals, as well as an excess of chemicals flowing from land and land into

rivers, causing various forms of coastal and marine pollution.

Oxygen levels in the oceans and coastal areas have increased tenfold due to nitrogen, phosphorus, sewage, and organic material. These marine and coastal environments have changed dramatically in a very short period due to human and other biological activities and have enormous ecological impacts. Most of the world's waste, about 20 billion tons per year, enters the coasts and oceans without pretreatment. With the growing world population, which is expected to reach nearly one billion people by 2050, resource consumption and use will increase significantly, resulting in large amounts of waste, and coastal and marine pollution, despite recycling some consumer goods (Matthies-Wiesler & Franziska, 2019).

In addition, the production and consumption of chemicals are increasing daily. The production and use of these chemicals, which exceeds one million tons per year, also contribute to the global increase and concentration of marine and coastal pollution and undermine the role of governments in providing a sustainable environment.

***Environmental Sustainability***

A sustainable environment supports the satisfaction of the needs of current inhabitants without compromising the ability of future generations to meet their needs (Morelli & Morelli, 2011). Environmental sustainability encompasses a wide range of issues, from site-specific to global. Global issues include greenhouse gas reduction, climate change and renewable energy, while site-specific issues include soil erosion, water management, water quality and pollution.

***Pollution and marine environment***

The sources of pollution in the world's marine (oceans) are as varied and numerous as the types of human activities. The diversity is as great as the types of human activities. First, they fall into several broad categories. They can also be classified according to the following factors. The nature of human activity in domestic wastewater, industrial and agricultural waste disposal. Disposal of agricultural wastes, intentional and operational discharges of pollutants from ships. Adverse effects on the marine environment from exploration and exploitation of marine minerals, disposal of radioactive waste from peaceful uses of nuclear energy, and disposal of radioactive waste from military activities (Theint, 2017). Disposal of radioactive waste from peaceful nuclear energy and military uses of the sea. The enormous number and size of today's ships raise serious concerns about the increased risk of marine pollution.

Another factor is the traditional use of fishing which has also experienced unprecedented expansion. Since ancient times, pelagic fishing has become an industry (Theint, 2017). Today, pelagic fishing has become an industry that impacts living resources in even the most remote and inhospitable parts of the oceans. Total annual catches are declining for many stocks. As total annual catches of many stocks decline, sustainable management of living marine resources appears to be reaching its limits. The fact is that fish caught today are increasingly showing signs of contamination and degradation. Signs of contamination include concentrations of carcinogens, tumours, wounds and deformities. In addition, malformations make them unfit for consumption and threaten their ability to reproduce. Concentrations and impacts of contaminants vary from area to area, but coastal waters are generally affected.

In general, coastal waters are the most polluted, while the open ocean is relatively clean. The high seas, on the other hand, are relatively clean. Its' devastating effects permeate almost every aspect of marine activity (Theint, 2017). Therefore, the marine environment must be protected for its own sake so that society can function effectively and productively.

Effective legislation must therefore be prioritised to strengthen the national marine pollution regulations, marine perspective in regional treaties, and international conventions

on marine pollution. The marine perspective in regional treaties and international conventions should be considered. In this context, it is noteworthy that many comprehensive international conventions provide uniform standards for controlling global marine pollution.

However, the most important determinant of coastal behaviour is the desire for profitability. When we can show that communities improve through sustainable funding Mechanisms. Community attitudes and awareness play an important role in implementing regulations and adopting adaptive management plans. Relationships between people and their environment, especially in developing coastal communities, rely on the availability of marine resources to survive (Epps & Benbow, 2007). In addition to the biological properties of the environment, human interdependence should also be recorded to determine the sustainability of coastal ecosystems. The long-term integrity of protected areas in low-income countries relies heavily on support for rural communities living adjacent to protected areas.

The human spots can be chargeable for the main decline of the world`s organic diversity, and the trouble will become more complex, whilst mixed human effects should be more advantageous, giving loss prices to 1000 – 10000 in some cases. In the seas, marine lifestyles face threats in many ways, along with overexploitation and harvesting, a deposit of waste, contamination, exclusive species, soil recovery, dredging and global weather change. One of the fundamental sorts of human effects constitutes the main hazard to marine lifestyles: The pollutants of using plastic particles (Vikas & Dwarakishb, 2015).

The worldwide network has diagnosed that herbal assets are getting used up at a quicker tempo than they may be restored, that the Earth`s assets aren't limitless, and that environment maintenance is carefully associated with maintaining the human species. Specifically, these concerns pertain to the international stock of the nation of the Earth about ecosystems and, more importantly, the attitude and mindset of the general public and organisations concerning natural resources (Diener & Mudu, 2021). This attempt is a try and meets the developing needs for goods (i.e., food, clean water, timber, fibre, and fuel), manage of increased danger of surprising environmental changes, accelerate poverty for a few companies of people, control decay of the environment service.

Marine and coastal environments all over the globe provide a conducive habitat for various kinds of living organisms (the benefits people acquire from nature), which include the provision of food and other mineral resources to quite a large number of people and recreational opportunities and transcendent enhancement (Liquete *et al.,* 2013). Any danger to the continuous provision of these ecosystem services has the potential to have a large negative impact on human well-being worldwide due to the loss of food security, livelihoods, income, and good health (Naeem *et al.,* 2016).

Plastic contamination in the marine environment is significant and increasing (Geyer *et al.*, 2017). The marine and coastal environment is a highly productive zone consisting of various subsystems such as coral reefs and sea grass. It is a complex environment rich in biodiversity, from various primitive organisms (horseshoe crabs) to advanced organisms (dolphins). The marine environment is a vast body of water that covers 71% of the Earth's surface. However, the world's marine system is divided into five major oceans and many oceans based on historical, cultural, geographical, and scientific characteristics and size differences. The five basins of the Atlantic, Pacific, Indian, Arctic, and Antarctica are the most prominent marine systems invaded by humans.

In 2010, an estimated 4.8 – 12.7 million metric tons of plastic were released into the world's oceans through land-based sources, and the flow of plastics into the oceans is expected to increase by order of magnitude over the following decade (Jambeck *et al.,* 2015). Even with these effects, there is still a lack of understanding of the holistic consequences of marine plastic and the resulting impact on

ecosystem services and the implications for human health, society, and the economy. What is known is typically based on small-scale, local research that is difficult to transfer or scale up (Ten Brink *et al.*, 2016). However, the impact of marine plastic is a global concern, and a summary of current research is needed.

While some of this plastic may break down into minute fragments known as "Microplastics" (0.1 m – 5 mm) over time, the great majority of it remains intact over geological time-frames in the environment in some way (Andrady, 2015). While it is possible to remove some marine plastic, it is time-consuming, costly, and inefficient. Based on this development Nander (2017) revealed measures regarding the protection of the marine environment under the law of the sea by the United Nations to include harsh sanctions for violators and train younger ones to develop a positive attitude toward a better environment.

### *Human Attitude toward the Environment*

The implementation of the initiated development against the damage in coastal areas, such as the pollution of water bodies, flows not only from land and river areas but also from coastal areas to the sea. The destruction of biological resources through various unnatural means harms biological resources (mangroves, coral reefs, and fish) and the socio-economic decline. Various development activities such as port development, industry, housing, tourism, mining and fishing on the beaches and coasts of the region have created various issues and problems in the use and development process, creating many life challenges. The above situation stems from the ambiguity of using the coast and coastal areas.

In a similar narrative, Allen (2011) stated that humans are among the polluters of coastal and marine pollution, which is not a new phenomenon in our world but is increasing due to their actions. Sources of pollution in coastal waters usually include sewage, industrial wastes, and liquid wastes (municipal store stormwater shipping, fisheries, and agricultural cultivation). Most of the pollutants in waste disposal have been found in nutrients, sediments, toxic metals, pathogenic organisms, pesticides, garbage and oxygen gases that reduce dissolved oxygen in seawater. Pollutants originating from various industrial and agricultural production and households on the continent negatively impact rivers, coastal waters, and oceans (Herman, 2012). The effects that occur cause damage to mangrove ecosystems, the life of various biota), coral reefs, scraping occurs, and the land of appendix seeds and shrimp.

Residents must consider the possible interaction between the materials in the aquatic environment, including the water body shore, i.e., the carrying capacity and dissents of water associated with local marine conditions, chemical and biological properties of waste and the aquatic environment. However, the possibility of showing mutually supportive processes that neutralise the effects of already present pollutants that later enter is worth mentioning. Therefore, it is important to understand the potential for increased pollution and environmental degradation by understanding the physical properties of chemical contaminants and water. For example, waste from the gold mining process is never separated in gold mining. The physical diversity of wastes includes gases, liquids and solids. Physically, the waste gas contains dust and particles; chemically, it can be a solution of different gases, depending on the type of ore processed. Liquid wastes contain toxic chemicals of heavy metals and cyanide in relatively high concentrations. For solid wastes, the chemical composition depends mainly on the source rock.

Disposal of domestic waste, industrial waste, leaks from water tanks, and surplus and radioactive materials dumping are the main sources of marine and coastal pollution. Heavy metals and industrial wastes can contaminate water bodies and threaten human and animal life. In addition, toxins from industry are the main cause of immune system destruction, reproductive disorders, infectious diseases such as fever and cholera (Juneja & Chaudhary,

2013) and other gastroenteritis diseases such as vomiting, diarrhoea, kidney and skin problems, transmitted by polluted marine and coastal waters (Herman, 2012). The direct damage to plant and animal nutrients indirectly affects human health. Marine and coastal pollutants kill algae, mussels, seabirds, fish, lobsters and other marine organisms that serve as food for humans. Concentrations of pesticides such as DDT increase in tandem with organic phenomena. Marine pollutants affect the health of organisms in the marine and coastal environment, their inhabitants, and those who feed on and shelter from the water. Every day, more and more chemicals are being released intentionally or unintentionally, and more and more litter, mostly plastic waste, is entering waterways and the marine environment (Lloyd-Smith & Immig, 2018).

***Ecological Sustainability***

Ecological sustainability is the organised interaction with the natural environment to provide for the reduction of natural resources and pollution of the natural environment and to maintain the quality of the environment over time. A sustainable environment supports the satisfaction of the needs of current inhabitants without compromising the ability of future generations to meet their needs (Morelli & Morelli, 2011). A closer look at the natural environment shows that it can renew and maintain its capacity. A common example: When a plant falls over, it decays and releases nutrients into the soil. The chemicals in the nutrients help ensure that new and immature plants have normal conditions to grow and thrive.

When the natural environment is unimpeded, it can sustain itself tremendously. However, the situation changes when humans invade the environment and use the vast amounts of natural resources it provides. Human behaviour consumes natural resources, and long-term practicality is threatened without an environmental sustainability approach.

One way to implement a sustainable environment is through sustainable agriculture. This is also referred to as using environmentally sound agricultural practices. Sustainable agriculture emerged from the need to industrialise agriculture, which began in the 20th century (Matthies-Wiesler & Franziska, 2019). Although industrial agriculture can provide large quantities of food at cheaper prices, its farming strategies can harm environmental sustainability. When chemicals flow into canals, these strategies lead to water pollution, depletion of water resources through overuse, depletion of soil nutrients and reduction of soil quality through forcible cultivation. Farmers reduce their water use and reliance on fertilisers, pesticides, and pest control products in sustainable agriculture. They also reduce tillage and rotate crops yearly to ensure better soil quality.

The role of bio-fuels in a sustainable environment is primarily about greenhouse gases. It is about reducing emissions (carbon dioxide, methane, and nitrous oxide), but the impacts are controversial. The main sources of non-CO2 greenhouse gas emissions are agricultural practices such as fertiliser use, tillage, pesticides, irrigation methods, and harvesting (Morelli & Morelli, 2011). Land use upstream of biofuel production is important in assessing environmental factors. The use of forests and grasslands for conversion to bio-fuels will significantly reduce greenhouse gas emissions. The sustainability of biomass-derived biofuels is typically measured through life cycle analysis (LCA), which requires input and output data for all stages of the product life cycle (biomass production, feed-stock storage and transportation, biofuel production, transportation, and end-use). All production data includes leaked gas, recovered gas, and by-products. However, the environmental impacts of biofuel production and consumption in LCAs depend highly on the assumptions made for key parameters, and results can vary significantly.

Another important reason for using bio-fuels may be the replacement of fossil fuels with bio-fuels, which provide energy substitution. It is important to track the energy content of bio-fuels and the number of fossil fuels used in their

production, as this determines their contribution to emissions reduction (Matthies-Wiesler & Franziska, 2019). The energy required to produce bio-fuels also includes the energy needed to grow and harvest the feedstock. This process requires a certain amount of energy, such as fertilisers, pesticides, irrigation, and tillage systems. The conversion of feed-stocks into bio-fuels and their use in production and marketing is also essential.

The sliding islands of waste and the monstrous accumulation of plastics have become painfully apparent. Our oceans have gradually become a major source of pollution, with extreme environmental, health, social and financial implications. This threatens lifestyles and viable improvements in many parts of the world (Morelli & Morelli, 2011). A striking example is the Caribbean, where many people depend on the blue economy, including tourism and fishing.

The sliding islands of trash, a monstrous accumulation of plastic, are now painfully apparent. Our oceans have gradually become repositories for many enormous pollutants with extreme environmental, health, social and financial impacts. This poses a real threat to lifestyles and viable improvements in many parts of the globe (Morelli & Morelli, 2011). A striking example is the Caribbean, where many people depend on the blue economy, including tourism and fishing.

As stated in another World Bank report regarding Marine Pollution, around 80% of pollution comes from land, and more than 320,000 tons of plastic waste go uncollected each year in blue waters and on white-sand beaches. The destruction of coral reefs and marine pollution is expected to result in revenue losses of between $350 million and $870 million per year

### *Design Thinking for Better Awareness of Environmental Sustainability*

Effective environmental education is not just a one-way transfer of information but a toolkit that develops and improves environmental awareness, attitudes, values, and knowledge and builds skills that prepare individuals and communities to work together for positive environmental action (Ardoin, Bowers, and Gaillard, 2020). Environmental education also facilitates the connection between actionable research and on-the-ground practice by creating spaces of synergy and enabling stakeholders to work together over time to address dynamic environmental issues. Because of this commitment to application and repetition, environmental education can provide immediate environmental benefits and address conservation issues concretely. However, achieving these tangible impacts can be tortuous, and solid data documenting change is difficult to obtain.

Bongarts *et al*. (2021) stated that in the face of rising sea levels and increasingly extreme events, people in coastal areas are developing measures to address the situation on the ground. A comprehensive analysis of the literature on adaptation measures in coastal areas has identified various adaptation strategies. The analysis of these strategies draws on the complexity of their institutional and technical implementation. It reveals two contrasting paradigms - 1). Resilience to sea-level rise or adaptation to new climatic conditions; 2). The level of integrated management of the strategy. This typology distinguishes four archetypes and the most commonly related management models. They then highlight the need for hybrid approaches and adaptation pathways that consider local sociocultural, geographic, and climatic conditions and involve stakeholders in the design and implementation of measures. They note that adaptation actions rely on the knowledge and participatory engagement, multilevel governance, political monitoring, and territorial solidarity. These conditions are particularly important for densely populated areas that will face sea-level rise, especially for coastal cities. The government also needs to carry out certain actions, for example, preventing the degradation of the marine environment from land-based activities by promoting the fulfilment of States' obligations to conserve and protect the marine environment.

The CAP aims to assist states within their respective policy priorities and resources to act individually or collectively to prevent, reduce, control, and/or eliminate marine environment degradation and recover from land-based activities' impacts (Horan, 2016). Achieving the goals of the Action Program will help maintain and, where appropriate, ensure the protection of human health and promote the conservation and sustainable use of living marine resources.

It is now clearly established that plastic harms marine life (Galloway *et al*., 2017). While research on plastic pollution has exploded in the last decade, there is still needed to explore the effect of some approaches, such as design thinking to develop marine and coastal environmental attitudes among students. This paper therefore investigated and responded to the following research objectives:

The following research objectives guided the conduct of this research. The research aims to identify; I. Students' awareness of marine and coastal environments after exposure to the design thinking approach. II. The existence of the perceived effects of marine and coastal pollution and III. What measures were suggested to control and regulate marine and coastal pollution? With the research questions i. What is the student's awareness of marine and coastal environments after exposure to the design thinking approach? ii. What are the perceived effects of marine and coastal pollution? and iii. What measures were suggested to control and regulate marine and coastal pollution?

## Methodology

The paper employed an experimental design measuring respondents' marine and coastal environmental sustainability awareness. It adopted purposive sampling involving thirty-five (35) undergraduate students in an educational institution that participated in an online workshop on marine environment sustainability using design thinking. Students were grouped and engaged in workshops on design thinking stages. Each group presented their proposed solution to marine and coastal pollution problems using Jamboard. The sample responded to the items using an online Google form as a questionnaire validated by three experts in educational research and statistics. This instrument was shared with the participant at the end of the workshop. Their responses were analysed using frequency count and percentages based on the research objectives.

### *Participants and Course Structure*

Participants in this study were 35 final-year undergraduate students (27 females and 8 males) in an institute of teacher education in Malaysia. These students took an elective Education for Sustainable Development course, three-credit units consisting of 30 hours of lectures and 15 hours of the tutorial. The course is intended to help students gain knowledge and environmental management skills. Specifically, at the end of the course, students were expected to be able to achieve the following:

a) Explaining the concept of sustainable development based on UNESCO documents

b) Relating the concepts of sustainable development and environmental education in global contexts

c) Elaborating on the solutions to environmental issues based on local contexts

d) Carrying out projects to address local environmental issues

The course content was organised into four main topics: (i) Introduction to environmental education and sustainable development, (ii) Education for sustainable development & education for international understanding, (iii) Human interaction with the environment and natural resources and (iv) Strategies for Education for Sustainable development. The assessment of student's achievement in this course is fully by coursework: Group presentation (10%), quiz (15%), reflective writing (25%) and project report (50%). The nature of assessment by the coursework was intended to provide ample

opportunities for students to be immersed in real-world issues instead of theoretical pen-and-paper final examinations.

## Results

Table 1 gathered that most respondents (i.e. 80%) disagree or even strongly with the statement that "Marine and coastal pollution is not personally affecting me" with only 20% believing that marine and coastal pollution has no personal effect on their lives. This indicates that there is awareness of the effect of marine and coastal pollution on the personal hygiene of living organisms within an environment. This statistic was further confirmed by their reactions to a statement that "The benefits of modern consumer products are more important than the pollution that result from their production and use", in which 68.6% of the respondents disagreed or strongly disagreed. In addition to that confirmation, it was established that 100% of the respondents agreed to contribute time and money to organisations that work to improve the quality of the marine and coastal environment if asked and that 97.5% of them are willing to make personal sacrifices to slowing down marine and coastal pollution even though the immediate result may not seem significant. This indicates that the respondents are fully aware of marine and coastal pollution and its consequences on human lives.

Table 1: Awareness of coastal marine pollution and future direction

| S/N | Items | SA | | A | | D | | SD | |
|---|---|---|---|---|---|---|---|---|---|
| | | *f* | *%* | *f* | *%* | *f* | *%* | *f* | *%* |
| | **Awareness of Marine and Coastal Pollution** | | | | | | | | |
| 1 | Marine and coastal pollution is not personally affecting me | 4 | 11.4 | 3 | 8.6 | 10 | 28.6 | 18 | 51.4 |
| 2 | If asked, I would contribute time and money to an organisation that works to improve the quality of the marine and coastal environment | 18 | 51.4 | 17 | 48.6 | 0 | 0 | 0 | 0 |
| 3 | The benefits of modern consumer products are more important than the pollution that result from their production and use | 5 | 14.3 | 6 | 17.1 | 12 | 34.3 | 12 | 34.3 |
| 4 | I am willing to make personal sacrifices to slow down marine and coastal pollution, even though the immediate result may not seem significant | 13 | 37.5 | 21 | 60 | 0 | 0 | 1 | 2.5 |
| | **Perceived Effects of Marine and Coastal Pollution** | | | | | | | | |
| 5 | We should not worry about throwing plastic waste because, in the long-term run, things will balance out | 5 | 14.3 | 3 | 8.5 | 5 | 14.3 | 22 | 62.9 |
| 6 | Although there are continual contaminations of our rivers and oceans, nature's purifying processes soon return them to normal | 4 | 11.4 | 9 | 25.7 | 15 | 42.9 | 7 | 20 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 | We must prevent any plastic product become rapidly increasing in production, even if it means sacrificing something from ourselves | 15 | 42.9 | 15 | 42.9 | 3 | 8.2 | 2 | 6 |
| | **Regulation/ Control of Marine/ Coastal Pollution and Future Direction** | | | | | | | | |
| 8 | The currently active anti-pollution organisations are more interested in disrupting society than they are in fighting marine and coastal pollution | 7 | 20 | 21 | 60 | 4 | 11.4 | 3 | 8.6 |
| 9 | The industry is trying its best to develop effective anti-pollution technology | 6 | 17.1 | 20 | 57.1 | 7 | 20 | 2 | 5.8 |
| 10 | The government will have to introduce harsh measures to halt marine and coastal pollution since few people will regulate themselves | 21 | 60 | 13 | 37.5 | 1 | 2.5 | 0 | 0 |
| 11 | Courses focusing on marine and coastal pollution should be taught in schools | 20 | 57.5 | 14 | 40 | 1 | 2.5 | 0 | |

*The notations were represented as SA = Strongly Agree, A = Agree, D = Disagree and SD = Strongly Disagree.*

Regarding perceived effects of marine and coastal pollution, it was revealed that 77.2% of the respondents disagreed with the statement that "we should not worry about throwing plastic waste because, in the long-term run, things will balance out", meaning they were worried about throwing plastics waste leading to marine and coastal pollution in the form of plastic debris. Also, it was disclosed that 62.9% of the respondents believed that even after polluting the marine and coastal environment, the natural purifying process returns them to normal without much effect on the life's majority of them. This is indicated in there that they either disagree or strongly disagree with the statement that "although there are continual contaminations of our rivers and oceans, nature's purifying processes soon return to normal. It was, however, revealed that respondents were ready to prevent any plastic product become rapidly increasing in production, even if it means sacrificing something, as indicated by their responses on the item that "We must prevent any types of plastic product become rapidly increasing in production, even it is mean sacrificing something from ourselves". The finding revealed that the respondents perceived a greater effect of marine and coastal pollution on living organisms.

Thirdly, based on regulation/control of marine and coastal pollution and future direction, it was learned that some of the control measures were misleading. For example, the currently active anti-pollution organisations are more directed toward disrupting society than they are in fighting marine and coastal pollution, as confirmed by 80% (20% strongly agree and 60% agree) of the respondents as against 20% (11.4% disagree and 8.6 strongly disagree) that believed the measures were in order and could disrupt society in any way. The results show that 64.2% of the respondents were optimistic that industries are on the right track in proffering solutions to marine and coastal pollution issues, as shown by their responses to the statement that "Industry is trying its best to develop effective anti-pollution technology" as they either strongly agree or agree with the statement. In addition, the majority of the respondents (87%) either strongly agree or agree that the government will have to introduce harsh measures to halt marine

and coastal pollution since few people will regulate themselves, indicating their willingness to make personal sacrifices to slow down marine and coastal pollution even though the immediate result may not seem significant.

The respondents stress the need to include courses that could teach students how to regulate marine and coastal pollution. This was confirmed by 97.5% (i.e. either agree or strongly agree) of their responses to the statement that "courses focusing on marine and coastal pollution should be taught in schools". Hence, when learners were introduced to courses on managing and regulating marine and coastal pollution, their attitude toward the environment may change for the better.

**Discussions**

The findings of this research were discussed based on the research objectives of this study about the findings revealed by the existing literature. The finding regarding the first research objective on the awareness of the respondents on marine and coastal pollution after the design thinking approach used revealed that there is awareness of marine and coastal pollution and its consequences on human lives. This finding is in line with the expression by Bongarts *et al.* (2021) that in the face of rising sea levels and increasingly extreme events, people in coastal areas are developing measures to address the situation on the ground. A comprehensive analysis of the literature on adaptation measures in coastal areas has identified various adaptation strategies. The analysis of these strategies draws on the complexity of their institutional and technical implementation. It reveals two contrasting paradigms: 1). Resilience to sea-level rise or adaptation to new climatic conditions; and 2). The level of integrated management of the strategy. This typology distinguishes four archetypes and the most commonly related management models. They then highlight the need for hybrid approaches and adaptation pathways that consider local sociocultural, geographic, and climatic conditions and involve stakeholders in the design and implementation of measures. They noted that adaptation actions rely on the knowledge, participatory engagement, multilevel governance, political monitoring, and territorial solidarity. These conditions are particularly important for densely populated areas that will face sea-level rise, especially for coastal cities.

This finding varies with that of Stefan *et al*. (2014) on Europe citizens, who revealed that they are moderately aware of the impacts of marine and coastal pollution on the habitat based on their personal experience. It, however, contradicts the findings of up Ten-Brink *et al*. (2016) that even with these effects, there is still a lack of understanding of the holistic consequences of marine plastic and the resulting impact on ecosystem services, as well as the implications for human health, society, and the economy.

Secondly, the finding revealed the perceived effects of marine and coastal pollution, which is the greater effect on living organisms. These perceived effects are in line with that of Naeem *et al.* (2016) where there are dangers to the continuous provision of plastic ecosystem services has the potential to have a large negative impact on human well-being around the world due to the loss of food security, livelihoods, income, as well as good health and that plastic contamination in the marine environment is significant and increasing (Geyer *et al.,* 2017). Also, the main sources of marine and coastal pollution are the disposal of domestic waste, industrial waste, leaks from water tanks, and the dumping of surplus and radioactive materials. Heavy metals and industrial wastes can contaminate water bodies and threaten human and animal life. In addition, toxins from industry are the main cause of immune system destruction, reproductive disorders, infectious diseases such as fever and cholera (Juneja & Chaudhary, 2013), as well as other gastroenteritis diseases such as vomiting, diarrhoea, kidney and skin problems, transmitted by polluted marine and coastal waters (Herman, 2012). The direct damage to plant and animal nutrients indirectly affects human health. Marine and

coastal pollutants kill algae, mussels, seabirds, fish, lobsters and other marine organisms that serve as food for humans. Concentrations of pesticides such as DDT increase in tandem with organic phenomena. Marine pollutants affect the health of organisms in the marine and coastal environment, their inhabitants, and those who feed on and shelter from the water. Every day, more and more chemicals are being released intentionally or unintentionally, and more and more litter, mostly plastic waste, is entering waterways and the marine environment (Lloyd-Smith & Immig, 2018).

Finally, the finding revealed the need for government to take serious measures on the spread of marine and coastal environments through harsh measures and introduce courses such as project-based learning using design thinking in the school curriculum to guide learners to develop a better attitude to the environment. This finding, however, supported the measures suggested by Nander (2017) regarding the protection of the marine environment under the law of the sea by the United Nations – the Nippon Foundation of Japan fellowship programme. These measures would no doubt bring about a solution to the lingering marine and coastal pollution issue. They were preventing the degradation of the marine environment from land-based activities by promoting the fulfilment of States' obligations to conserve and protect the marine environment. The Global Plan of Action is intended to assist States to act, individually or collectively, within their respective policy priorities and resources to prevent, reduce, control, and/or eliminate degradation of the marine environment and to enable it to recover from the effects of land-based activities (Horan, 2016). Achieving the goals of the Action Program will help maintain and, where appropriate, ensure the protection of human health and promote the conservation and sustainable use of living marine resources.

Environmental education has been a promising approach to minimise the impact of human activities on the environment. As future global citizens, students' knowledge and attitudes towards their natural surroundings should be cultivated from the early stage of school education (Basile, 2000). Instead of introducing environmental education as a new subject in school, themes related to education for sustainable development should be integrated into existing school subjects (Erhabor & Don, 2016). Numerous environmental education integration in the school curriculum is effective in promoting environmental literacy using various methods and strategies such as Arduino technology (Alò *et al.,* 2020), socio-scientific issues (Ntobuo *et al.,* 2018; Cha *et al*., 2020), comic drawing (Pursitasari *et al.,* 2019), extracurricular activities (El-Batri *et al.,* 2019), bird feeding (White *et al.,* 2018), and food waste management (Schmitz & Da Rocha, 2018). Marine and coastal environmental attitudes investigated in this study can be improved using various strategies and approaches to deliver the school curriculum. Additionally, environmental education-embedded learning experiences at higher education institutions should consider six dimensions of students' online service experience (i.e. ease of use, enjoyment, usefulness, positive surprise, reliability and perceived risk) to make environmental education interventions for students at higher learning relevant and meaningful (Liang *at al*., 2021).

## Conclusion

Even with the awareness of marine and coastal pollution, there is still a lack of understanding of the holistic consequences of marine plastic and the resulting impact on ecosystem services and the implications for human health, society, and the economy. There are dangers to the continuous provision of plastic ecosystem services has the potential to have a large negative impact on human well-being around the world. Hence, the government needs to take serious measures against the spread of marine and coastal environments through harsh measures and introduce courses such as design thinking in the school curriculum to guide learners to develop a better attitude to the environment.

The study is limited to the following factors, which may affect the generalisation of the findings. Hence, future researchers may take them into cognisance; 1. Limited sample, which was due to time and financial constraints from the side of the respondent. 2. Quantitative data was only generated without exploring its qualitative aspect, thereby interacting with the respondents through interviews or observation. 3. Use simple statistical tools for data analysis involving frequency counts and percentages. These may not give the actual effect size, unlike the complex statistics.

The outcome of this study revealed that students' awareness regarding marine and coastal pollution for environmental sustainability could be improved by using various strategies and approaches in delivering the school curriculum. Such strategies include design thinking. Additionally, environmental education-embedded learning experiences at higher education institutions should consider six dimensions of students' online service experience (i.e. ease of use, enjoyment, usefulness, positive surprise, reliability and perceived risk) to make environmental education interventions for students at higher learning relevant and meaningful.

However, it revealed many dangers to the continuous use of plastic environmental services, which can potentially impact human well-being worldwide.

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