An Intelligent Computer-aided Design System Incorporating Considerations for Aesthetics and the Environment

By

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This thesis title is submitted in accordance with the requirements of Dublin City University for Doctor of Philosophy

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DECLARATION

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of *Doctor of Philosophy*, is entirely my own work, that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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ABSTRACT

An Intelligent Computer-aided Design System incorporating Considerations for Aesthetics and the Environment

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Amidst intense competition, manufacturers are constantly striving to improve their competence with others. In this respect, aesthetics of the product has become one of the prime factors in capturing market share. On the other hand, ever increasing pressure from the public, customers and governments has forced manufacturers to take environmental considerations very seriously.

This study focuses on the development of an intelligent computer-aided design system in order to assist designers to design specifically on the basis of aesthetic and environmental considerations. The study began with an extensive literature survey. It was found that small volume of research work had been done in the topic of design for aesthetics whereas a substantial volume of research had been ongoing in the field of design for environmental considerations. Although the aspect of combination of these two factors of design was not fully investigated. So the project was understood to be a novel one.

To achieve the objectives of the research, two research surveys were conducted to gauge public viewpoint about the aesthetical attributes of the bottles of several consumer products. The first survey was conducted among Dublin City University (DCU)'s students and staff, and the second one among the residents of Dublin city and its suburb. The information obtained from these two surveys was used in the development of the design system. The design system consists of overall score & aesthetics advisor, simple material selection for bottles index, simple life cycle analysis and golden section ruler modules. The author created threshold values for the first three modules that work as benchmarks to judge the design in terms of aesthetics and environmental considerations. This novel approach of design and the software tool developed will be helpful aids to the designers to consider aesthetics and environmental aspects of design at the primary stage leading to faster product development and savings of money.

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List of Abbreviations

CAD	Computer-aided Design
CAM	Computer-aided Manufacturing
DCU	Dublin City University
DD	Destructive Assembly
DFD	Design for Disassembly
DFE	Design for Environment
LCA	Life Cycle Assessment / Analysis
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Analysis
SMSB	Simple Material Selection for Bottles

Chapter One - Introduction to Thesis

1.0 Introduction

Computer aided design (CAD) has now a day's become almost indispensable in any kind of engineering design. Ongoing research is constantly adding new features. Among the new features, inputting intelligence to the CAD process is one of the most complex tasks. Some objective artificial intelligence features like technicality, functionality etc have been successfully incorporated as a result of research done by many researchers worldwide. But not much research has been done on adding subjective features like aesthetical evaluation of product designed. On the other hand, growing consumer concern with environmental friendliness requires manufacturers to seriously consider this factor. Consequently they have allocated resource and funding on the research and development on this subject.

In Dublin City University, the Centre for Intelligent Design, Engineering Analysis and Simulation (C-IDEAS), has been working on different aspects of design, namely product design, simulation, visualisation, etc. It has been perceived that integration of aesthetics and environmental consideration in the design process would be beneficial for both manufacturing enterprises and society as a whole. Since there is a perceived gap in the field of design of aesthetics implementation to the design system, it has undertaken this project. This project deals with both design for aesthetics and design for environment. The research project has been pursued in the following phases:

1. Evaluate the feasibility of building an intelligent design system that would incorporate environmental and aesthetical consideration.

2. To develop the system, gather information by different means (e.g. literature review, survey etc).

3. Develop an intelligent computer-aided product design system incorporating considerations for aesthetical and environmental design issues.

1.1 Outline of the intelligent design system

Assisting designers on aesthetical and environmental aspects of the product at the

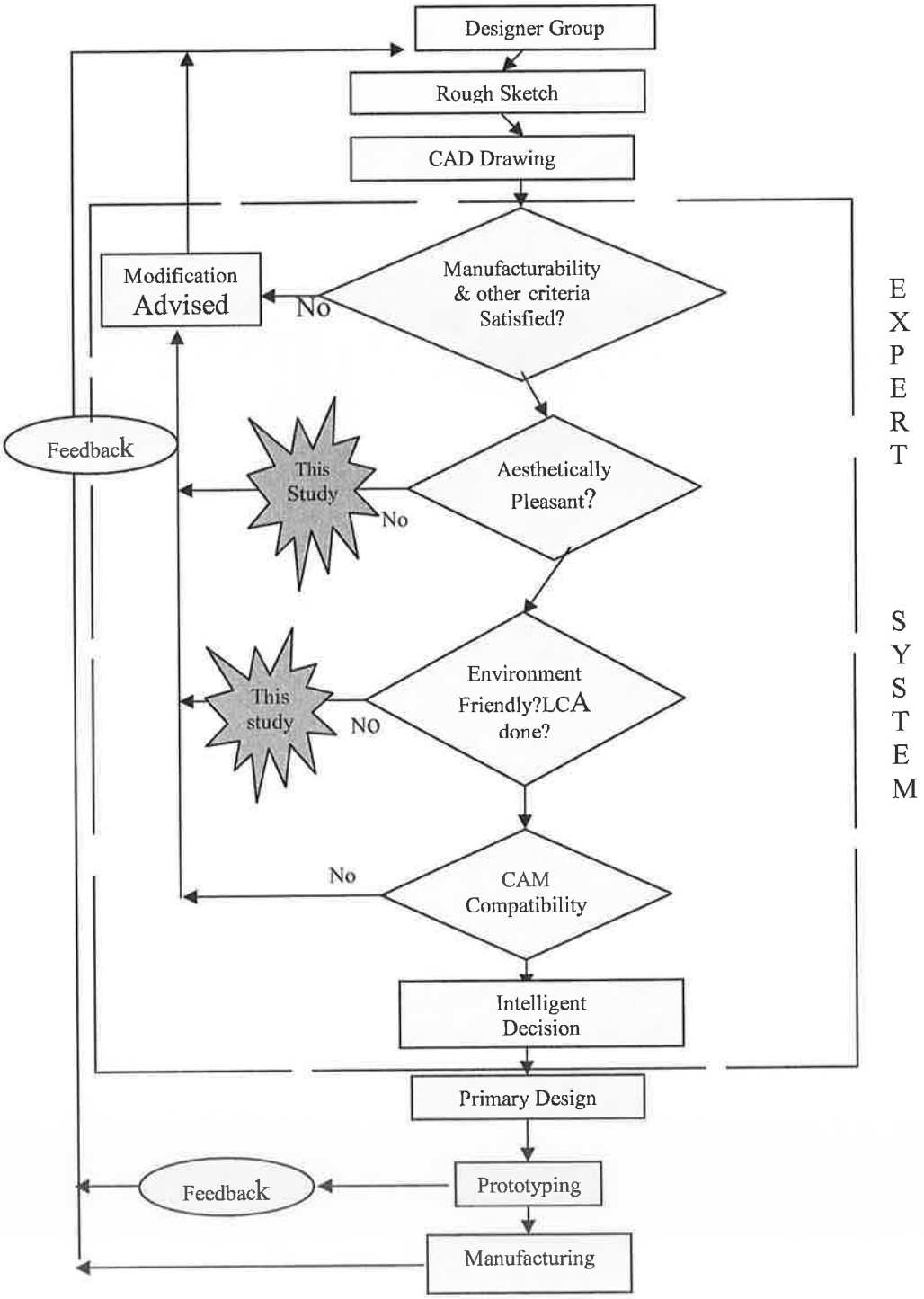

Figure 1.1: Flowchart of the computer-aided design system

very early phase of design is the prime objective of the proposed intelligent design system. Primarily, a guideline is to be prepared regarding aesthetics and environmental attributes of a particular product. Later this guideline would be transformed into a software module that will be easy for designers to use during their design.

1.2 Thesis Structure

The thesis is divided into five chapters as summarised below:

Chapter Two	This chapter describes the background to the research by referencing to literature to demonstrate what has been previously achieved and thereby putting the present work in context.
Chapter Three	The methods and procedures used to gather the information for this study are described in this chapter. It includes statistical methods and analysis techniques.
Chapter Four	The detail procedures of conducting the first survey, its results and analysis are presented in this chapter. The first survey was carried out among Dublin City University (DCU)'s students and staff.
Chapter Five	The detail procedures of conducting the second survey, its results and analysis are reported in this chapter. The second survey was conducted among the residents of Dublin City and its suburb.
Chapter Six	The development of the Simple Material Selection for Bottles Index (SMSB) is described.
Chapter Seven	Four modules developed as part of the intelligent design system are depicted in this chapter. The four modules are total design score, simple life cycle analysis, SMSB index and golden section ruler.
Chapter Eight	Conclusion and suggested future works are stated here.

Chapter Two - Literature Survey

2.0 Introduction

The objectives of this chapter are to:

- Introduce the fields of Product Design, Design for Aesthetics, Design for Environmental Consideration, Artificial Intelligence, and Expert System.
- Provide a brief description of past research and development of the above-mentioned fields.
- Provide a summary and short illustration of the different computer-aided design tools.
- Provide an overview of the proposed intelligent design system.

Customers come into the forefront of attention now a day's since competition has become intense among manufacturers. Therefore, to win customers, companies have to use all available methods. Previously products were generally designed without giving deep thought to some factors like aesthetic or environmental consideration, ergonomics, etc. Now these factors have to be considered seriously in design to get hold of the market. Examining through all available literature, it has been determined that though some methods/tools are available for assessing different areas of present product design requirements but there is little available on design for aesthetics and design for environmental consideration in a combined package. However, integrating all aspects of design considerations in the initial design phase would be very much economical and go a long way to minimize product development time. Hence integration of aesthetic and environmental consideration in design process has been taken as the research topic of the work described in this thesis.

2.1 Definitions

A few definitions or brief description of the terms related to the present research have been given in the following:

2.1.1 Computer-aided Design (CAD)

Groover and Zimmers [1] of Leigh University define CAD as: "Computer-aided Design (CAD) can be defined as the use of computer system to assisting the creation, modification, analysis, or optimization of a design." While Besant [2] defines CAD as: "Computer-aided Design (CAD) is a technique in which man and machine are blended into a problem-solving team, intimately coupling the best characteristics on each. The result of this combination works better than either man or machine would work alone, and by using a multi-discipline approach it offers the advantage of integrated team-work." Fellows's [3] definition of CAD is as follows: "In the broader sense of meaning, Computer-aided Design (CAD) refers to any application of a computer to the solution of design problems. However, the generally accepted and somewhat restricted meaning is the application of computers to engineering design problems wherein an extensive use is made of computer graphics."

While twenty years ago CAD was taken to mean computer-aided drawing and nothing more, today the term applies to the whole sphere of product design from core design, finite element analysis (FEA) to virtual reality techniques.

2.1.2 Database

Abiteboul et al. [4] define database as: "A large amount of data stored in a computer is called a database. The basic software that supports the management of this data is called a database management system (DBMS)."

While Elmasri and Navathe [5] specify database as: "A database is a collection of related data. A database has the following implicit properties:

- A database represents some aspect of real world, sometimes called the mini world or the Universe of Discourse (UoD). Changes to the mini-world are reflected in the database.
- A database is a logically coherent collection of data with some inherent meaning. A random assortment of data cannot correctly be referred to as a database.

- A database is designed, built, and populated with data for a specific purpose. It has an intended group of users and some preconceived applications in which these users are interested.

In other words, a database has some source from which data are derived, some degree of interaction with events in the real world, and an audience that is actively interested in the contents of the database."

Dates [6] defines database as: " A database is essentially nothing more than a computerized record-keeping system. The database itself can be regarded as a kind of electronic filling cabinet-that is, as a repository for a collection of computerized data files." Ullman and Widom [7] provide another definition of database as: "In essence a databae is nothing more than a collection of information that exists over a long period of time, often many years. In common parlance, the term database refers to a collection of data that is managed by a database management system, also called a DBMS, or just database system."

2.2 Product Design

Since the research presented in this thesis is focused on design of the product, it is important to examine different design theories to find the most appropriate one to the present research work. Although all basic product design cycles follow a generic common path, any small addition would make a huge difference to a particular product design, especially when dealing with the subjective realm of aesthetics. So in this section, a few design definitions will be explored. Some theories and models will also be described briefly.

2.2.1 Design

In general terms, design is the synergy of creative manipulation of available knowledge to cater a particular set of requirements. The ICSID (International Council of Societies of Industrial Design) [8] specifies design in the following way:

"*Design is a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles. Therefore, design*

is the central factor of the innovative humanization of technologies and the crucial factor of cultural and economic exchange." The Ministry of International Trade and Design, Japan [9] defines design as: "Design is more than shape, colour and dimensions of products. Design is the decision-making process that deals with the manifestation of objects with consideration to economy and technical functions and in answer to various consumer demands".

Cross [10] depicts modern design as follows: "Perhaps a way towards understanding this modern design activity is to begin at the end; to work backwards from the point of where designing is finished and making can start. If making cannot start before designing is finished, then at least it is clear what the design process has to achieve. It has to provide a description of the artefact that is to be made." In this design process description, almost nothing is left to the discretion of those involved in the process of making the artefact-it is specified down to the most detailed dimensions, to the kinds of surface finishes, to the materials, their colours, and so on. He also points out that the focus of all design activities is to provide a final description of the proposed artefact.

2.2.2 General Product Development Cycle

The general product development cycle can be described with the following flow chart:

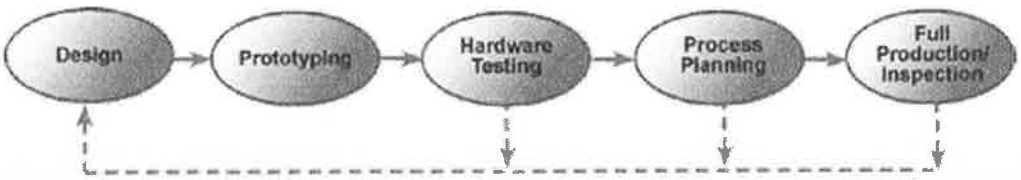

Figure 2.1: Product Development Cycle [11]

That is at first design, then prototyping, hardware testing, process planning, full production or inspection respectively. However feedback is imparted from every stage. And the focus of this research mentioned in this thesis would be on the very first portion, that is the very basic design stage.

Nigel [10] presents a simple four-stage model of the design process as shown in Fig2.2.It consists of four stages-exploration, generation, evaluation and communication. At first, designers have to explore through available information.

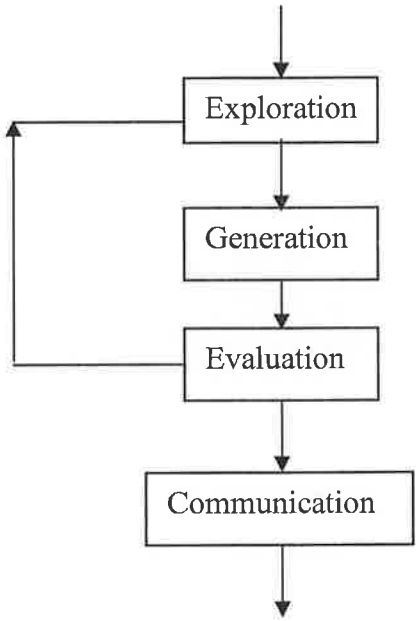

Figure 2.2 : A simple four-stage model of the design process

In this stage, designers may draw sketches of the tentative design and see whether it satisfies the objectives of that design. Because normally there is no short cut or straightforward way to generate an optimum solution from the data or information provided. The next part is to generate a design proposal. This generation requires creativity on part of the designer. This design proposal is then checked. At this stage, the design might have to be modified according to errors discovered during checking. Thus generation and evaluation form an iterative process. In the final stage, the design has to be communicated for manufacturing. The most convenient way of this communication is drawing. Here the drawing must be precise and should be drawn maintaining standard rules and conventions. At present, numerous computer-aided design tools are available on the market and so the design might be created and later communicated using the format supported by the specific CAD tools; therefore it is not necessary that design must be on paper-based drawing.

2.2.3 Concurrent Design

The concurrent design and manufacturing process is depicted in Figure 2.3. When a CAD model of the product is made, it is evaluated with regard to different aspects, e.g. performance evaluation, reliability evaluation, manufacturing cost etc.

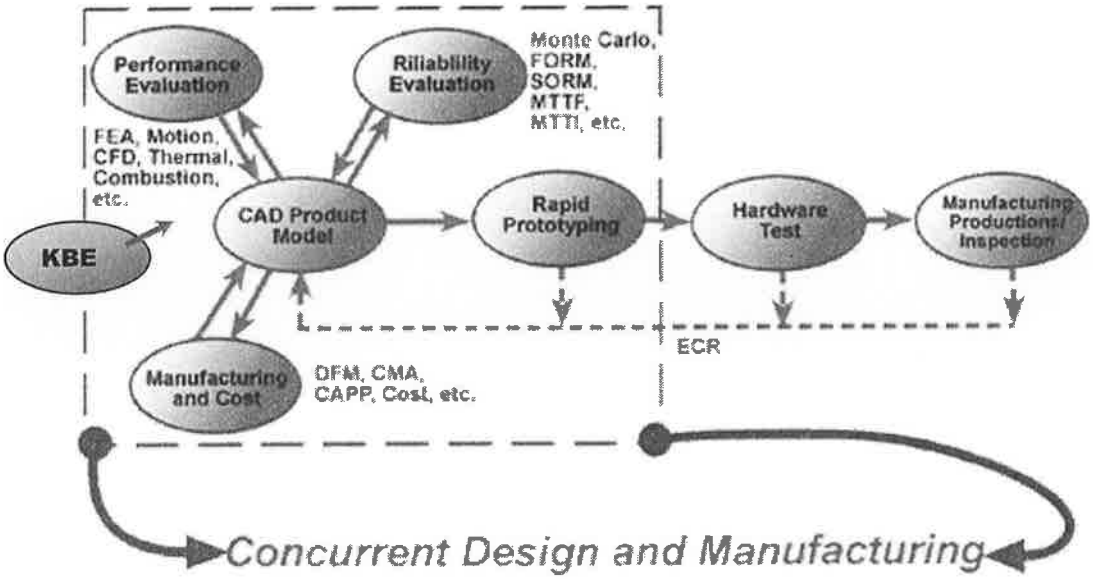

Figure 2.3: Concurrent Design and Manufacturing Cycle [12]

For performance evaluation; finite element analysis (FEA), thermal analysis etc. could be carried out. Manufacturing and cost evaluation methods include DFM, CMA, CAPP, Cost, etc. Reliability methods include Monte Carlo, FORM, SORM methods. All of these evaluation processes fall under the field of knowledge based engineering (KBE). Then it follows the general product guideline as rapid prototyping, hardware test, manufacturing, production, inspection and feedback is provided as before on every stage.

2.2.4 Design Models

Generally design models are classified into two groups as follows [10]:

- Descriptive models
- Prescriptive models

Descriptive model of the design process is a solution-focused nature of design thinking. These models put more importance on generating a solution concept early in the design. At first, a solution is thought of using previous knowledge of

designers, general guidelines, rules of thumbs, etc. It can be termed as a heuristic process. Later this initial solution is subjected to analysis, evaluation, refinement and development. The four-stage model described earlier is an example of descriptive models of the design process. Another descriptive model developed by French is presented later. On the other hand, perspective models emphasize on organised and improved ways of dealing with the design process. They suggest understanding the design problem thoroughly and then going for a solution. Three prominent prescriptive models are described later.

2.2.5 French's Model

French [10] developed a detailed model of design process based on the following four core activities:

1. Analysis of the problem
2. Conceptual design
3. Embodiments of schemes
4. Detailing

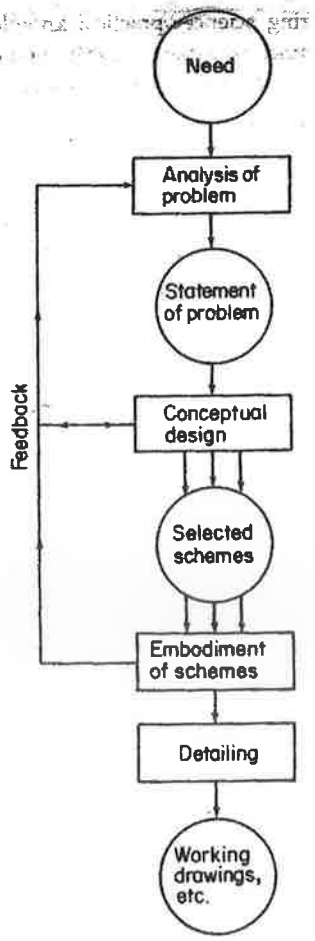

Figure 2.4: French's model of the design process [10]

This model is shown in Fig 2.5. In his model, at first need of the design is to be clarified and analysis of the problem should be done. Need generally has three elements:

- A statement of the design problem
- Limitations placed upon the solution

The criterion of excellence to be worked to

Conceptual design follows the statement of the problem. This phase takes the problem and generates broad solutions in the form of schemes. The next phase is embodiment of scheme where the schemes are worked up in greater detail. If there is more than one solution, a final choice between them is made. The output of this phase is usually a set of general arrangement drawings. Detailing is the last phase where many small but essential points of the design have to be decided. The detailing works should be of good quality otherwise delay or expense or even failure might be incurred. In this model, feedback is provided from all the intermediate phases to designers, especially a lot of feedback from embodiment of design schemes phase.

2.2.6 John's Model

John [10] presented a basic perspective model of the design process. It consists of three phases:

1. Analysis
2. Synthesis
3. Evaluation

In the analysis phase, all design requirements are listed and these are reduced to a complete set of logically related performance specifications. In the synthesis phase, possible solutions are to be found for each individual performance specification. Then complete designs are to be built. In the evaluation stage, different alternative designs have to be evaluated on the basis of operation, manufacture and sales and eventually final design is to be selected.

2.2.7 Archer's Model

Archer [10] developed a more detailed perspective model as summarized in Figure 2.6.

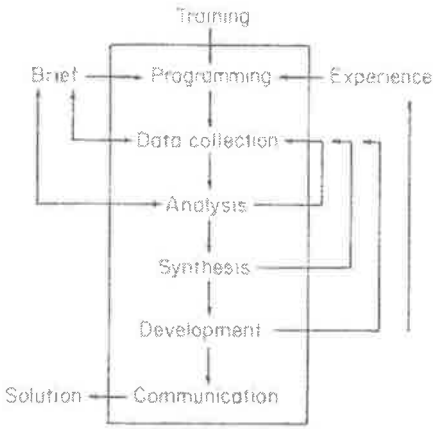

Figure 2.5: Archer's model of the design process [10]

It includes interactions with the world outside of the design process itself, such as input from the client, the designer's training and experience etc. At first, crucial issues are to be established and a course of action should be proposed. Next data will be collected, classified and stored. Then sub problems are to be identified and performance specification, reappraisal of the proposed programme and estimation are to be done. In the synthesis stage, outline design proposals will be prepared.

Then prototype designs are to be developed and validation studies should be executed. Feedback is provided from all intermediate steps. The output is the communication of a specific solution. Archer again summarized the process into three broad phases: analytical, creative and executive. These phases are shown in Figure 2.7.

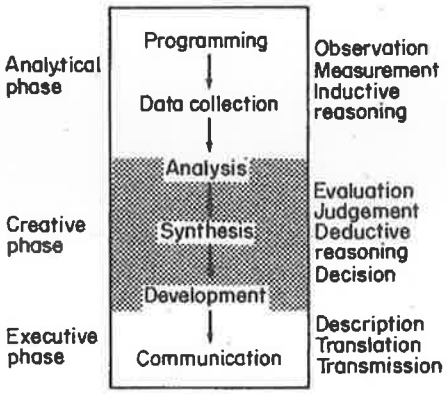

Figure 2.6: Archer's three-phase summary model of the design process [10]

Analytical phase requires objective observation and inductive reasoning; the creative phase requires involvement, subjective judgement and deductive reasoning. Once the

crucial decisions are made in the creative stage, the design process continues with working drawings, schedules etc.

2.2.8 Hubka's Model

Hubka [13,14] viewed design as a transformation process and his model has the following steps:

- Designers
- Working means
- Design Information Systems
- Design Management
- Feedback
- Information Needs
- Outcome Information that is generally technical things

The operand of the transformation process is information, the input is design requirements and the output is detailed information about the product model. Normally the output is provided in the form of geometric or textual or numeric representation. This design process is affected by some key aspects as stated by Hubka are:

- Human operators
- Working means
- Design Information
- Design Management

Actually the coherent mix of all these will ensure a successful design.

2.2.9 Pugh's Model

Pugh [15] visualised the design process within a total design framework. He used a design core to depict the process as shown in Figure 2.8. It is a typical design model almost universally used. The steps are- market, specification, concept design, detail manufacture and lastly sell. In this model, in every stage a trial and error proposition is used to fine-tune the product.

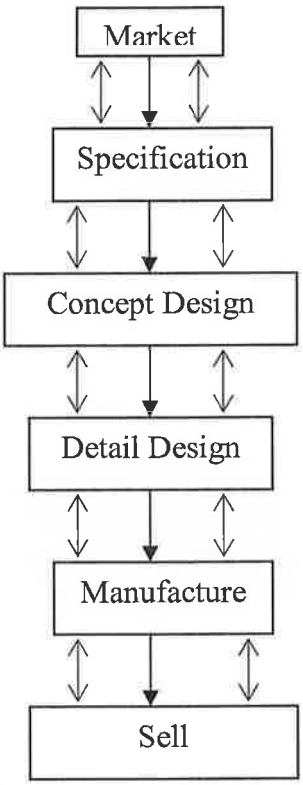

Figure 2.7: Pugh's Model

2.2.10 De Boer's Model

De Boer [16] developed a five stage generic model for design and decision-making, which is depicted in Table 2.1. He described the basic generic process in any kind of design with a precise form. For example, in the design process of a mineral water bottle, at first the attributes of the proposed design are to be identified.

Table 2.1: De Boer Model

Phase	Activities	Synonyms
Diagnose	Identify and depict the problem	What? Why? Go/ No Go
Plan	Organise the works to be done beforehand	How-who-when-where?
Develop	Put forward in the plan in real terms	Formulate, draft, design, prepare
Implement	Bring into effect	Execute, produce
Review	Have look into the outcome	Measure, Access, Appraise, Conclude, Improve. Correct, Refine

For instance, size, colour, shape and other aspects of the bottle. Then a plan for later design phases is to be prepared. A draft drawing should be produced to bring the design into active or visible state. Experts will verify different aspects of the design at this stage and a prototype may be produced. After producing the prototype or the test specimen, it will be reviewed by the experts and opinions of the customers will be considered. This feedback will be presented to the designers and a final design will eventually be generated.

2.3 Design for Aesthetics

Aesthetics is an important part of design. Previously it was not given that much importance. But with the present highly competitive business atmosphere, it is now treated with special consideration. The terminology and the history of design for aesthetics and related research done in this field are discussed in the subsequent sections.

2.3.1 Introduction to Design for Aesthetics

Aesthetics is a vague and fuzzy word and it is hard to quantify. So it is a daunting task for designers to justify how and to what extent a product would be aesthetically pleasant. The term aesthetics broadly describes the characteristics of the appearance in design. According to Britannica [17], aesthetics is the study of beauty. Alexander Baurmgarten [18] gave the name aesthetics to this study in his book 'Reflection of Poetry' (1735). He pointed out that sensation and perceptions, the sources of aesthetic experiences, are neglected as subjects of study in the rationalistic school of Philosophy. He then embarked on a mathematical study of aesthetics. In a similar manner, some two thousands year ago, the Roman architect and artist Vitruvius claimed that, for human products, 'firmitas', 'utilitas' and 'venustas' are the key ingredients, as well as their harmony. Another illustrious Belgian architect and designer- Henry van de Velde stated that Beauty is the result of clarity and system, and not an optical illusion [19]. In last three centuries many contributions have been made in the field of this field the philosophy of aesthetics by philosophers including Kant, Tolstoy and Bearsdley. Mainly two theory have emerged: firstly the ***theory of taste,*** which was originated in the Eighteenth century, sees aesthetics as reactions in an observer, that are triggered by specific kind of object [20]. According to this

theory, the following five components are required to evaluate aesthetics by a human being-

a) faculty of perception, b) faculty of reaction, c)object to be perceived, d)a mental state resulted from reaction to the object and e) a judgement of taste The other theory, the ***attitude theory,*** states that the appreciation of aesthetics is more subjective and requires certain modes of perception or consciousness from the observer [10].

2.3.2 Different Viewpoints on Aesthetics

Lenikowski [21] stated, "Struggle between intellect and emotion, reason and instinct, rationalism and romanticism is the fundamental creative force behind Western (and may be universal) cultures." He discussed are the two main facets of aesthetics dilemma raising the question whether beauty is a quality of objects themselves or whether it solely exists in the mind of the observer. The rationalists are in favour of the former while the romanticists the latter. In this regard, Santayana [22] presented a compromising view that our ideas about an object are the residuum of our encounters with this object. Our experience is subjective although it refers to an object. Ideas of people from different cultures and at different times may be completely different. These two confronting viewpoints are described in the following sections.

2.3.2.1 Rationalistic View

Rationalists view aesthetics as a science of beauty. According to this domain of the philosophy of aesthetics, it is not enough to appreciate an artefact, rather mandatory to understand why, explain, and evaluate the origins of this appreciation. Since aesthetic experience depends on the amalgamation of sensory pleasures by associations, general rules could not be easily formulated. While formulating such rules, the drawbacks like limited attention span of perceptions of human beings should be considered [18]. A number of hypotheses have been already proposed towards understanding aesthetics. As for instance, one rule may state that compositional forms should avoid monotony since monotony can cause fatigue. The prevention of fatigue can be achieved by adhering to laws of contrast that introduce novelty and complexity. Another principle is the concept of order (e.g. symmetry or coherence). Intriguingly, the two aspects, contrast and order, contradict each other and may distort the aesthetic experience. Though some aestheticians propound that

this tension is a manifestation or essence of aesthetic experience. Most of the laws of aesthetics are based on the laws of proportion. Its use dates back to the ancient times and still persists today. Pythagoras examined the relation between sound and form of perceptions. Vitruvius used the law of proportion in relation to architecture; and the architects Palladio and Le Corbusier used proportioning laws in their designs [17]. So it can be commented that rationalistic viewpoints of aesthetics provide background for quantitatively, though not in the complete sense, measure aesthetical attributes.

2.3.2.2 Romanticist View

Raskin [23] said, "A thing of a beauty is a joy for ever" and this statement is considered to be the basic statement of romanticist view. Consequently the romanticists object to the stipulation of laws that can solely account for aesthetic creation and judgement. Because they think that laws cannot truly define aesthetics since some perceptions cannot be explained by appealing to elementary impressions. So it can be concluded that aesthetic principles derived from the romanticist view can be applied to classification or overall evaluation processes along with criteria derived from rationalist view.

2.3.3 Terminology of Aesthetics

Aesthetical evaluation directly relates with human emotions. Goldman [24] breaks up human emotion into the following eight categories:

- **Broadly evaluative**, e.g. beautiful, ugly, sublime, dreary.
- **Formal**, e.g. balanced, graceful, concise.
- **Emotional**, e.g. sad, angry, joyful, serene.
- **Evocative**, e.g. powerful, stirring, amusing, hilarious, boring.
- **Behavioral**, e.g. sluggish, bouncy, jaunty.
- **Representational**, e.g. realistic, distorted, artificial.
- **Perceptual**, e.g. vivid, dull, flashy.
- **Historical**, e.g. derivative, original, conservative.

According to the most philosophers of Aesthetics, the following three attributes are very important criteria for judging a product on the basis of aesthetics [25]:

Expression: If a product generates emotion in the heart of an observer, it is called expressive.

Representation: points towards the content of the design. A design might be represented as actual, idealized or imagined.

Form: It encompasses the totality of shape and structure, organisation and composition of an object.

The following two factors are also important for judging a product on the basis of aesthetics.

Transparency: It refers to cases where the reactions to art works (designs) depend on not only their representations, but also on what the representations may evoke via association with other elements such as emotions, experiences or ideas [26].

Style and Originality: Many aesthetical perceptions are related with these two concepts. A style refers to designs, which possess a number of recognizable common characteristics. Originality of style gives rise to the singular individuality of a design and often enhances its value [27].

2.3.4 Physical Characteristics

Some terms of physical significance in the field of aesthetics are discussed below:

Geometry: Spatial representation is provided by geometry. It includes the mathematical documentation like points, lines, surfaces, etc. Topology and Morphology provide exact descriptions of the structure and specific properties of geometric elements [25,28].

Form: It is the representation of global properties of the geometry. It is three-dimensional whereas shape is two-dimensional. In terms of design for aesthetics, the role of form is to *influence* the product [25,29].

Shape: It is defined as the totality of local characteristics of the geometry-that is an abstract generalization of the local properties. When lines meet, shapes are formed. Shapes are flat. Some shapes are geometric, such as squares, circles, triangles, etc. Other shapes are organic or irregular. Organic shapes look like things from nature

[29]. The local geometric properties (e.g. sharp edges) are shape features, which form the basis for shape manipulation in semantic level. For example, a star is a shape where its edges could be branded as shape features or local geometric properties. In terms of design for aesthetics, the role of shape is to *express* the product [25].

Composition: It deals with arrangement of different aesthetical features, specifically of shape features [25].

Colour

H.J.Eysenck [30] tabulated a mass of research involving some 21,060 individual judgements. Blue ranked first,then red,green,violet, orange, and yellow. In a similar recapitulation of sex differences,the order was the same, except that while men put orange in fifth place and yellow in sixth, women put yellow in fifth place and orange in sixth.

Figure 2.8 : Some prominent colours

Combination of colour

At present, most of the products have combination of colour in packaging. This packaging includes plastic printed foil wrapped around the bottle, direct print on the bottle. This study discusses about the colour given to the bottle material during the preparation of the bottle. Thus it excludes the external packaging or printing on the

bottle while considering the combination of colour. The author acknowledges that there is a very thin line between the inherent colour of bottle, external packaging and the colour given to the liquid inside the bottle. To make it clear, in this study only internal colour features given to the bottles on the time of manufacturing them was considered. It has been found that only a few products use combination of colour internally on the bottle. The reason may be that it is difficult to sort out how to distribute different colours in the bottle while manufacturing. It is rather easier to use a printed plastic or paper wrap around the bottle to give the combination of colour effect. The exception is on some costly perfume. Since people give much importance other than any other commodity on the look of the bottle for perfume, some perfume bottles are designed with combination of colour. Consequently the price goes up for this combination of colour. For example, bottle of Chanel, El D Ros etc. Edward Tuft [31] suggests to look into the nature to find the colour combination that will be attractive to human beings

Colour scheme

By colour scheme, it is meant that different colours may be used to denote different segments of the bottle. For example, reusable caps may have red colours while non-recyclable caps may get blue colour. Another example is that upper part of the bottle may have different colour than the lower one. There may be numerous ways to formulate such colour schemes. However, constrains on manufacturing them may set a boundary on which colour scheme may be taken. A few colour scheme has been located by the author. It may be noted these colour scheme has no legal or any sort of bindings up to manufacturers though it seems that they comply with certain colour scheme. For example, in soft drink bottle, if it is a cola, the cap is usually red colour while if it is a orange flavoured drink, the cap is orange. Some environmental campaigners suggest that cap should be colour-coded so that general people could understand easily about the recyclability of the product.

Shape

Shape is the geometry of a product or any entity. Like geometry, in product design some shapes are considered primary shapes. They are:

- Round or circular
- Square
- Ellipse or oval
- Rectangle

It is generally believed that shape has impact on the customers on their buying decision. Some studies done earlier by other researchers and agencies have confirmed this statement. There may be numerous variations of the general shapes. Sometimes designers put curve on the shape to give it another effect. Some designers use gradual changer over of shape to appeal it to the customers. Previous researches and designers have developed and reported some interesting shapes. Among these shapes, a few have become famous among designers and researchers.

Size

By the word size, it is referred to the amount or volume a bottle or container could contain of a specific product. Sometime size plays a role on the people's judgment of aesthetics. For consumer products, different sizes are selected regarding to firstly use, transport, manufacturability and aesthetics.

Material

People sometime prefer a specific material as the container for a specific product. The three most common materials that are used in consumer products are plastics, glass and aluminium. Apart from aesthetical consideration, there are other factors to be taken into account when selecting a material like environmental impact, manufacturability etc. Different aspects of material regarding bottle design are described elaborately in Chapter 6.

Transparency

Transparency is the visibility of a material in day light or normal light. Normal light refers to sunlight or the light generated by normal bulbs and fluorescent tubes. In physics, it is said to be the light coming and not being reflected by the particles of the material. There are three types of transparency generally used.

1. Transparent: it is fully transparent property as mentioned in the top.
2. Opaque: no light passes through. Therefore, anything on the other side of the material may not be seen in the normal light.
3. Translucent: a little light passes through and something on the side is a little bit visible.

Other Physical attributes: There are some other physical features of a product that have significant importance in terms of aesthetics. For example impression, cap, handle, etc.

Golden Section

Golden section is a ratio that is believed to provide pleasant feeling when used in design. It is a ratio or proportion in which a straight line is divided into two unequal proportions in such a way that the ratio of the small part to the large part is equal to the ratio of the large part to the whole line [32]. The ratio is 0.618: 1. Roughly it means the smaller section is 62% of the large section and similarly the larger section is 62% of the whole line. It is the inverse of the mathematical value 'Phi'. This ratio or proportion is also known as the Golden Mean, Golden Ratio, Divine Proportion etc.

Figure 2.9: Golden section ratio

In Figure, the ratio is AB: BC = BC : AC

This ratio has been found in nature and art. Pythagoras, the Greek geometer, proved that it is the basis of the proportions in the human figure. He showed that the human body is built with each part in a definite golden proportion to all the other parts. Leonardo Da Vinci, the famous artist in the 1700s, concurred to this idea It is said that the Egyptians used golden section on designing the great pyramids. The Greeks also used it in the design of architecture. Medieval Churches show golden section in their structural design. For example, NotreDame Cathedral in Paris. Le Modular is a form of building design developed by the 20th Century architect Le Corbusier (1887-1965). It is based on the structure of a human body, whose height is divided into a golden section commencing at the navel.

2.3.5 Interaction of Aesthetics and Product Design Characteristics

To formulate a methodology for aesthetically pleasant design, the interaction or interrelation between the product design characteristics and aesthetics should be identified. Pham [25] breaks up this interrelation into the following nine categories.

Balance: Balance is an important terminology of aesthetics. Ruskin [23] defines a balanced composition as a composition that puts several things together to make one thing of them. There are mainly two ways of creating balance-symmetry and asymmetry. Symmetry means both sides of imaginary lines are the same. In other words, symmetry is the grouping of objects according to characteristics of complimentary order [29]. It may be noteworthy that most things are symmetric in nature, e.g. two eyes, two ears, etc. Generally symmetry renders soothing affect,

however, it might cause monotony sometimes. In those cases, asymmetrical balance may be used.

Proportion: Proportion is a design principle that has to deal with the relationship between size and scale. There are three types of proportion: Linear, Areal and Volumetric [25]. Linear proportion deals with the relation between the dimensions (e.g. length, width) of a single object (or feature) or between linear dimension of one object or feature to that of another. Areal proportion deals with area and volumetric proportion deals with volume.

Dominance / Principality: Dominance describes an object or something that dominates in a situation or presentation. In principle, unity of design could be achieved by focusing only one thing [25,28].

Contrast / Interchange / Alteration: Contrast is defined as the dissimilarity of things that are present in a design or work. Maximum visibility could be attained using contrast. For instance, light against dark, positive against negative shapes, smooth against sharp curvature, etc. To get contrast in a design; size, value, colour, shape etc. should be used judiciously [25,28].

Continuity/ Gradation: In a design, viewers' attention could be directed or continued to the other portion of the design when primary object directs it to some other portions by any pointing techniques. Examples of pointing techniques are- eye direction, paths, arrows etc. Apart from having attention transferred, continuity or change in gradual fashion generates soothing and calm feeling [25].

Solidity / Structural Coherence: Psychologically, solid structures imply the feeling of a strong and durable structure to human beings. Thus this sensation creation is important in product design. Generally double curved surfaces give an impression of a stronger product than a single curved surface. Abrupt transitions between the parts convey the message of fragility to brain; therefore such abrupt transition should be avoided in design. Combination of small parts focusing in a point generates the feeling of stability and strength [25,28].

Simplicity: If a design generates the feeling of complexity it will not be accepted by most of the customers. So efforts must be made to bring the design to as simple as possible [25,29].

Dynamics: Human beings prefer dynamic pattern rather than rigid and stiff one. So incorporating dynamic effect in design will be appreciated by most of the consumers.

Examples of the techniques of getting dynamics in design are - spiral composition around an axis, smooth transition from one colour to another colour, etc [25].

Rhythm: The prime receptors of aesthetics value are eyes. Rhythm in design is very pleasant to the eyes. Generally rhythm could be created by repetition of form, colour, etc. However, too much use of the same pattern without variation might cause monotony [25,29]

2.3.6 Past Research and Development on Design for Aesthetics

Many research works have been done in the past on the field of aesthetics but mainly those have been focused on art, philosophy, music and painting. Only a few research initiatives have been taken on design for aesthetics [33]. In psychology, a number of studies have been focused on emotion and feelings [34]. To gauge consumers' attitude, many market research studies have been carried out [35,36]. A great deal of research works has been done in the field of civil engineering regarding the design of aesthetically pleasant structures like bridges, dams, buildings etc [18, 37-39]. In the field of Industrial Engineering, some researchers have worked on topics related to design for aesthetics in the last two decades. Kuranga [40] developed Fresdam, a computer-aided path generation tool. And finally, Takala and Woodward [41], Hisao and Chen [42] developed some computer-oriented methods to assist product design. Wallace and Pham have done some noteworthy works on the field of aesthetical and environmental design consideration. Pham [28,43] described the interactions between design variables and aesthetic properties and proposed a methodology of analysis that would facilitate building of computer tools for aesthetic design. To develop the methodology, he used the analogy of information communication with the communication of aesthetics. The semantic content is carried by digital/ analogue signals in communication of information. While for communication aesthetics, the meaning is delivered by shape properties. Thenceforth, Pham concluded that aesthetics designers at first should understand comprehensively how shape evokes feeling in the case of a particular product and a group of consumers.

Wallace developed a Computer Model of Aesthetics in Industrial Design and has been working on upgradation of the model [44-51]. He and Jakiela [46] proposed a computer-aided industrial design to integrate industrial design and engineering

concerns into the initial concept stage of the product design, specifically to consumer electronic gadgets those being injection moulded.

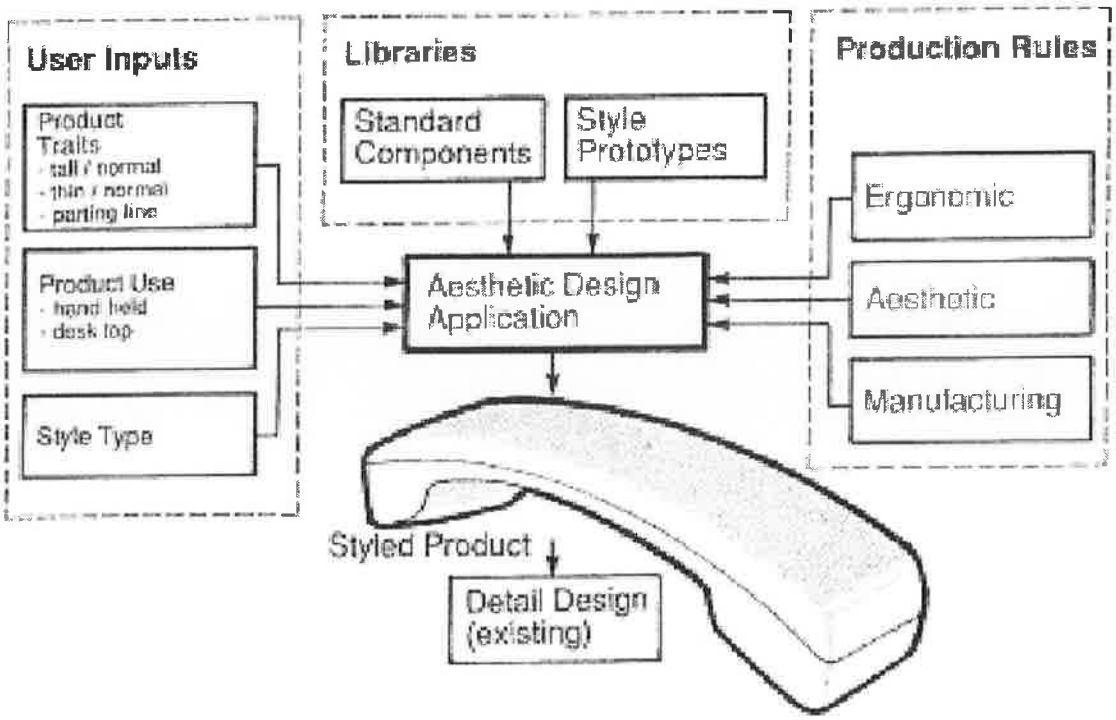

Figure 2.10: Different phases of the design system envisaged by Wallace [44]

This design system uses the three kinds of data as follows:

- Data specific to the product
- Component data and style prototypes from the library
- Program rules that include ergonomic, aesthetic and manufacturability considerations

At first the designer has to choose some initial descriptive specifications and select elements from the systems library of standard components and sub assemblies. Then the program comes in action with regard to configure the product to suit the chosen components and specifications. The automated design develops conceptual design alternatives through a four-stage process; no intervention is possible from the user in this stage. The four stages are as follows:

- Positioning of the components in 3D space relative to the mould parting plane
- Enclosing component configuration in an appropriate styled surface

- Adding styled specific details to the surface

Applying graphical element

The model is executed in four-stage levels:

1. Organization level
2. Surface design level
3. Surface detailing level
4. Graphics

Fujita et al.[52] presented a novel methodology that first propose initial design, derive measurement, add aesthetic features, check functional aspect and at the end generate final design. This way it combines constraint management in geometric modelling for engineering with the consideration of aesthetics. Write some more with Computer supports.

2.4 Design for Environment

Growing public concern for environment, stringent legislations from the governments and intense competitions have prompted manufacturers to shift from conventional design to concurrent design. Design for environment (DFE) is one of the prime focuses of the concurrent design methodology. In general terms, DFE is the design philosophy, which has its goal as the minimization of harm caused to the environment during the product's entire life cycle. Again, Fiskel and Wapman [53] define design for environment as "the systematic consideration, during new production and process development, of design associated with environmental safety and health over the full-product life-cycle."

2.4.1 Goals of DFE

DFE is the new design philosophy to minimize, and if possible, completely eradicate harm done by the product to the environment during its life cycle. Whenever a product is produced and introduced to the market, inevitably it has some impact on environment. For instance, it may use energy, create waste etc. Eventually it may have contribution to different environmental hazards like global warming, destruction of the ozone layer, acid rain, problems associated with toxic waste

disposal etc. Design for Environment addresses these issues and its goals could be summarised as [54]:

- To minimize the use of non-renewable resources
- To effectively manage renewable resources, and
- To minimize toxic release to environment

The other ways to express the goals of DFE are as follows-

- Minimizing the production of toxic materials
- Minimizing pollution of all sorts
- Minimizing waste of limited resources
- Minimizing energy usage

2.4.2 Methods for Studying DFE

The study of design for environment consists of different methods and techniques. Among them, Life Cycle Assessment (LCA) is the most prominent. The others are Environmental Impact metric, Environmental Accounting Method etc. A brief description of the important methods is presented in the following sections.

2.4.2.1 Life-Cycle Assessment

According to Society of Environmental Toxicology and Chemistry [55], product life-cycle assessment is an objective process to evaluate the environmental burdens associated with a product or activity by identifying and quantifying energy and materials used and wastes released to the environment, to access the impact of those energy and material uses and release to the environment. In simple terms, it is based on the life-cycle costs of a product, that is, product-specific costs that occur within the life-cycle framework. These costs occur from extraction and processing of raw materials, to manufacturing, transportation and distribution, and eventually reuse, maintenance, recycling, and final disposal [56,57]. These costs may be segmented into two sections as:

- Cost of product development and manufacturing
- Cost of operation, maintenance and/or service

The product's life cycle cost in different stages is depicted in Table 2.2

Table 2.2: Total life cycle cost [58]

Product life-cycle cost (Jovane, 1993)

Life-cycle phase	Company costs	User costs	Society costs
Need	Market recognition		
Design	Development		
Production	Materials, energy, facilities, wages and salaries		Waste, pollution and health damage
Distribution	Transportation, storage, waste	Transportation, storage	Waste, pollution, packings and health damages
Use	Warranty service	Energy, materials, maintenance	Waste, pollution and health damages
Disposal		Disposal dues	Waste handling, disposal, health damages, pollution
Recycling		Recycling dues	Waste, pollution and health damages

LCA is probably the most commonly accepted and viable method for assessing the environmental impact of products [59]. A standard LCA has four major stages, which are as follows [60]:

- Goal definition
- Inventory Analysis
- Impact Assessment
- Improvement Assessment

To design a life cycle analysis procedure for a product, the following six phases [61] should be considered:

- Need recognition
- Design Development
- Production
- Distribution
- Use
- Disposal

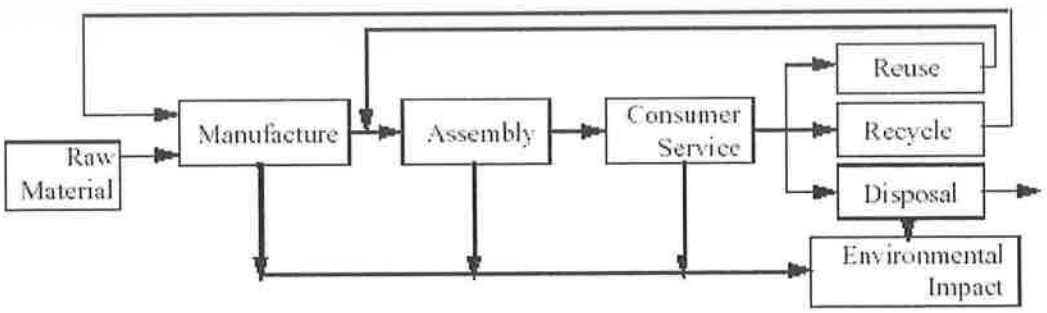

Figure 2.11: Product Life Cycle [61]

The objectives of LCA are to:

a) Provide a complete picture of an activity and its interactions with the environment both internally and externally

b) Contribute to the understanding of the overall and independent nature of the environmental consequences of human activities

c) Offer relevant information to decision makers to take measures for possible environmental improvements.

There are some new methods developed to use in conjunction with life cycle analysis. For instance, LCI (life-cycle inventory) is the LCA stage during which a list for all materials inputs and output for each process are prepared. Life-cycle impact assessment (LCIA) provides some numeric value to the amount of damage expected in each impact classes [62,63,64]. Life cycle cost analysis also uses an extended time scale, from the time of production through procurement, storage, use, and disposal (65).

2.4.2.2 Environmental Impact Metric

Veroutis and Fava [66] define environmental impact metric as an algorithmic interpretation of levels of performance within an environmental criterion. Like impact assessment, environmental impact metric assigns value (i.e. metric) regarding environmental attribute of the product.

2.4.2.3 Environment Accounting Method

Monetary aspects should be considered before taking any design decision. Shen [67] highlighted this financial consideration in context of effective life-cycle design. In general, it consists of activity-based costing (ABC) and cost benefit analysis. On the proposed system of Bras and Emblemsvag [68], costs are traced from activities to products based on each product's consumption of such activities as per ongoing modern ABC system. Similarly, Kuo [69] presented a disassembly sequence and cost analysis for the end of life products during design stage.

He categorized disassembly sequence with regard to cost into three types:

I. Target disassembly
II. Full disassembly
III. Optimal disassembly

When material and energy flows are determined, inventory analysis will be beneficial as it provides a detailed template for assigning cost to individual products.

The EPA(Environmental Protection Agency) Pollution Benefits Manual [65] provides a financial analysis approach to compare alternatives for pollution prevention. It suggests that life cycle cost could be shared by different manufacturing companies, users and society. Lee and Tapiero [70] proposed a framework to identify interaction between quality control parameters and product service in order to reduce product service cost. The need for an economic structure to be observed in the market for product support was felt by Hegde and Karamarkar [71]. Hedge [72] divided failure cost into four categories as follows for the ease of analysis :

I. Failure cost to the customer as the sum of fixed and variable costs of failure
II. Failure cost of downtime proportional to a power of the length of downtime
III. Failure cost as a storage device
IV. Failure cost as almost zero to calculate the total discount cost

2.4.2.4 Eco Indicator

Eco indicator method was developed by Pre Netherlands. After conducting extensive research, they created eco-indicator method for environmental impact assessment. The first version was Eco-indicator95 and the current version is Eco-indicator99. These methods provide eco indicator scores to evaluate the impact of materials and processes. Eco-indicator 99 method documents more than 200 predefined scores for commonly used materials and processes. Eco-indicator99 and Eco-indicator95 scores are freely available online[73]. Using the eco-indicator value, it developed the software 'SimaPro'. It is a popular software used widely to find the environmental impacts. In the ecoindicator methodogy[74], the higher the eco-indicator socre, the worse impact it has on the environment.

2.4.3 Design for Disassembly

One of the main aspects of environmentally viable design is to enable it to be dismantled easily for recycling, remanufacturing or reuse purpose. Design for disassembly deals with the study of dismantling process. Brennan et al [75] defines Design for Disassembly as " The process of systematic removal of desirable constituted parts from an assembly while ensuring that there is no impairment of the

parts due to the process". Many research works have been done in the last few decades on design for disassembly. It has been found that the volume of discarded products multiplies in an unprecedented fashion and thereby creating a bad impact on the environment. One of the prime ways to minimize environmental hazards of a product is to recycle it. If the product could be easily dismantled, then it is more likely to be recycled [68]. For this reason, the study of design for disassembly is very important.

2.4.3.1 Basic Methods of Disassembly

Many technical and design characteristics are associated with disassembly. Disassembly methods could be the use of alternative adhesives and connection devices that can be used to form and disassemble products. Leonard [76] presented two basic methods of disassembly as depicted in Figure 2.11. They are Reverse

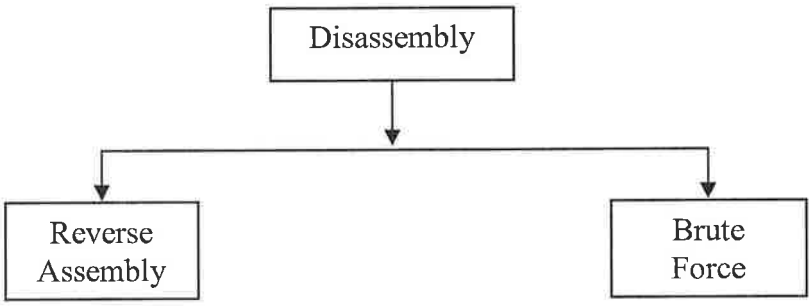

Figure 2.12: Basic methods of disassembly

assembly and brute force. Reverse assembly is economically and environmentally more sustainable or justifiable [76]. However, the other proves to be good in some specific circumstances.

2.4.3.2 Problems in Disassembling

Zussman et al. [77] identified a few major problems that occur during the process of disassembling. Firstly, it is difficult to gain all the information necessary to plan the disassembly, e.g., part of the product might have been modified on repair and wear. Secondly, still a huge number of consumer products are not designed for ease of assembly.

2.4.3.3 Determination of Disassembly Sequence

Different disassembly methods have been developed to meet the specific needs. Zust and Wagner [78] of Swiss Federal Institute of Technology developed an evaluation procedure to support product design based on conflicting DFD criteria. Subramani

and Dewthrust [79] pointed out three prime issues points associated with disassembly sequence as depicted in Figure 2.12.

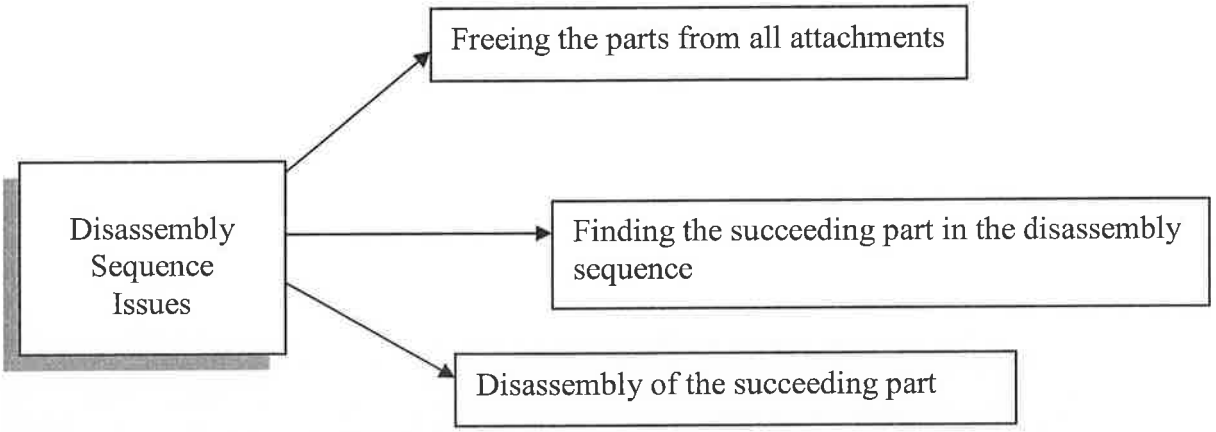

Figure 2.13: Disassembly Sequence

Gu and Yan [80] developed a graph-based heuristic approach for automatic generation of disassembly sequence from a feature-based database. The stages involved are depicted in Figure 2.14:

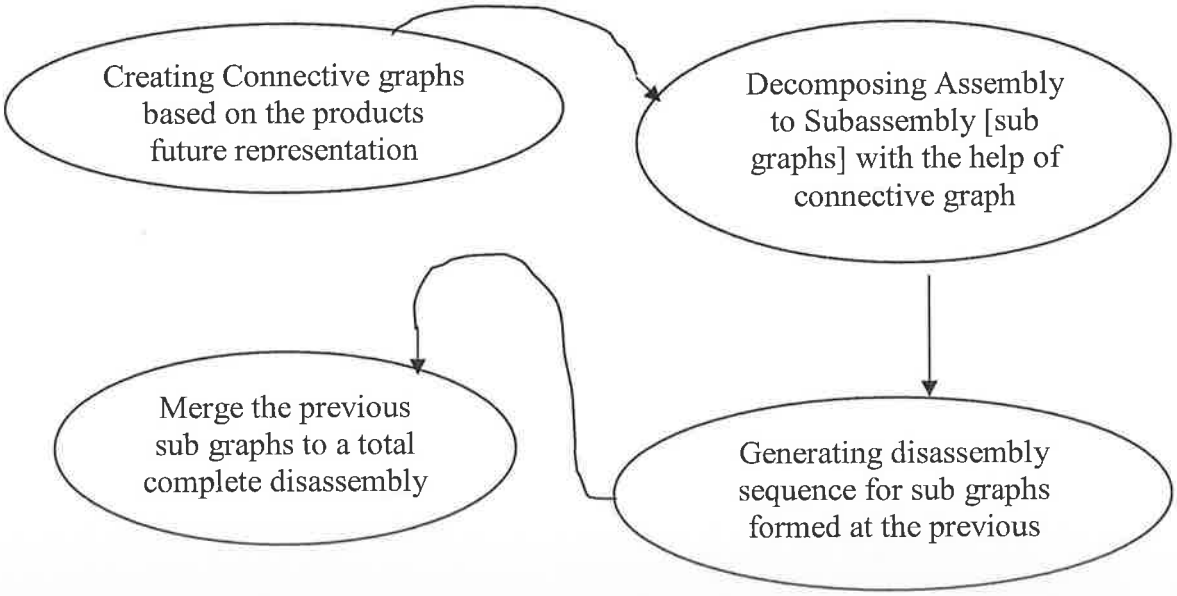

Figure 2.14: Stages in automatic generation of disassembly sequence

Following the approach based on destructive disassembly (DD), Lee and Gadh [81] developed a computerized design for disassembly. On the specialized field of electromechanical products, Kuo et al. [82] provided a graph-based heuristic approach to perform disassembly analysis. The procedure is depicted in Figure 2.15. At first, a component fastener graph is drawn according to the components of a product and their assembly relationship. Search option comes into action where the

previous graph is to be split into sub graph to represent modular sub assemblies. A disassembly tree is generated afterwards using disassembly precedence analysis method. At the end, a disassembly sequence is generated. It's an intelligent heuristic approach to generate disassembly sequence.

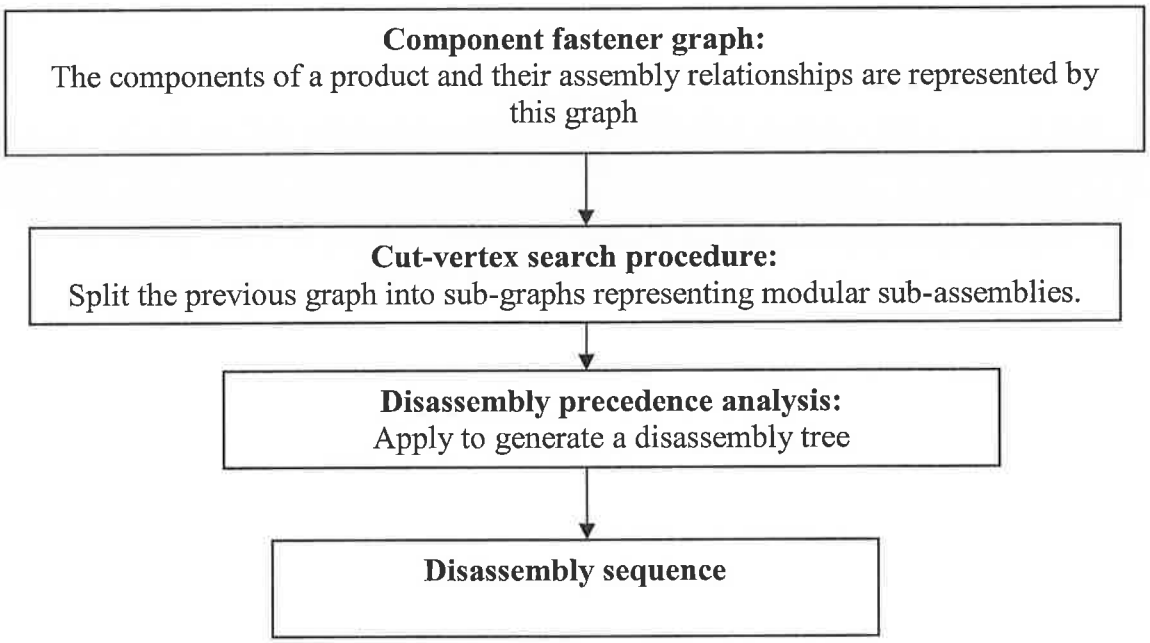

Figure 2.15: Heuristic approach to perform disassembly analysis

2.4.4 Design for Recycling

Design for Recycling (DFR) deals with the study of recycling techniques, methods, procedures etc.

2.4.4.1 Aim of Recycling

The aims of recycling are:

- Maximizing the recycling resource
- Minimizing the mass and pollution potential of the remaining product

2.4.4.2 Persuasion for Recycling

The General Public has become aware about environmental implications of products and now they prefer to buy products that can be recycled. In addition, many

governments now have ecolabelling schemes to inform consumers about environmentally friendly products. To get ISO certification companies must have to comply with requirements regarding recycling. In present competitive business scenario, companies must have to get ISO certification to earn consumers confidence and in some cases to comply with government legislation.

2.4.4.3 Research Highlights on Design for Recycling (DFR)

Substantial research works have been performed in the field of design for recycling. Simon [83] observes that two engineering problems are inevitably associated with dismantling techniques and research costs. He says that dismantling requires the knowledge of the destination or recycling possibility of the component parts disassembled. He suggests two probable optimised ways of dismantling for recycling:

- Removing the most valuable parts first, and
- Maximizing the yield of each dismantling operation

It is a better guideline to handle the problems. Henstock [84] mentioned some principles of DFR with respect to recycling practices of various metal based items with specific focus on steel scrap in automobiles. They are:

- Simplify mechanical assembly
- Avoid self-contaminating combinations of materials
- Standardize materials used
- Separate high copper content items from steel items

In the field of Plastic manufacturing, several research works have been performed. Ishii et al. [85] developed a training tool based on design compatibility analysis on

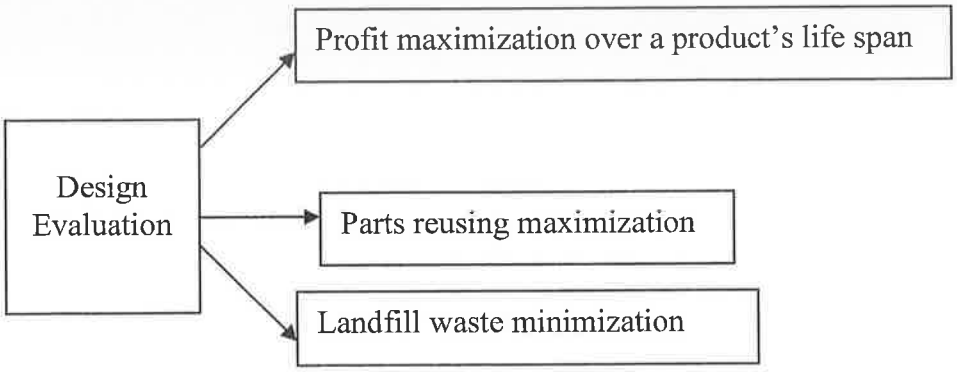

Figure 2.16: Design Evaluation Objectives

For disposal purpose, the disposal destinations should be identified.

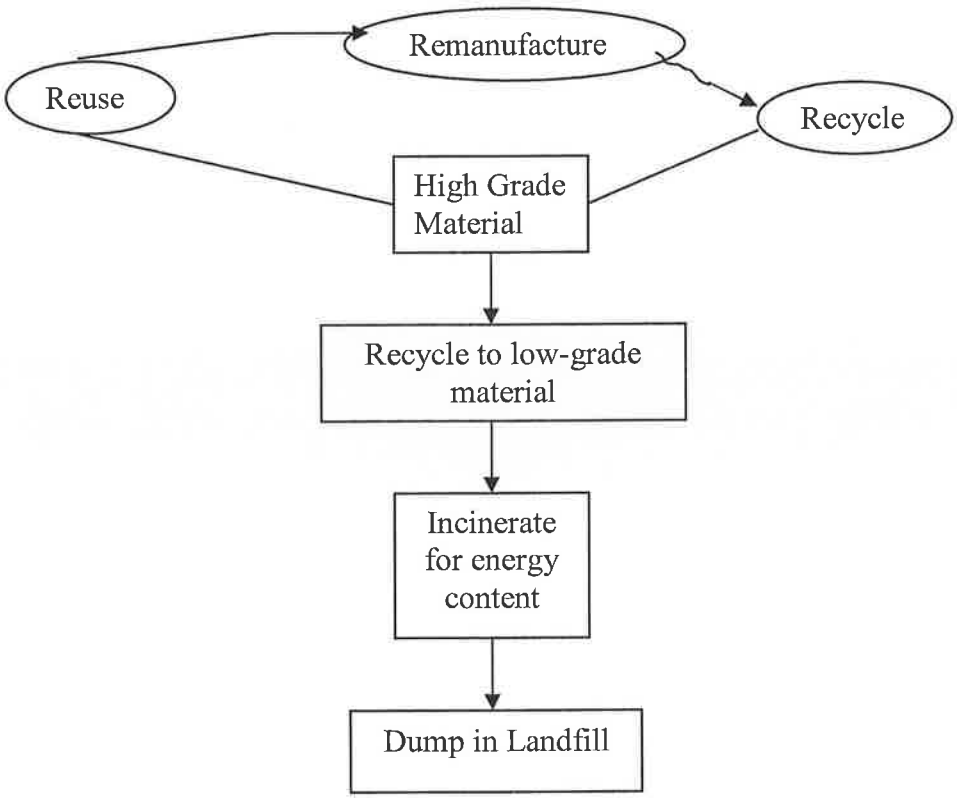

Figure 2.17: Hierarchy in recycling

injection moulding. Navinchandra [86] developed an extensive environmental impact analysis that considers disposal together with the cost associated in overall product and material recycling loop. Rose and Evans [87] carried out research in CIM institute of Georgia Tech on assembly oriented life-cycle analysis, where recyclability of a product is evaluated under possible future trends in the development of recycling technology and economy. On that procedure, each criterion is weighted and then final decision is made. Zussman et al. [77] stated three main criteria of design evaluation on the basis of environment. They are depicted in Figure 2.16.Simon [83] presents the hierarchy of recycling and disposal destinations as depicted in Figure 2.17.

2.4.4.4 Concept of Clumping for Disassembly and Recycle

Ishii et al. [88] proposed clumping for disassembly concept that heralded a new dimension to disassembly and recycle analysis. The concept could be described briefly as follows:

Clumping for recycle: If the product materials are not compatible, then mechanical connections among the components should be easily breakable. This could be achieved by using snap fit, press- fits, screws, screw insert etc.
Clumping for disposal: In this case, neither the material nor the fastening method is important, only degradability should be considered.

2.4.4.5 Material Recognition or Selection for Recycling

Material selection has vast impact on disassembly and recycling. Material Selection done on the earlier stage should be compatible to be recognised easily at later recycling process. Shergold [89] indicates that the Fourier Transform Infra-Red (FTIR)-based equipment developed by Rover and Bird is good at identifying plastics and some other filler materials.

2.4.4.6 Automotive Industry Related Recycling Research

A potentially economic viable recycling could be done on automotive parts and significant progress has been made in this direction. Shergold [89] points out that 75% of the weight of each vehicle disposed can be recovered for recycling. According to his assessments, the parts removed by a dismantler are determined by the market demand and now the most demanded recycled items are engine, gearbox and other mechanical parts as well as electronic components used in the car.

Wittenburg [90] worked on the concept of recycling path of components and material. Later he proposed a 'cascade model' of decreasing values, that means attention should be given firstly to the dismantled parts suitable for reuse which have the highest values. BMW, a German car company, has successfully implemented recycling techniques [91]. For instance in BMW's Z1 model, all plastic skin could be removed from the metal chassis in 20 minutes. Further, the doors, bumpers, the front, rear, and side panels are made of recyclable thermoplastics produced by GE (General Electrics). A short description of BMW success [92] is given in the following section as it will give a practical insight about how environmental friendly measures could be implemented in the real industrial world.

A great deal of research has been undertaken to make a BMW car as recyclable as possible. BMW plays a pioneering role in developing the planned recycling of parts and materials. Plastic components are granulated and used to make new parts for current models. BMW co-operates with raw material companies to create the necessary material processing and supply cycles. It is now possible to recycle 85% of a BMW car by weight. The company's target is to make 90% of the weight of the car recyclable.

German law requires all manufacturers to arrange for their products to be taken back at the ends of their lives and recycled. In 1990, BMW opened one of the first disassembly lines for scrapped cars in Landshut, Germany. By 1994 a comprehensive network of scrapped car recycling firms had been set up in consultation with other car manufacturers. When laws in other European countries require the same level of recycling as is current in Germany, these facilities will be extended. BMW would welcome standardised legislation establishing general conditions throughout Europe for the recycling of cars.

In the UK, the neighbouring country of Ireland, dealers provide an environmentally sound disposal route for hazardous materials. The tasks done by BMW in this regard are:

- Waste oil is reprocessed as part of a national agreement.
- Batteries are recycled.
- Damaged bumpers are returned to Germany for recycling.
- Paint shop solvents are reprocessed.

BMW is using recycled plastics to an increasing amount in its manufacturing process. For instance, the linings of the floor and luggage compartments and air ducts of the new 3 Series are made entirely of recycled bumpers from the former 3 Series and current 5 and 7 Series.

2.4.5 Existing System or Development in DFE

Some prominent systems and softwares developed in the field of Design for Environment are briefly described in the following sections.

2.4.5.1 Hewlett-Packard DFE Tools

DFE guidelines, product assessments, product stewardship metric-these are the tools provided by Hewlett-Packard company for helping concerned bodies on environmentally friendly design [93].

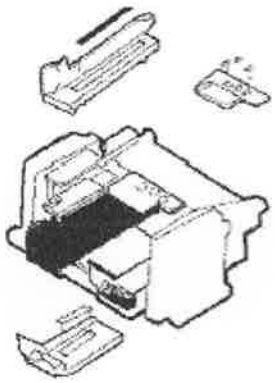

Figure 2.18: HP Inkjet Paper Tray [93]

The guidelines encompass product use, product consumable and supplies, shipment packaging, manufacturing processes, and end-of-life strategies.

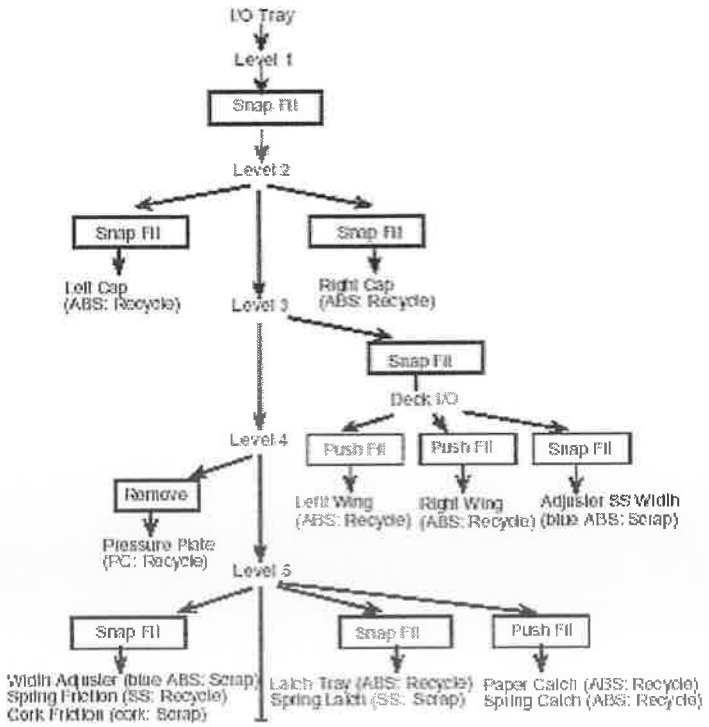

Figure 2.19: Fishbone Diagram [94]

The product assessments assist the designer to measure results and think about improvement opportunities. The product metrics comprises of material conversation,

waste reduction, energy efficiency, design for environment, manufacturing emissions etc. HP/Micrometallics has a recycling center at which they retrieve a significant portion of subassemblies and parts to be used by HP's service group. Their initial effort was to find out optimal disassembly steps in "clumps" that could be reused or recycled for highest value. The inkjet tray is shown in Figure 2.18 and recovery process is depicted in Figure 2.19 [94,95].

2.4.5.2 Software Tool for End-of-Life Cycle

There are several software tools already developed for end-of- life cycle analysis. Spicer and Wang [96] made a prototype software tool namely Environmental Design Industrial Template (EDIT). It focuses on inventory assessment of the retirement phase of life cycle analysis. The framework of the development stages of EDIT is depicted in Table 2.3 and Figure 2.20.

Table 2.3: Inventory Assessment for the Life Cycle Stages [97]

Life Cycle Stage	Inventory Assessment Criteria
Material Extraction	• Resource scarcity • Ecological damage and pollution • Energy used in extraction
Material Processing	• Analysis of byproducts produced • Level of waste • Energy use
Manufacturing	• Analysis of byproducts produced • Level of waste • Energy use
Usage	• Functional effects • Length of life • Energy use
Retirement	• Recovery levels and conditions • Energy use

In the EDIT software, a Microsoft Windows based graphical interface has been used. At first, the user has to supply data to estimate the likely retirement phase of the product. In this way, it could be useful as a design for environment decision support system. Its working procedure is shown in Figure 2.20.

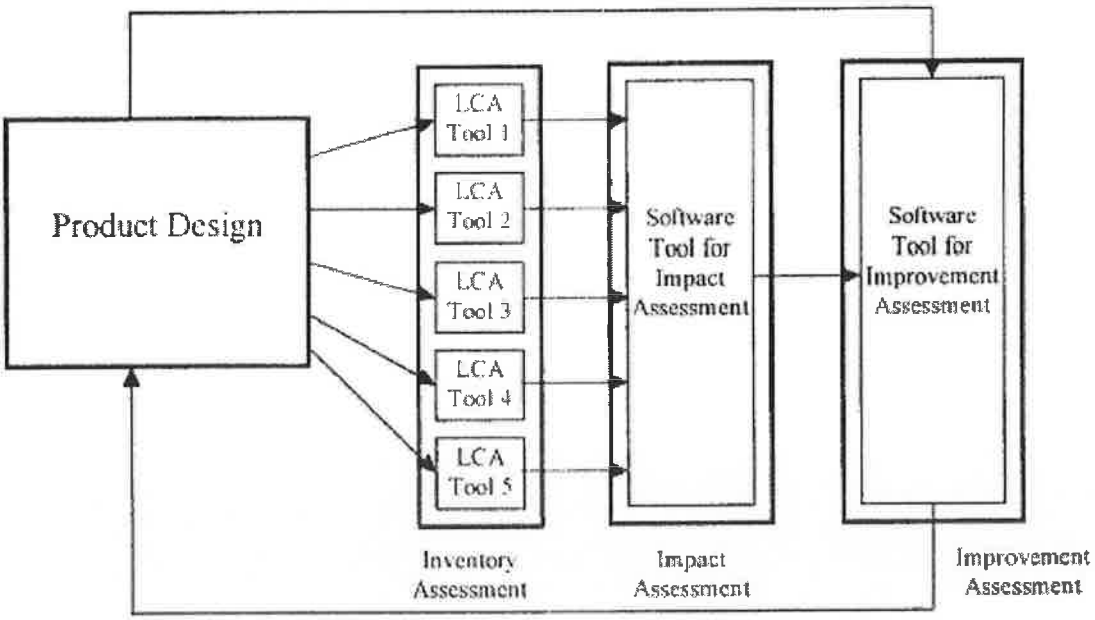

Figure 2.20: Framework for a DFE DSS [93]

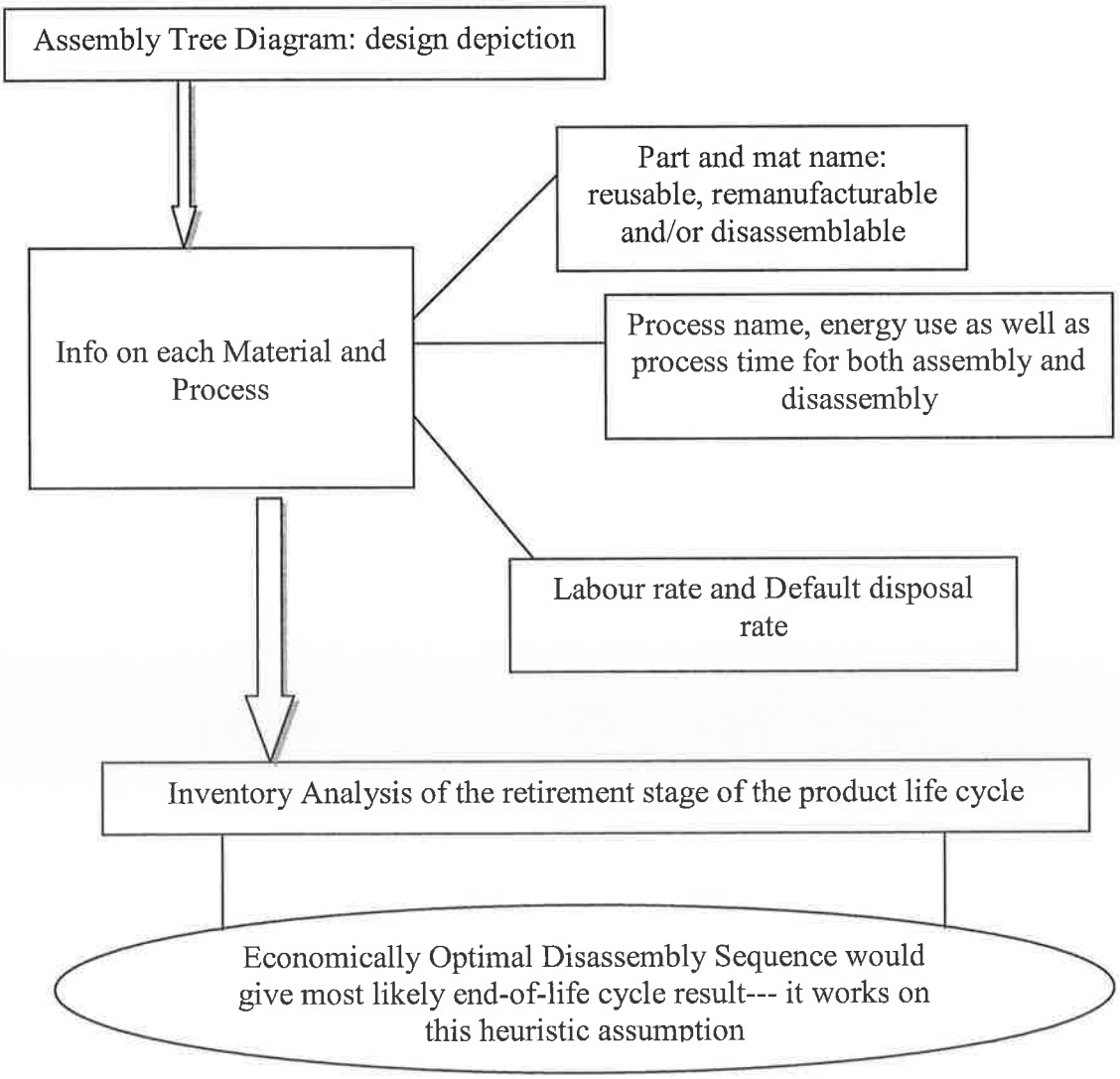

Figure 2.21: EDIT working Sequence

2.4.6 Life Cycle Analysis (LCA) Tools

Life-cycle-analysis is one of the principal elements of Design for Environment [DFE]. Several methods or tools have been developed to carry out LCA. Simplified LCA is the need of the day as most companies or manufacturers could not use LCA due to time constraint. Detailed LCA takes long time to perform but the designer has to hand over the design product within a short period of time in most of the cases [98]. So the possible solution to this issue could be the use of simplified methods that product designers can apply themselves [59,99].

Concurrent-modelling approach has opened window for applied DFE methods. Schott [100] proposed **IPPD**, the Integrated Product and Process Development method, based on concurrent modelling approach. It allows the designer to model the life cycle along with the design of the product. The **NORDLIST-LCA** project [101] developed a prototype version of a LCA program for eliminating ecological consequence of a product through its life span.

Disassembly tools have been also developed, for example, the LEGASE (Life-cycle Engineering Group) program at Stanford. It developed a guideline for assisting the product developer in 'end of life' strategies called **ELDA** (End of Life Design Advisor)[97]. Lately it has been made available online and so can be used by any designer prepared to pay subscription. Two sample snapshots from this advisor are presented in Fig 2.21 and Fig 2.22.

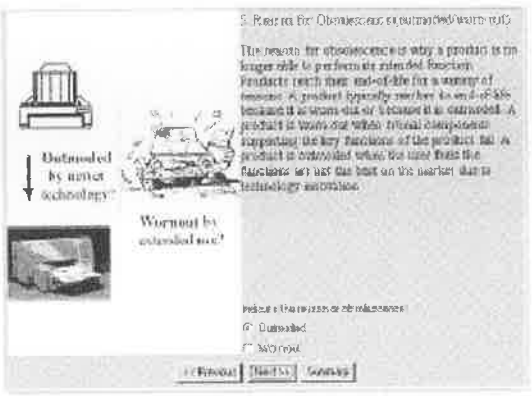

Figure 2.22: Input Screen of ELDA [97]

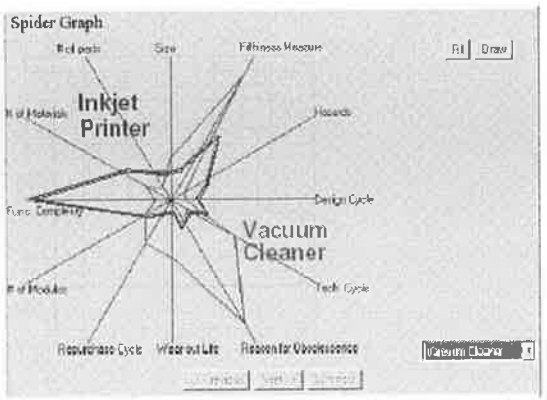

Figure 2.23: ELDA Spider Graph [97]

Menka and David [102] compiled a comprehensive list of LCA tools and it is presented in Table 2.4.

Table 2.4: List of LCA Tools [102]

Name[a]	Vendor	Version	Cost, $K	Data Location
1. **Boustead**	Boustead	2	24	Europe
2. **CLEAN**	EPRI	2	14	U.S.
3. CUMPAN	Univ. of Hohenheim	Unknown	Unknown	Germany
4. EcoAssessor	PIRA	Unknown	Unknown	UK
5. **EcoManager**	Franklin Associates, Ltd.	1	10	Europe/U.S.
6. ECONTROL	Oekoscience	Unknown	Unknown	Switzerland
7. **EcoPack2000**	Max Bolliger	2.2	5.8	Switzerland
8. EcoPro	EMPA	1	Unknown	Switzerland
9. EcoSys	Sandia/DOE	Prototype	Unknown	U.S.
10. EDIP	Inst. for Prod. Devel.	Prototype	Unknown	Denmark
11. EMIS	Carbotech	Unknown	Unknown	Switzerland
12. EPS	IVL	1	Unknown	Sweden
13. **GaBi**	IPTS	2	10	Germany
14. Heraklit	Fraunhofer Inst.	Unknown	Unknown	Germany
15. IDEA	IIASA	Unknown	Unknown	Europe
16. **KCL-ECO**	Finnish Paper Inst.	1	3.6	Finland
17. LCAI	P&G/ETH	1	Not Avail.	Europe
18. LCAD	Battelle/DOE	Prototype	< 1	U.S.
19. **LCAiT**	Chalmers	1.1	3.5	Sweden
20. LCASys	Philips/ORIGIN	Unknown	Unknown	Netherlands
21. **LIMS**	Chem Systems	1	25	U.S.
22. LMS Eco-Inv. Tool	Christoph Machner	1	Unknown	Austria
23. Oeko-Base II	Peter Meier	Unknown	Unknown	Switzerland
24. **PEMS**	PIRA	3.1	9.1	U.S.
25. **PIA**	BMI/TME	1.2	1.4	Europe
26. PIUSSOEECOS	PSI AG	Unknown	Unknown	Germany
27. PLA	Visionik ApS	Unknown	Unknown	Denmark
28. REGIS	Sinum Gmbh	Unknown	Unknown	Switzerland
29. **REPAQ**	Franklin Associates, Ltd.	2	10	U.S.
30. **SimaPro**	PRe' Consulting	3.1	3	Netherlands
31. SimaTool	Leiden Univ.	Prototype	Unknown	Netherlands
32. Simbox	EAWAG	Unknown	Unknown	Switzerland
33. **TEAM**	Ecobalance	1	10	Europe
34. **TEMIS**	Oko-Institute	2	Unknown	Europe
35. TetraSolver	TetraPak	Unknown	Unknown	Europe
36. Umberto	IFEU	Unknown	Unknown	Germany
37. Umcon	Partcip Gmbh	Unknown	Unknown	Germany

2.4.6.1 TEAM (Tools for Environmental Analysis and Management)

TEAM is a widely used life cycle inventory modeller as it provides databases of life cycle inventories for various processes, along with means for modelling the flows between the processes [102,103].

TEAM is one of the most powerful and flexible of the tools evaluated in Menke and David's study [102]. Because of this, however, the features and capabilities are the most difficult to fully understand and utilize. Selecting and defining inputs and outputs within the lowest process/unit level is quite simple using the tool bar; flows may be defined by values or variables and equations. Unit flexibility is similar to KCL-ECO; units are associated with each variable (i.e. termed an "Article" in TEAMTM) and can be defined by the user. Once defined, this unit convention must be maintained throughout the LCA project. The use of formulas to specify allocation methods for each process unit is a unique feature of TEAM. At each process level, Check and Compile options allow the user to ensure system consistency and integrity even before the system is fully defined. Calculating the LCA inventory from anywhere within the system (called "propagation") is yet another flexible feature of TEAM. Tabular results are typical of other software tools evaluated, with customization and export capabilities supported. Graphical representation of results as a feature of the tool is supported only within the "Compare Results" option described above. Unique features of TEAM include the following:

- Systems and sub-systems can be defined as Modules, allowing highly detailed and complex systems to be simplified.
- Inventory calculations can be propagated from anywhere within the system;
- Allocation rules can be defined within the lowest process/unit level for any flow;
- The various data protection and data access levels allow easy maintenance of data integrity; and
- A networking version of TEAM is also available which offers multiple remote access to a single system.

Limitations of TEAM include the lack of support for user-defined weighting factors for impact assessment and the limited (only one parameter between two Inventories) comparison of results capabilities as a feature within the software tool.

2.4.7 Integrated / Collaborative Design Tools

Concurrent Engineering or integrated design tools are becoming popular increasingly. A substantial number of such tools are available including the following:

- **SHARE-** A methodology and environment for collaborative Product development [104]
- **NODES-** Numerical and Object Modelling technique concept, developed by CAD centre in Glasgow [105]
- **COOM-** Cooperative Object Modelling concept [106]

Furthermore many research works are ongoing for the development of such integrated tools. In the beginning, the researchers in this field develop a paper-based guideline for the consideration of different design aspects. It is then transformed into a computer-based software, known as an expert system and later arrangements are made to connect it to a largely available design tool.

Poyner [107] developed an ecodesign tool specifically tailored for electronics companies. His work was built upon the research done by Simon and Dowie [108]. He chose an action based research methodology that is suitable for the real world problem accommodation. Analysing the disassembly of telecommunication products with the viewpoint of environmental impact reduction, he developed a paper-based guideline. Finally that paper-based guideline was transformed into a computer-based expert system that will help designers on different aspects of design with respect to the environment. He used Kappa language for building the expert system. Though his prototype version was not been linked to any CAD tools initially, a later modified version was attached to ProEngineer. Poyner tested his tool with some experiments in NORTEL Technology Ltd., UK. This tool is a remarkable example of industry-oriented expert system developed for environmental consideration.

DFE Workbench is developed by Roche [109] to help designers in analysing, synthesising, evaluating and improving environmental characteristics in an emergent design candidate. At the onset, he extensively studied traditional design strategies and cognitive approach . On the basis of findings derived from the above-mentioned

study, he developed a new life cycle design framework called the PAL framework. Later the software DFE workbench was built for continuous improvement of environmentally superior characteristics of virtual prototypes. He tested the software for real design situations involving design engineers by way of protocol analysis and found that the software had satisfactory performance.

DOME- Distributed Object based Modelling and Evaluation is a modelling environment developed by MIT CADLAB [44]. The underlying attributes are:

- Easily buildable object-oriented model that could be visualized as entity relationship graphs
- Both variable types, discrete and continuous, are allowed
- Parameters with uncertain value defined as probability density functions
- Goal setting option
- Calculation of overall quality of design alternatives
- Built-in Optimization Tool

Wallace and Borland have investigated DOME along with TEAM. They incorporated geometric models in the system by using ProEngineer and the spreadsheet model was generated using MS Excel. The communication architecture used was named COBRA(Common Object Request Broker Architecture). Later the system developed was validated by using it on the design of a beverage container. The main features of their works are depicted in Figure 2.24, Figure 2.25, Figure 2.26, Figure 2.27 and Figure 2.28.

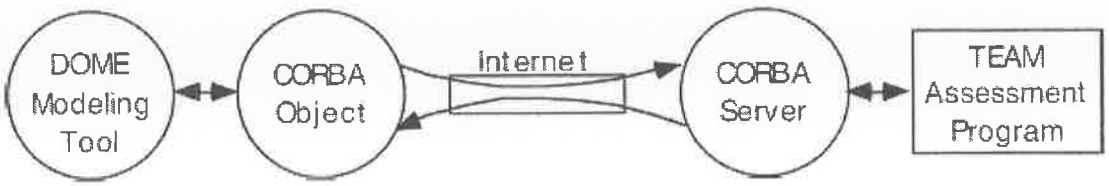

Figure 2.24: The communication stream for each update [44]

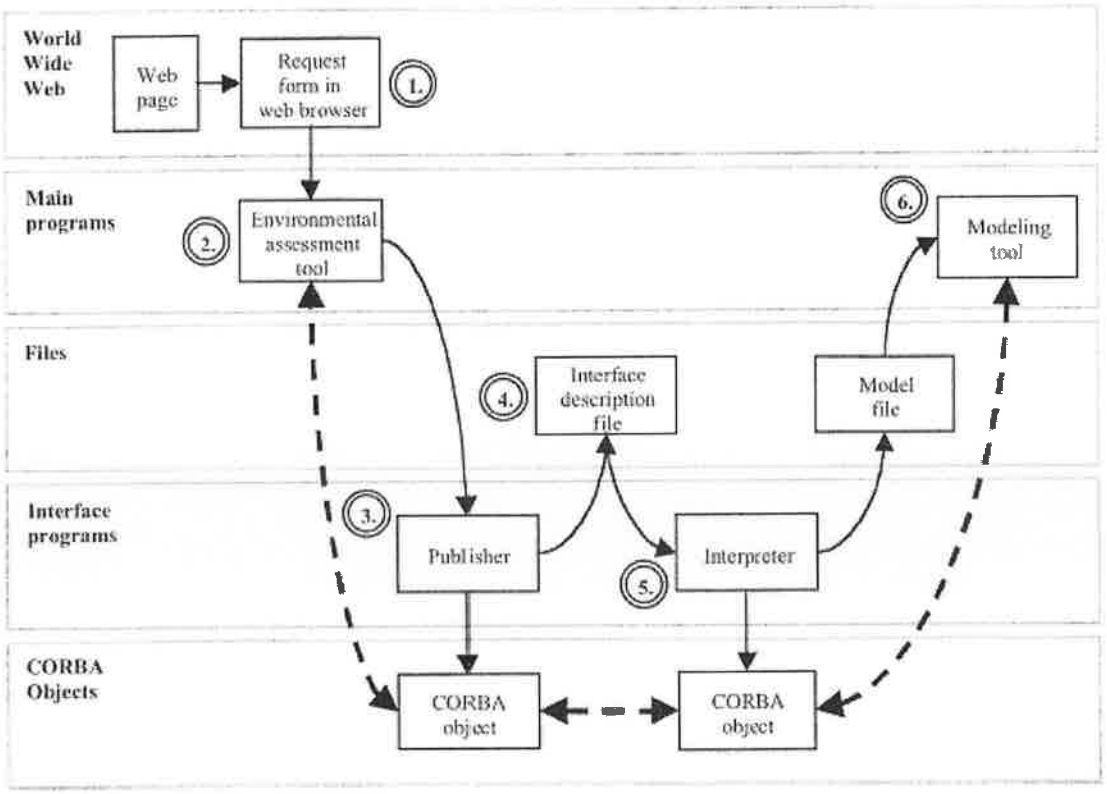

Figure 2.25: The process of establishing communication in COBRA. Solid lines show the initial procedure. Once communication is established, automated network communication occurs along the dashed lines [44]

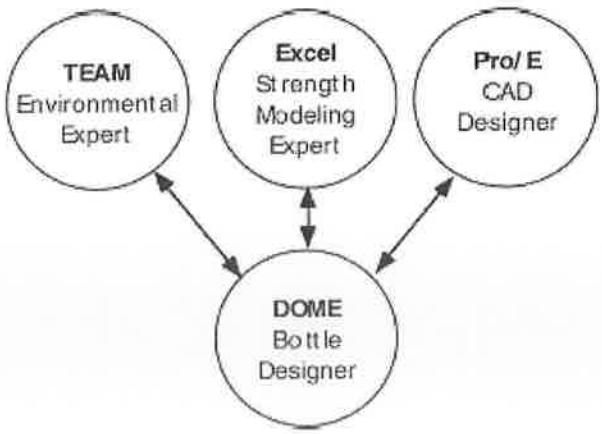

Figure 2.26: Schematic of the bottle model [44]

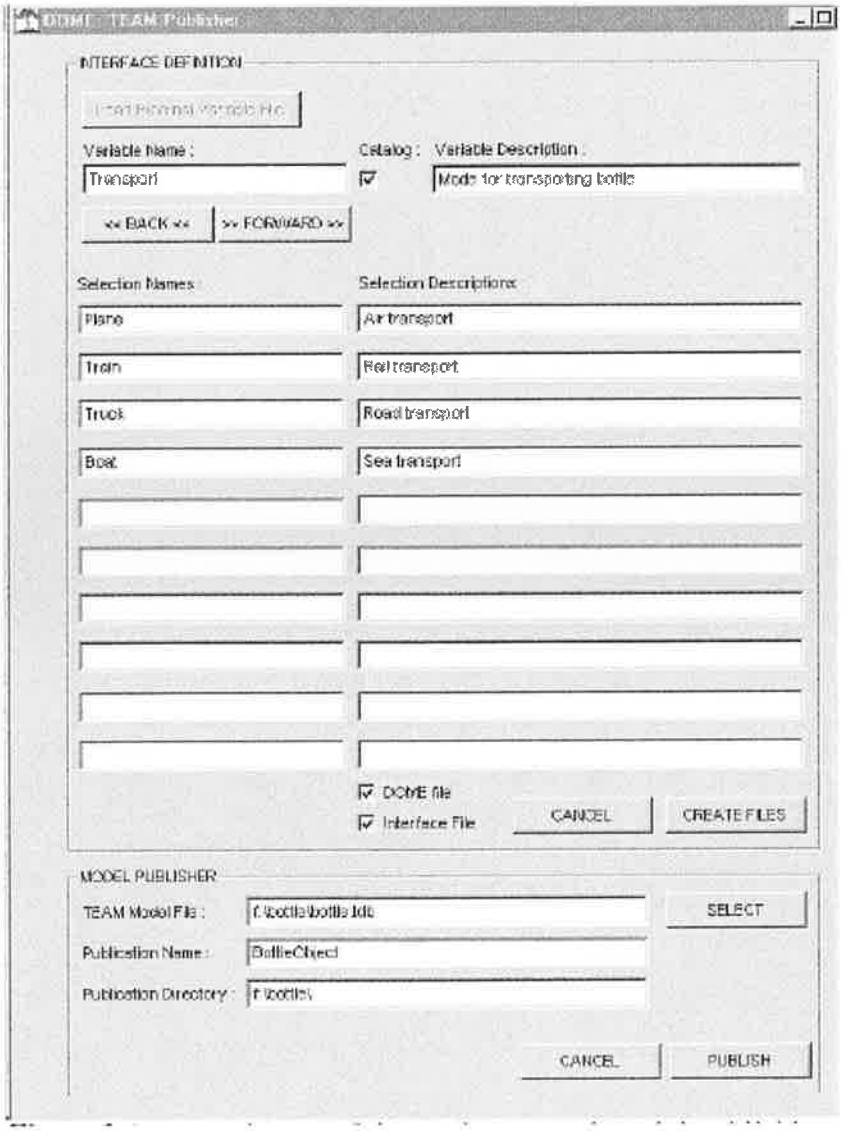

Figure 2.27: A screen image of a portion of the interface definition in the environment model publishing program [44]

```
www.typicalenvironmentalexpert.com:BottleObject
Transport       Mode for transporting bottle
   Plane        Air transport
   Train        Rail transport
   Truck        Road transport
   Boat         Sea transport  ;
Bottle type     Material of the bottles
   Aluminum     Typical aluminum used in beverage containers
   Plastic      Polyethylene Terephthalate (PET) is usually used for bottles
   Glass        Typical glass used in beverage containers  ;
Mass            Mass of the bottle in kg  ;
Distance        Distance in km of the transportation  ;
```

Figure 2.28: The interface definition file for the bottle example [44]

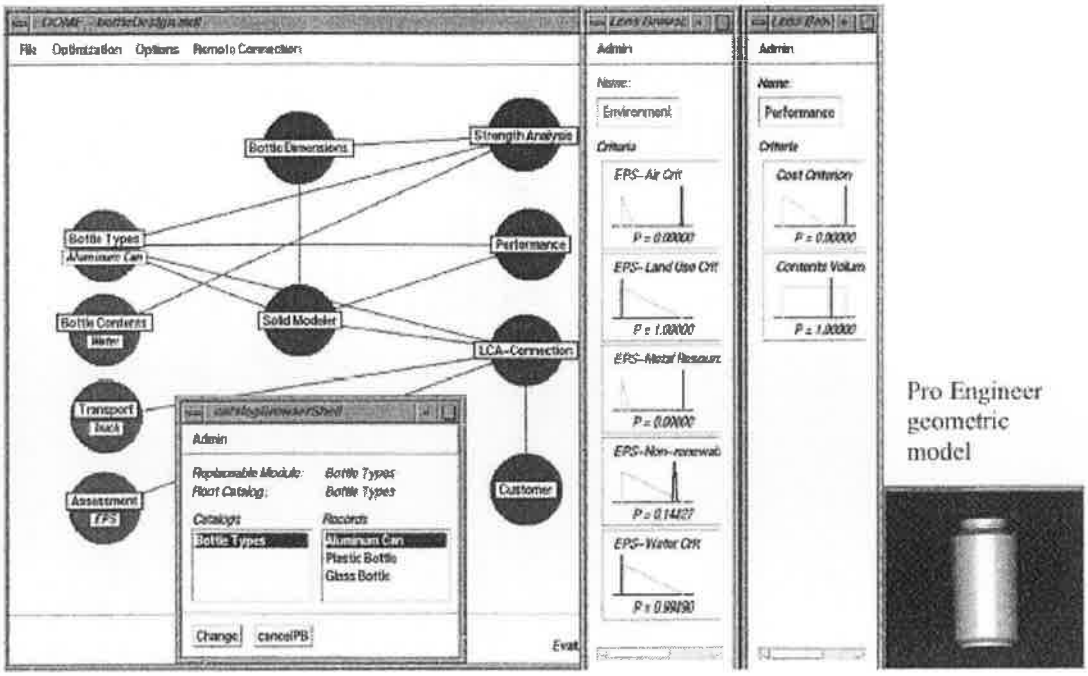

Figure 2.29: Analysis of an aluminium can by DOME [44]

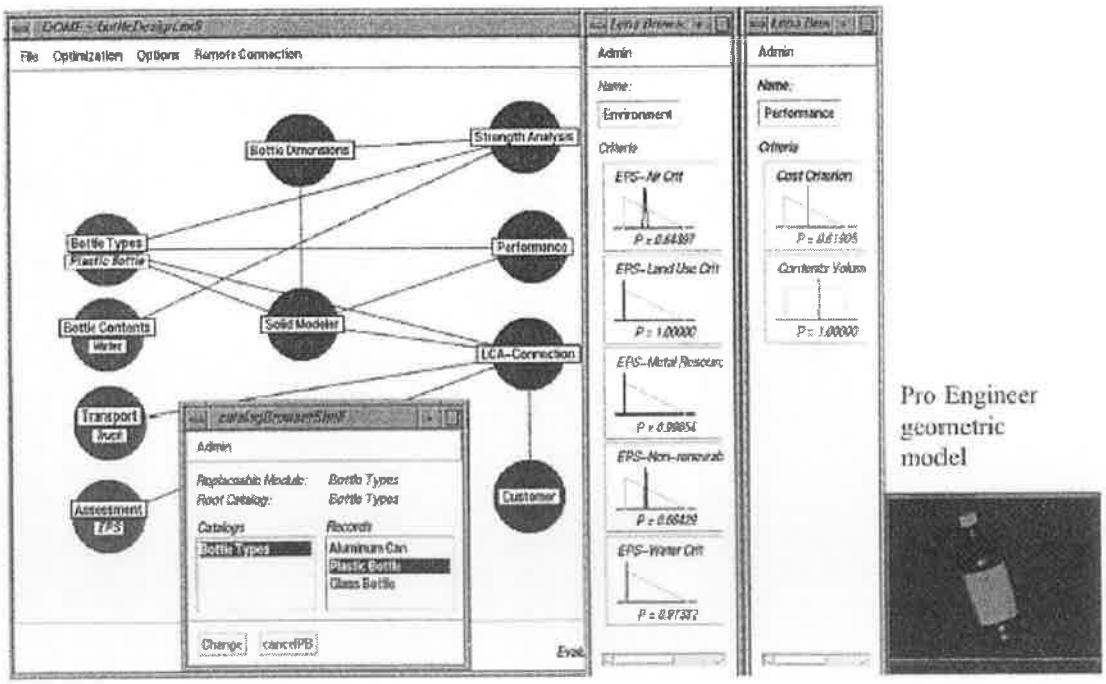

Figure 2.30: Analysis of a plastic bottle by DOME [44]

The main advantage of this collaborative method is that interaction between models takes a very short time. So it can be used with ease to determine trade offs among different configurations and eventually choose the optimal one.

2.5 Summary

Definitions of the key terms related to the research work presented in this thesis were described in the beginning of this chapter. Later different schools of thoughts in design were presented with a discussion of their relevance to Design for Aesthetics and Design for Environment. Past research works done in the field of design for aesthetics were highlighted first. Very few works have been reported in this field. There are identifiable gaps in formulating a tool to help designers in selecting different aesthetical attributes like colour, shape etc. Different branches of the study of Design for Environment were succinctly detailed along with different tools developed or currently in use in this chapter. It has emerged that despite large volume of research in the field of Design for Environment, the possibility of combining aesthetics and environmental consideration have not been fully investigated. Therefore this research was carried out to develop an innovative design system combining both aesthetics and environmental considerations. Besides, most of the systems are complex, time consuming and required specific knowledge of the systems to interpret the output. Thus a simple system with easy to understand output is appeared to be liked by the designers. In order to understand public preference on aesthetical attributes of bottles, two surveys were conducted. Different terms, methods and tests related to the surveys are discussed in Chapter 3. Two surveys are described with results and analyses in Chapter 4 and Chapter 5. The procedure of developing a material selection is described in Chapter 6. The intelligent design system with different modules is presented in Chapter 7.

Chapter Three - Statistical Methods

3.0 Introduction

The objectives of this chapter are to:

- Discuss different terms and methods of statistical analysis and survey
- Detail about the method of survey used

This study looks into aesthetics aspects of consumer product's bottle design. Since aesthetics is a subjective topic, it was found that using statistical methods is an appropriate way to know about the topic. In this chapter, different statistical methods and terms related to this study are explored.

3.1 Statistical methods

There are two main types of statistical methods.

- Survey
- Experiment

The survey method deals with already existent environment. While experiment method deals with a controlled environment. It controls some parameters and analyses the impact using statistical analysis. For this study, survey method was chosen.

3.1.1Choice of Statistical Methods

It is very important to choose right statistical methods for a given study. This choice depends on different factors. Some of the major factors are-

- Sampling Method
- Probability Distribution
- Data type

3.1.2 Sample Characteristics

Most of the statistical tests are designed for samples obtained through probabilistic sampling methods like simple random sampling. For non-probabilistic sampling methods like haphazard sampling, convenience sampling etc, generally descriptive analysis like frequency, percentage, median, mode etc. are used. Whether the sample is independent or dependent is an important consideration for the selection of tests. Another aspect to be considered is the number of groups.

The advantage of simple random sampling is that it would get normal distribution for sufficient sample size. Many statistical tests require the distribution to be normal (Gaussian) distribution. There are some tests available to decide whether a sample falls under normal distribution criteria. Sometimes, samples might be skewed. In that case, median better represent the sample characteristics. Mean and Variance (Standard Deviation) substantially affected by skewed distribution. Such distributions generally have outliers or the data that are largely different from the majority of the data.

3.1.3 Nature of the Data

Consideration of nature of the data includes number of variables for the specific objective at hand, not necessarily the whole study and data type (e.g. nominal, ordinal, interval etc) [110].

3.2 Types of Variables

A variable is a characteristic or thing that is measured or controlled or manipulated in research and it may assume more than one set of values to which numerical measure could be assigned. [111,112].The general classification of variables in statistics is shown in Figure 3.1. Variables are primarily classified into two groups: Qualitative(categorical) and Quantitative(numeric).

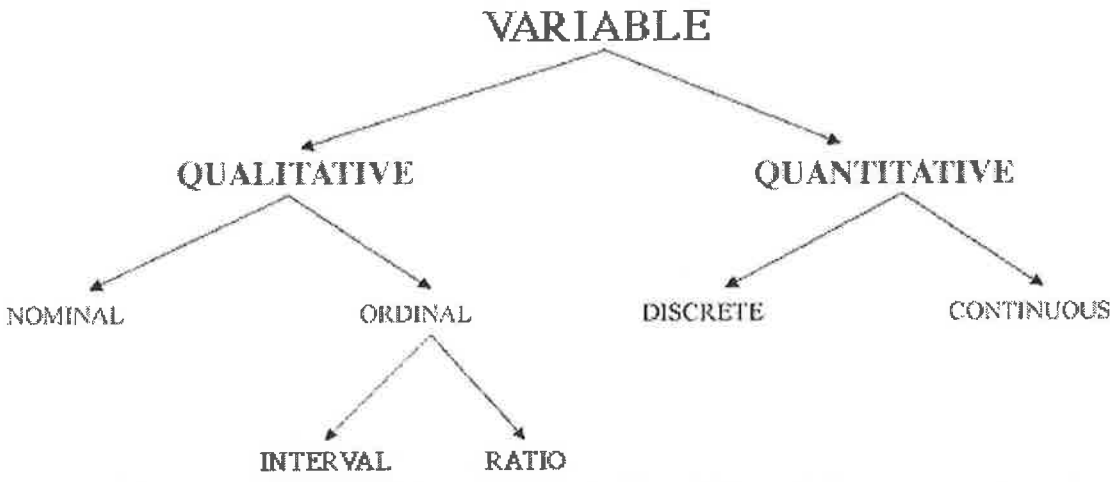

Figure 3.1: Classifications of variables [111]

3.2.1 Qualitative or Categorical Variables

A qualitative variable gives a name, title, label or category to the same type of things/items for which each response or observation could be assigned to a specific category or class. Here each response or observation is a code or word. Qualitative variables can be divided into two groups: nominal variables and ordinal variables. Then ordinal variables are subdivided into two types: interval and ratio

3.2.1.1Nominal Variable

This type of variable does not appear in order. For example, gender, colour, nationality etc. Generally, Demographic data are nominal. While working with this data in SPSS, some value is assigned to the response options of the nominal variable. These assigned value are only given to perform analysis by using as computers only understandable numbers. These are like jersey number for players allocated in a football team just for identification purpose. Number 9 player is not supposed to be better than number 8 player or Number 10 player.

3.2.1.2 Ordinal Variable

This kind of variable comes in as orderly fashion but there is no predefine or exact distance between two members of variables. The data of this kind of variables indicate more than or less than unlike nominal data. However, like nominal data, ordinal data do not have mathematical value. It only suggests some datum is better or worse than other data but it could not measure how much better or worse. For

example, the distance between agree and neutral with disagree to strongly disagree could not be termed as the same. Another example is different choice like first place, second, third etc. are ordinal data. From this data, it could be said that first place is better than second place but could not be said that first place holder has got 10 marks more than second place holder and second place holder has got 20 marks more than third place holder. It may be 10, 20, 1 or anything.

3.2.1.3 Interval Variable

This type of variable has fixed distance between any two adjacent members but without a true zero point. Data of this type of variables have mathematical value. For example, annual income in different bands but with 5000 pounds difference. Ratio is a special sub group of interval variable. Another example is the options in a survey that asks about the most comfortable temperature. The options provided are 0- 20 degree, 21- 30 degree, 31-40 degree. Here 30 degree C is 10 degree warmer than 20 degree C. In interval data scale, there is no true zero. If in this survey, interval range were not the same for different options like 21-25,26-35 etc, it would be still interval data. For example, zero degree C does not mean there is no temperature. It's the freezing temperature. Again, another example of no true zero point is that 88 degree C does not necessarily means the double temperature of 44 degree C though the difference between 43 and 44 degree and that of 88 and 89 degree is the same. Besides, if the options are provided in this manner like mention the comfortable temperature in the box. Here the respondent could put any value. This is also an example of interval variable. Another example of options for a interval variable is , "Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree" and "Infrequently 1 2 3 4 5 6 7 Frequently." Again, if the respondents are asked to give ratings on a product between 1 to 10, the product that got 4 rating does not necessarily two times better than the product that got 2 rating.

3.2.1.4 Ratio

It is a type of interval data. The ratio data does have a true zero. For example, in a survey it is asked how many children one family have. Here the answer might be zero. Since it is interval variable, the options might be presented as 0-2, 3-4, 5-6. Other examples of ratio variables are age, height, distance etc.

3.2.2 Quantitative or Numeric Variables

A quantitative variable measures amount or quantity of something, either these may be of same type or different types, for which each response or observation could be assigned to an amount or a count. Here each response or observation is a number.

3.2.2.1 Discrete Variable

A discrete variable consists of isolated finite points or counts or amounts. It can only take finite number of real values. For example, an examiner could give score to an answer sheet within the range of 0 to 10 with one decimal point. Here the score given by the examiner is limited from 0 to 10, not infinite. Another example is the options given in a survey for the question of how many subjects are taken in semester 1. Here there are a maximum and minimum number of subjects to be taken in semester 1. Therefore the options are data of a discrete variable.

3.2.2.2 Continuous Variables

A continuous variable is supposed to assume infinite number of real value or counts or amounts. Though the data for a continuous variable in most of the cases are grouped for ease in processing. For example, age, distance, temperature.

3.2.3 Common Variables

If one variable has only two options it could be considered as any type of variables mentioned above. For example, gender.

3.2.4 Covariates or Control Variables

In addition to independent variables (predictor or cause or treatment or antecedents or determinants, denoted by X) and dependent variables (effect or outcome or criterion or consequences, denoted by Y), sometimes another variables called control variables or covariates are considered specifically in experimental design and sometimes in non-experimental situations too. The independent variable is one, which is changed in the experiment, and the dependent variable is one that is measured. In scientific experiments, more than one independent variable is not recommended though in social research it is acceptable. A control variable is a variable, which influence is unwanted in the study and therefore it's effect, is to be removed or controlled. Though it is unwanted, it may influence the variables being studied or the relationship between the studied variables. So a technique is used to

analysis its effect and it is called analysis of covariance [113]. It is notable that a particular variable may be independent in one study, while dependent or control variable in another study.

3.3 Probability Distributions

In statistics, for different specific situation different distributions are used. It is said that most of the natural phenomena could be represented by normal distribution. Nevertheless, other distributions have been modelled by the statisticians and mathematicians to easily and extensively describe and analysis different specific situations. The most widely used distributions in statistics are as follows:

- Normal distribution
- t- distribution
- Student distribution
- Binomial distribution

The key features of the mostly widely used distribution are presented in Table 3.1 In another way, distributions are primarily classified into discrete and continuous. Table 3.2 shows a list of distributions under these three classification. Another classification is done on the basis of whether the variable on discussion is only one or more than one. According to this criterion, distribution are of two types: univariate and multivariate.

Table 3.1 Features of different distributions

Name of Distribution	Feature	Special Use
Normal Distribution	Bell-shaped	Occurs in all natural phenomena
Bernoulli Distribution	It is to be described with mathematical notation. It takes value 1 with probability p and value 0 with q = 1-p	
Binomial	Only two options available yes/no	
Poisson	Regular time interval persists within this time interval a lot of unlikely events occur	No of cars passing a point in a city road
Gamma	-defines the time -consecutive rare random events occurs	
Pareto	-It states only a few factors are important in most of the problems	Financial Analysis

Table 3.2: Different Distributions [114]

	Univariate	Mulitvariate
Discrete	Benford • Bernoulli • binomial • Boltzmann • categorical • compound Poisson • discrete phase-type • degenerate • Gauss-Kuzmin • geometric • hypergeometric • logarithmic • negative binomial • parabolic fractal • Poisson • Rademacher • Skellam • uniform • Yule-Simon • zeta • Zipf • Zipf-Mandelbrot	Ewens • multinomial • multivariate Polya
Continuous	Beta • Beta prime • Cauchy • chi-square • Dirac delta function • Coxian • Erlang • exponential • exponential power • F • fading • Fisher's z • Fisher-Tippett • Gamma • generalized extreme value • generalized hyperbolic • generalized inverse Gaussian • Half-Logistic • Hotelling's T-square • hyperbolic secant • hyper-exponential • hypoexponential • inverse chi-square (scaled inverse chi-square)• inverse Gaussian • inverse gamma (scaled inverse gamma) • Kumaraswamy • Landau • Laplace • Lévy • Lévy skew alpha-stable • logistic • log-normal • Maxwell-Boltzmann • Maxwell speed • normal (Gaussian) • normal-gamma • normal inverse Gaussian • Pareto • Pearson • phase-type •	Dirichlet • inverse-Wishart • Kent • matrix normal • multivariate normal • multivariate Student • von Mises-Fisher • Wigner quasi • Wishart

	polar • raised cosine • Rayleigh • relativistic Breit-Wigner • Rice • shifted Gompertz • Student's t • triangular • type-1 Gumbel • type-2 Gumbel • uniform • Variance-Gamma • Voigt • von Mises • Weibull • Wigner semicircle • Wilks' lambda	
Miscellaneous	Cantor • conditional • equilibrium • exponential family • infinitely divisible • location-scale family • marginal • maximum entropy • posterior • prior • quasi • sampling • singular	

Since Normal distribution is of prime importance in probability, it is discussed in detail in the next paragraph.

3.3.1 Normal Distribution

Many physicists call it Gaussian distribution and it is termed as bell-shape distribution due to its bell shape when presented in graph. It is the most common in natural phenomena. Most of the statistical analysis based on the presumption that the distribution is normal or it is approximately normal. There is a empirical rule called 68-20 rule[115] that describes roughly the spread of the data in a normal distribution. This thumb rule is as follows:
68% of data will fall within the one standard deviation from the mean on both sides
90% of data within two standard deviation
99% or almost all data will be within three standard deviation

The approximation of normal distribution is mathematically made possible with the rule mentioned by the central limit theorem. According to central limit theorem, if a sample size is large enough, the distribution tends to be normal. Therefore the phenomenon, which follows the other distribution, could be statistically analysed considering it as a normal distribution.

3.4 Sample Types, Sampling Methods and Selection

Generally it is not possible to reach every person of the target population and mathematically it is not needed to do so. Because a small well-designed sample could give the top quality assessment of the whole population and thereby saving lots of money and time [116,117,118]. A working sample is not the final one, rather a sample used to help decide about the required one. It is chosen considering cost, time availability etc. A statistical estimation of sample size is not possible until the sampling design has been formulated while at the same time sampling design depends on the sample size. So it is difficult to outline a design without a viable working sample. The reason of this dilemma is on the variance formula that depends on both sample size and sampling design.

However, the following three rules of thumbs [116] may be used to get the actual task of sampling done:

- Special treatment for special cases
- Sample like (unalike) groups lightly (heavily)
- Creating artificial groups
- Spreading the sample out
- Using probability proportional to size for unequally sized groups

3.4.1 Different Sampling Methods

Sampling Methods are generally classified into two main categories:

- Probability Sampling
- Non probability Sampling or judgement sampling

There are sub categories under each of the two main categories. Table 3.3 summarizes different aspects of all these sampling methods.

Table 3.3 Features of different sampling methods [119-122]

Sampling Method	Features	Advantages	Disadvantages
Purposive/ Voluntary response/ Convenience	Sample selected by human choice of convenience, not random	Easy and convenient to administer	No sampling theory backs it. So data is almost useless
Quota Sampling	-Divide the population into different strata from available info, e.g.	-economical -easy to administer -takes less time -no calculation or	-standard deviation could not be measured -within a

	census. -Decide sample size using simple random sample -allocate number of sample proportionally as to strata proportion in the whole proportion -Within a strata, the selection of the respondents is not done by random sampling-the surveyor decides it.	determination of sampling required within strata	stratum, sampling may be unrepresentative, e.g. selection of who ever lives near to the surveyor. -Defining social strata/groups is subjective -supervising field work would be difficult
Stratified Random Sampling	-Divide the population into different strata from available info, e.g. census. There is no restriction how many strata could be made up. The strata should be non-overlapping. -Decide sample size using simple random sample -allocate number of sample proportionally as to strata proportion in the whole proportion -Within a strata, the selection is done by random sampling.	-Much precision could be found as heterogeneous population is transformed into almost homogenous groups -In certain situations, specific sampling procedure required,e.g. inside prisons, general households -If a known precision is required for a sub group, that could be achieved easily -convenient to supervise	-analysis is complex -classification of strata is subjective. So if not defined clearly, later problems arise.
Cluster (area) Sampling	-Calculate sample size required for the population using simple random sampling -Divide the population to the convenient clusters with equal no of people or things or events. Non equal numbers will be	-reduced cost to administer -when no complete lists of units are available, this may be a good choice	-analysis is complex -clusters may not be representative of the whole population -Within a cluster, samples may be too alike

	also ok. -Select a few clusters randomly to get the required no of sample size for the whole population -Take all units of the selected clusters. Sometimes random sampling is done inside the selected cluster too. Then it turns into multi stage cluster sampling.		
Multi stage sampling	-it could be termed as a subgroup of cluster sampling or stratified sampling -for large population, sampling may be required to be done in 2 or more stages -its like quota sampling with Simple random sampling in every stage	-same as cluster	-same as cluster
Multi-phase sampling	-some information is collected from the whole sample and the rest are collected from sub-samples of the full sample		

3.4.2 Types of Samples

There are two types of samples that are to be considered for selecting appropriate test.

3.4.2.1 One Group or Matched Groups

When a single question is asked to a group, that group is called one group of respondents. When two or more groups of respondents within the target population

have some predefined characteristics (one or more) in common, they are called matched groups or matched samples. Such identical characteristics may be age distribution, gender split, weight distribution, income etc. Here researchers explicitly match the groups or this matching occurs naturally. For example, study of progress in learning between identical twins. Again, if the same group or groups are measured for the same attribute(s) or variable(s) under different circumstances, they are also termed as matched groups. For example, study of efficiency of the same group of stuff in the morning and afternoon. At times the difference between each matched pair in the matched groups/ sample is tabulated and it forms a new sample for statistical analysis [123,124].

3.4.2.2 Independent Groups

When the samples/groups are selected from the same target population or different populations, which are distinct and separate. It means there are no correlations among them, they are mutually exclusive and they do not exert effect or influence on one another. For example, male and female groups in the same sample, engineers selected from different countries.

3.4.3 Sample Size

Sample size selection depends on the method. In this study, simple random sampling was used. The mathematical background of the sample size determination deals with probability, variance, normal distribution, etc. To simplify the formula, some assumptions are to be made.

In a simple random sample without replacement, every component of the population has the equal probability of being selected as the sample. Suppose a sample size n is to be selected from the population N. Here the probability of selecting any individual sample S of n units is

$$\mathbf{P\ (S)} = \frac{1}{\binom{N}{n}} = \frac{n!(N-n)!}{N!}$$

The sample mean is $\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$

Here $\bar{y}$ is the unbiased estimator of the exact population mean $\bar{y}_U$

The variance of $\bar{y}$ is $V(\bar{y}) = \frac{S^2}{n}\left(1-\frac{n}{N}\right)$

where S is the standard deviation of the population. It denotes the variability of the population values from the mean.

Mathematically, $S = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(y_i - \overline{y_U})^2}$

The factor (1 - n/N) is called the finite population correction (fpc). If the population size is large, in the most survey this is the case, fpc becomes approximately one and therefore it is not considered.

The population standard deviation S is generally unknown before the conduction of the survey and therefore instead of it estimated standard deviation s is used. The formula for s is:

$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(y_i - \overline{y})^2}$

Now, an unbiased estimator of the variance of sample mean $\overline{y}$ is

$$\hat{V}[\overline{y}] = \left(1 - \frac{n}{N}\right)\frac{s^2}{n}$$

Standard deviation of the variance of the sample mean is the square root of the variance and is called Standard Error(SE).

So the equation for sample size becomes

$$n = \frac{s^2}{(SE)^2}\left(1 - \frac{n}{N}\right)$$

The finite population correction (1 - n/N) could be omitted for large population size. Then the equation turns out to be

$$n = \frac{s^2}{(SE)^2}$$

Estimating proportion is a special case of estimating a mean and therefore the above equations hold for proportions as well. They take a simpler form than the above. Suppose P is denoted as the proportion of the population n and P has a definite characteristic (e.g. prefer red colour for cars). Now any unit of the population yi becomes 1 if the unit has the characteristic and 0 if it does not have(e.g. the unit does not prefer red colour for cars).

Here mathematically $p = \sum_{i=1}^{N}\frac{y_i}{N} = \overline{y}_U$

where $\bar{y}_U$ = Mean of the Population

In this case, the estimator of P becomes $\hat{p} = \bar{y}$

$\hat{p}$ is the estimated mean of P and as presented above is equal to the estimated mean of the sample size $\bar{y}$

For the response y_i that can take either the value 1 or 0, Variance of the population becomes using the equation

$$S^2 = \frac{\sum_{i=1}^{N}(y_i - p)^2}{N-1}$$

3.5 Types of Surveys

Four types of surveys [125,126] are generally conducted. They are:

- Mail Survey
- Interview in person
- Telephone Survey
- Online survey

Sometimes one method is combined with another or more due to addition benefits. Each of these has its advantages and disadvantages. In Table 3.1, a compiled summary of comparisons between these four has been presented. The choice of survey methods depends on the research topic, the sample frame, characteristics of the sample and resources [125-127].

Table 3.4: Comparison of different survey methods

Points to be compared	***Mail***	***Interview***	***Online***	***Telephone***
Staff required	Minimum	Substantial number of staff or working hours required	Least required; actually one can handle whole thing.	Substantial number of staff or working hours required
Expense	Moderately Expensive	Most Expensive	Minimal	Depends; though on most cases expensive
Response time	Takes time	Quick response	Quick response	Quick response
Special Requirement	Literacy required	Needs trained Interviewers	Access to internet	Telephone trained

Points to be compared	*Mail*	*Interview*	*Online*	*Telephone*
Reminder	Needed	Might have to make an appointment	Needed	Might have to make an appointment
Collecting List	Difficulty might arise on collecting accurate mailing lists.	No problem, can reach inaccessible person in any other mode	e-mail address collection might be difficult	Difficulty might arise on collecting phone numbers, especially on unpublished phone numbers.
Specific Advantage	Established traditional method	-Face-to-face contact offers intimacy, trust etc. -can interview a group of people together in a specific location -can reach otherwise inaccessible persons	Very cheap and less time consuming provided specific software used and the person conducting the survey has sufficient knowledge about web and computer analysis.	Instant response available and can be inexpensive if dialling is local or internal.
Specific Disadvantage	Can get buried in junk mail	Respondents may give socially acceptable answers to sensitive questions	Can get buried in junk email	People might not like to talk due to time and other facts like annoying experience of telemarketers call

If the internet is available to the most of the target population, an online survey provides more advantages or gains on cost, flexibility, time and else[128-130].

3.6 Formulating the Goals and Uses of Surveys

Although it sounds like the easiest part of designing a survey, defining the goals and uses of the survey in precise terms is one of the hardest tasks [115,116, 131,132]. The goal of the current survey under discussion was to determine the aesthetic value sought by the general consumers on soft drink and mineral water bottles.

3.7 Specifying the Potential Target Population

The target population is to be described in a clear and precise way. Sometimes it is not easy to properly define the target population but efforts must be taken to do so. The next part is to choose the frame (e.g. sample size) upon which actually the survey will be carried out. When both decisions have been made, the relationship between these two should be reviewed [131].

3.8 Questionnaire Design

Communicating with the people with written and verbal words may seem very easy but in practice it's not the case especially when it comes to questionnaire. People with different backgrounds, or cultures might understand the same wording with different meanings. Sudman [133] presented the three steps in questionnaire design as follows:

- Question wording
- Order of Questions
- Formatting the questionnaire

While drafting a questionnaire, the General rule is to ask continuously to oneself "Why am I asking this question" for every question and harmonize with the objective of the survey. Fink's [134] provided noteworthy guidelines in this regard:

- Draft questions that are related to survey's objectives.
- Avoid two-edged questions (the use of "and")
- Use tried questions from similar surveys
- Ask specific and discriminating questions (requiring ordinal or numeric data)
- Order the questions in sequence.
- Format the questions
- Precode and postcode the responses
- Draft questionnaires be given to peers, supervisors and consultant group for comments and critical evaluation
- Conduct a pilot test
- Review, revise and eliminate problem questions

Therefore words should be carefully chosen so that the questionnaire is easily understandable to the target population. The next is to make sure all relevant or required measurements according to the set goals have been fulfilled. If possible or feasible, pilot testing should be conducted with the tentative questionnaire on a small number of the targeted population [116,131].

3.9 Finalizing Sampling Selection Criteria

In the final stage of the survey, specific decisions about sample allocation, sample size and non-response have to be taken. At first, the working sample has to be distributed proportionally over the groups. Then statistical variance should be calculated and then comparison should be made with the accuracy requirement of the survey goals or objectives. Generally, these two will not match exactly and if the difference is not too big, then the design is considered satisfactory. However, if it is found that important parameters are represented with low-low accuracy, larger sample size might be taken [116]. At the end, the inevitable non-response phenomena should be considered. Non-response might be mechanical or human-though the latter is more acute.

3.10 Reliability

Reliability is a prime concept in the measurement in statistical data analysis. Literally it means dependable. In the realm of statistical analysis it denotes the quality of being consistent. It has two prominent aspects [113,135]:

- Stability or consistency over time
- Internal Consistency

For reliability analysis, sometime both are used and sometime either of the above two procedures are used. However, using both procedures is suggested in most of the literatures.

3.10.1 Stability or Consistency Over Time or Temporal Stability

It means if the same questions were given to the same respondents at a different time, the possibility of getting the same response from them should be high. If this possibility is high, then the survey would be termed as highly stable or consistent or

reliable. This reliability test is called test-retest reliability. To do this test, at least two administrations of the survey are required over time. The draw back of this method is that generally more than one variable is present in most surveys. And if one of these variables varies significantly then the situation of the two administrations fall into completely different situations. Again if the same questionnaire is given to the same examinees, the examinees will adapt to the test format and most probably score higher than the previous one.

3.10.2 Internal Consistency

Internal consistency means that all questions are suitable for the desired objectives and working in the same direction. A couple of methods are available to perform the test of internal consistency. The few prominent ones are:

- Split Half Techniques
- Kuder –Richardson formulas
- Coefficient of Alpha

For internal consistency, only one administration of any of the methods is required unlike stability where several administrations at different points of time are needed.

3.10.3 Form Equivalence

It is evolved on the drawbacks of the above-mentioned two reliability estimation methods. In this method, the same examinee needs to fill out two forms. Questions are different in the two forms but contents or contexts are of the same.

3.10.4 Importance of Reliability

Every statistical measurement or score has two parts: one is true part and the other error part. Basically reliability and error are conversely related. That is, the higher the reliability, the lower the error.

3.11 Validity

Validity is a technical term in statistics and it is also called measurement validity. It gauges whether an instrument of measurement or an indicator measures or represents to the extent what it is supposed to measure or represent. In another view, validity looks into the interpretation inferred from the measurement and figures out whether

these interpretations are defendable. To have validity, a study must be reliable but the opposite is not true. A reliable study may not be valid.

There are many approaches of validity and among those, three prominent ones are:

- Content validity
- Criterion validity
- Construct validity

A brief description of major types of validity appears in the following paragraphs:

3.11.1 Content validity

It goes over the issue whether the full content of a conceptual description is represented in the measure in a survey. Sometimes other validity criterion may suggest everything is fine but content validity may say the survey is not done the way it should be for the specific objective. To have content validity, the test should be referred to expert opinions [113,135-137].

3.11.2 Predictive Validity

It refers to the ability of the test to predict a future happening. This type of validity is measured with the help of correlation coefficient between the test score and the actual score or achievement on a task by the same sample. If it shows higher correlation, then the measure is said to be have predictive validity. For example, scholastic aptitude test (SAT) is supposed to measure ability of a student to the extent of his performance in college. So if a student gets high score in SAT and subsequently does well in the college, SAT test will be said to have a good predictive validity [113,136,137].

3.11.3 Concurrent Validity

It refers to the match between the studied test with an already established test. So if the variables in the studied test vary directly with the same type of variables or indirectly vary with the opposite type of variables from an established test, the studied test is said to have concurrent validity. One problem may arise on choosing a

valid test since even an established test might have disapproval from a certain group of experts. In this aspect, the selection of the test accepted by the majority of experts should suffice [138,139].

3.12 Analysis of Data

For any kind of statistical analysis, the scope and selection of different estimators, method and tests are of great importance. In selection of analysis, in most cases some criteria are to be met before applying them. In general, the data should be in normal distribution or approximately conform to normal distribution to perform such analysis. A brief description of different aspects of analysis are presented in this section

3.12.1 Univariate and Bivariate Analysis

If the analysis is doing with one variable or one question, it is called univariate analysis. If the analysis is about two variables or two questions, it is called bivariate analysis. In these univariate analysis and bivariate analysis, there may be interaction with variables. In case of univariate analysis, the single variable on consideration may have interaction with another variable or variables outside the study. For example, comparing liking of a product over another by a sample/respondents is a univariate analysis without interactions. For bivariate analysis, the two variables might have interaction between them or with another variable or variables outside of the study. If univariate or bivariate analysis does not interact within the study or outside the study, it is categorised as univariate or bivariate analysis without interaction. Mathematically analysis with interaction is probability without replacements. For example, several independent samples rate a product and a comparison is made about these ratings.

3.12.2 Multivariate Analysis

If the analysis is dealing with more than one variable, it is called multivariate analysis. Bivariate is a subgroup of multivariate analysis that deals with only two variables. In this type of analysis, there are two options. One is without interaction

among the variables, and the other is interaction with the variables. For example, two or more products are rated several times by a sample of respondents with respect to several factors like colour, shape etc.

3.12.3 Response Sets

Statistical analysis could be carried on different combinations of samples. The possible combinations are:

Single sample drawn from a target population: For example, an analysis is carried out to find difference between the answers (experimental mean) of a group/respondents with a given value, e.g. norm or mean. In this case response set is one.

Two or more groups within the same sample drawn from the same target population: For example, an analysis is carried out to test/find difference between two groups within the same sample or in the same population (e.g. male and female) or between answers to two questions (e.g. colour liked in mineral water bottles and colour liked in soft drink bottles). In this case, response sets are two.

Three or more separate samples drawn from the target population:. For example, an analysis is carried out to find / test the difference among three or more respondent groups within the same sample or the same target population (e.g, three or more age range, three or more level of education, three or more level of income). In this case response sets are three or more.

3.12.4 Specific Factors on Selecting a Statistical Test

Depending on the types of data and kind of the study, certain tests are more relevant than others. Table 3.5 provides a list of test appropriate for certain data type and study requirement.

Table 3.5: Choosing appropriate Statistical Test [140,141]

Goal	Data Set			
	Measurement (from a Normal Distribution)	Rank, Score, or Measurement (Non-Normal Distributions)	Binomial	Survival
Describe One group	Mean, SD	Median, interquartile range	Proportion	Kaplan-Meier survival curve
Compare one group to a hypothetical value:	One-sample t test	Wilcoxon test	Chi-square or Binomial test	
Compare two unpaired groups:	Unpaired t test	Mann-Whitney test	Fisher's exact test (or chi-square for large samples)	Log-rank test or Mantel-Haenszel
Compare two paired groups:	Paired t test	Wilcoxon test	McNemar's test	onditional proportional hazards regression
Compare three or more unmatched groups:	One-way ANOVA	Kruskal-Wallis test	Chi-square test	Cox proportional hazard regression
Compare three or more matched groups:	Repeated-measures ANOVA	Friedman test	Cochrane Q test	Conditional proportional hazards regression
Quantify association between two variables:	Pearson correlation	Spearman correlation	Contingency coefficients	
Predict value from another measured variable:	Simple regression	Nonparametric regression	Simple logistic regression	Cox proportional hazard regression
Predict value from several measured or binomial variables:	Multiple regression		Multiple logistic regression	Cox proportional hazard regression

Table 3.5: Choosing appropriate Statistical Test

3.12.5 Parametric and Non-Parametric Methods for Data Analysis

Generally normal distribution appears in the majority of the statistical study. If a study gets continuous data (continuous variable under numeric variable group) which is sampled from a population with an underlying normal distribution or whose distribution could be rendered normal by mathematical manipulation or transformation, parametric methods are used. The tests available for parametric methods include:

- t-test
- Anova
- Regression
- Correlation

Regardless of the distribution of the data, non-parametric methods could be used for any study. Non-parametric methods have drawbacks such as less precision and power than parametric methods. However, sometimes these methods are the only option for both qualitative and quantitative data when no assumptions could be made about the population's probability distribution or the distribution is the other than normal distribution. The tests for non-parametric methods include:

- Chi-squared test
- Wilcoxon signed-rank test
- Mann-Whitney-Wilcoxon test
- Spearman rank correlation coefficient

3.12.6 Goodness of Fit and Test for Independence

Goodness of fit tests that variables are consistent with the expectations or an observed distribution conforms with a know one like students distribution or distribution found from the census. While test for independence measures whether there is any relationship between the variables.

3.12.7 Correlation

There are two types of correlation in use in applied statistics. They are:

- Pearson's Correlation
- Spearman Correlation

3.12.7.1 Pearson Correlation

In applied statistics, it is used when both variables are interval or ratio or one interval and the other ratio. It is notable that the nominal (categorical) variable with only two options e.g. gender could be treated as any type of variable like interval, ratio or nominal. In addition, even for interval or ratio data when collected as group e.g. age group not exact age, spearsmans rho is better option. The distribution is also supposed to be normal. In this study, the first small survey among DCU students and stuff, the distribution found was normal distribution and the variables were nominal. Here the respondents selected only one option for a question or variable. So Pearson correlation was used for this survey.

3.12.7.2 Spearman Correlation

In applied statistics, When one or both variables are ordinal in a two variable,i.e. bivariate analysis, spearman correlation is to be used. Again, when the distribution is not normal, it is the right choice for correlation analysis. Non-normal distributions are also referred as non-parametric distributions [139]. Since the second survey had ranked/ordinal variables, spearman rho was the preferred correlation coefficient.

3.12.8 Chi Square Test

Mathmatically, the chi-square statistic is computed the sum of the squared difference between the observed frequency and the theoretical frequency divided by the theoretical frequency [142]. In applied statistics, chi square test used as non parametric test. Besides, when one or more variables are nominal(categorical), it is suggested to chi square test to find the relation, not the other correlation like Spearman or Pearsons correlations. Some terms are related to chi square test are described below:

Degree of freedom: It is also mentioned as df in constricted form.

In mathematical notion,

degree of freedom = (number of row-1) X (number of column - 1)

Expected value: The value the researcher expects or puts on the hypothesis. In SPSS, these values should be put on the exact order as the variables are put in the variables sections of the SPSS pop up window. For example, if the researcher claims that 70% people like blue colour, 20% people like black colour and 10% like green colour, expected value should be put in as 70,20,10. Here it is not necessary to be in

percentage it could be any unit or ratio but only one unit or ration could be used in one instance of the chi-square test.

Residual: It is the difference between expected and observed value.

Asymp value: it is the significance measure of the chi square test. It must be less than 0.05 for to be significant.

Likelihood ratio: It is also used for nominal variables. In general, it gives the same value s Pearsons chi square. Pearson chi square could be used for nominal variables and all other variables too. It's interpretation is the same as Pearson chi square. That is, asymp sig value less than 0.05 is significant.

Linear by linear association: It is for ordinal variables. It assumes equal interval according to the definition of ordinal variables. It is used to find trend in a larger than 2X2 table[143].

Pearson chi square: It is not pearsons correlation but the main term to be looked at from the result of chi square. If it's asymp sig(2tailed) value is significant ,that is less than 0.05, it is said that the variables have strong relationship. But it does not give the direction of the relationship.

Suitability of chi square test:

- Non parametric analysis when the distribution is not normal or could be assumed to be normal by any means.
- To find relation between two or more variables, when one or more variables are nominal(categorical).

Interpretation of chi-square test: If the the value obtained is greater than critical value then the two variables are said to have good correlations. It indicates there is some relation between the two variables, though it does not indicate the strength or direction of the relationship[144].

3.12.9 Regression

Regression determines the relationship between two random variables. In linear regression, a straight line is attempted to fit amid data that goes as close as possible to the majority of the data.

3.12.9.1 Linear Regression

Linear regression and correlation in general could be termed as the same thing[145,146]

Mathematically, if X and Y are two random variables, the linear regression is described with the following equation:

$$Y = a + b\,X + e$$

Where e is called residual or a random variable with mean zero.

For example, suppose linear regression is to be done between height and weight, two random variables, of a sample of adults. To do so, let's put height values of adults in the X axis and weight values in the Y axis. For an adult's height and weight, there is a corresponding point. When all these points are drawn in the graph, a straight line is to put on which goes into the proximity of the majority of the points. So using this straight line or equation, if an adult's height is known, his weight could be predicted with reasonable accuracy.

3.12.9.2 Multiple Regression

Multiple regression is another group of regression analysis. When there is more than one independent variable, multiple regression analysis is used [147]. The term was coined by Pearson in 1908. It gives insight about the relationship between several independent variables (predictor or explanatory variables) with a dependent variable(criterion or response variable).[148,149]

3.12.10 Difference Between Correlation and Regression

Generally correlation and regression appear to be the same since both of them measure the relationship between two or more variables. But the main difference between correlation and regression is that correlation takes into account of both the variables, dependent and independent, to judge how close they are whereas regression fits a line only considering independent variable (i.e. generally X) thereby making best prediction of Y values from the X values. Thus, if in an analysis, dependent and independent variable were swapped, correlation coefficient would be the same as its calculation is symmetrical about X and Y-axis but it would not be true for regression line. Regression should be used other than correlation when independent variable (i.e. X) is manipulated in an experiment. It means predictor or independent variables cause or influence dependent variables [150].

3.12.11 Significance Level or Type I error (alpha) and Confidence Level

The probability or odds or risk of sating there is a relationship or effect when in reality there is not is called significance Level or Type I error[151]. In other words, it is the odds or probability to state incorrectly that alternate hypothesis (theory) is true. It is denoted by Greek letter alpha. Since it's a probability, its value can be between 0 and 1. The researcher tries to keep this as small as possible and generally it is taken as 0.05. When it is deducted from one, the resultant value is called confidence level. It is the probability or odds to state that there is no relationship, effect, gain, difference when in reality there is not. This means it is the probability or odds to correctly not conforming to the alternative hypothesis (theory) when it is not true. Significance is called negative true.

3.12.12 Power and Type -II error (Beta)

The probability of finding statistical significance when the alternate hypothesis (theory that is put up) appears true is called statistical power [152]. In other words, it is the odds or probability to observe treatment effect or relationship when it occurs or there is actually one. In general research or survey design, it is taken as 0.8 and the researcher wants it to be taken as large as possible. Since it's a probability its value can be between 0 and 1. The statistical power is denoted by 1- Beta. When this value is deducted from 1, the resultant value is called probability or risk taken to commit Type-II error. It is also denoted by Greek letter Beta. This error is sometimes mentioned as false negative which means that coming into conclusion that there is no effect or relationship when in reality there is one. In other words, the odds or probability of not conforming to the alternative hypothesis (theory) when it is true Power is called positive true.

3.12.13 Trade off between power and significance

When power is increased, significance level increases, i.e. probability of Type I error increases. In other words, the higher the power, the higher the significance and vice versa. This dilemmatic situation is sometimes called built-in tension. Therefore, the researcher needs to take the optimal values for power and significance that best suits his research.

3.13 Summary

Different statistical terms, methods and analysis techniques related to the context of this study were briefly described in this chapter. At the beginning, different statistical methods were discussed in terms of selection and characteristics. Different variables were described after that. Then types of distributions and nominal distribution were presented. Discussion on different types of surveys was followed by the introduction of the concept of validity and reliability. Finally, different analysis techniques and parameters were outlined.

Chapter Four - First Survey Procedures, Results and Analyses

4.0 Introduction

The objectives of this chapter are to:

- Detail about the procedures of the first survey.
- Present the analyses of the data obtained from the survey.

It is difficult to determine public opinion about the aesthetical attributes of a product, therefore a survey was designed and carried out to gauge people's viewpoint about the aesthetical attributes they prefer in mineral water and soft drink bottles. The whole procedure of designing of the survey together with analysis of the data obtained has been detailed in this chapter.

4.1 Selection of the Type of Survey

Among the different survey types, if the internet is available to the most of the target population, an online survey [119-121] provides more advantages or gains on cost, flexibility, time and else. In this survey, the target population was DCU (Dublin City University) students and staff who have free online access. Therefore the online survey option was chosen to gather information on aesthetical attributes of a product.

4.2 Formulating the Goals and Uses of the Survey

Although it sounds like the easiest part of designing a survey, defining the goals and uses of the survey in precise terms is one of the hardest tasks [117,119-121]. The goal of the current survey under discussion was to determine the aesthetic value sought by the general consumers on soft drink and mineral water bottles.

For this survey, the following aesthetical attributes have been taken for consideration-

- Shape
- Size
- Colour
- Weight
- Transparency
- Cap
- Specific Material

Furthermore, some other personal statistics have been collected, i.e. Gender, Age, Education, Occupation, and Income. As the target population was the students and staff of a university, it was assumed that the survey results would represent the young as well as the highly educated segment of the Irish population.

4.3 Specifying the Potential Target Population

DCU students and staff were divided into two groups- students and staff. E-mails were sent to them through the two lists namely 'Allstudents' and 'Allstaff'. Every registered student is subscribed to 'Allstudents' list and the every staff is subscribed to 'Allstaff' list. All DCU students and staff have free and conveniently available internet access. As no bouncing was logged in, it can be stated that the e-mail request to fill out online survey reached the inbox of all students and staffs. The respondents filled out the form on their own volition, therefore it can be termed as random sampling.[117,122,123].

4.4 Questionnaire Design for the First Survey

In the present survey, the aesthetical features of bottles available in the Irish market were studied. Letters were sent to different companies to gather information regarding the make and type of bottles used in the respective company. The responses obtained from the companies were low, five responses were received out of twenty five mails sent. However, these responses were important on the design stage of the questionnaire as feedback from the stakeholders of different companies. Furthermore, the potential features of the bottle have been obtained analysing the

bottles available in the market. For this, different brands bottles were collected and analysed minutely. Later a tentative questionnaire was drafted. Then it was checked on the basis of what would be done with each measurement and whether the accuracy needed for this measurement was practically useful. It was found that a few variables had been missed and those should be included. Then a slight modification of the questionnaire was made. At the end, everything was checked once again on the ground whether it met the target or goals precisely.

4.5 Sampling Selection

As the target population of the sample is fairly straightforward in the survey conducted in this research, it is not required to strictly follow the above criteria. Here the students and staffs of DCU were chosen as the target population and the random selection of the respondents was ensured by sending the survey email to all of them.

4.6 Finalizing Sampling Selection Criteria

In the final stage of the survey, specific decisions about sample allocation, sample size and non-response have to be taken. At first, the working sample has to be distributed proportionally over the groups. Then statistical variance should be calculated and then comparison should be made with the accuracy requirement of the survey goals or objectives. Generally, these two will not match exactly and if the difference is not too big, then the design is considered satisfactory. However, if it is found that important parameters are represented with low-low accuracy, larger sample size might be taken [117]. At the end, the inevitable non-response phenomena should be considered. Non-response might be mechanical or human- though the latter is more acute.

4.7 Choosing the Estimators

The thoughtful selection of estimators will reduce substantial amount of errors in surveying. Confidence interval could be much reduced by the wise choice of estimators[117]. Variance could be reduced in this way too. On the context of present survey, estimators were chosen according to the subjective nature of the survey and the software was used to calculate the details.

4.8 The Online Survey for the First Survey

A tentative questionnaire was drafted and after being reviewed, a web questionnaire was created with hypertext markup language -HTML [153-156]. Microsoft FrontPage was used as the editor. For getting the response, response-o-matic, a free webbased form processor [157], was used as it saves time writing the CGI (Common Gateway Interface) script needed to fetch the data. The filled-out questionnaire was sent by the respondent to the response-o-matic cgi bin server. From the cgi bin server of resopnse-0-matic, the submitted information was transmitted to the surveyor via email. The URL of the online questionnaire is:

http://student.dcu.ie/~rashida2/surveydcu.html

The first e-mail to Allstudents list was sent on 4 March 2003 and subsequently a reminder was posted on 1 April 2003. On the other hand, the online survey e-mail to Allstaff list was sent on 6 March 2003.

4.9 Response Obtained

After completing the data collection, the analysis of the data was performed. In Table 4.1, the break up of the student and faculty numbers of Dublin City University with the response obtained is given. As the table shows, the total response obtained from students was 312 out of 9689 students on 2002-2003 session. Whereas the response from staff was 47 out of 800 staff. The number of students and staffs was generously supplied by the Registry and Human Resources Office of DCU respectively. In percentage, the overall response rate is 3.42%. This was sufficient for having the statistical judgement over a population because samples are often less than 1% of the size of the target population and are nearly always less than 5%[131].

Table 4.1: Response of the target population in first survey

	Number	Response Obtained	Percentage of Response Received
DCU Students	9689	312	3.22%
DCU Staffs	800	47	5.88%
Total	10489	359	3.42%

On the demographic basis, the majority of the target population were students and so age and income followed that particular trend. The dominant age group was 15 to 26 years as most of the students were studying undergraduate level (5442 undergraduates out of 9689 total students of DCU i.e.56.17%). Regarding income, some students work part time to defray maintenance cost and obviously that is not much. So under 10,000 euro income was the dominant income group in the survey. However, staffs have significant income but since they were the minority (7.63%) of the target population, their income level could not come as the dominant one. On occupation, staffs were generally categorised into two segments- academic and private job. On education, academic staff had higher degrees while students were either studying in third level having completed secondary education or Masters students or PhD students. Third level students were highest responders as they represent the highest number on the target population. According to gender, though male students (50.98%) outnumbered females in the population, the response of females (52.1% response by female) was higher by a small margin. On the other hand, it reasserts the established opinion that women are more likely to respond positively to survey questionnaire.

4.10 Analysis of the Data Obtained

To perform the statistical analysis on the data obtained from the survey, SPSS (Statistical Package for the Social Sciences) package [158] was used. It was chosen because it is the most popular package for general statistical analysis, user friendly and easy-to-use [159-162]. DCU Computer Services have a subscription to SPSS11.01.01 version and so this version has been used. Firstly a descriptive frequency analysis was performed. Later cross tabulation was done among some variables.

4.11 Descriptive Analysis for Responses

Descriptive analysis breaks up the options answered on the specific variable in percentage form. Descriptive analysis was done from responses of allstudents and staff of DCU. The findings from this descriptive analysis are presented in the following sections.

4.11.1 Preferred Bottle Shape

The analysis shown in Figure 4.1 and Table 4.2 reveal that most of the respondents (53.2%) liked circular bottles. The second popular choice was elliptical shape.

Table 4.2: Shape of the bottle liked by the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rectangle	20	6.4	6.4	6.4
	Square	9	2.9	2.9	9.3
	Ellipse	57	18.3	18.3	27.6
	Circle	166	53.2	53.2	80.8
	Oval	46	14.7	14.7	95.5
	Others	14	4.5	4.5	100.0
	Total	312	100.0	100.0	

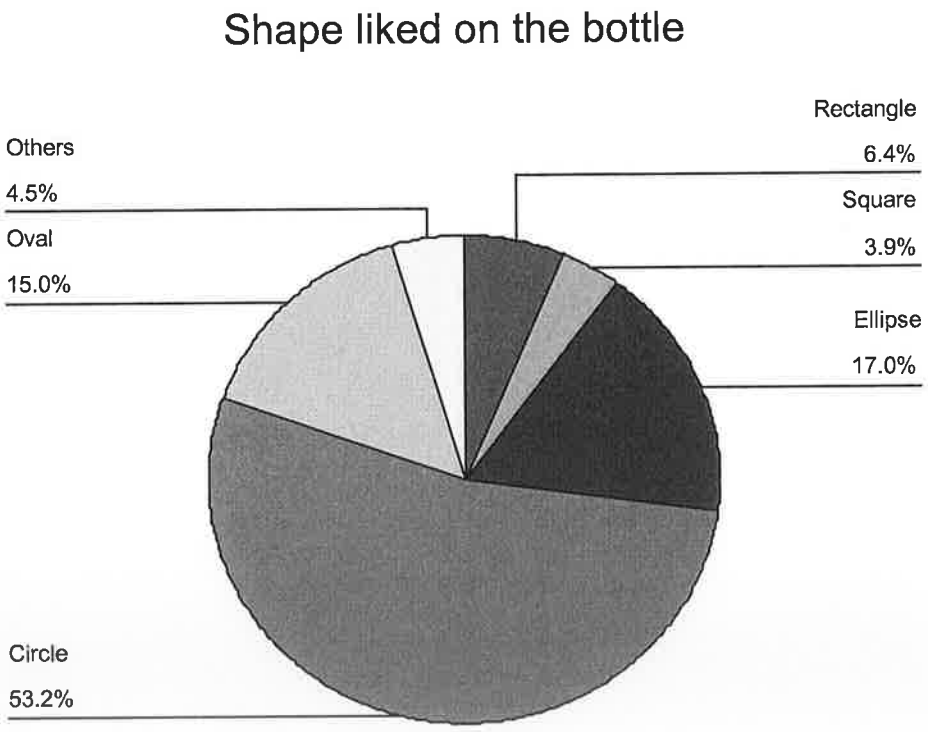

Figure 4.1: Shape liked on the bottle by the respondents

So it can be concluded that circular as well as elliptical cylindrical shape is the popular choice among the target population. It has been observed that the circular

shaped bottle is used in most of the soft drinks and mineral water products in the Irish market and so their dominance is justified by this survey.

4.11.2 Special Shape Attribute

Table 4.3 and Figure 4.2 depict that most of the respondents liked curved surface whereas smooth finishing and gradual change over follow it with a meagre margin. So it can be concluded that a combination of these three attributes on shape should be given first priority while designing the bottle.

Table 4.3: Special shape attribute liked by the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Curved surface	134	37.3	37.3	37.3
	Smooth finishing	112	31.2	31.2	68.5
	Gradual changeover	101	28.1	28.1	96.7
	No preference	2	.6	.6	97.2
	Others	10	2.8	2.8	100.0
	Total	359	100.0	100.0	

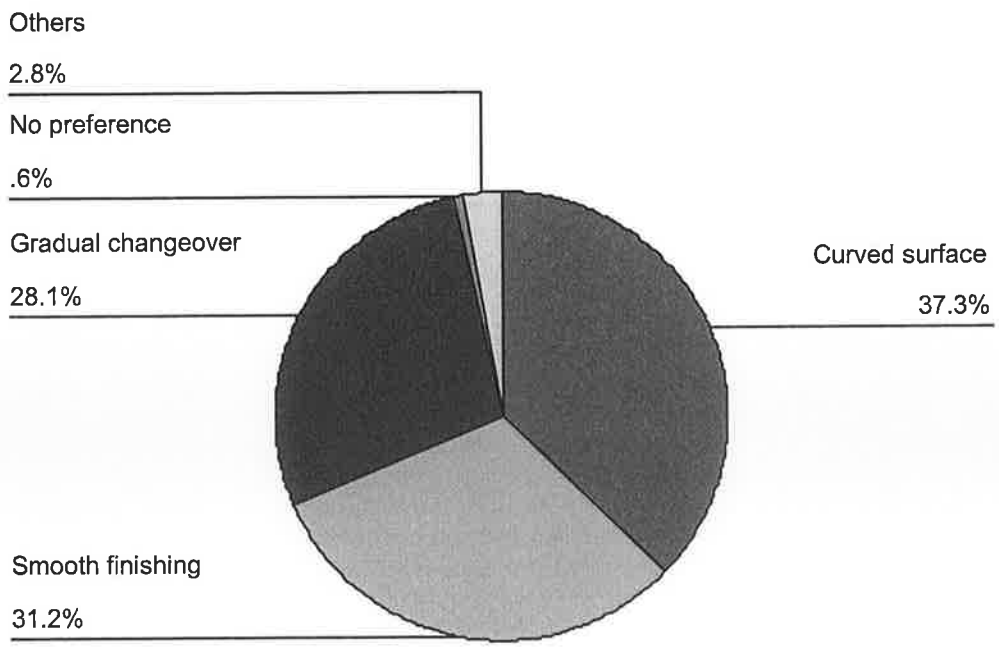

Figure 4.2: Special shape attribute liked by the respondents

4.11.3 Bottle Colour Preference

Regarding colour of the bottle, Blue was the most preferred one followed by sky blue, clear or white as shown in Table 4.4 and Figure 4.3.

Table 4.4: Colour liked by the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Red	38	10.6	10.6	10.6
	Green	31	8.6	8.6	19.2
	Blue	83	23.1	23.1	42.3
	White	33	9.2	9.2	51.5
	Black	13	3.6	3.6	55.2
	Yellow	11	3.1	3.1	58.2
	Sky blue/ Turquoise	59	16.4	16.4	74.7
	Pink	6	1.7	1.7	76.3
	Violet	18	5.0	5.0	81.3
	other colour	5	1.4	1.4	82.7
	clear	59	16.4	16.4	99.2
	No Preference	3	.8	.8	100.0
	Total	359	100.0	100.0	

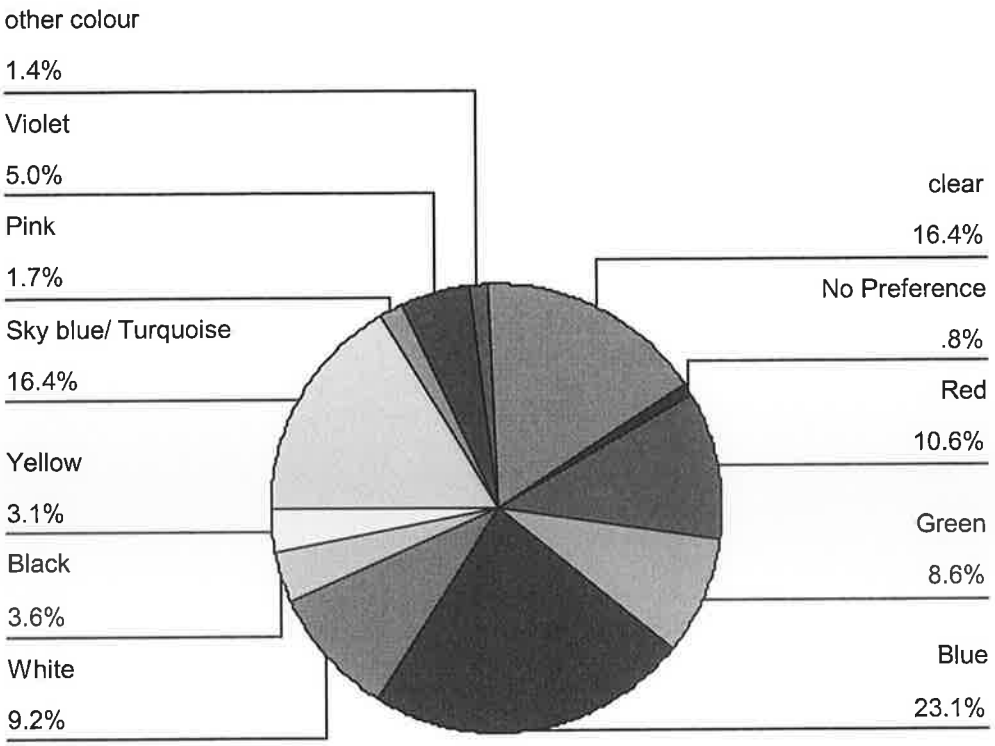

Figure 4.3: Colour preferred by the respondents

However, there were also substantial people who preferred other bright colours like red, violet, green etc. So it can be concluded that the producers of soft drinks should have their products either on blue or clear or white bottle at a larger scale while also offering the same products in a range of few other bright colour bottles at a smaller scale.

4.11.4 Combination of Colours

Table 4.5 and Figure 4.4 show that the majority of the respondents did not like combination of colours. So it would be judicious to adhere to single colour on designing the bottle.

Table 4.5: Combination of colour liked by the Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not liked	169	47.1	47.1	47.1
	Two colour	89	24.8	24.8	71.9
	Three Colour	28	7.8	7.8	79.7
	Any Combination	66	18.4	18.4	98.1
	Others	5	1.4	1.4	99.4
	No Preference	2	.6	.6	100.0
	Total	359	100.0	100.0	

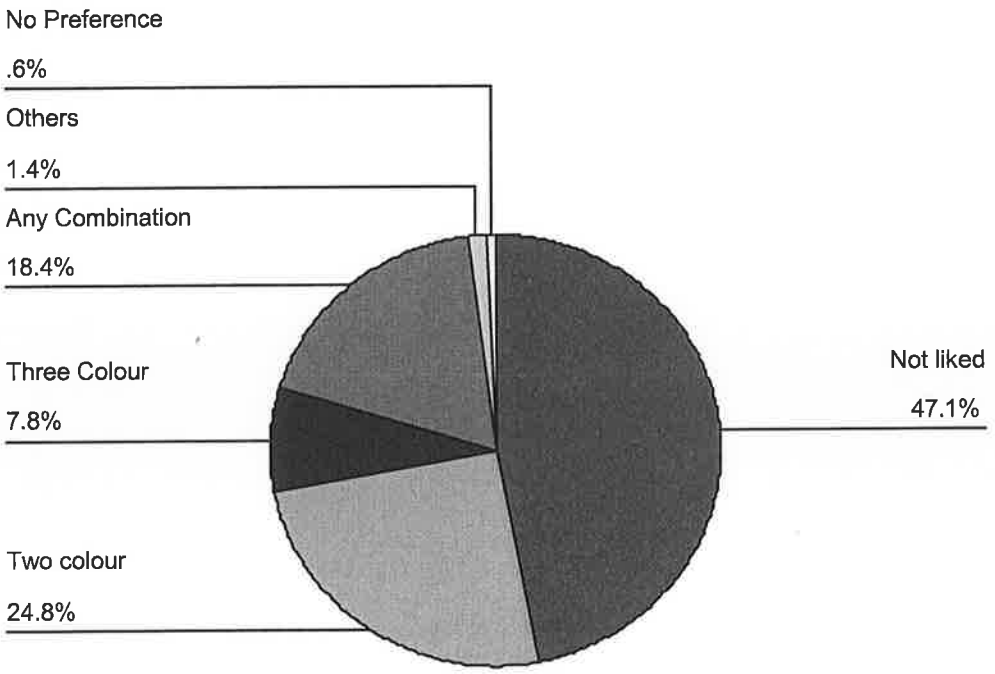

Figure 4.4: Combination of colour liked by the respondents

However, two different type of bottle may be used for one kind of product. One is of single colour and the other is of combination of colours. But the later one might be produced in a small quantity compared to first one since the minority of the customers prefer combination of colours. Again, the use of more than two colours is discouraged on the basis of environmental and recycling viewpoints.

4.11.5 Size

Regarding the size of the bottle, respondents were in favour of medium size with a resounding majority (82.2%) as Table 4.6 and Figure 4.5 demonstrate.

Table 4.6: Size liked by the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Small	24	6.7	6.7	6.7
	Medium	295	82.2	82.2	88.9
	Large	31	8.6	8.6	97.5
	Others	9	2.5	2.5	100.0
	Total	359	100.0	100.0	

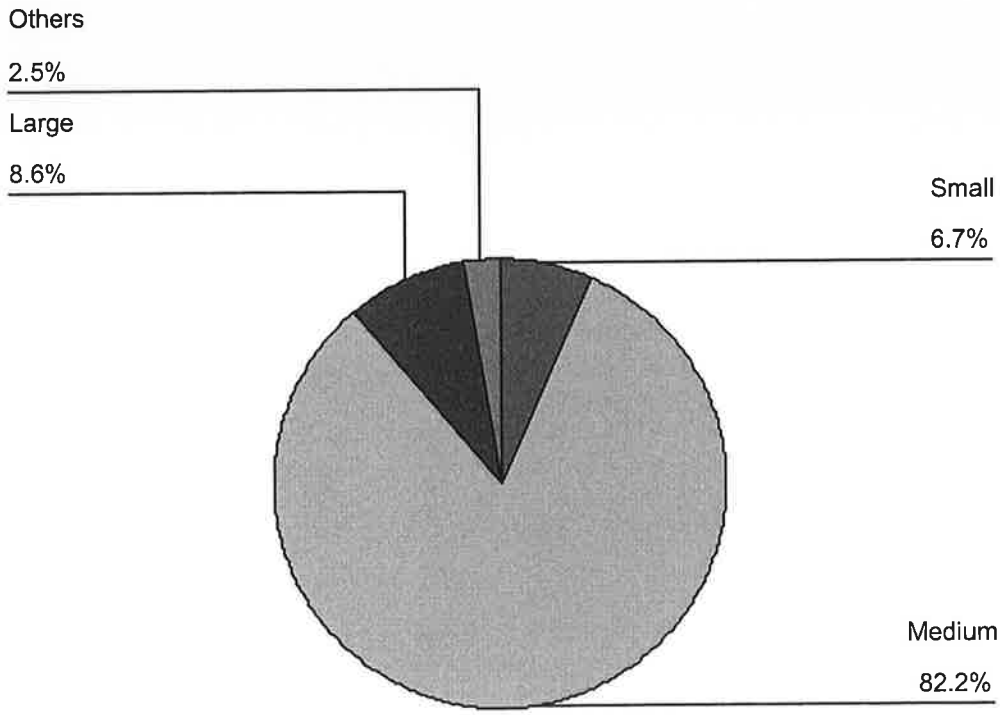

Figure 4.5: Size liked by the respondents

So it can be suggested that the producer should design the bottle to medium size in general though other two extreme sizes may be considered for production in a small quantity

4.11.6 Special Material

Most of the respondents had no preference for special material as Table 4.7 and Figure 4.6 show.

Table 4.7: Special material liked by the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	1	.3	.3	.3
	No preference	293	81.6	81.6	81.9
	Yes strongly like a material	65	18.1	18.1	100.0
	Total	359	100.0	100.0	

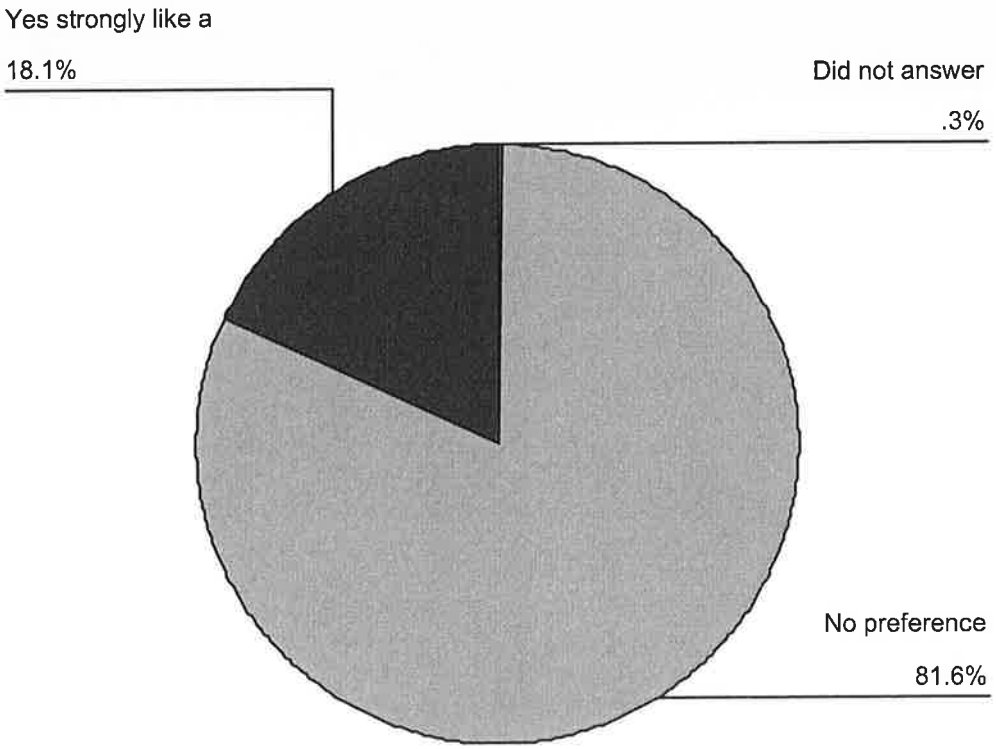

Figure 4.6: Special material liked by the respondents

Those who had said they had strong liking for a special matter generally referred to glass or plastic. These are common materials used for bottles. Besides, some respondents also mentioned about recyclable and environment friendly products. As a general guideline, it may be stated that the material to be used in bottle should be environment friendly and have maximum recyclable attributes.

4.11.7 Paying a bit more for Environmentally Friendly Product

In line with the growing awareness on environment, the majority of the respondents expressed their willingness to pay a bit more money for environment friendly product as shown in Table 4.8 and Figure 4.7.

Table 4.8: Paying for environment friendly product-respondent's view

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	237	66.0	66.0	66.0
	No	114	31.8	31.8	97.8
	Others	8	2.2	2.2	100.0
	Total	359	100.0	100.0	

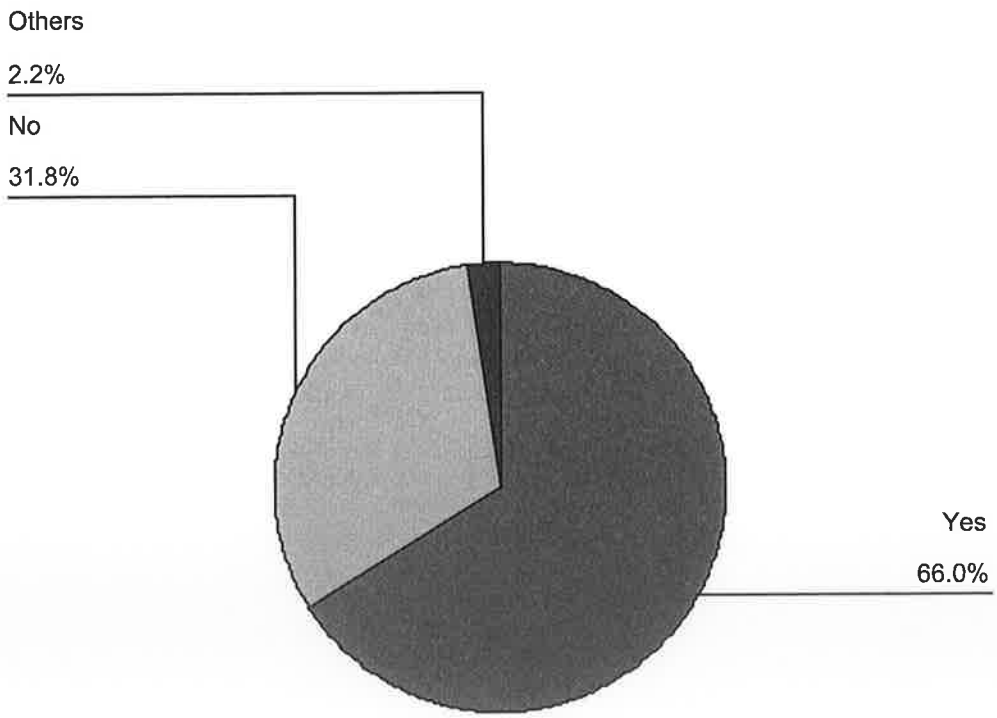

Figure 4.7: Paying for environment friendly product-respondent's view

However, a considerable number showed their reluctance in this regard as well. Therefore, while choosing an environmental friendly material, considerations should

also be given to cost, as costly environment friendly products will not be able to capture essential market share.

4.11.8 Weight of the Bottle

For the ease of carrying, most people preferred lightweight soft drink bottle as illustrated in Table 4.9 and Figure 4.8.

Table 4.9: Weight liked by the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	2	.6	.6	.6
	Light	213	59.3	59.3	59.9
	Medium	127	35.4	35.4	95.3
	Heavy	12	3.3	3.3	98.6
	Others	3	.8	.8	99.4
	No Preference	2	.6	.6	100.0
	Total	359	100.0	100.0	

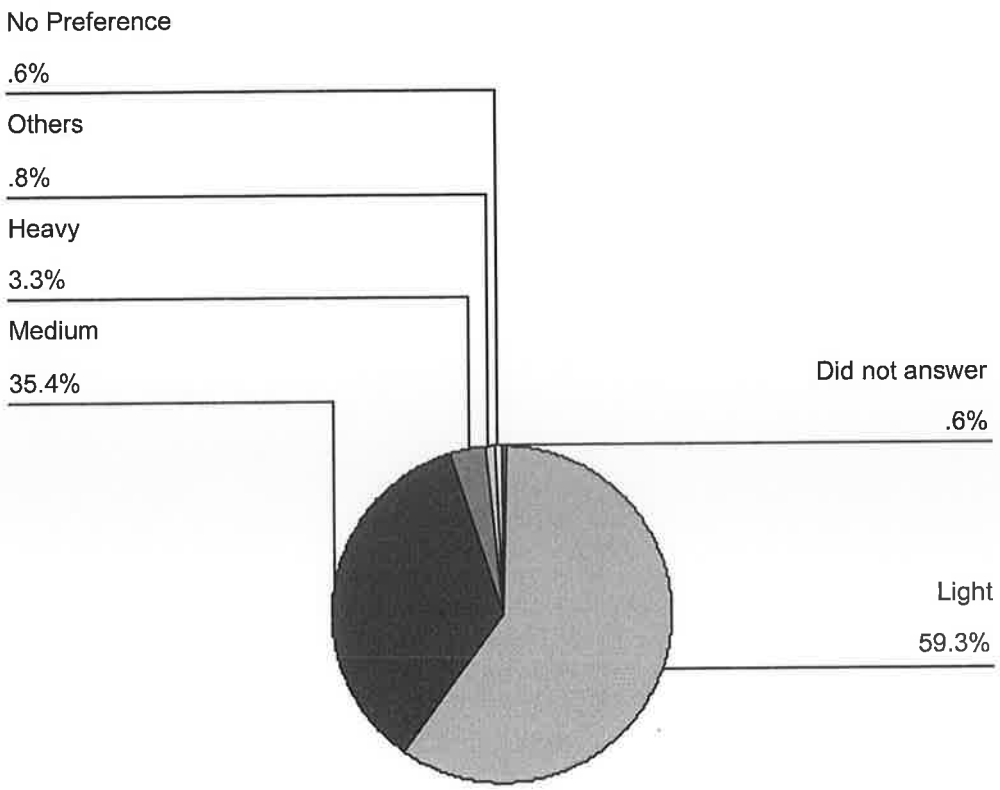

Figure 4.8: Weight liked by the respondents

A substantial number of people though opted for medium weight bottle. Thus the bottle should be designed in such a way that it remains light, however, medium and heavy versions may be provided to cater the need of certain category of people as well as specific situations.

4.11.9 Transparency of the Bottle

Regarding transparency of the bottle, the majority were in favour of transparent bottles as depicted in Table 4.10 and Figure 4.9.

Table 4.10: Transparency of the bottle liked by the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	2	.6	.6	.6
	Opaque	53	14.8	14.8	15.3
	Transparent	219	61.0	61.0	76.3
	Translucent	79	22.0	22.0	98.3
	Others	3	.8	.8	99.2
	No Preference	3	.8	.8	100.0
	Total	359	100.0	100.0	

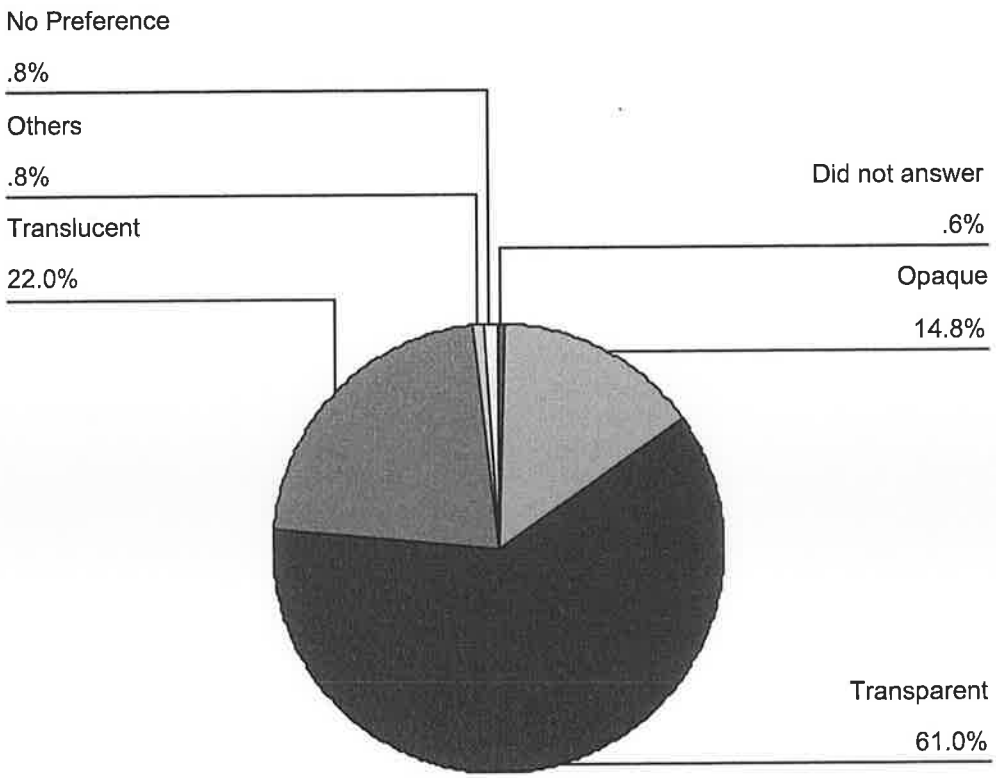

Figure 4.9: Transparency of bottle liked by the respondents

A substantial number of the respondents preferred translucent bottles and a few opted for opaque bottles. So it might be stated that transparent or translucent bottles should be the choice when designing a bottle for soft drink or mineral water.

4.11.10 Cap Type Liked

Though the majority liked sport cap in bottles, the number of respondents who preferred the conventional round cap in bottles was not far behind from the former as illustrated in Table 4.11 and Figure 4.10.

Table 4.11: Cap type liked by the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	5	1.4	1.4	1.4
	Conventional round cap	135	37.6	37.6	39.0
	Sport cap	213	59.3	59.3	98.3
	Others	6	1.7	1.7	100.0
	Total	359	100.0	100.0	

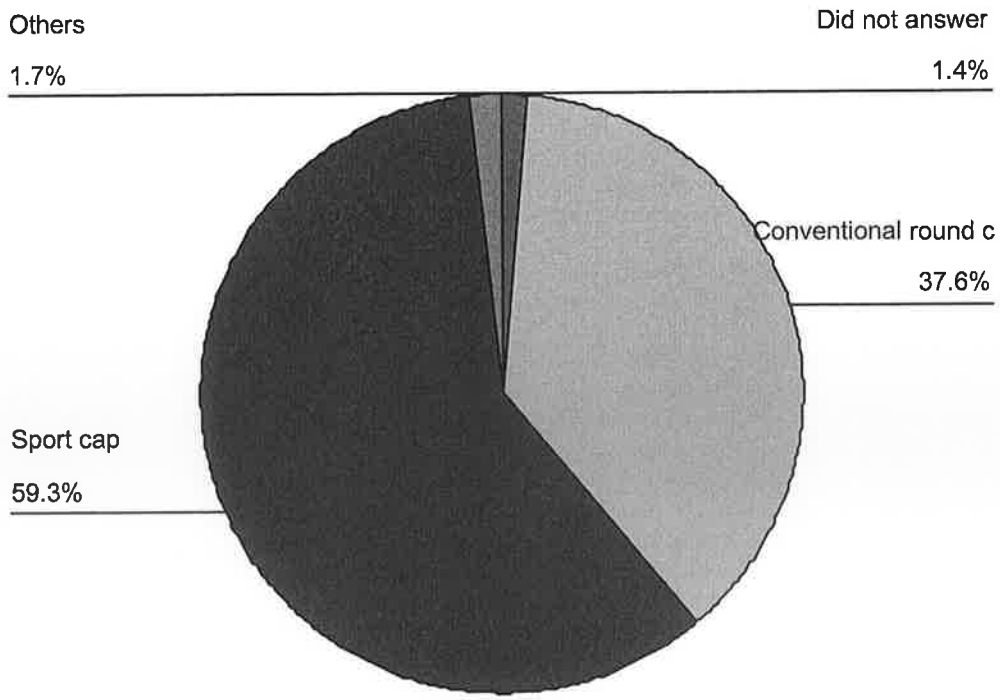

Figure 4.10: Cap type liked by the respondents

So it can be concluded that the mineral water or soft drink company should have two types of bottles for one single product-one having sport cap and the other conventional one.

4.11.11 Gender

More females responded to the survey than their male counterparts as portrayed in Table 4.12 and Figure 4.11. However, this difference was too small to imply any gender bias on the survey. But it shows that females are more likely to respond to survey questionnaire.

Table 4.12: Gender of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	5	1.4	1.4	1.4
	Female	187	52.1	52.1	53.5
	Male	167	46.5	46.5	100.0
	Total	359	100.0	100.0	

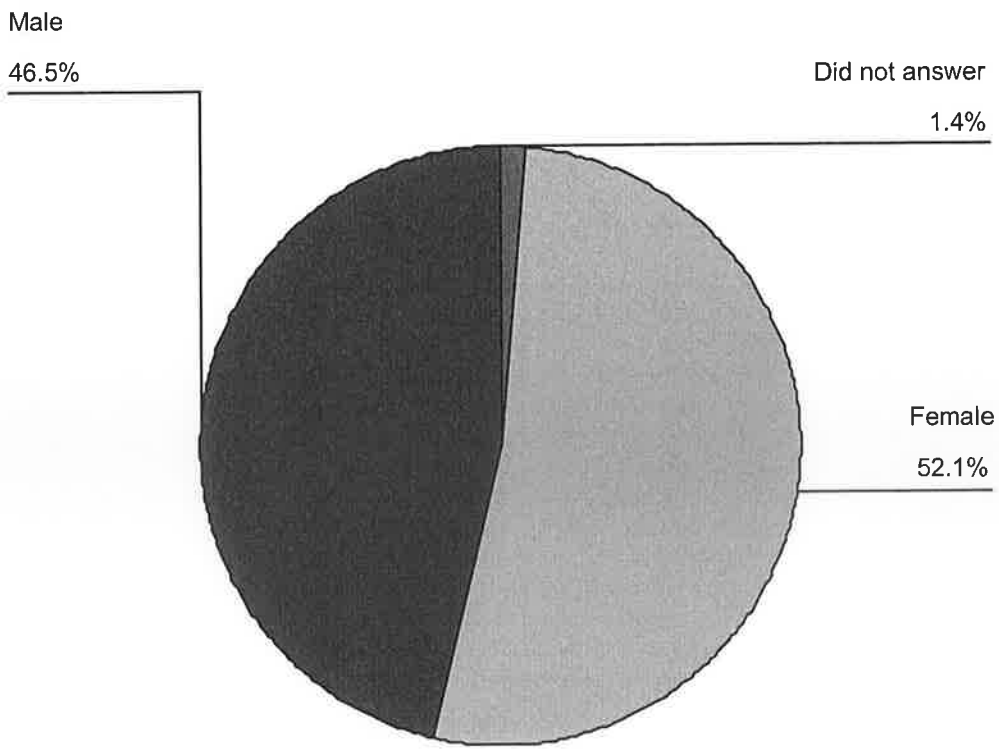

Figure 4.11: Gender of the respondents

4.11.12 Age Group

The majority of the respondents were between the age group of 14-25 years as shown in Table 4.13 and Figure 4.12.

Table 4.13: Age group of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not asnwer	3	.8	.8	.8
	Under 14	1	.3	.3	1.1
	14-20 years	132	36.8	36.8	37.9
	21-25 years	143	39.8	39.8	77.7
	26-30 years	34	9.5	9.5	87.2
	31-35 years	18	5.0	5.0	92.2
	36-40 years	7	1.9	1.9	94.2
	41-45 years	7	1.9	1.9	96.1
	46-50 years	5	1.4	1.4	97.5
	51-55 years	4	1.1	1.1	98.6
	56-60 years	4	1.1	1.1	99.7
	Over 60 years	1	.3	.3	100.0
	Total	359	100.0	100.0	

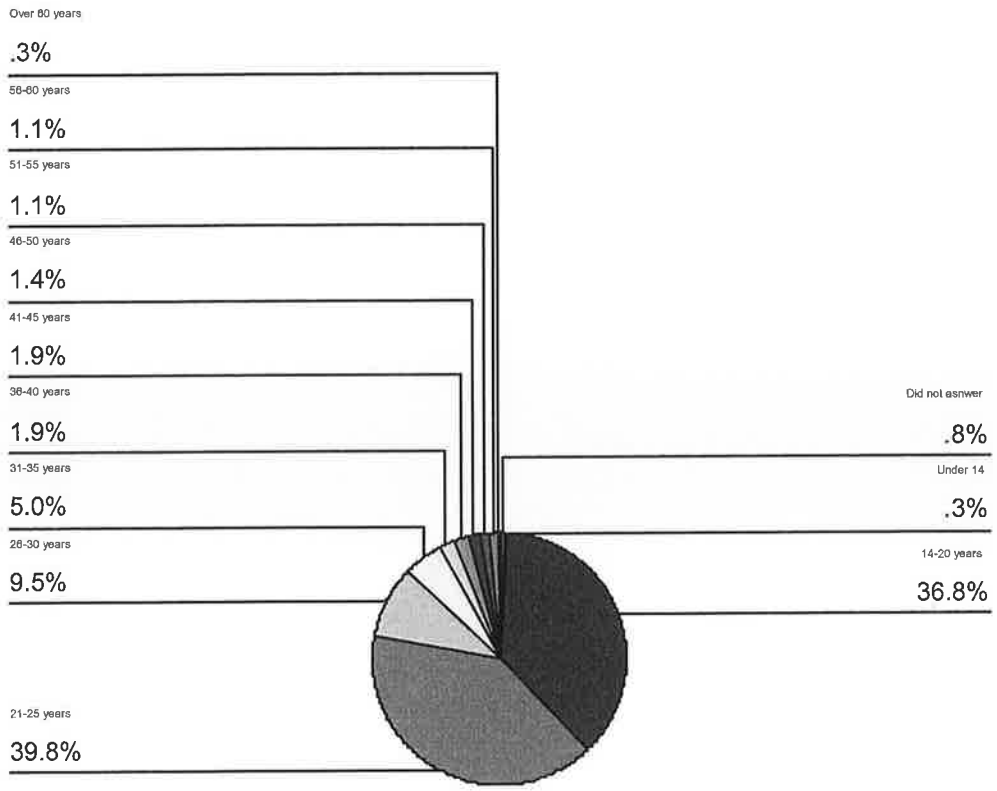

Figure 4.12: Age group of the respondents

4.11.13 Education

Since the majority of the target population were students and among them undergraduate students outnumbered others in a large number, the dominant education level in the survey was studying in third level just after completing Secondary education as illustrated in Table 4.14 and Figure 4.13.

Table 4.14: Education of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	2	.6	.6	.6
	Secondary	12	3.3	3.3	3.9
	Third level	43	12.0	12.0	15.9
	Masters	17	4.7	4.7	20.6
	PhD	10	2.8	2.8	23.4
	Third level studying	228	63.5	63.5	86.9
	Masters studying	31	8.6	8.6	95.5
	PhD studying	15	4.2	4.2	99.7
	Others	1	.3	.3	100.0
	Total	359	100.0	100.0	

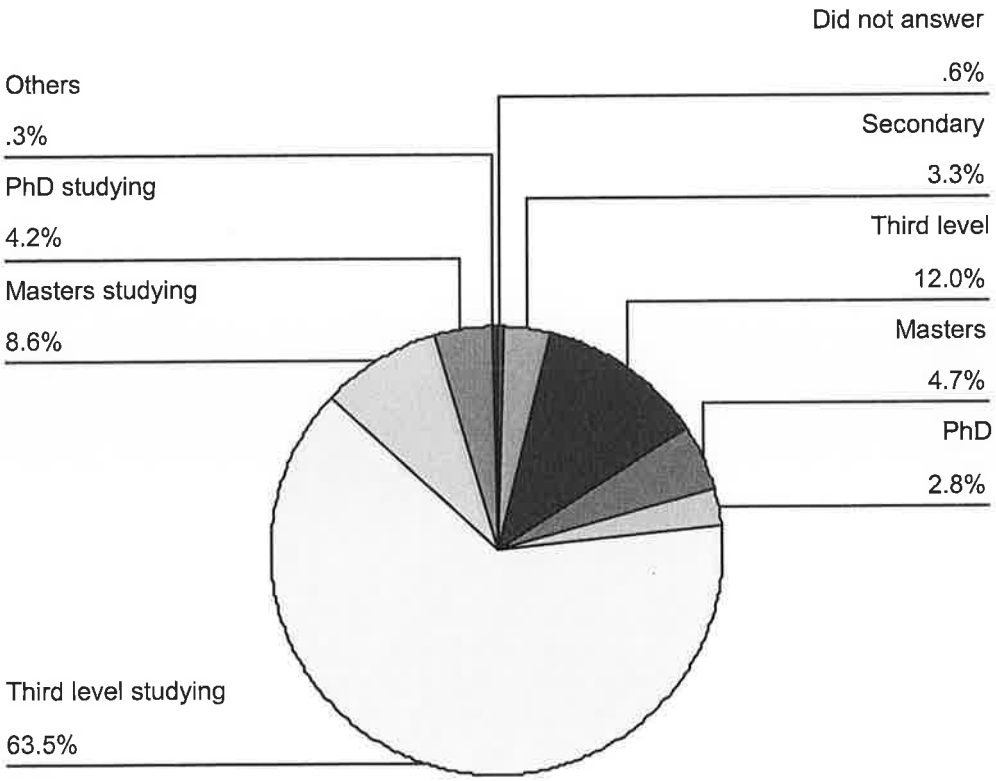

Figure 4.13: Education of the respondents

4.11.14 Occupation

The majority of the target population were students and hence it is logical the dominant occupation on the survey was student as depicted on Table 4.15 and Figure 4.14.

Table 4.15: Occupation of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	4	1.1	1.1	1.1
	Student	298	83.0	83.0	84.1
	Govt. service holder	3	.8	.8	85.0
	Private job	30	8.4	8.4	93.3
	Business	1	.3	.3	93.6
	Agriculture/Dairy	2	.6	.6	94.2
	Academician	16	4.5	4.5	98.6
	Others	4	1.1	1.1	99.7
	Part-time student	1	.3	.3	100.0
	Total	359	100.0	100.0	

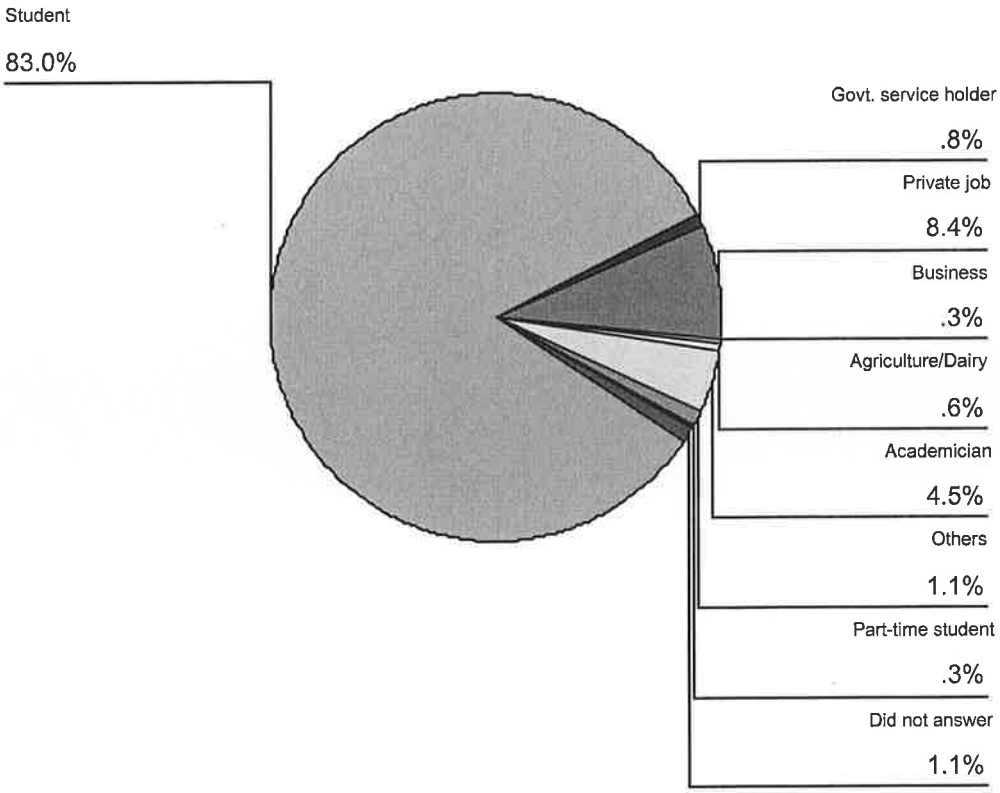

Figure 4.14: Occupation of the respondents

Staff were generally categorised into two segments- academician and private job. On education, academic staffs had some higher degrees while students were studying in third level having completed secondary education or Maters students or PhD students. Third level students were highest responders as they are the majority in the target population

4.11.15 Income

Under 10,000-euro income group was the dominant one in the survey as shown in Table 4.16 and Figure 4.15. In the survey, the majority of the respondents were undergraduate students. Therefore, they had not any significant income other than salary obtained from part-time jobs. Staffs had significant income but they were the minority of the target population, so their high-income level could not able to come up as the dominant income level in the survey. In general, 10,000 to 15,000 euro group followed the under 10,000euro income level group. After this level, the

percentage of people having much higher income level was very low. So it can be concluded that the survey largely reflects the opinion of the young student body.

Table 4.16: Income of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	24	6.7	6.7	6.7
	under 10,000 euro	247	68.8	68.8	75.5
	10,000 to 15,000 euro	27	7.5	7.5	83.0
	15,001 to 20,000 euro	5	1.4	1.4	84.4
	20,001 to 25,000 euro	6	1.7	1.7	86.1
	25,001 to 30,000 euro	8	2.2	2.2	88.3
	30,001 to 35,000 euro	7	1.9	1.9	90.3
	35,001 to 40,000 euro	7	1.9	1.9	92.2
	40,001 to 45,000 euro	6	1.7	1.7	93.9
	45,001 to 50,000 euro	4	1.1	1.1	95.0
	50,001 to 55,000 euro	5	1.4	1.4	96.4
	55,001 to 60,000 euro	2	.6	.6	96.9
	Over 60,000 euro	11	3.1	3.1	100.0
	Total	359	100.0	100.0	

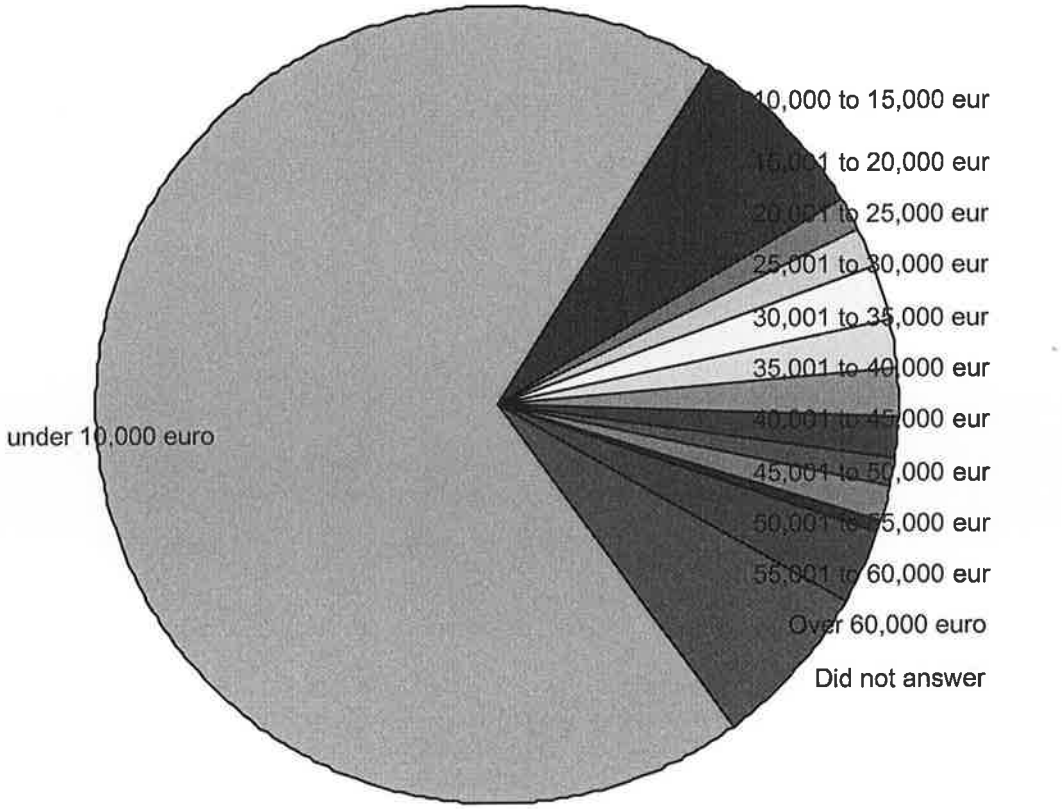

Figure 4.15: Income of the respondents

4.12 Cross Tabulation of the Survey Data

To get a deep insight to the data obtained from the survey, cross tabulation is to be done. In this work, the variables that provide very close responses among different choices were chosen for cross tabulation.

4.12.1 Gender versus the Rest

From cross tabulation of Gender versus the rest of the variables, no significant variations was found between male and female with respect to most of the variables. However, the following might be a bit noteworthy findings from this cross tabulation.

-On special shape attribute, among those who opted for gradual changeover, males were 61.4% while females were 37.6%. Curved surface and smooth finishing were preferred more by female, i.e. 58.2% and 58.9% respectively.

-Within females 64.2% preferred light bottles while within males 54.2% opted for that.

4.12.2 Age

The prominent findings from the cross tabulation done with regard to age are as follows:

-Within 31-35 years age group, 66.7% liked conventional cap while 27.8% preferred sports cap Within 41-45 year age group, 57.1% liked conventional while 42.9% went for sports cap. It suggests that there is a considerable acceptance for sports cap in senior age groups too.

4.12.3 Income

From the cross tabulation between income level and the other variables, the following significant information has been found.

-With the increasing income level, the respondents seem to more prone to positive towards paying a bit more environmentally efficient product as displayed in Table 4.18. In Table 4.18, within each income group what percentage of the respondents opted for yes or no regarding paying a bit more for environment friendly product is shown. Then percentage of yes or no within the total respondents is presented. For instance, under 10000 euro income level, 62.8% said yes and 36% said No; on the 10000 to 15000 euro income level, yes soared to 77.8% and No plummeted to 18.5%; over 60000 euro income level 81.8% said Yes and only 18.2% said No.

- With the increase of income level, at some stage conventional cap was liked by the majority while in the next income level it turned out the other way. So no significant trend was found in this respect.

Annual income of the respondent * Pay a bit for environ friendly product? Crosstabulation

			Pay a bit for environ friendly product?			Total
			Yes	No	Others	
Annual income of the respondent	Did not answer	Count	10	14		24
		% within Annual income of the respondent	41.7%	58.3%		100.0%
		% within Pay a bit for environ friendly product?	4.2%	12.3%		6.7%
		% of Total	2.8%	3.9%		6.7%
	under 10,000 euro	Count	155	89	3	247
		% within Annual income of the respondent	62.8%	36.0%	1.2%	100.0%
		% within Pay a bit for environ friendly product?	65.4%	78.1%	37.5%	68.8%
		% of Total	43.2%	24.8%	.8%	68.8%
	10,000 to 15,000 euro	Count	21	5	1	27
		% within Annual income of the respondent	77.8%	18.5%	3.7%	100.0%
		% within Pay a bit for environ friendly product?	8.9%	4.4%	12.5%	7.5%
		% of Total	5.8%	1.4%	.3%	7.5%
	15,001 to 20,000 euro	Count	4	1		5
		% within Annual income of the respondent	80.0%	20.0%		100.0%
		% within Pay a bit for environ friendly product?	1.7%	.9%		1.4%
		% of Total	1.1%	.3%		1.4%
	20,001 to 25,000 euro	Count	6			6
		% within Annual income of the respondent	100.0%			100.0%
		% within Pay a bit for environ friendly product?	2.5%			1.7%
		% of Total	1.7%			1.7%
	25,001 to 30,000 euro	Count	5	1	2	8
		% within Annual income of the respondent	62.5%	12.5%	25.0%	100.0%
		% within Pay a bit for environ friendly product?	2.1%	.9%	25.0%	2.2%
		% of Total	1.4%	.3%	.6%	2.2%
	30,001 to 35,000 euro	Count	5	2		7
		% within Annual income of the respondent	71.4%	28.6%		100.0%
		% within Pay a bit for environ friendly product?	2.1%	1.8%		1.9%
		% of Total	1.4%	.6%		1.9%
	35,001 to 40,000 euro	Count	6		1	7
		% within Annual income of the respondent	85.7%		14.3%	100.0%
		% within Pay a bit for environ friendly product?	2.5%		12.5%	1.9%
		% of Total	1.7%		.3%	1.9%
	40,001 to 45,000 euro	Count	6			6
		% within Annual income of the respondent	100.0%			100.0%
		% within Pay a bit for environ friendly product?	2.5%			1.7%
		% of Total	1.7%			1.7%
	45,001 to 50,000 euro	Count	3		1	4
		% within Annual income of the respondent	75.0%		25.0%	100.0%
		% within Pay a bit for environ friendly product?	1.3%		12.5%	1.1%
		% of Total	.8%		.3%	1.1%
	50,001 to 55,000 euro	Count	5			5
		% within Annual income of the respondent	100.0%			100.0%
		% within Pay a bit for environ friendly product?	2.1%			1.4%
		% of Total	1.4%			1.4%
	55,001 to 60,000 euro	Count	2			2
		% within Annual income of the respondent	100.0%			100.0%
		% within Pay a bit for environ friendly product?	.8%			.6%
		% of Total	.6%			.6%
	Over 60,000 euro	Count	9	2		11
		% within Annual income of the respondent	81.8%	18.2%		100.0%
		% within Pay a bit for environ friendly product?	3.8%	1.8%		3.1%
		% of Total	2.5%	.6%		3.1%
Total		Count	237	114	8	359
		% within Annual income of the respondent	66.0%	31.8%	2.2%	100.0%
		% within Pay a bit for environ friendly product?	100.0%	100.0%	100.0%	100.0%
		% of Total	66.0%	31.8%	2.2%	100.0%

Table 4.17: Annual Income vs Pay a bit for environmentally friendly product Cross-tabulation

4.12.4 Chi-square Test Results

Chi-square tests were performed among all attributes and personal information (e.g.gender, age group). The results are presented in Table C at Appendix A. When

both Pearsons chi square value and likelihood ratio give the values less than 0.05, the two variables concerned are considered to have strong relationship. Such strong relationships were found among the following variables:

- Shape and education
- Paying for environment with age, education and occupation
- Transparency with gender
- Cap with age, education and occupation

4.13 Conclusion

The survey conducted in relation to the present research was described elaborately in this chapter. The survey was a success as it provided valuable information regarding general public opinion about aesthetics attributes of soft drink and mineral water bottles. The main findings are as follows:

- Circular shaped bottles with curved surface and smooth finishing are mostly liked by the surveyed population.
- Transparent, clear or blue colour, medium sized bottles with pop up sports caps are the most popular.

Chapter Five - Second Survey Procedures, Results and Analyses

5.0 Introduction

The objectives of this chapter are to:

- Detail about the method of survey used.
- Perform an analysis of the data obtained from the survey.
- Detail the development of the proposed Intelligent Design System

It is difficult to determine public opinion about the aesthetical attributes of a product, therefore a survey was designed and carried out to gauge people's viewpoint about the aesthetical attributes they prefer in mineral water and soft drink bottles. The whole procedure of designing of the survey together with analysis of the data obtained has been detailed in this chapter.

The proposed Intelligent Design system is envisaged to help designers to design aesthetically pleasant and environmentally friendly products. The initial set up of that system and related tasks have also been described in this chapter.

5.1 Type of Survey Selection for Second Survey

As mentioned in earlier chapter 4, there are four major types of surveys. They are:

- Mail Survey
- Interview in person
- Telephone Survey
- Online survey

Considering different aspects, for the second survey combination of postal and online survey was used. Postal survey method was the primary method in the second survey. Online survey supplemented it. That is, when a person receives the postal survey, for convenience their respondent may reply via online as the link is given on

the forwarding letter of the postal survey. Each of these has its advantages and disadvantages. Online survey is the most economical online. But in the second survey, the target population was the inhabitants of Dublin city. Only a small percentage of people have internet access or actually use internet. In addition, there is no public e-mail database of people. If such were available, spam and junk mail law would have obstructed the use of such e-mail database. Since the goals of the second survey was subjective, interviewing in person would generally give better response. But to do so, interviewers need to go the sample population who are supposed to be live in different location. Willingness of the sample population is required. In many cases, people may ask for compensation for their time. For the author himself alone, conducting such interviews would take a long time. Therefore, basically it was not found economically viable option considering limited budget of the project and time constrains. Telephone interview was another option. Since the second survey was long containing 13 pages, most of the people would not like to give that much time without compensation. To record the conversation of the interview, equipments installation is necessary. Furthermore, extracting the information from the interview and put it on a statistical software would take substantial time. Thus, telephone interview was not deemed to be a optimal option. So the remaining two options , i.e. postal survey and online survey, methods were used for the second survey. In the second survey, sample population was selected randomly from the phone book published by Eircom. This phone book is freely available and it contains postal address too. In Ireland, most of the household has land phone connection. So it could be logically presumed that this phone book represented the population of Dublin city. There were cost of posting, printing questionnaire but it was less costly than other options. There are drawbacks in the postal survey method too. For example, one need to put substantial time to put the filled out data information to the statistical software. But when compared with other option, it was found to be less time consuming and less costly. Consequently, postal survey method was chosen as the main tool and online survey as supplementary one to get the second survey done.

5.2 Formulating the Goals and Uses of the Survey

The goal of the second survey was the same as the first one, gauging the aesthetic attributes liked by the general public in some products. In the second survey, a few more products were included and it was targeted towards the population of Dublin.

Like the first survey, the following aesthetical attributes have been taken for consideration-

- Shape (common geometrical and image specific)
- Size
- Colour
- Weight
- Transparency
- Cap
- Specific Material

For some products, a few more attributes were considered.

- Hand position
- Hook
- Combination of colour
- Curvy section or gradual changeover
- Impression
- Colour scheme
- Handle
- Neck
- Trigger

The personal information collected were Gender, Age, Education, Occupation, and Income. This personal information was optional for the respondent to provide. It was the researcher strict policy to keep this information for only contacting the persons regarding the feedback of the research. It was mentioned also that such personal information would not be given to any other person.

5.3 Questionnaire Design for the Second Survey

The second survey used similar questionnaire that had been used for the first survey. Therefore, the procedure to design this questionnaire was shortened as most of the steps were done in the first survey. The first survey was considered as a pilot test for the second survey. Besides, another pilot survey was carried out to test the second survey. For the pilot test of the second survey, 100 survey questionnaires were sent by post. The sample of people for this pilot test was randomly selected from the Eircom telephone directory. For this selection of people, same procedure was used as the original one, i.e. simple random sampling. The response or return rate of the pilot survey was 25%. Accordingly, some changes were made to the draft questionnaire. For example, in the first draft, no images of the shape were included. At the final stage, the second draft was reviewed by the supervisors of this study and some fellow postgraduate students. Thenceforth, Some respondents gave the feed back that it would be more helpful to judge shape of a product's bottle if images were given. The author met with two design experts teaching in National College of Art and Design (NCAD) at Dublin to discuss with the aesthetical attributes questions presented in the draft questionnaire. One of them was Paul Fortune, who was the head of Industrial Design Department. The other one was Gearoid O'Conchubairm of the same department, who lectures on aesthetics. Therefore the survey questionnaire was considered to be valid. For reliability analysis, Cronbach Alpha was determined (refer to Appendix D). Most of the values of the Cronbach Alpha were found to be greater than 0.7. Thus the questionnaire was considered to be reliable.

5.4 Sampling Selection

The sampling method used in the second survey was simple random sampling.
The sample population was selected from Eircom Phone book for 01 zone(Dublin and its surrounding locality) for the year 2005. The population of Greater Dublin area(including Dublin City,Dun Laoghaire,Rathdown,Fingal and South Dublin) is 1,122,821 according to census 2002, CSO 2004 [163].For this population, with

95%cofidence level and 5% error or confidence interval, the sample size needed is 384. In the pilot survey, the response rate was 26%. Therefore the number of questionnaires to be sent was 1477. Rounding this number, 1500 persons were randomly selected from the phonebook. The random selection was done by using MS Excel package. In MS Excel, there is a function to generate random numbers. The function is =RAND() . One has to type that into a cell and it will produce a random number in that cell. Copying the formula throughout a selection of cells will produce random numbers between 0 and 1.

In Eircom Phonebook 2005 for 01 zone, residential listings start from page 17 and end in page 598. Every page has four columns with 123 rows. The total no of pages that contains residential listings is 582. Thus in an excel sheet, random number function was applied to five columns. In the first column, page no was generated randomly using the function =INT(582*RAND())+1 [164]. The 'INT' eliminates the digits after the decimal. In the next column, 16 was added to the previous cell on the first column to get the exact page no in the phone book using the formula = A1+16 and copying into subsequent cells in the second column. In the third column, column no was generated randomly using the function =INT(4*RAND())+1. In the fourth column, row no was generated using the function =INT(123*RAND())+1.

The final sample size allocation was taken after reviewing the pilot test results. The author discussed with Mr. Gary Keogh, Lecturer in Computer Application, DCU who teaaches survey related topics. Mr. Gary evaluated the sampling plan and endorsed it. Since the response rate in the pilot test was 25%, it was decided to send survey mails four times the required one. Accordingly, it was calculated that the no of posts to be sent was 1400. So using the simple random sampling method and procedure described previously, the sample population were selected from randomly from the Eircom Phone book. As stated earlier, MS Excel was used to generate the random sequence of the sample population. Some other necessary arrangements for the mail shots were taken in this stage. A free reply license was taken from Anpost. An Post at GPO at Dublin was to be contacted. They gave the number instantly upon paying them with a cheque of 100 euro. The freebox number given was Free post F 3980. The design of the envelope to be used for this mail shot was also given to the

Anpost for record. The breakdown of the payment was- 100 euro charge and 100 euro deposit to cover the postage bill to be paid. An post later sent the bill when the postage exceeded the deposit. A stationery supplier, Byrne & McCrea Ltd of Dublin , was contacted to supply envelope. They supplied larges envelopes (C4),small envelopes(C5) printed with the return address with freepost no and labels(L7 160 labels). With the free reply post, the respondent did not have to pay for the postage; it was bore by the research fund of this project.

5.5 Choosing the Estimators

The estimators selected for the second survey were the same as the first survey. With the statistical software SPSS, frequency distribution, cross tabulation, chi square analysis, correlation analysis were performed. The outputs were displayed with tables and pie charts. The validity and reliability were checked. These are described in the relevant sections in this thesis.

5.6 The Online Survey for the Second Survey

The online survey was created as the same way as done in the first survey. The new things are addition of two picture files and images of shapes inside the questionnaires. The online survey for the second one was developed using HTML. Microsoft Frontpage was used as the editor for this purpose. Response was collected via response-o-matic, a free webbased form processor [157]. The URL of the second online questionnaire is:
http://www.abida.co.uk/volj.html

5.7 Procedures of Conducting the Mail Shot

The mail shot was begun in November 2005 and continued throughout 2006. The questionnaires were printed in DCU Hub. Labels were printed by the author. Before that, randomly selected people's addresses were taken from the Eircom Phone book. It took a lot of time, per address noting and keying in the computer document took 5 minutes in average. When labels, questionnaires, envelopes were ready, each set of the questionnaires was manually put in by the author. The label was stick outside

with the address printed on it. In the large envelope, a stamp of the school of Mechanical and Manufacturing Engineering DCU was given. With this stamp, the postal department charged the required amount of postage to the school. . Inside the large envelope, the small envelop was put in together with questionnaire, a forwarding letter, two additional sheet containing images to assist the respondent to understand well about a few aspect of the attributes given in the questionnaire.

5.8 Combination of Postal and Online Survey

It is thought that some people might prefer to reply online as the internal connectivity is growing rapidly. Keeping this in mind, the same survey was put online and the link of this online survey was put on the covering letter of the survey.

5.9 Response Obtained

At first, it was planned to send 1400 sets of questionnaires, which is four times the original sample size calculated to compensate non-response. After sending 500 questionnaire, it was found that the response rate was only 6.2%. It was low comparing to the target of 25% response rate. The prominent reasons might be the time constrain of people, nature of the survey and not giving any incentive for the time spent on filling out the survey. Thus the whole mail shot procedure was reviewed. It was decided that telephone calls would be made to the sampled people population to persuade them to fill out the survey form. Furthermore, it was found that in many market research surveys, response rates are around 5%[131]. Therefore, it was concluded to accept response rate around 5%. Accordingly cold call was made during evening hours. Later altogether 800 sets of survey questionnaires were sent. The final response rate for the second survey was 11.63%(93 out of 800).

Table 5.1: Gender distributions of the respondents in the second survey

GENDER

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	2	2.2	2.2	2.2
	Female	33	35.5	35.9	38.0
	Male	57	61.3	62.0	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

Considering gender, the majority of the respondents (61.3%) were male as shown in Table 5.1 . The percentage of female respondents was 35.5%. The highest number of response(26.9%) came from the age group of 31-35 years followed by 41-50 years

Table 5.2 Age group break down of the respondents in the second survey

AGE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not asnwer	1	1.1	1.1	1.1
	21-25 years	4	4.3	4.3	5.4
	26-30 years	14	15.1	15.2	20.7
	31-35 years	25	26.9	27.2	47.8
	36-40 years	7	7.5	7.6	55.4
	41-50 years	18	19.4	19.6	75.0
	51-60 years	8	8.6	8.7	83.7
	Over 60 years	15	16.1	16.3	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

as shown in Table 5.2. The response from 26-30 years group and over 60 years group were nearly same. This distribution confirms the fact the most of the land phone

Table 5.3 : Education level break down of the respondents of the second survey

EDU

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	3	3.2	3.3	3.3
	Primary	1	1.1	1.1	4.3
	Secondary	16	17.2	17.4	21.7
	Third level	47	50.5	51.1	72.8
	Masters	12	12.9	13.0	85.9
	PhD	10	10.8	10.9	96.7
	Third level studying	2	2.2	2.2	98.9
	Others	1	1.1	1.1	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

owners are of middle age persons. Generally the land phone is taken against the name of the senior male member of the family. #21-25 years, 36-40years and 51-60 years group constituted of a small portion of the survey respondents whose

percentage did not cross one digit number. . 21-25 years, 36-40years and 51-60 years group constituted of a small portion of the survey respondents. Table 5.3 reveals that approximately half of the respondents had third level degree or were studying third

Table 5.4: Occupation break down of the respondents

OCCUP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	5	5.4	5.4	5.4
	Student	14	15.1	15.2	20.7
	Govt. service holder	9	9.7	9.8	30.4
	Private job	19	20.4	20.7	51.1
	Business	3	3.2	3.3	54.3
	Academician	7	7.5	7.6	62.0
	Others	35	37.6	38.0	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

Table 5.5 : Income level break down of the respondents

INCOME

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	13	14.0	14.1	14.1
	under 10,000 euro	7	7.5	7.6	21.7
	10,000 to 20,000 euro	16	17.2	17.4	39.1
	20,001 to 30,000 euro	12	12.9	13.0	52.2
	30,001 to 40,000 euro	19	20.4	20.7	72.8
	40,001 to 50,000 euro	9	9.7	9.8	82.6
	50,001 to 60,000 euro	5	5.4	5.4	88.0
	Over 60,000 euro	11	11.8	12.0	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

level at the time of the survey. Secondary degree holders emerged as the second largest group as they represented approximately one fifth of the respondents. With regard to occupation, the majority (37.6%) ticked others option (Table 5.4). This points out that be their job description might not exactly fall into the occupation list mentioned in the questionnaire. After this, private job emerged as the leading profession of the respondents. One in five respondents were doing private jobs. Student constituted 15.1% of the respondents. Considering income as shown in Table 5.5, the majority (24.7%) were below the income level of 20 thousand euro.

20.4% people were in the range of 30 thousand to 40 thousand euro. Over 60 thousand euro constitute 11.8% of the people replied the survey.

5.10 Analysis of the Data Obtained

To perform the statistical analysis on the data obtained from the survey, SPSS (Statistical Package for the Social Sciences) package was used as it was used for the first survey.

5.11 Mineral Water 500 ml Bottles - Descriptive Analysis

The descriptive analysis of mineral water 500 ml bottles is presented in this section.

5.11.1 Geometric Shape Preference

From the analysis result represented in Figure 5.1, it was found that the most popular shape for mineral water 500ml was round (53%). The other preference of shape in the descending order was: ellipse (19%), rectangle (13%) and square (2%). No preference option was selected by 11% of the respondents and 2% chose others.

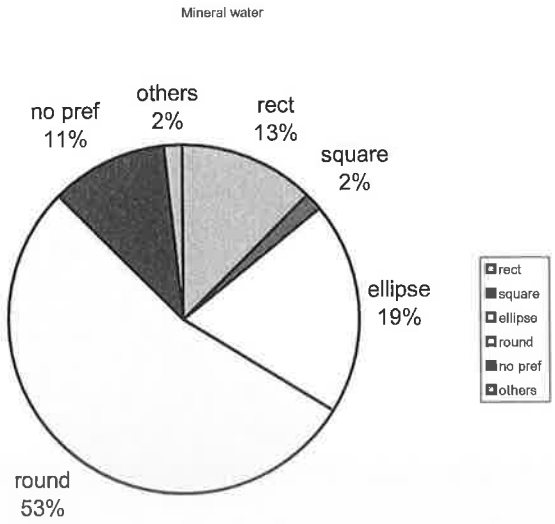

Figure 5.1: Mineral water 500ml geometric shape preference

5.11.2 Shape Preference

Frequency distribution shown in Figure 5.2 points out that two shape A(24%) & B(20%) got the same percentage of preference as first choice. They were jointly topped the list. The other two popular choices in descending order were Shape F (22%) and E (11%). Some shape images did not get response as first choice at all and so those were not included in this analysis.

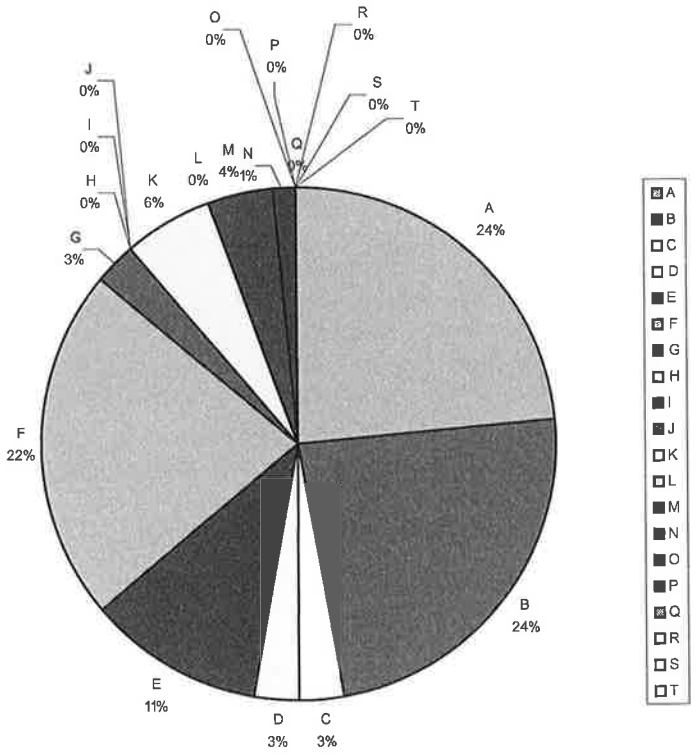

Figure 5.2 : Mineral water 500ml shape preference

5.11.3 Colour Preference

The analysis presented in Figure 5.3 shows that the favourite colour for mineral water 500ml was white(18%). The majority (24%) of the respondents selected others option followed by no preference (23%). The other popular colours in descending order were skyblue, blue/ green, offwhite, pink/orange/grey, red (1%).

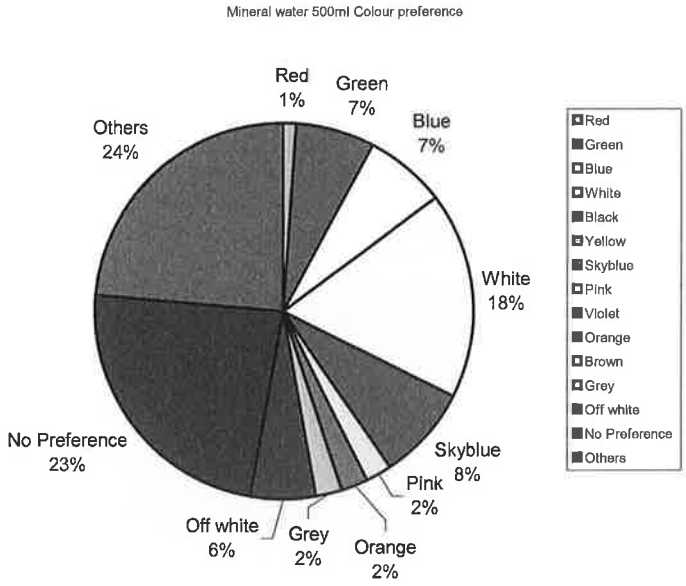

Figure 5.3 : Colour preference in mineral water 500ml bottles

5.11.4 Transparency

The majority of the respondents preferred for transparent bottles as shown in Figure 5.4. The percentage of choice for this option was 78%. 2% of the respondents liked opaque and 6% liked translucent. 14% of the respondent opted for no preference about the transparency of the mineral water bottles.

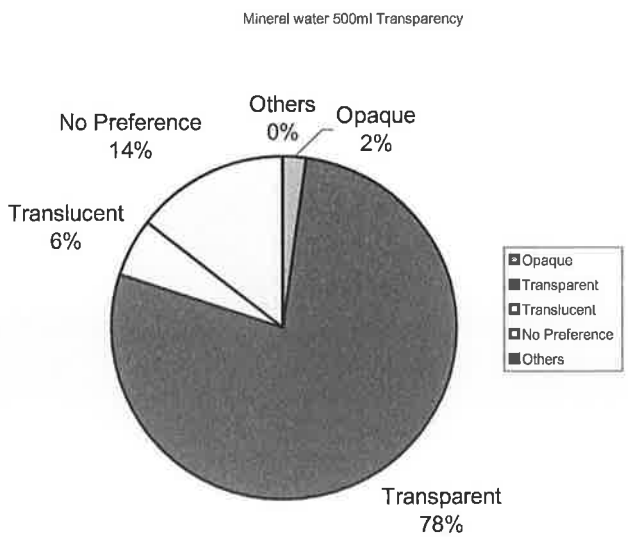

Figure 5.4 : Transparency preference in mineral water 500ml bottles

5.11.5 Curvature preference

The analysis shown in Table 5.6 points that 54.3% people opted for curvy section in mineral water bottles. 17.2% people did not like the curvy section and 23.7% had no preference.

Table 5.6: Curvature preference in mineral water 500ml bottles

MW_CURV

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	4	4.3	4.3	4.3
	yes	50	53.8	54.3	58.7
	no	16	17.2	17.4	76.1
	no pref	22	23.7	23.9	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

5.11.6 Combination of Colour preference

The majority (67%) of the respondent did not like combination of colour as shown in Table 5.7. Only 11% preferred two colour combination, 2.2% liked three-colour and 18.7% opted for any combination.

Table 5.7: Combination of colour preference in mineral water 500ml bottles

COLCOMB

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	any combi	17	18.3	18.7	18.7
	no	61	65.6	67.0	85.7
	two colour	10	10.8	11.0	96.7
	three colour	2	2.2	2.2	98.9
	no preference	1	1.1	1.1	100.0
	Total	91	97.8	100.0	
Missing	System	2	2.2		
Total		93	100.0		

5.11.7 Size Preference

The majority (43.5%) liked 500ml bottles as shown in Table 5.8. There was substantial preference for 2 litre (14.1%) ,1 litre (22.%) and 1.5 litre (9.8%) bottles too.

Table 5.8: Size preference in mineral water 500ml bottles

SIZE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.1	1.1
	500ml	40	43.0	43.5	44.6
	1litre	21	22.6	22.8	67.4
	1.5litre	9	9.7	9.8	77.2
	2 ltr	13	14.0	14.1	91.3
	no preference	3	3.2	3.3	94.6
	others	5	5.4	5.4	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

5.11.8 Material preference

The analysis as shown in Table 5.9 reveals that the majority (53.3%) had no preference in material for mineral water bottles. 23.9% liked plastic and 17.4% liked glass. 3.3% stated they had preference for a specific material but did not mention the name.

Table 5.9: Material preference in mineral water 500ml bottles

SPMAT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	2	2.2	2.2	2.2
	yes	3	3.2	3.3	5.4
	no	49	52.7	53.3	58.7
	glass	16	17.2	17.4	76.1
	Plastics	22	23.7	23.9	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

5.11.9 Environment Friendly Bottle Preference

The majority (76.1%) expressed their willingness to pay a bit more for the environmental friendly bottles (Table 5.10). 21.7 % respondents did not want to pay for this cause.

Table 5.10: Environment friendly preference in mineral water 500ml bottles

ENVIRON

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	2	2.2	2.2	2.2
	yes	70	75.3	76.1	78.3
	no	20	21.5	21.7	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

5.11.10 Cap preference in Mineral water 500ml bottles

The majority (43.5%) liked conventional cap whereas 35.9% preferred sports cap (Table 5.11). So there was small difference between conventional and sport cap preferences. A substantial number of people (19.6%) did not have any preference.

Table 5.11: Cap preference in mineral water 500ml bottles

CAP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.1	1.1
	conventional	40	43.0	43.5	44.6
	sports cap	33	35.5	35.9	80.4
	no preference	18	19.4	19.6	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

5.11.11 Impression preference

Table 5.12 shows that most of the respondents (47.8%) did not like impression in mineral water bottles. A large number of the respondents (38%) had no preference in this matter.

Table 5.12: Impression preference in mineral water 500ml bottles

IMPRE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.1	1.1
	yes	12	12.9	13.0	14.1
	no	44	47.3	47.8	62.0
	no preference	35	37.6	38.0	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

5.11.12 Colour Scheme preference

According to the anlaysis result presented in Table 5.13, the majority(54.3%)

Table 5.13: Colour scheme preference in mineral water 500ml bottles

COLSCM

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	3	3.2	3.3	3.3
	yes	2	2.2	2.2	5.4
	no	50	53.8	54.3	59.8
	no preference	35	37.6	38.0	97.8
	6.00	2	2.2	2.2	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

did not like colour scheme while 38% said they had no preference.

5.12 Mineral Water 1 to 1.5L Bottles - Descriptive Analysis

The descriptive analysis of mineral water 1 to 1.5L bottles is presented in this section.

5.12.1 Geometric Shape Preference

From the analysis result represented in Figure 5.5, it was found that the most popular shape for mineral water large was round (46%). The other preference of shape in the

descending order was: ellipse (21%), rectangle (15%) and square (4%). No preference option was selected by 12% of the respondents and 2% chose others.

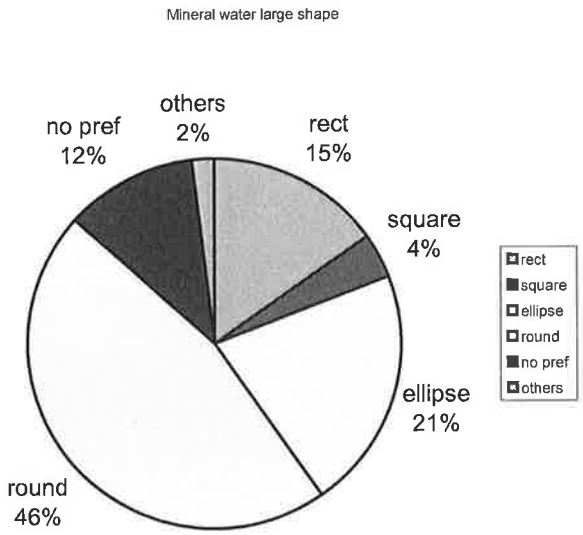

Figure 5.5: Geometric shape preference in Mineral water 1 to 1.5L bottles

5.12.2 Shape Preference

Frequency distribution shown in Figure5.6 points out that the most popular shape with a large margin of vote was Shape D (61%). The second popular one was Shape A(20%). The other three popular choices in descending order were Shape C (9%), B (7%) and E (3%). Some shape images did not get response as first choice at all and so those were not included in this analysis.

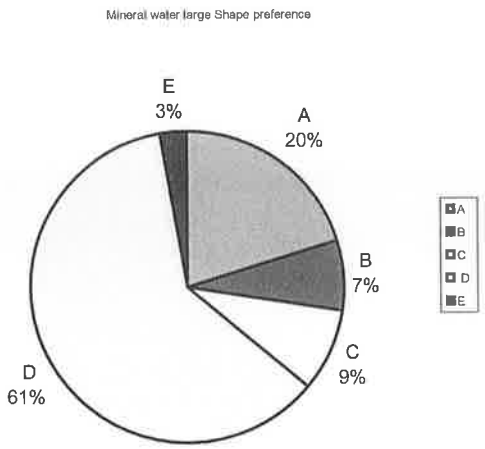

Figure 5.6: Shape preference in Mineral water 1to 1.5L bottles

5.12.3 Colour Preference

The analysis as presented in Fig 5.7 shows that the favourite colour for mineral water large was white(20%). The majority of the respondents selected no preference (25%) and others(25%). The other popular colours in descending order were skyblue; blue, green; offwhite,; pink, orange, grey; red (1%).

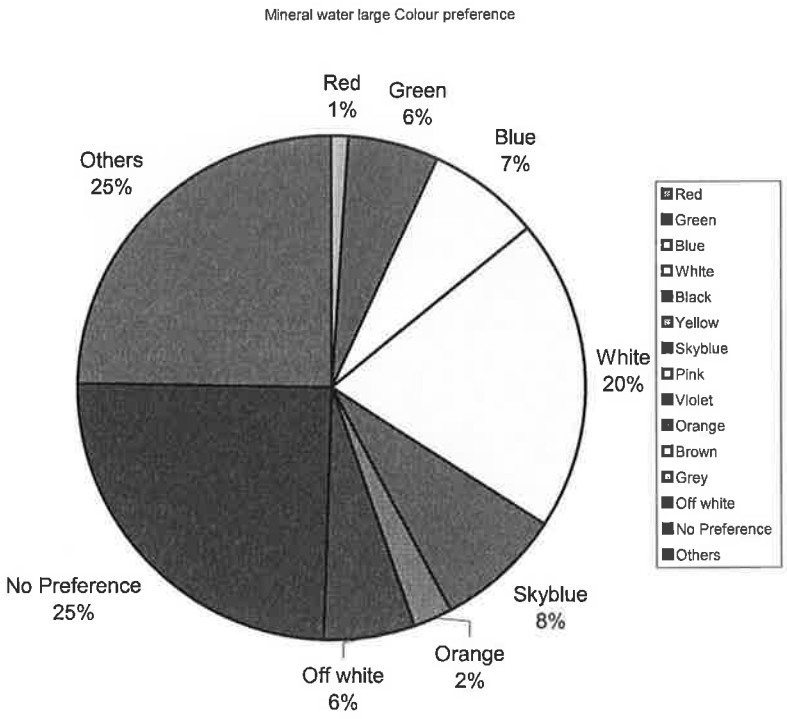

Figure 5.7 : Colour preference in mineral water 1 to 1.5L bottles

5.12.4 Transparency

The majority of the respondents preferred for transparent bottles (Figure 5.8). The percentage of choice for this option was 73%. 3% of the respondents liked opaque and 9% liked translucent. 14% of the respondent opted for no preference about the transparency of the mineral water bottles.

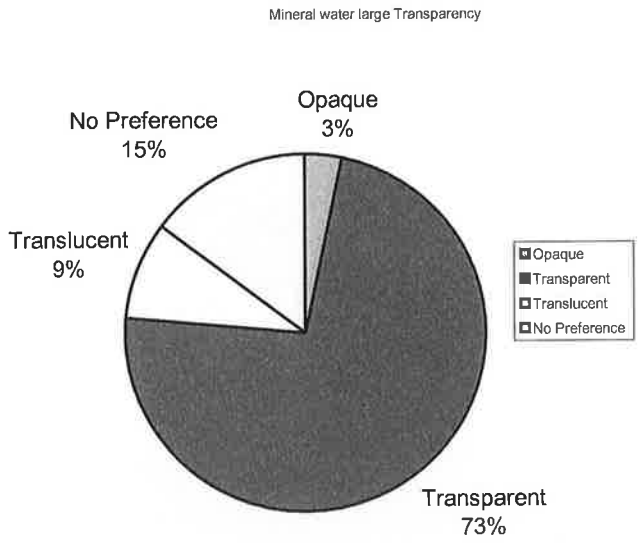

Figure 5.8: Transparency preference in mineral water 1 to 1.5L bottles

5.12.5 Curvature preference

The analysis shown in Table 5.14 points that the majority (45.7%) people opted for curvy section in mineral water 1 to 1.5L bottles. 27.2% people did not like the curvy section and 20.7% had no preference.

Table 5.14: Curvature preference in mineral water 1 to 1.5L bottles

MWB_CURV

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	5	5.4	5.4	5.4
	yes	42	45.2	45.7	51.1
	no	25	26.9	27.2	78.3
	no pref	19	20.4	20.7	98.9
	others	1	1.1	1.1	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

5.12.6 Combination of colour preference

The majority (68.1%) of the respondents did not like combination of colour as shown in Table 5.15. Only 8.8% preferred two colour combination, 3.3% liked three-colour and 16.5% opted for any combination.

Table 5.15: Combination of colour preference in mineral water 1 to 1.5L bottles

COLCOM_B

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	2	2.2	2.2	2.2
	any combi	15	16.1	16.5	18.7
	no	62	66.7	68.1	86.8
	two colour	8	8.6	8.8	95.6
	three colour	3	3.2	3.3	98.9
	no preference	1	1.1	1.1	100.0
	Total	91	97.8	100.0	
Missing	System	2	2.2		
Total		93	100.0		

5.12.7 Size preference

The majority (43.5%) liked 1 to 1.5L bottles as shown in Table 5.8 in the size section of mineral water 500 ml preference. There was substantial preference for 2 litre (14.1%) ,1 litre (22.%) and 1.5 litre (9.8%) bottles too.

5.12.8 Material preference

The analysis as shown in Table 5.16 reveals that the majority (55.4%) had no preference in material for mineral water bottles. 23.9% liked plastic and 15.2% liked glass. 3.3% stated they had preference for a specific material but did not mention the name.

Table 5.16: Material preference in mineral water 1 to 1.5L bottles

SPMAT_B

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	2	2.2	2.2	2.2
	yes	3	3.2	3.3	5.4
	no	51	54.8	55.4	60.9
	glass	14	15.1	15.2	76.1
	Plastics	22	23.7	23.9	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

5.12.9 Environment Friendly Bottle Preference

The majority (76.1%) expressed their willingness to pay a bit more for the environmental friendly bottles (Table 5.17). 21.7 % respondents did not want to pay for this cause.

Table 5.17: Environment Friendly bottle preference in mineral water 1 to 1.5L

ENVIR_B

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	2	2.2	2.2	2.2
	yes	70	75.3	76.1	78.3
	no	20	21.5	21.7	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

5.12.10 Cap preference

The majority (63%) liked conventional cap whereas 15.2% preferred sports cap (Table 5.18). So there was large difference between conventional and sport cap preferences. A substantial number of people (20.7%) did not have any preference.

Table 5.18: Cap preference in mineral water 1 to 1.5L bottles

CAP_BIG

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.1	1.1
	conventional	58	62.4	63.0	64.1
	sports cap	14	15.1	15.2	79.3
	no preference	19	20.4	20.7	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

5.12.11 Impression preferences

Table 5.19 shows that most of the respondents (45.7%) did not like impression in mineral water bottles. A large number of the respondents (39.1%) had no preference in this matter. Only 12% liked impression.

Table 5.19: Impression preference in mineral water 1 to 1.5L bottles

IMPRE_B

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	3	3.2	3.3	3.3
	yes	11	11.8	12.0	15.2
	no	42	45.2	45.7	60.9
	no preference	36	38.7	39.1	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

5.12.12 Colour Scheme Preference

According to the analysis result presented in Table 5.20, the majority(53.3%)

Table 5.20: Colour Scheme preference in mineral water 1 to 1.5L bottles

COLSCM_B

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	4	4.3	4.3	4.3
	yes	1	1.1	1.1	5.4
	no	49	52.7	53.3	58.7
	no preference	36	38.7	39.1	97.8
	6.00	2	2.2	2.2	100.0
	Total	92	98.9	100.0	
Missing	System	1	1.1		
Total		93	100.0		

did not like colour scheme while 39.1% said they had no preference

5.13 Men's Perfume Bottles- Descriptive Analysis

The descriptive analysis of men's perfume bottles is presented in this section.

5.13.1 Geometric Shape Preference

From the analysis result represented in Figure 5.9, it was found that the most popular shape for men's perfume and after shave was square (26%). The other preference of shape in the descending order was: rectangle (20%), round(20%) and ellipse (12%).

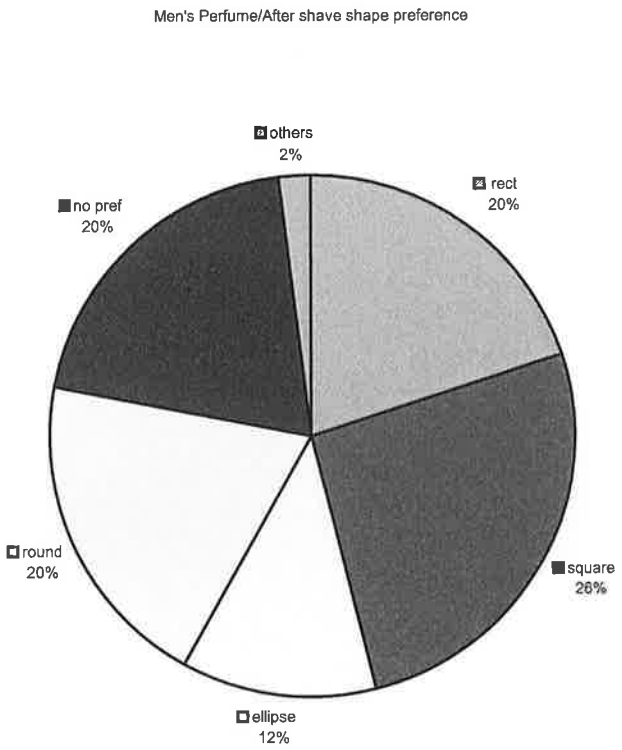

Figure 5.9: Men's perfume / aftershave geometric shape preference

5.13.2 Shape Preference

Frequency distribution shown in Figure5.10 points out that the most popular shape was Shape A (25%), followed by Shape B, shape F, P, D, C, Q, L, H.

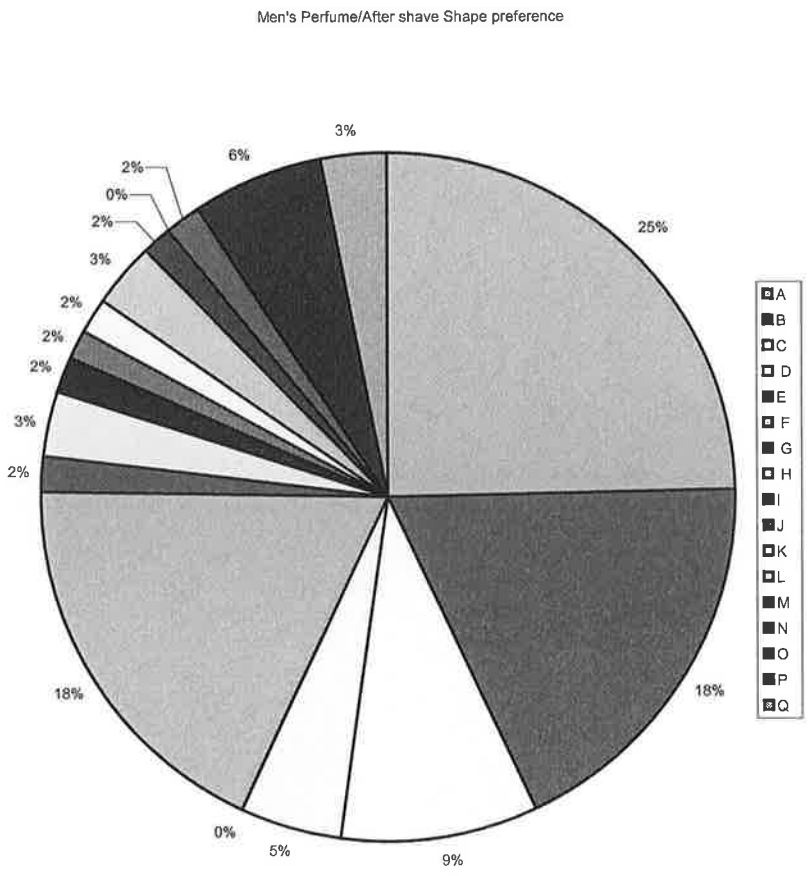

Figure 5.10: Shape preference in Men's Perfume / After shave bottles

5.13.3 Colour Preference

The most popular choice of colour for men's perfume/after shave was blue (18%), followed by green, white and black as shown in Figure 5.11. A substantial percentage of people, i.e. 18%, said they had no preference on colour of men's perfume / after shave.

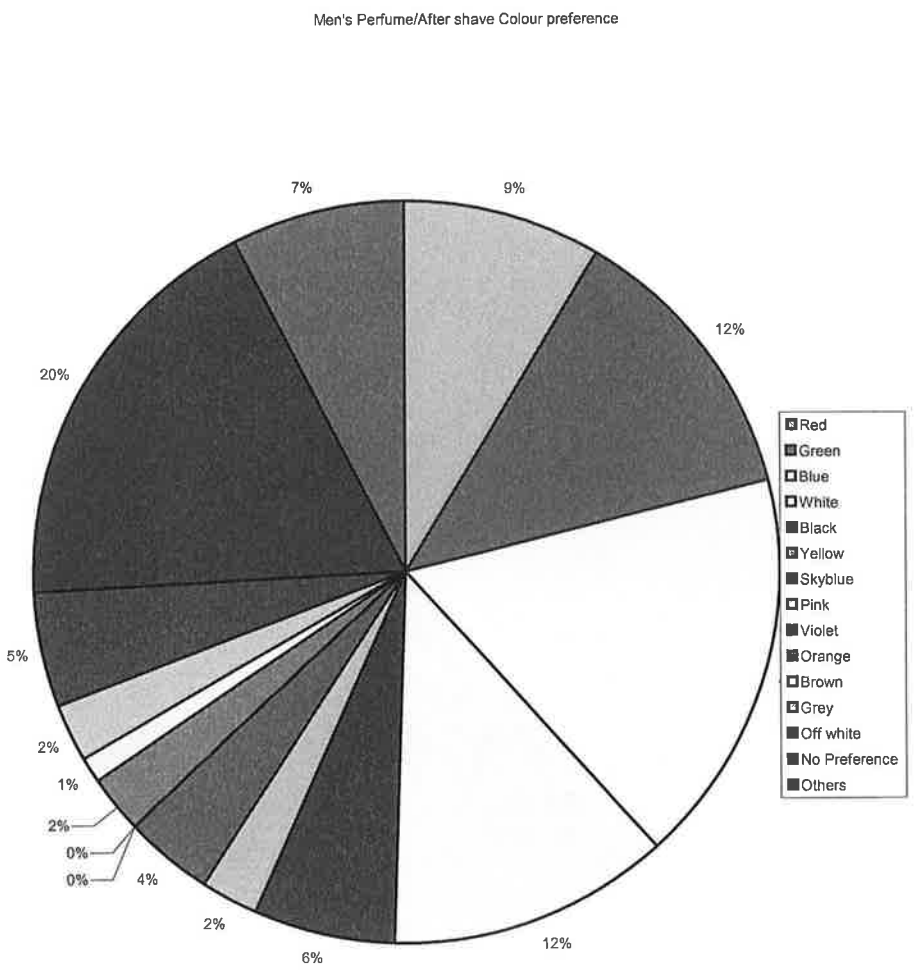

Figure 5.11: Colour preference in men's perfume bottles

5.13.4 Transparency

The majority of the respondents preferred for transparent bottles as shown in Figure 5.12. The percentage of choice for this option was 51%. The same number of people (18%) liked opaque and translucent bottles for men's perfume. 12% of the respondent opted for no preference about the transparency of the men's perfume bottles.

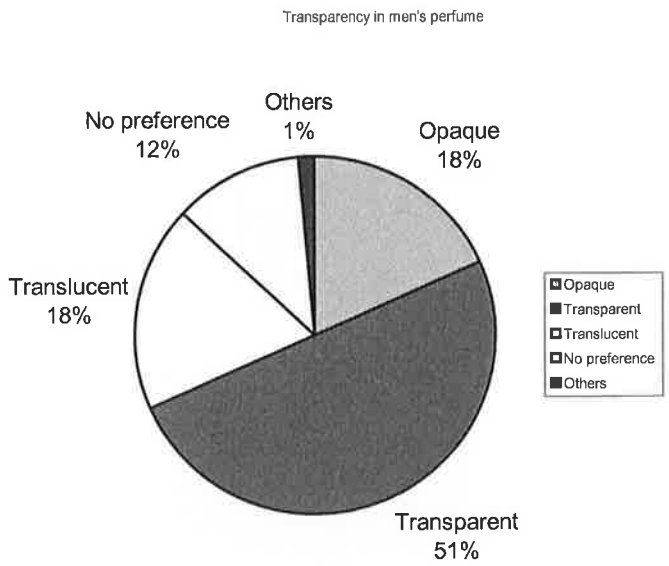

Figure 5.12: Transparency preference in men's perfume bottles

5.13.5 Curvature preference

The analysis shown in Figure 5.21 points that 55.8% people opted for curvy section in men's perfume bottles. 20.8% people did not like the curvy section and 19.5% had no preference.

Table 5.21: Curvature preference in men's perfume bottles

CURV

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	9	9.4	10.6	10.6
	yes	24	25.0	28.2	38.8
	no	27	28.1	31.8	70.6
	no pref	23	24.0	27.1	97.6
	others	2	2.1	2.4	100.0
	Total	85	88.5	100.0	
Missing	System	11	11.5		
Total		96	100.0		

5.13.6 Combination of Colour Preference

The majority (61%) of the respondent did not like combination of colour as shown in Table 5.22. Only 18.2% preferred two colour combination, 1.3% liked three-colour and 18.2% opted for any combination.

Table 5.22: Combination of colour preference in men's perfume bottles

COMBCOL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	3	3.1	3.5	3.5
	no ans	5	5.2	5.8	9.3
	any combi	15	15.6	17.4	26.7
	no	47	49.0	54.7	81.4
	two colour	16	16.7	18.6	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.13.7 Size Preference

The majority (24.7%) liked 31 to 50ml bottles as shown in Table 5.23. There was substantial preference for 51 to 75 ml (18.2%) and 76 to 100 ml (15.6%) bottles too.

Table 5.23: Size preference in men's perfume bottles

SIZE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	1	1.0	1.2	1.2
	no ans	12	12.5	14.1	15.3
	30ml or smaller	12	12.5	14.1	29.4
	31ml to 50ml	21	21.9	24.7	54.1
	51 to 75ml	17	17.7	20.0	74.1
	76 to 100ml	12	12.5	14.1	88.2
	101 to 125ml	4	4.2	4.7	92.9
	126 to 200ml	5	5.2	5.9	98.8
	others	1	1.0	1.2	100.0
	Total	85	88.5	100.0	
Missing	System	11	11.5		
Total		96	100.0		

5.13.8 Material Preference

The analysis as shown in Table 5.24 reveals that the majority (42.9%) had no preference in material for men's perfume bottles. Those who had preference on material, plastic (26%) was the top choice followed by glass (19.5%).

Table 5.24: Material preference in men's perfume bottles

MAT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	11	11.5	12.8	12.8
	yes	8	8.3	9.3	22.1
	no	32	33.3	37.2	59.3
	glass	34	35.4	39.5	98.8
	Al	1	1.0	1.2	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.13.9 Environment Friendly Bottle Preference

The majority (75.3%) expressed their willingness to pay a bit more for the environmental friendly bottles as shown in Table 5.25. 18.7 % respondents did not want to pay for this cause.

Table 5.25: Environment friendly bottle preference in men's perfume

ENVPAY

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	12	12.5	14.0	14.0
	yes	51	53.1	59.3	73.3
	no	23	24.0	26.7	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.13.10 Cap Preference

The majority (51.2%) had emphasis on the importance of the cap in the bottles of men's perfume as shown in Table 5.26. Nearly similar percentage of people (40.7%) did not put the importance on it.

Table 5.26: Cap preference in men's perfume bottles

CAPEMP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	1	1.0	1.2	1.2
	no ans	6	6.3	7.0	8.1
	yes	44	45.8	51.2	59.3
	no	35	36.5	40.7	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.13.11 Impression preference

Table 5.27 shows that most of the respondents (44.2%) did not like impression in men's perfume bottles. A large number of the respondents (40.3%) had no preference in this matter.

Table 5.27: Impression preference in men's perfume bottles

IMP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	7	7.3	8.1	8.1
	yes	7	7.3	8.1	16.3
	no	38	39.6	44.2	60.5
	no preference	34	35.4	39.5	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.13.12 Colour Scheme preference

According to the analysis result presented in Table 5.28, the majority (46.5%) had no preference regarding colour scheme. Nearly same proportion of people(33.7%) said they did not like impression.

Table 5.28: Colour scheme preference in men's perfume bottles

COLSCHM

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	11	11.5	12.8	12.8
	yes	6	6.3	7.0	19.8
	no	29	30.2	33.7	53.5
	no preference	40	41.7	46.5	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.13.13 Trigger Preference

The majority (43%) had no preference on trigger in men's perfume bottles as shown in Table 5.29. A substantial no of people(30.2%) liked trigger. Nearly one in seven (15.1%) opted for orifice.

Table 5.29: Trigger preference in men's perfume bottles

TRIGR

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	10	10.4	11.6	11.6
	pump or trigger	26	27.1	30.2	41.9
	opening or orifice	13	13.5	15.1	57.0
	no preference	37	38.5	43.0	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.14 Women's Perfume Bottles-Descriptive Analysis

The descriptive analysis of women's perfume bottles is presented in this section

5.14.1 Geometric Shape Preference

From the analysis result represented in Figure 5.13, it was found that the most popular shape for women's perfume was round (33%). The other preferences of shape in the descending order were: ellipse (27%), square(10%) and rectangle (10%).

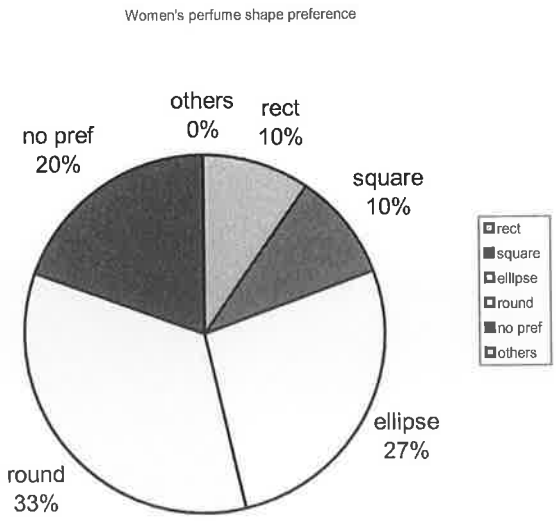

Figure 5.13: Geometric shape preference in women's perfume bottles

A large number of the respondents (20%) said they had no preference in this issue.

5.14.2 Shape Preference

Frequency distribution presented in Figure 5.14 points out that Shape B (20%) and Shape F (20%) were jointly the most popular. The other popular shapes were Shape B, shape H,K, G; C,D, E,Q,R; A, S, O, N.

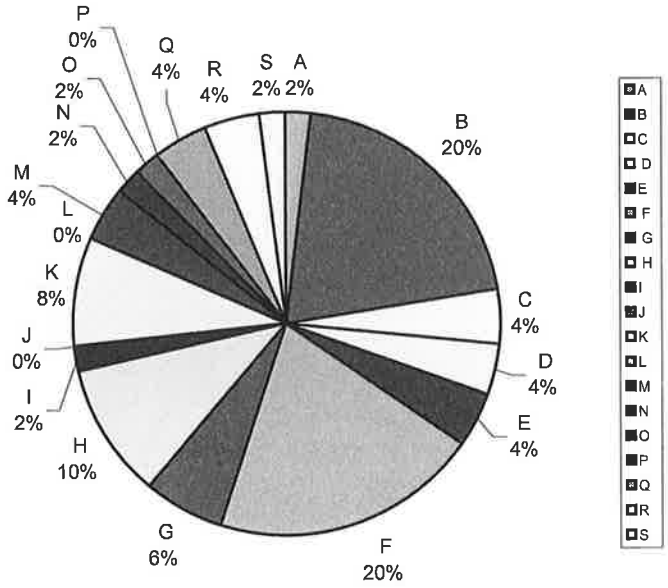

Figure 5.14 : Shape preference in women's perfume bottles

5.14.3 Colour Preference

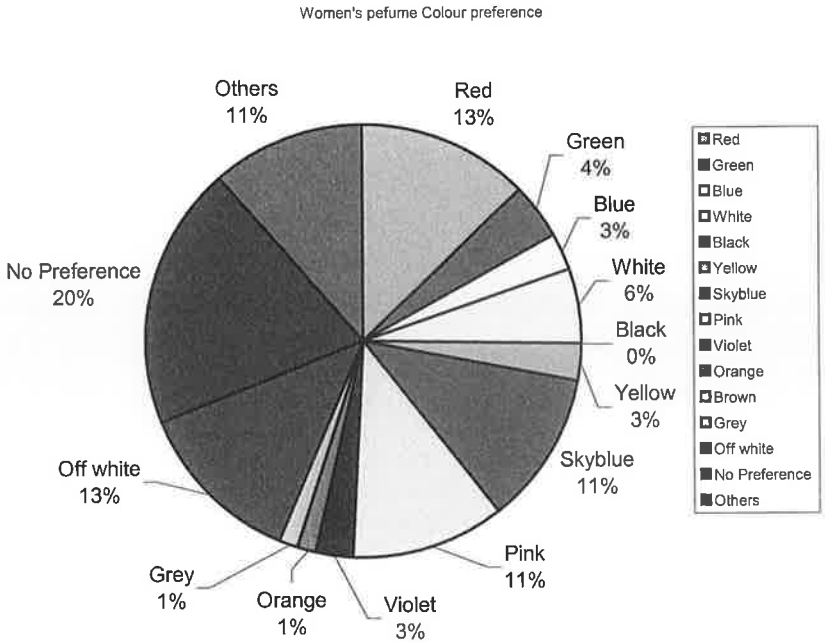

Figure 5.15: Colour preference in women's perfume bottles

The popular choice of colour for women's perfume was jointly red (13%) and offwhite(13%), followed by jointly pink(11%) and skyblue (11%)as shown in Figure 5.15. A substantial percentage of people(20%), said they had no preference on colour of women's perfume while 11% opted for others.

5.14.4 Transparency Preference

The majority of the respondents preferred for transparent bottles as shown in Figure 5.16. The percentage of choice for this option was 46%. The second choice was translucent bottles(19%) and third choice was opaque(17%). A substantial percentage of people(17%)opted for no preference about the transparency of the women's perfume bottles.

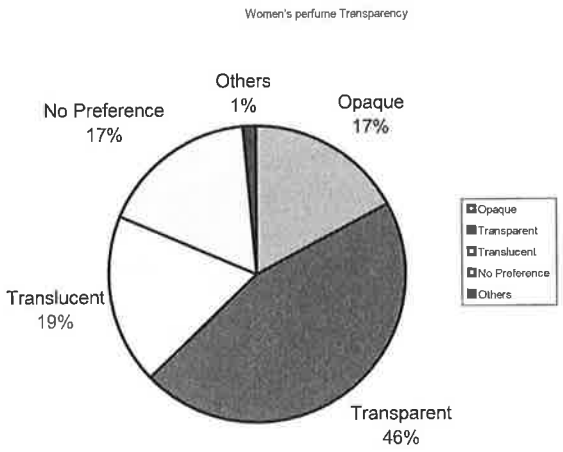

Figure 5.16 : Transparency preference in women's perfume bottles

5.14.5 Curvature Preference

The analysis shown in Table 5.30 points that 55.8% people opted for curvy section in women's perfume bottles. 20.8% people did not like the curvy section and 19.5% had no preference.

Table 5.30 : Curvature preference in women's perfume bottles

CURV_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	15	15.6	17.4	17.4
	yes	34	35.4	39.5	57.0
	no	12	12.5	14.0	70.9
	no pref	23	24.0	26.7	97.7
	others	2	2.1	2.3	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.14.6 Combination of Colour Preference

The majority (61%) of the respondent did not like combination of colour as shown in Table 5.31. Only 18.2% preferred two colour combination, 1.3% liked three-colour and 18.2% opted for any combination.

Table 5.31 : Combination of colour preference in women's perfume bottles

COMCOL_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	3	3.1	3.5	3.5
	no ans	15	15.6	17.4	20.9
	any combi	12	12.5	14.0	34.9
	no	40	41.7	46.5	81.4
	two colour	13	13.5	15.1	96.5
	three colour	3	3.1	3.5	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.14.7 Size Preference

The majority (47.7%) did not answer this question as shown in Table 5.32. There were substantial preference for 31 to 50ml (18.6%) and 30 ml or smaller (11.6%).bottles.

Table 5.32 : Size preference in women's perfume bottles

SIZE_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	41	42.7	47.7	47.7
	30ml or smaller	10	10.4	11.6	59.3
	31ml to 50ml	16	16.7	18.6	77.9
	51 to 75ml	9	9.4	10.5	88.4
	76 to 100ml	4	4.2	4.7	93.0
	126 to 200ml	3	3.1	3.5	96.5
	others	3	3.1	3.5	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.14.8 Material Preference

The analysis as shown in Table 5.33 reveals that the majority (42.9%) had no preference in material for women's perfume bottles. Those who had preference on material, glass (34.9%) was their top choice.

Table 5.33 : Material preference in women's perfume bottles

MAT_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	19	19.8	22.1	22.1
	yes	8	8.3	9.3	31.4
	no	27	28.1	31.4	62.8
	glass	30	31.3	34.9	97.7
	Plastics	2	2.1	2.3	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.14.9 Environment Friendly Bottle Preference

The majority (75.3%) expressed their willingness to pay a bit more for the environment friendly bottles as shown in Table 5.34. 18.7 % respondents did not want to pay for this cause.

Table 5.34 : Environment friendly bottle preference in women's perfume

ENVPAY_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	17	17.7	19.8	19.8
	yes	47	49.0	54.7	74.4
	no	22	22.9	25.6	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.14.10 Cap Preference

The majority (41.9%) did not put emphasis on cap though nearly similar percentage of people (39.5%) said they did put preference on cap (Table 5.35).

Table 5.35 : Cap preference in women's perfume bottles

CAPEMP_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	2	2.1	2.3	2.3
	no ans	14	14.6	16.3	18.6
	yes	34	35.4	39.5	58.1
	no	36	37.5	41.9	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.14.11 Impression Preference

Table 5.36 shows that most of the respondents (38.4%) had no preference for impression in women's perfume bottles. A large number of the respondents (27.9%) did not like it.

Table 5.36 : Impression preference in women's perfume bottles

IMP_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	1	1.0	1.2	1.2
	no ans	18	18.8	20.9	22.1
	yes	10	10.4	11.6	33.7
	no	24	25.0	27.9	61.6
	no preference	33	34.4	38.4	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.14.12 Colour Scheme Preference

According to the analysis result presented in Table 5.37, the majority (46.5%)

Table 5.37 : Colour scheme preference in women's perfume bottles

COLSCM_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	16	16.7	18.6	18.6
	yes	6	6.3	7.0	25.6
	no	24	25.0	27.9	53.5
	no preference	40	41.7	46.5	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

had no preference regarding colour scheme. A considerable number of people (27.9%) said they did not like colour scheme.

5.14.13 Trigger Preference

The majority (43%) had no preference on trigger in women's perfume bottles as shown in Table 5.38. A substantial no of people (32.6%) liked trigger. Nearly one in seven (7%) opted for orifice.

Table 5.38 : Trigger preference in women's perfume bottles

TRIGR_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	15	15.6	17.4	17.4
	pump or trigger	28	29.2	32.6	50.0
	opening or orifice	6	6.3	7.0	57.0
	no preference	37	38.5	43.0	100.0
	Total	86	89.6	100.0	
Missing	System	10	10.4		
Total		96	100.0		

5.15 Soft Drink Bottles- Descriptive Analysis

The descriptive analysis of soft drink bottles is presented in this section

5.15.1 Geometric Shape Preference

From the analysis result represented in Figure 5.17, it was found that the most popular shape for soft drink was round (47%). The other preference of shape in the descending order was: ellipse (20%), square(10%) and rectangle (8%). No preference option was selected by 10% of the respondents.

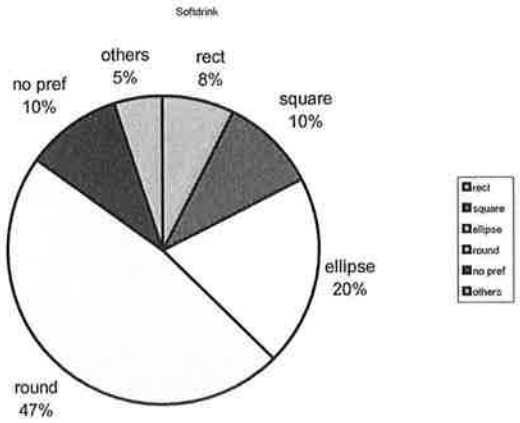

Figure 5.17 : Geometric shape preference in soft drink bottles

5.15.2 Shape Preference

Frequency distribution shown in Figure5.18 points out that the most popular shape was Shape B (29%) . The other popular choice in descending order was Shape A,E, C. Some shape images did not get response as first choice at all and so those were not included in this analysis.

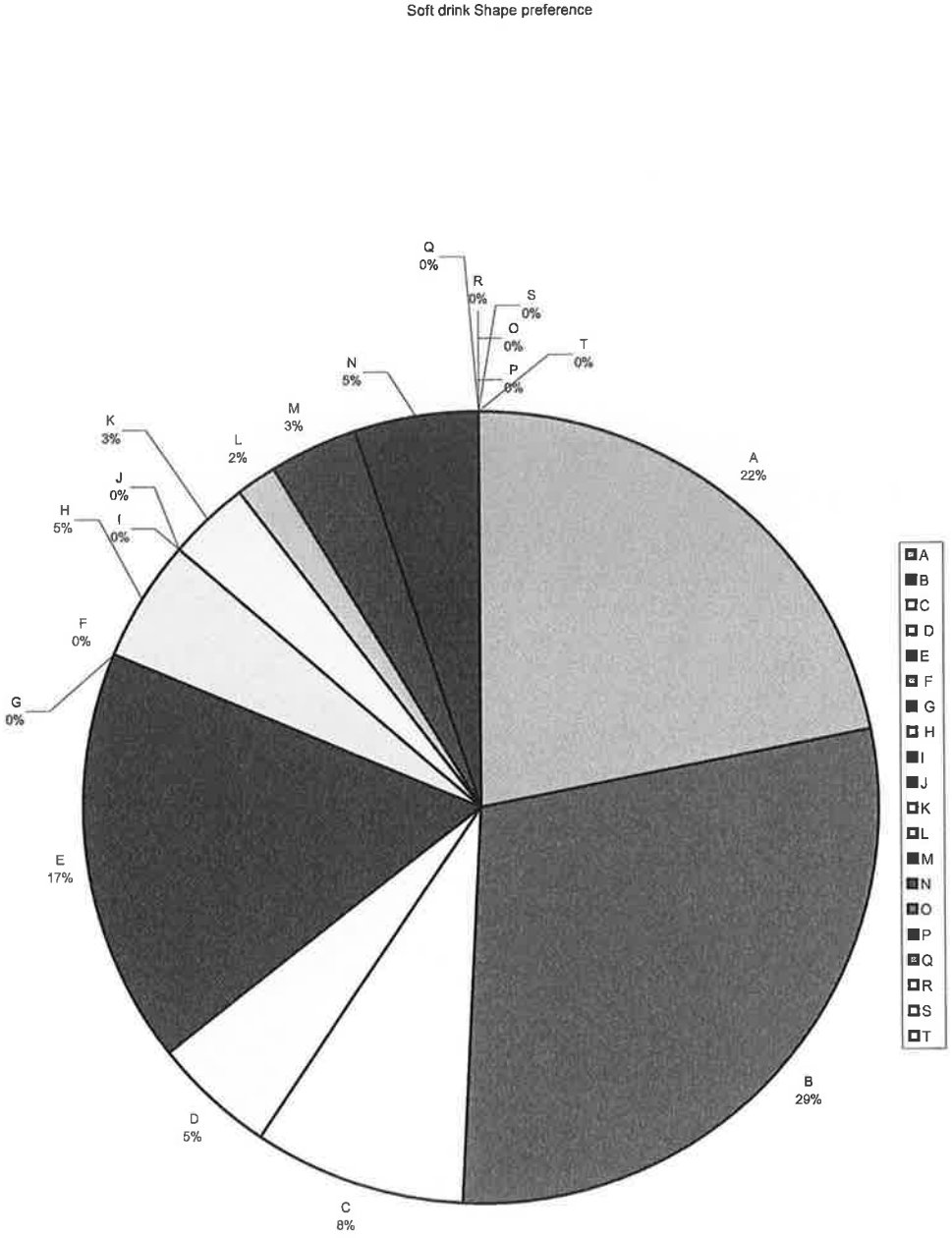

Figure 5.18 : Shape preference in soft drink bottles

5.15.3 Colour Preference

The analysis as presented in Figure 5.19 shows that the favourite colour for soft drink 500ml was white(14%). The majority of the respondents expressed no preference in this matter. The other popular colours in descending order were orange, blue/ green/sky blue/yellow.

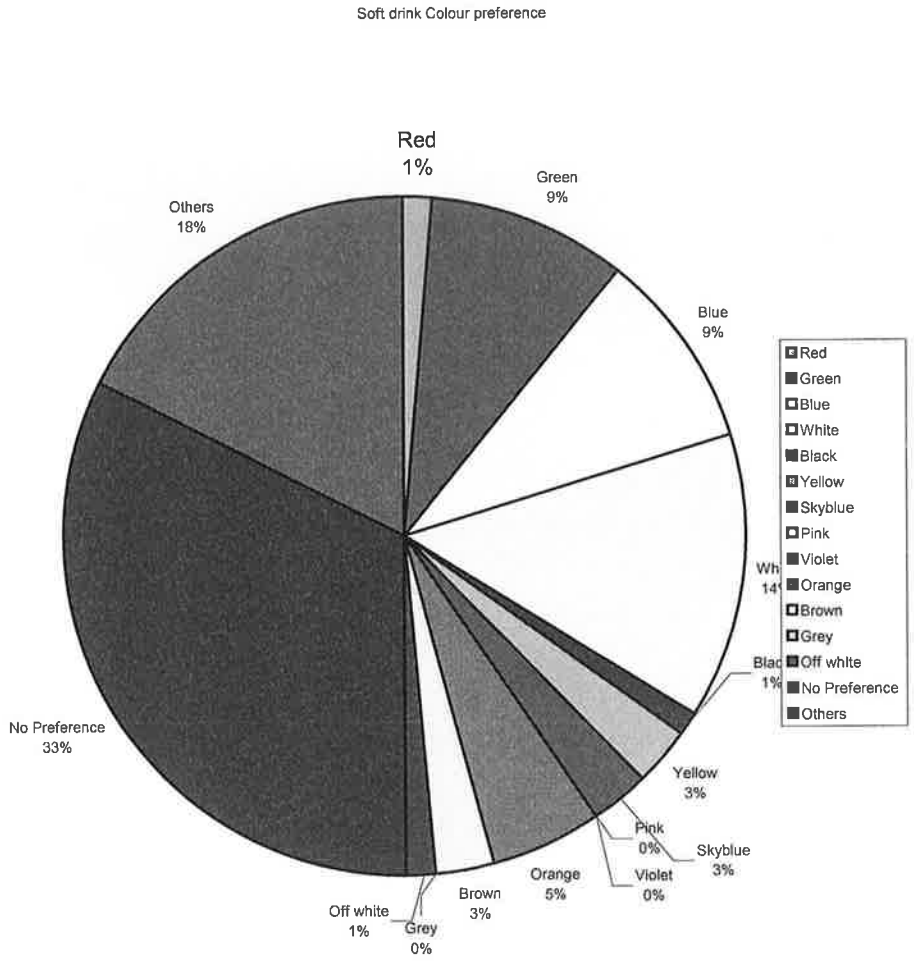

Figure 5.19 : Colour preference in soft drink bottles

5.15.4 Transparency Preference

The majority of the respondents preferred for transparent bottles as shown in Figure 5.20. The percentage of choice for this option was 73%. 4% of the respondents liked opaque and 9% liked translucent. 14% of the respondent opted for no preference about the transparency of the soft drink bottles.

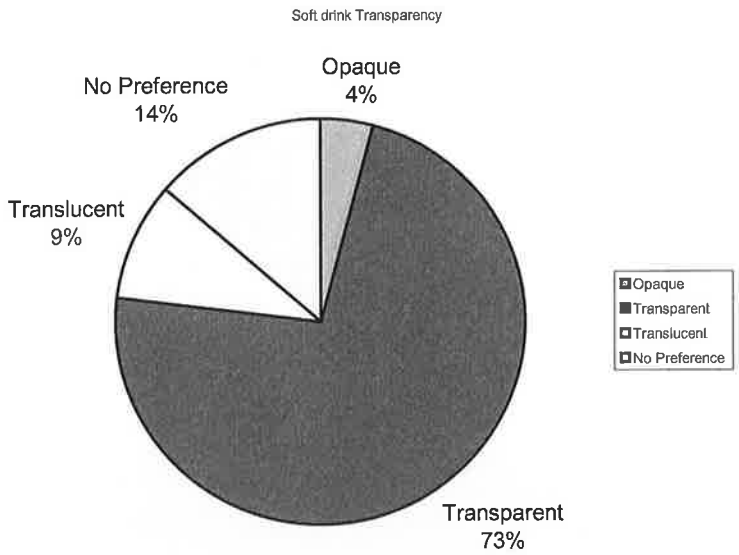

Figure 5.20 : Transparency preference in soft drink bottles

5.15.5 Curvature Preference

The analysis shown in Table 5.39 points that 55.8% people opted for curvy section in soft drink bottles. 20.8% people did not like the curvy section and 19.5% had no preference.

Table 5.39 : Curvature preference in soft drink bottles

CURV

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	3	3.3	3.9	3.9
	yes	43	47.3	55.8	59.7
	no	16	17.6	20.8	80.5
	no pref	15	16.5	19.5	100.0
	Total	77	84.6	100.0	
Missing	System	14	15.4		
Total		91	100.0		

5.15.6 Combination of Colour Preference

The majority (61%) of the respondent did not like combination of colour as shown in Table 5.40. Only 18.2% preferred two colour combination, 1.3% liked three-colour and 18.2% opted for any combination.

Table 5.40 : Combination of colour preference in soft drink bottles

COLCOMB

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	any combi	14	15.4	18.2	19.5
	no	47	51.6	61.0	80.5
	two colour	14	15.4	18.2	98.7
	three colour	1	1.1	1.3	100.0
	Total	77	84.6	100.0	
Missing	System	14	15.4		
Total		91	100.0		

5.15.7 Size Preference

The majority (49.4%) liked 500ml bottles as shown in Table 5.41. There was substantial preference for 2 litre (18.2%) and 1 litre (15.6%) bottles too.

Table 5.41 : Size preference in soft drink bottles

SIZE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	1	1.1	1.3	1.3
	no ans	2	2.2	2.6	3.9
	500ml	38	41.8	49.4	53.2
	1litre	12	13.2	15.6	68.8
	1.5litre	4	4.4	5.2	74.0
	2 itre	14	15.4	18.2	92.2
	no preference	4	4.4	5.2	97.4
	others	2	2.2	2.6	100.0
	Total	77	84.6	100.0	
Missing	System	14	15.4		
Total		91	100.0		

5.15.8 Material Preference

The analysis as shown in Table 5.42 reveals that the majority (42.9%) had no preference in material for soft drink bottles. Those who had preference on material, plastic (26%) was the top choice followed by glass (19.5%).

Table 5.42: Material preference in soft drink bottles

SPMAT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	3	3.3	3.9	3.9
	yes	5	5.5	6.5	10.4
	no	33	36.3	42.9	53.2
	glass	15	16.5	19.5	72.7
	Plastics	20	22.0	26.0	98.7
	Al	1	1.1	1.3	100.0
	Total	77	84.6	100.0	
Missing	System	14	15.4		
Total		91	100.0		

5.15.9 Environment Friendly Bottle Preference

The majority (75.3%) expressed their willingness to pay a bit more for the environmental friendly bottles as shown in Table 5.43. 18.7 % respondents did not want to pay for this cause.

Table 5.43 : Environment friendly bottle preference in soft drink

ENVIRON

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	2	2.2	2.6	2.6
	yes	58	63.7	75.3	77.9
	no	17	18.7	22.1	100.0
	Total	77	84.6	100.0	
Missing	System	14	15.4		
Total		91	100.0		

5.15.10 Cap Preference

The majority (59.7%) liked conventional cap whereas 23.4% preferred sports cap as shown in Table 5.44. A substantial number of people (16.9%) did not have any preference on it.

Table 5.44: Cap preference in soft drink bottles

CAP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	conventional	46	50.5	59.7	59.7
	sports cap	18	19.8	23.4	83.1
	no preference	13	14.3	16.9	100.0
	Total	77	84.6	100.0	
Missing	System	14	15.4		
Total		91	100.0		

5.15.11 Impression Preference

Table 5.45 shows that most of the respondents (44.2%) did not like impression in soft drink bottles. A large number of the respondents (40.3%) had no preference in this matter.

Table 5.45 : Impression preference in soft drink bottles

IMPRE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	3	3.3	3.9	3.9
	yes	9	9.9	11.7	15.6
	no	34	37.4	44.2	59.7
	no preference	31	34.1	40.3	100.0
	Total	77	84.6	100.0	
Missing	System	14	15.4		
Total		91	100.0		

5.15.12 Colour Scheme Preference

According to the analysis result presented in Table 5.46, the majority (48.1%)

Table 5.46 : Colour scheme preference in soft drink bottles

COLSCM

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	4	4.4	5.2	5.2
	Not liked	34	37.4	44.2	49.4
	Others	2	2.2	2.6	51.9
	No Preference	37	40.7	48.1	100.0
	Total	77	84.6	100.0	
Missing	System	14	15.4		
Total		91	100.0		

had no preference regarding colour scheme. Nearly same proportion of people(44.2%) said they did not like impression.

5.16 Shampoo/Conditioner Bottles - Descriptive Analysis

The descriptive analysis of shampoo/conditioner bottles is presented in this section

5.16.1 Geometric Shape Preference

From the analysis result represented in Figure 5.21, it was found that the most popular shape for shampoo was rectangle (33%). The other preference of shape in the descending order was: ellipse (24%), round(15%) and square (2%). No preference option was selected by 20% of the respondents.

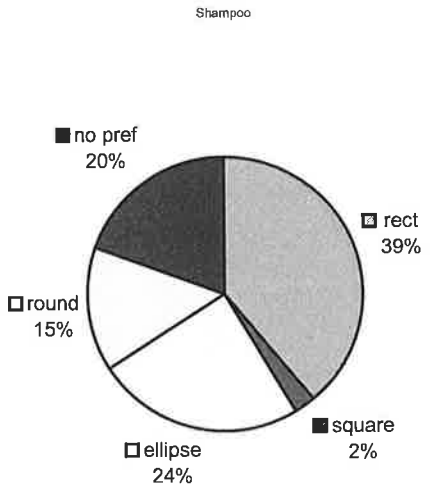

Figure 5.21 : Geometric shape preference in shampoo bottles

5.16.2 Shape Preference

Frequency distribution shown in figure5.22 points out that the most popular shape was Shape C (36%). The other popular choices in descending order were Shape D,A,E, P,S,B,F,G,L. Some shape images did not get response as first choice at all and so those were not included in this analysis.

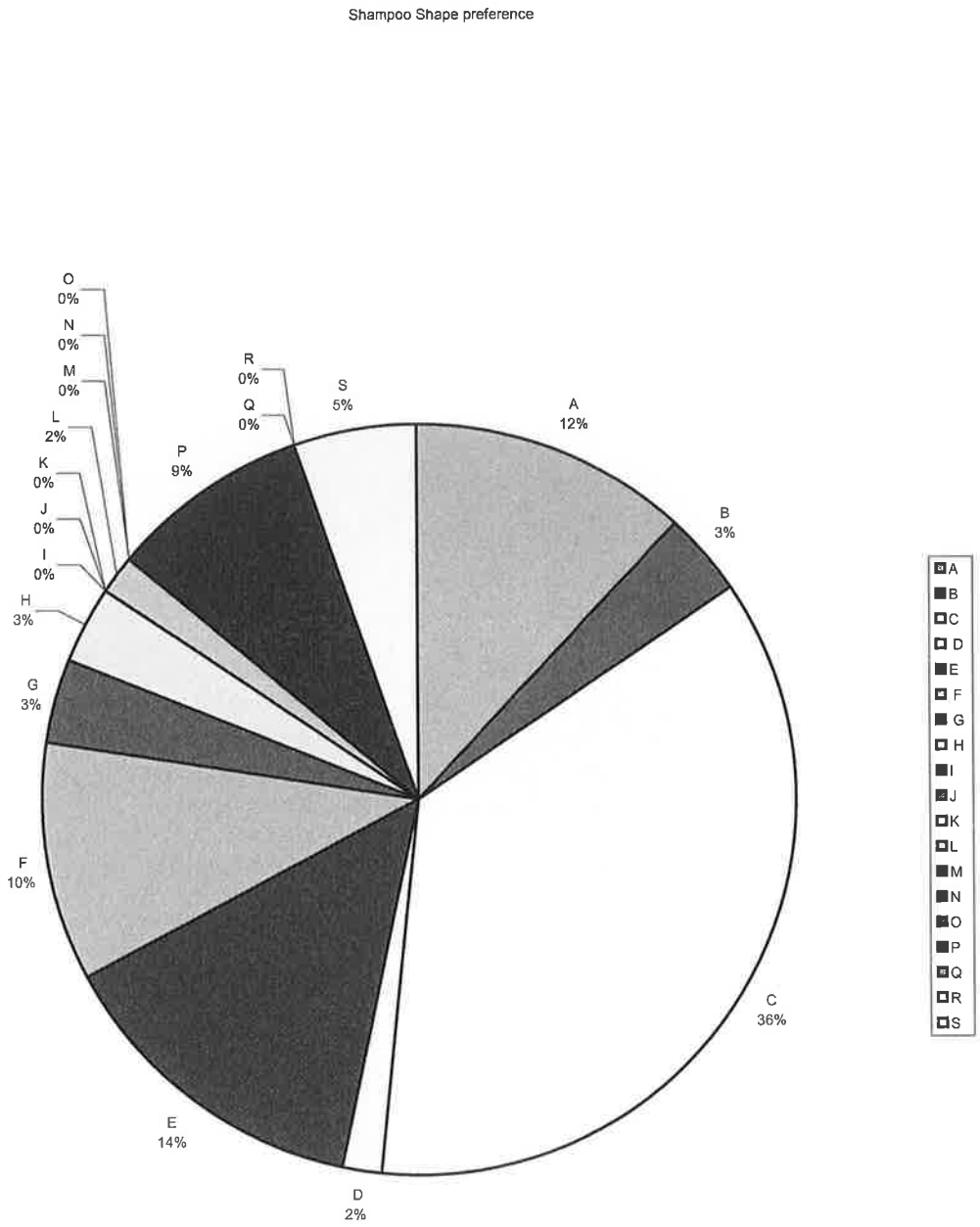

Figure 5.22 : Shape preference in shampoo bottles

5.16.3 Colour Preference

The analysis as presented in Figure 5.23 shows that the favourite colour for shampoo was offwhite(32%). The same percentage of people had no preference. The other popular colours in descending order were white, blue, green,sky blue, yellow, red, orange, black.

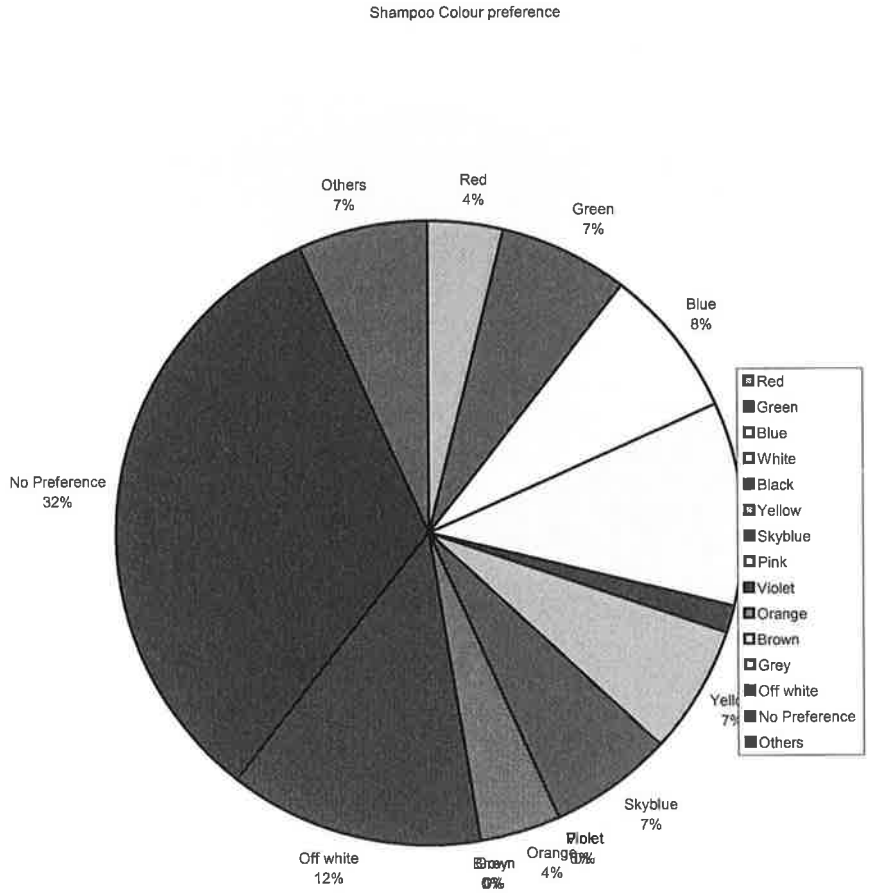

Figure 5.23 : Colour preference in shampoo bottles

5.16.4 Transparency Preference

The majority of the respondents preferred for transparent bottles as shown in Figure 5.24. The percentage of choice for this option was 33%. 23% of the respondents liked opaque and 15% liked translucent. 23% of the respondent opted for no preference about the transparency of the shampoo bottles.

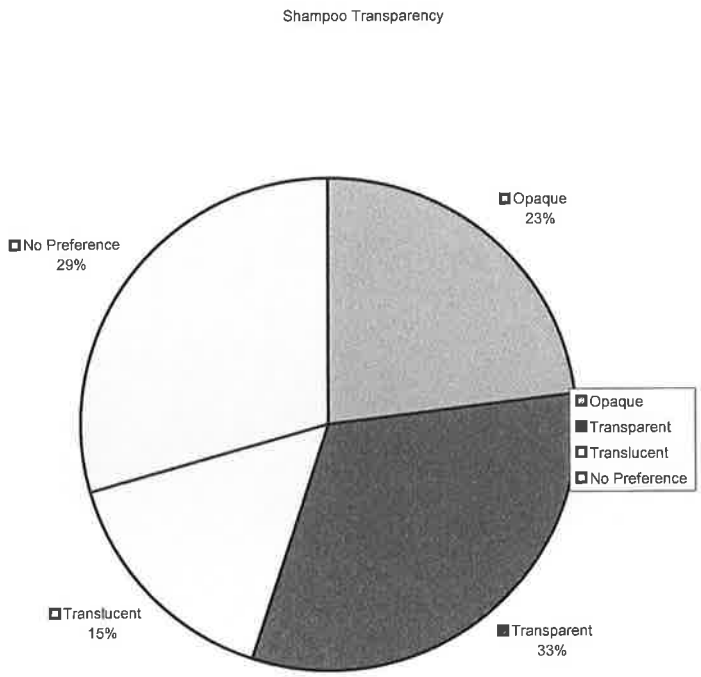

Figure 5.24 : Transparency preference in shampoo bottles

5.16.5 Curvature Preference

The analysis shown in Table 5.47 points that 37% people opted for curvy section in shampoo bottles. 15.2% people did not like the curvy section and 25% had no preference.

Table 5.47 : Curvature preference in shampoo bottles

CURV

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	2	2.2	2.6	2.6
	no ans	3	3.3	3.9	6.5
	yes	34	37.0	44.2	50.6
	no	14	15.2	18.2	68.8
	no pref	23	25.0	29.9	98.7
	others	1	1.1	1.3	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.16.6 Combination of Colour Preference

The majority (63.6%) of the respondent did not like combination of colour as shown in Table 5.48. Only 14.3% preferred two colour combination and 22.1% opted for any combination.

Table 5.48 : Combination of colour preference in shampoo bottles

COMBCOL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	any combi	17	18.5	22.1	22.1
	no	49	53.3	63.6	85.7
	two colour	11	12.0	14.3	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.16.7 Size Preference

Any significant insight was not found from the analysis regarding size as shown in Figure 5.49. The majority (72.7%) opted for others.

Table 5.49 : Size preference in shampoo bottles

SIZE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	8	8.7	10.4	10.4
	30ml or smaller	1	1.1	1.3	11.7
	31ml to 50ml	1	1.1	1.3	13.0
	76 to 100ml	2	2.2	2.6	15.6
	126 to 200ml	5	5.4	6.5	22.1
	others	56	60.9	72.7	94.8
	usual smaller larger	4	4.3	5.2	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.16.8 Material Preference

The analysis as shown in Figure 5.50 reveals that the majority (43.5%) had no preference in material for shampoo bottles. Those who had preference on material, plastic (31.5%) was the top choice.

Table 5.50 : Material preference in shampoo bottles

MAT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	6	6.5	7.8	9.1
	no	40	43.5	51.9	61.0
	glass	1	1.1	1.3	62.3
	Plastics	29	31.5	37.7	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.16.9 Environment Friendly Bottle Preference

The majority (75%) liked to pay extra for environment friendly bottles as shown in Table 5.51.

Table 5.51 : Environment friendly bottle preference in shampoo

ENVPAY

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	57	62.0	75.0	76.3
	no	18	19.6	23.7	100.0
	Total	76	82.6	100.0	
Missing	System	16	17.4		
Total		92	100.0		

5.16.10 Hand-position Preference

The majority liked indented side as shown in Table 5.52. Substantial number of people did not like any hand position. 13% liked general handle. One in ten liked hook in shampoo bottles.

Table 5.52 : Hand position preference in shampoo

HNDPOS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	general	10	10.9	13.0	13.0
	no	14	15.2	18.2	31.2
	hook	8	8.7	10.4	41.6
	indented side	26	28.3	33.8	75.3
	no pref	17	18.5	22.1	97.4
	others	2	2.2	2.6	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.16.11 Impression preference in Shampoo bottles

The majority did not like impression and nearly similar proportion of people had no preference as shown in Table 5.53.

Table 5.53 : Impression preference in shampoo bottles

IMP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	6	6.5	7.8	7.8
	no	38	41.3	49.4	57.1
	no preference	33	35.9	42.9	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.16.12 Colour Scheme Preference

The majority(50.6%) had no preference while similar percentage of people (46.8%) did not like colour scheme as shown in Table 5.54.

Table 5.54 : Colour scheme preference in shampoo bottles

COLSCHM

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	1	1.1	1.3	2.6
	no	36	39.1	46.8	49.4
	no preference	39	42.4	50.6	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.17 Shower Gel Bottles - Descriptive Analysis

The descriptive analysis of shower gel bottles is presented in this section

5.17.1 Geometric Shape Preference

From the analysis result represented in Figure 5.25, it was found that the most popular shape for shower gel was rectangle (33%). The other preference of shape in the descending order was: ellipse (22%), round(14%) and square (6%). No preference option was selected by 22% of the respondents.

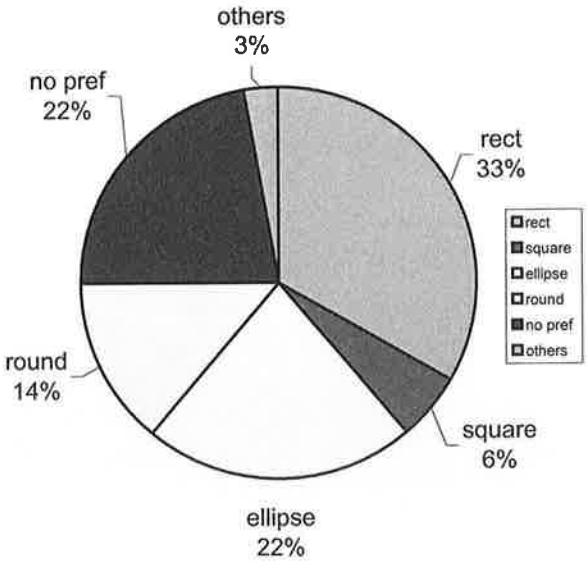

Figure 5.25: Geometric shape preference in shower gel bottles

5.17.2 Shape Preference

Frequency distribution shown in Figure 5.26 points that the most popular shape was Shape A (42%) . The other popular choice in descending order was Shape B(16%), C(10%), D (8%), F (8%). Some shape images did not get response as first choice at all, and so those were not included in this analysis.

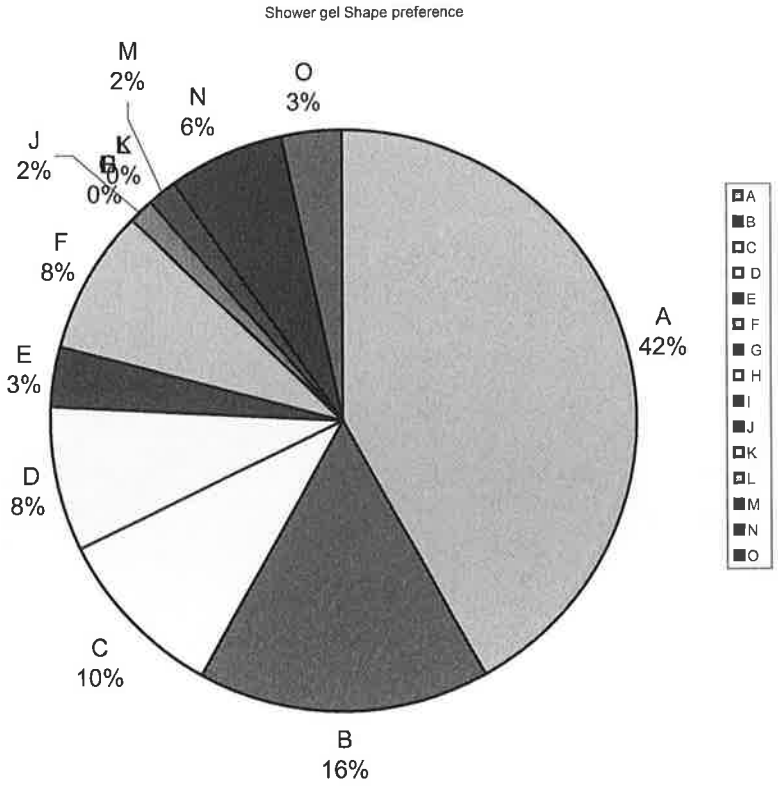

Figure 5.26 : Shape preference in shower gel bottles

5.17.3 Colour Preference

The analysis presented in Figure 5.27 shows that the favourite colour for shower gel was Blue(13%). The majority (36%) had no preference on colour of shower gel bottles. The other three popular colours in descending order were green (11%), black (11%)and white(9%).

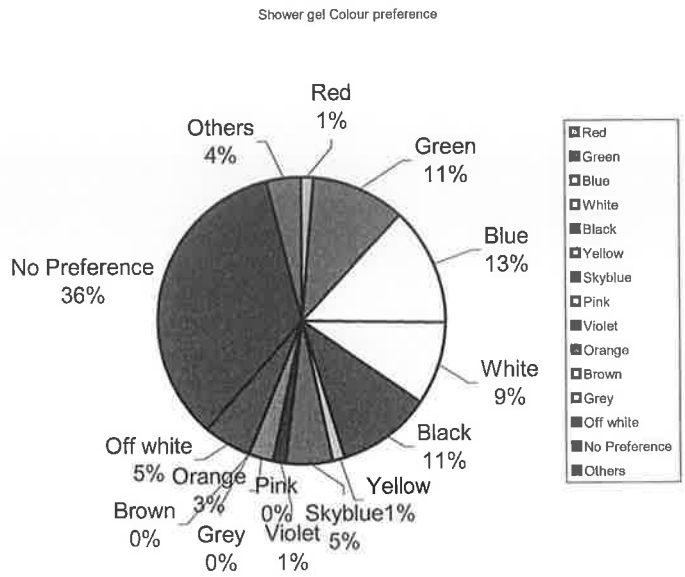

Figure 5.27 : Colour preference in shower gel bottles

5.17.4 Transparency Preference

The majority of the respondents preferred for transparent bottles as shown in Figure 5.28. The percentage of choice for this option was 42%. 20% of the respondents liked opaque and 12% liked translucent. 26% of the respondent opted for no preference about the transparency of the Shower gel bottles.

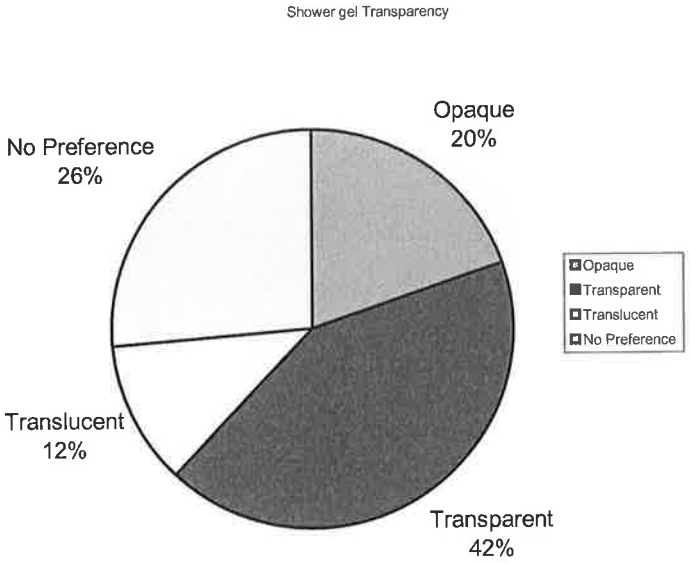

Figure 5.28 : Transparency preference in Shower gel bottles

5.17.5 Curvature Preference

The analysis shown in Table 5.55 points that the majority (39%) opted for curvy section in Shower gel bottles. 20.8% people did not like the curvy section and 32.5% had no preference.

Table 5.55 : Curvature preference in shower gel bottles

CURV_G

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	2	2.2	2.6	2.6
	no ans	3	3.3	3.9	6.5
	yes	30	32.6	39.0	45.5
	no	16	17.4	20.8	66.2
	no pref	25	27.2	32.5	98.7
	others	1	1.1	1.3	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.17.6 Combination of Colour Preference

The majority (58.4%) of the respondent did not like combination of colour as shown in Table 5.56. Only 9.1% preferred two colour combination and 26% opted for any combination. The preference for three colour combination was 9.1%.

Table 5.56 : Combination of colour preference in shower gel bottles

COMCOL_G

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	2	2.2	2.6	2.6
	any combi	20	21.7	26.0	28.6
	no	45	48.9	58.4	87.0
	two colour	7	7.6	9.1	96.1
	three colour	3	3.3	3.9	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.17.7 Size Preference

No significant insight was found from the analysis regarding size as shown in Table 5.57. The majority (67.5%) opted for others.

Table 5.57 : Size preference in shower gel bottles

SIZE_G

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	12	13.0	15.6	15.6
	30ml or smaller	1	1.1	1.3	16.9
	31ml to 50ml	1	1.1	1.3	18.2
	76 to 100ml	1	1.1	1.3	19.5
	101 to 125ml	2	2.2	2.6	22.1
	126 to 200ml	6	6.5	7.8	29.9
	others	52	56.5	67.5	97.4
	usual smaller larger	2	2.2	2.6	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.17.8 Material Preference

The analysis as shown in Table 5.58 reveals that the majority (51.9%) had no preference in material for Shower gel bottles. A small number of people mentioned that they had preference for a specific material. Plastic (31.5%) was the top choice among different materials.

Table 5.58 : Material preference in shower gel bottles

MAT_G

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	6	6.5	7.8	9.1
	no	40	43.5	51.9	61.0
	glass	1	1.1	1.3	62.3
	Plastics	28	30.4	36.4	98.7
	Al	1	1.1	1.3	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.17.9 Environment Friendly Bottle Preference

The majority (76.3%) said they would pay extra for environmental friendly bottles as shown in Table 5.59. 23.7%of the respondents did not like to pay for this cause.

Table 5.59 : Environment friendly bottle preference in shower gel

ENVPAY_G

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	58	63.0	76.3	76.3
	no	18	19.6	23.7	100.0
	Total	76	82.6	100.0	
Missing	System	16	17.4		
Total		92	100.0		

5.17.10 Hand-position Preference

The majority (36.4%) liked hook in shower gel bottles as shown in Table 5.60. Indented side (18.2%) got substantial preference. 24.7% people said they had no preference in this matter.

Table 5.60 : Hand position preference in shower gel bottles

HNDPOS_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	general	9	9.8	11.7	11.7
	no	7	7.6	9.1	20.8
	hook	28	30.4	36.4	57.1
	indented side	14	15.2	18.2	75.3
	no pref	19	20.7	24.7	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.17.11 Impression Preference

The majority(46.8%)did not like impression as shown in Table 5.61. 45.5% had no preference in this matter. Therefore it is evident the large majority either did not like or had no preference. There was small difference between the percentage of these two. Only 7.8 % said they liked impression. So only a tiny minority opted for impression.

Table 5.61 : Impression preference in shower gel bottles

IMP_G

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	6	6.5	7.8	7.8
	no	36	39.1	46.8	54.5
	no preference	35	38.0	45.5	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.17.12 Colour Scheme Preference

The analysis presented in Table 5.62 shows that the majority (51.9%) had no preference on colour scheme. 45.5% said they did not like colour scheme. So nearly the same number of people said they did not like colour scheme. Therefore it is evident that colour scheme was not popular to the people.

Table 5.62 : Colour scheme preference in shower gel bottles

COLSCM_G

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	1	1.1	1.3	2.6
	no	35	38.0	45.5	48.1
	no preference	40	43.5	51.9	100.0
	Total	77	83.7	100.0	
Missing	System	15	16.3		
Total		92	100.0		

5.18 Cooking Oil 1L Bottles - Descriptive Analysis

The descriptive analysis of cooking oil 1L bottles is presented in this section

5.18.1 Geometric Shape Preference

From the analysis result represented in Figure 5.29, it was found that the most popular shape for cooking oil 1l was rectangle (29%). The other preferences of shape in the descending order were: round (28%), ellipse(15%) and square (13%). Here the percentage of preferences on different option did not have large difference. No preference option was selected by 15% of the respondents.

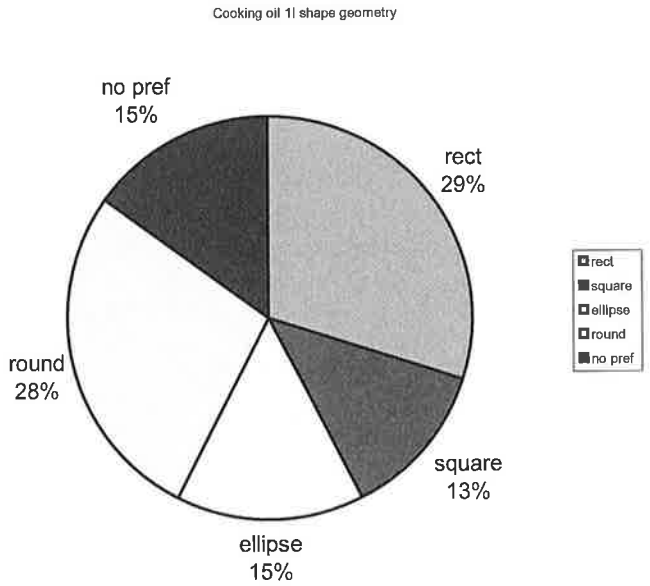

Figure 5.29 : Geometric shape preference in cooking oil 1L bottles

5.18.2 Shape Preference

Frequency distribution shown in Figureure5.30 points out that the most popular shape was Shape B (38%). The other three popular choices in descending order were Shape I, F, J ,A. Some shape images did not get any response as the first choice. Thus, those were not included in this analysis.

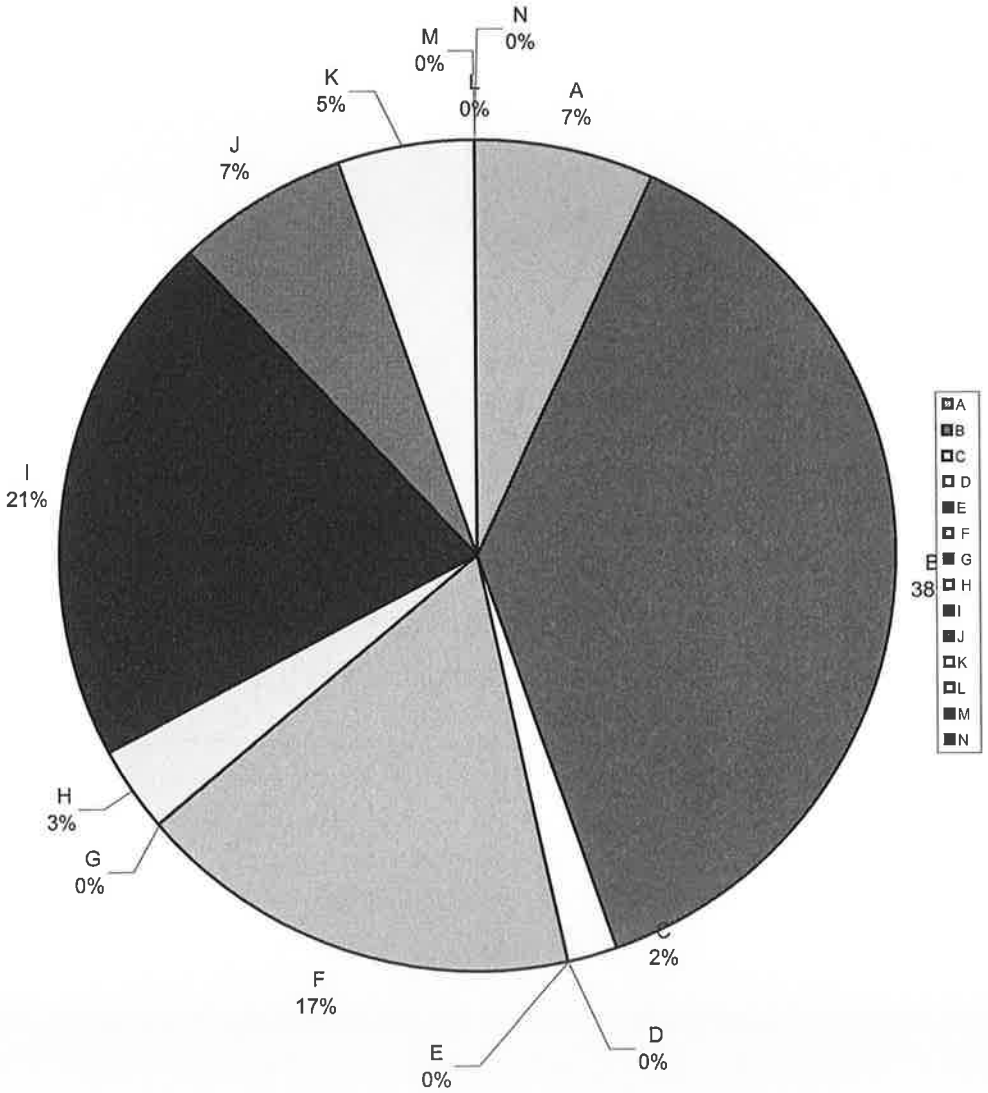

Figure 5.30 : Shape preference in cooking oil 1L bottles

5.18.3 Colour Preference

The analysis as presented in Figure 5.31 shows that the favourite colour for cooking oil 1l 500ml was yellow(20%). The majority of the respondents (31%) expressed no preference in this matter. A large number of people (18%) also voted others. The other popular colours in descending order were white, offwhite, green, blue.

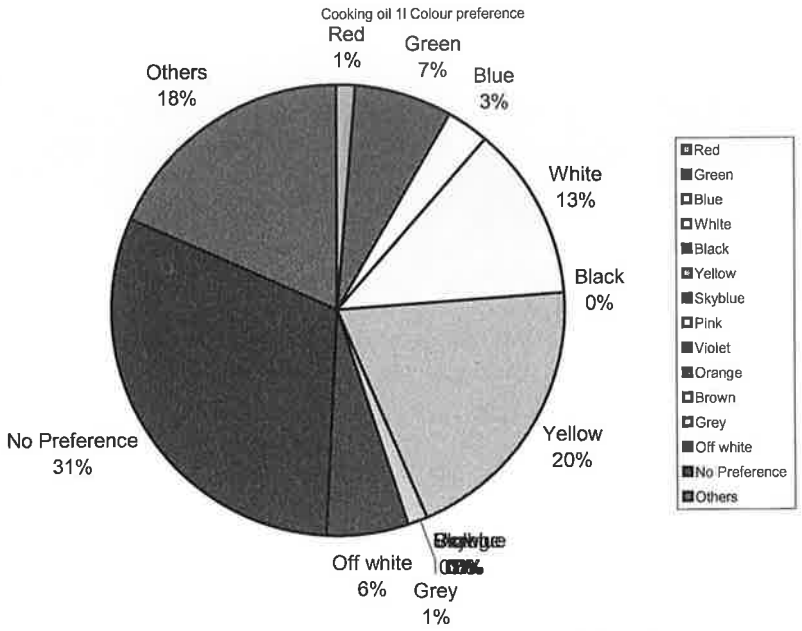

Figure 5.31 : Colour preference in cooking oil 1l bottles

5.18.4 Transparency Preference

The majority of the respondents (75%) preferred for transparent bottles as shown in Figure 5.32. 8% of the respondents liked opaque and 4% liked translucent. 13% of the respondent opted for no preference about the transparency of the cooking oil 1l bottles.

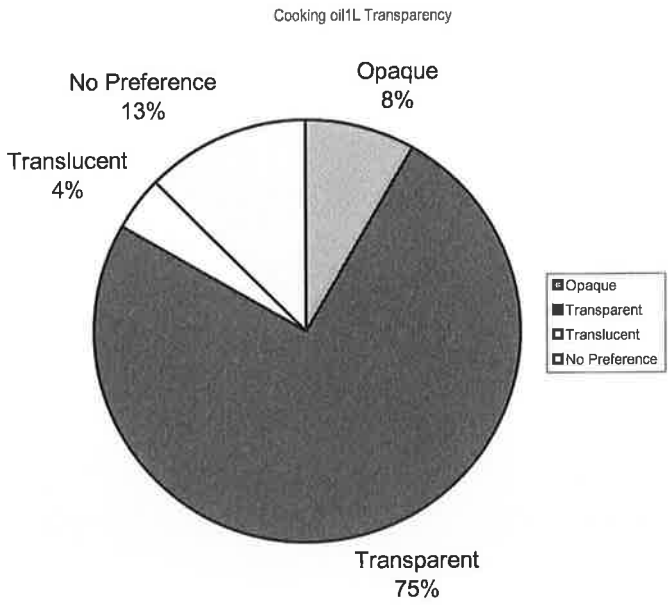

Figure 5.32 : Transparency preference in cooking oil 1l bottles

5.18.5 Curvature Preference

The analysis shown in Table 5.63 points that the majority (39.2%) people opted for curvy section in cooking oil 1l bottles. 20.3% people did not like the curvy section and 35.1% had no preference.

Table 5.63 : Curvature preference in cooking oil 1L bottles

CURV

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	4	4.3	5.4	5.4
	yes	29	31.2	39.2	44.6
	no	15	16.1	20.3	64.9
	no pref	26	28.0	35.1	100.0
	Total	74	79.6	100.0	
Missing	System	19	20.4		
Total		93	100.0		

5.18.6 Combination of Colour Preference

The majority (65.3%) of the respondent did not like combination of colour as shown in Table 5.64. Only 10.7% preferred two colour combination, none opted for three-colour and 22.7% voted any combination option.

Table 5.64 : Combination of colour preference in cooking oil 1L bottles

COMBCOL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	1	1.1	1.3	1.3
	any combi	17	18.3	22.7	24.0
	no	49	52.7	65.3	89.3
	two colour	8	8.6	10.7	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.18.7 Size Preference

The majority (42.7%) liked 1 litre bottles as shown in Table 5.65. There was small preference for 2 litre (13.3%) bottles followed by others viewpoint(9.3%).

Table 5.65 : Size preference in cooking oil 1L bottles

SIZE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	3	3.2	4.0	4.0
	no ans	11	11.8	14.7	18.7
	1 litre	32	34.4	42.7	61.3
	2 ltr	10	10.8	13.3	74.7
	smaller than 1 ltr	8	8.6	10.7	85.3
	bigger than 1 ltr	3	3.2	4.0	89.3
	no Pref	1	1.1	1.3	90.7
	others	7	7.5	9.3	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.18.8 Material Preference

The analysis as shown in Table 5.66 reveals that the majority (52%) had no preference in material for cooking oil 1l bottles. Those who had preference on material, plastic (26.7%) was the top choice followed by glass (14.7%).

Table 5.66 : Material preference in cooking oil 1L bottles

MAT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	4	4.3	5.3	6.7
	no	39	41.9	52.0	58.7
	Glass	11	11.8	14.7	73.3
	Plastics	20	21.5	26.7	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.18.9 Environment Friendly Bottle Preference

The large majority (73.3%) expressed their willingness to pay a bit more for the environmental friendly bottles as shown in Table 5.67. 25.3 % respondents did not want to pay for this cause.

Table 5.67 : Environment friendly bottle preference in cooking oil 1L

ENVPAY

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	55	59.1	73.3	74.7
	no	19	20.4	25.3	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.18.10 Handle and Indentation Preference

The majority (37.8%) liked indented side whereas 27% preferred general handle as

Table 5.68 : Handle & indentation preference in cooking oil 1L bottles

HANDLIN

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.4	1.4
	general	20	21.5	27.0	28.4
	no	11	11.8	14.9	43.2
	indented side	28	30.1	37.8	81.1
	no pref	14	15.1	18.9	100.0
	Total	74	79.6	100.0	
Missing	System	19	20.4		
Total		93	100.0		

shown in Table 5.68. A substantial number of people (18.9%) did not have any preference on it while 14.9% people did not like any handle.

5.18.11 Impression Preference

Table 5.69 shows that most of the respondents (53.3%) did not like impression in cooking oil 1l bottles. A large number of the respondents (36%) had no preference in this matter. A small minority (9.3%) liked impression.

Table 5.69 : Impression preference in cooking oil 1L bottles

IMP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	7	7.5	9.3	10.7
	no	40	43.0	53.3	64.0
	no preference	27	29.0	36.0	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.18.12 Colour Scheme Preference

According to the anlaysis result presented in Table 5.70, the majority (52%) did not like colour scheme. Nearly the same number of people(44.2%) said they had no preference regarding colour scheme.

Table 5.70 : Colour scheme preference in cooking oil 1L bottles

COLSCHM

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	3	3.2	4.0	4.0
	yes	1	1.1	1.3	5.3
	no	39	41.9	52.0	57.3
	no preference	32	34.4	42.7	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.18.13 Longer Neck Preference

The majority (52%) did not like longer neck in cooking oil 1l bottles as shown in Table 5.71. One third of the people (29.3%) voted for no preference. Only a small minority (16%) liked longer neck.

Table 5.71 : Longer neck preference in cooking oil 1L bottles

LNECK

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	2	2.2	2.7	2.7
	yes	12	12.9	16.0	18.7
	no	39	41.9	52.0	70.7
	no preference	22	23.7	29.3	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.18.14 Trigger Preference

From the analysis presented in Table 5.72, it is evident that trigger was not popular for cooking oil 1 l bottle. 65.3% people did not like it while only 12% were positive about it.

Table 5.72 : Trigger Preference in cooking oil 1L bottles

TRIGR

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	9	9.7	12.0	13.3
	no	49	52.7	65.3	78.7
	no preference	16	17.2	21.3	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.19 Cooking Oil 2L Bottles - Descriptive Analysis

The descriptive analysis of cooking oil 2L bottles is presented in this section

5.19.1 Geometric Shape Preference

From the analysis result represented in Figure 5.33, it was found that the three shapes got almost same votes as the first choice as shape for cooking oil 2 l bottles. These three shapes were rectangle (27%), round (25% and square(20%). No preference option was selected by 15% of the respondents.

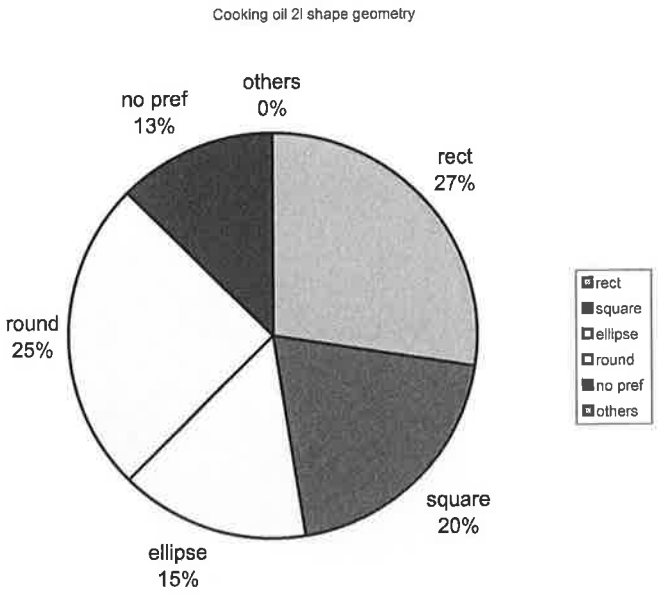

Figure 5.33 : Geometric shape preference in cooking oil 2L bottles

5.19.2 Shape Preference

Frequency distribution shown in Figure 5.34 points out that the most popular shape was Shape B (89%). The positions of the other two descending order were Shape I, F, J, A. Some shape images did not get any response as the first choice. Thus, those were not included in this analysis.

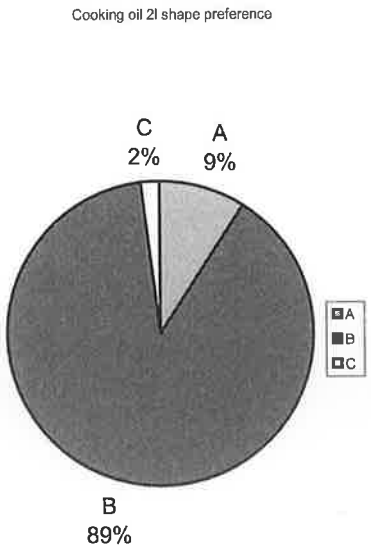

Figure 5.34 : Shape preference in cooking oil 2L bottles

5.19.3 Colour Preference

The analysis as presented in Figure 5.35 shows that the favourite colour for cooking oil 2l was yellow(17%) followed by white (11%). The majority of the respondents (32%) expressed no preference in this matter. A large number of people (20%) also voted others.

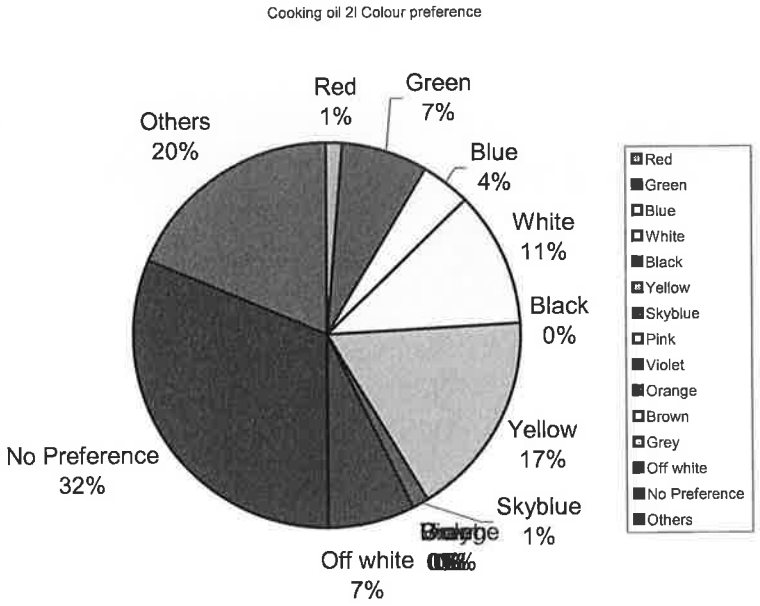

Figure 5.35 : Colour preference in cooking oil 2l bottles

5.19.4 Transparency Preference

The majority of the respondents (77%) preferred for transparent bottles as shown in Figure 5.36. 8% of the respondents liked opaque and 4% liked translucent. People's preference to opaque and translucent was little. 6% of the respondents liked opaque and 4% liked translucent 13% of the respondent opted for no preference about the transparency of the cooking oil 2l bottles.

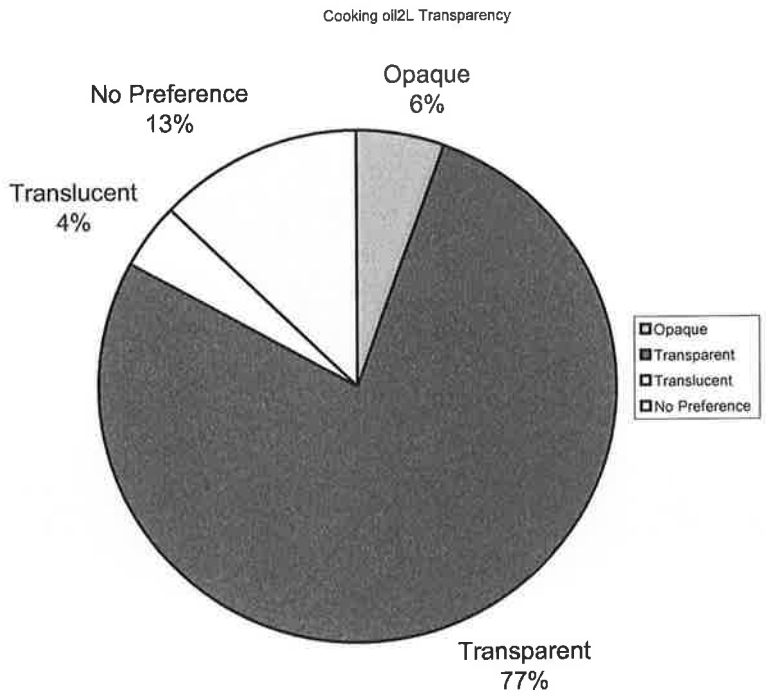

Figure 5.36 : Transparency preference in cooking oil 2l bottles

5.19.5 Curvature Preference

The analysis shown in Figure 5.73 points that the majority (36%) had no preference on curvature attribute. 30.7 % people liked the curvy section and 25.3% did not.

Table 5.73 : Curvature preference in cooking oil 2L bottles

CURV_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	5	5.4	6.7	6.7
	yes	23	24.7	30.7	37.3
	no	19	20.4	25.3	62.7
	no pref	27	29.0	36.0	98.7
	others	1	1.1	1.3	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.19.6 Combination of Colour Preference

The majority (65.3%) of the respondent did not like combination of colour as shown in Table 5.74. Only 10.7% preferred two colour combination, none opted for three-colour and 22.7% voted any combination option.

Table 5.74 : Combination of colour preference in cooking oil 2L bottles

COMCOL_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	1	1.1	1.3	1.3
	no ans	1	1.1	1.3	2.7
	any combi	17	18.3	22.7	25.3
	no	50	53.8	66.7	92.0
	two colour	4	4.3	5.3	97.3
	three colour	2	2.2	2.7	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.19.7 Size Preference

The majority (42.7%) liked 1 litre bottles as shown in Table 5.75. There was small preference for 2 litre (13.3%) bottles followed by others viewpoint(9.3%).

Table 5.75 : Size preference in cooking oil 2L bottles

SIZE_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	3	3.2	4.0	4.0
	no ans	11	11.8	14.7	18.7
	1 litre	32	34.4	42.7	61.3
	2 ltr	10	10.8	13.3	74.7
	smaller than 1 ltr	8	8.6	10.7	85.3
	bigger than 1 ltr	3	3.2	4.0	89.3
	no Pref	1	1.1	1.3	90.7
	others	7	7.5	9.3	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.19.8 Material Preference

The analysis as shown in Table 5.76 reveals that the majority (52%) had no preference in material for cooking oil 2l bottles. Those who had preference on material, plastic (26.7%) was the top choice followed by glass (14.7%).

Table 5.76 : Material preference in cooking oil 2L bottles

MAT_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	4	4.3	5.3	6.7
	no	40	43.0	53.3	60.0
	Glass	10	10.8	13.3	73.3
	Plastics	20	21.5	26.7	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.19.9 Environment Friendly Bottle Preference

The large majority (73.3%) expressed their willingness to pay a bit more for the environmental friendly bottles. 25.3 % respondents did not want to pay for this cause as shown in Table 5.77.

Table 5.77 : Environment friendly bottle preference in cooking oil 2L

ENVPAY_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	54	58.1	72.0	73.3
	no	20	21.5	26.7	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.19.10 Handle and Indentation Preference

The majority (37.8%) liked indented side cap whereas 27% preferred general handle as shown in Table 5.78. A substantial number of people (18.9%) did not have any preference on it while 14.9% people did not like any handle.

Table 5.78 : Handle & indentation preference in cooking oil 2L bottles

HANDLI_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	general	25	26.9	33.3	34.7
	no	8	8.6	10.7	45.3
	indented side	31	33.3	41.3	86.7
	no pref	10	10.8	13.3	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.19.11 Impression Preference

Table 5.79 shows that most of the respondents (53.3%) did not like impression in cooking oil 2l bottles. A large number of the respondents (36%) had no preference in this matter. A small minority (9.3%) liked impression.

Table 5.79 : Impression preference in cooking oil 2L bottles

IMP_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	7	7.5	9.3	10.7
	no	38	40.9	50.7	61.3
	no preference	29	31.2	38.7	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.19.12 Colour Scheme Preference

According to the analysis result presented in Table 5.80, the majority (52%) did not like colour scheme. Nearly the same number of people (44.2%) said they had no preference regarding colour scheme.

Table 5.80 : Colour scheme preference in cooking oil 2L bottles

COLSCM_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	3	3.2	4.0	4.0
	no	40	43.0	53.3	57.3
	no preference	32	34.4	42.7	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.19.13 Longer Neck Preference

The majority (52%) did not like longer neck in cooking oil 2l bottles as shown in Table 5.81. One third of the people (29.3%) voted for no preference. Only a small minority (16%) liked longer neck.

Table 5.81 : Longer neck preference in cooking oil 2L bottles

LNECK_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	2	2.2	2.7	2.7
	yes	12	12.9	16.0	18.7
	no	39	41.9	52.0	70.7
	no preference	22	23.7	29.3	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.19.14 Trigger Preference

From the analysis presented in Table 5.82, it is evident that trigger was not popular for cooking oil 1 l bottle. 65.3% people did not like it while only 12% were positive about it.

Table 5.82 : Trigger Preference in cooking oil 2L bottles

TRIGR_W

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.3	1.3
	yes	9	9.7	12.0	13.3
	no	48	51.6	64.0	77.3
	no preference	17	18.3	22.7	100.0
	Total	75	80.6	100.0	
Missing	System	18	19.4		
Total		93	100.0		

5.20 Washing Up Liquid Bottles - Descriptive Analysis

The descriptive analysis of washing up liquid bottles is presented in this section.

5.20.1 Geometric Shape Preference

From the analysis result represented in Figure 5.37, it was found that the most popular shape for washing up liquid was round (31%). The other preference of shape in the descending order was: rectangle (23%), ellipse (15%) and square (5%). No preference option was selected by 23% of the respondents. So it is evident a substantial no of people had no preference and there was small difference in percentage between the majority's chosen preference and no preference.

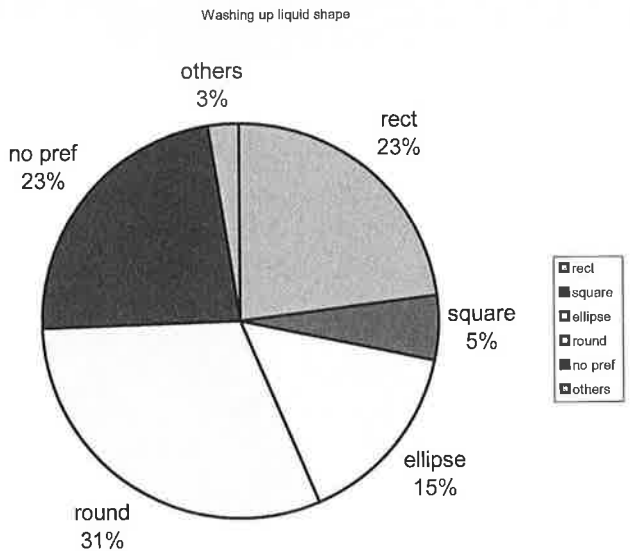

Figure5.37: Geometric shape preference in washing up liquid bottles

5.20.2 Shape Preference

Frequency distribution shown in Figure 5.38 points out that the most popular shape was Shape A (64%) . The other popular choice with substantial vote was Shape D (24%). Some shape images did not get response as first choice at all and so those were not included in this analysis.

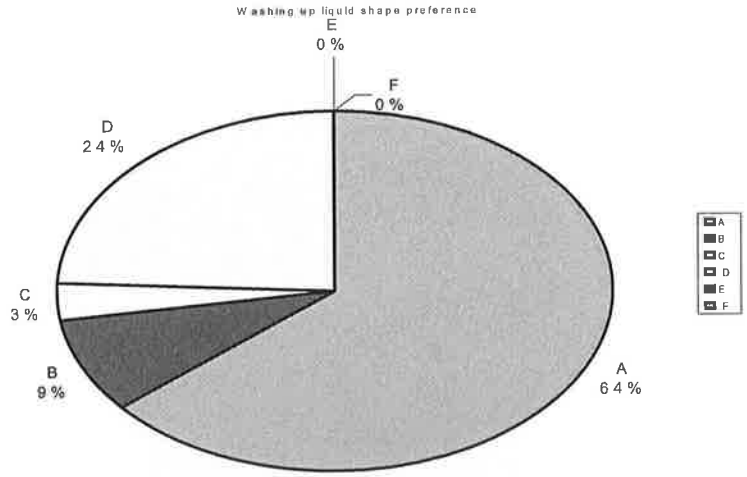

Figure 5.38 : Shape preference in washing up liquid bottles

5.20.3 Colour Preference

The analysis presented in Figure 5.39 shows that the favourite colour for washing up liquid was green (24%). Though the majority (29%)of the respondents expressed no preference in this matter. The other two popular colours in descending order were white(13%) and blue(10%).

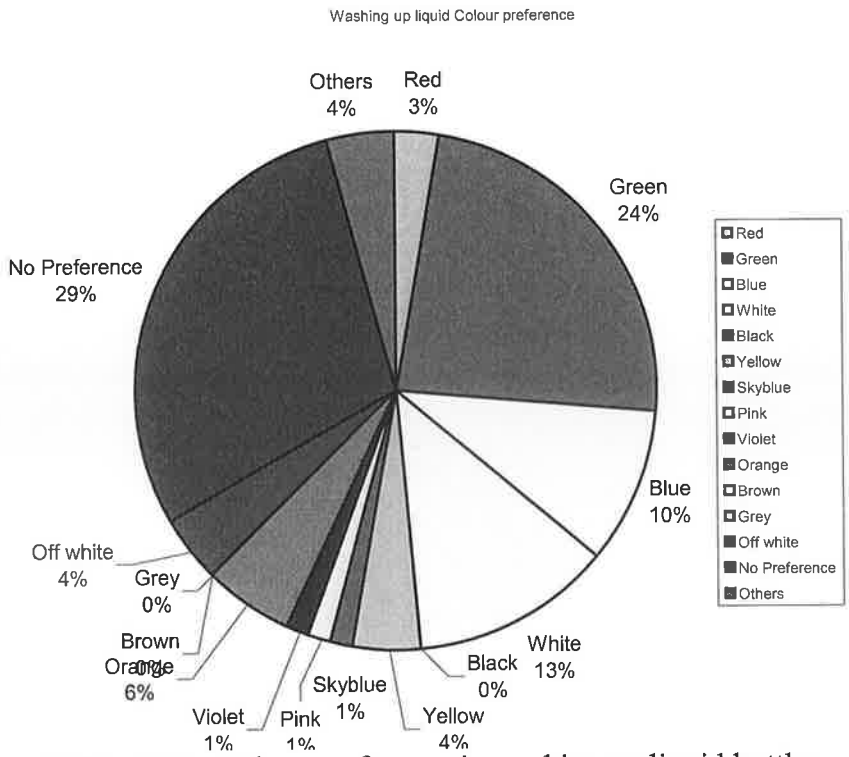

Figure 5.39 : Colour preference in washing up liquid bottles

5.20.4 Transparency Preference

The majority of the respondents preferred for transparent bottles as shown in Figure 5.40. The percentage of choice for this option was 73%. 4% of the respondents liked opaque and 9% liked translucent. 14% of the respondent opted for no preference about the transparency of the washing up liquid bottles.

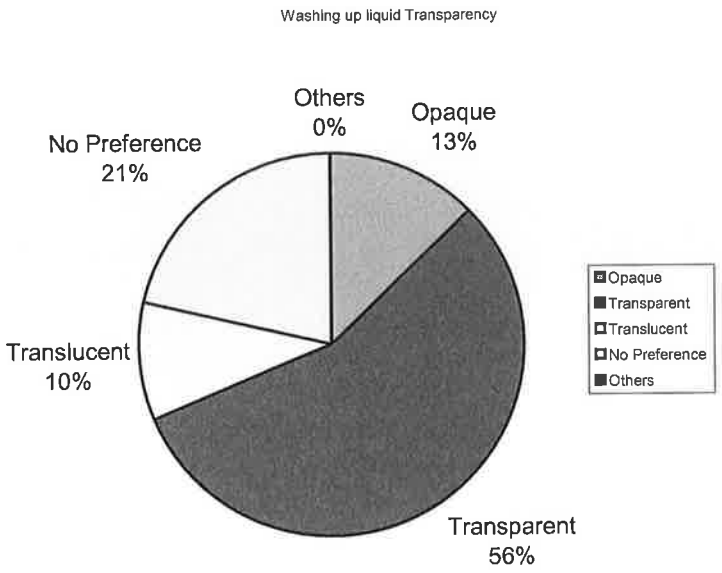

Figure 5.40 : Transparency preference in washing up liquid bottles

5.20.5 Curvature Preference

The analysis shown in Table 5.83 points that the majority (40.3%) had no preference for curvature. 34.7% people opted for curvy section in washing up liquid bottles. 16.7% people did not like the curvy section and 19.5% had no preference.

Table 5.83: Curvature preference in washing up liquid bottles

CURV

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	5	5.5	6.9	6.9
	yes	25	27.5	34.7	41.7
	no	12	13.2	16.7	58.3
	no pref	29	31.9	40.3	98.6
	others	1	1.1	1.4	100.0
	Total	72	79.1	100.0	
Missing	System	19	20.9		
Total		91	100.0		

5.20.6 Combination of Colour preference

The majority (66.7%) of the respondent did not like combination of colour as shown in Table 5.84. A good number of people (25%) liked any combination. Only 2.8% preferred two colour combination.

Table 5.84 : Combination of colour preference in washing up liquid bottles

COLCOMB

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	3	3.3	4.2	4.2
	any combi	18	19.8	25.0	29.2
	no	48	52.7	66.7	95.8
	two colour	2	2.2	2.8	98.6
	three colour	1	1.1	1.4	100.0
	Total	72	79.1	100.0	
Missing	System	19	20.9		
Total		91	100.0		

5.20.7 Size Preference

The majority (52.8%) liked usual size for bottles as shown in Table 5.85. There was substantial preference for bigger size(30.6%), while little preference for smaller size(4.2%).

Table 5.85 : Size preference in washing up liquid bottles

SIZE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	8	8.8	11.1	11.1
	usual	38	41.8	52.8	63.9
	smaller	3	3.3	4.2	68.1
	bigger	22	24.2	30.6	98.6
	others	1	1.1	1.4	100.0
	Total	72	79.1	100.0	
Missing	System	19	20.9		
Total		91	100.0		

5.20.8 Material Preference

The analysis shown in Table 5.86 reveals that the majority (54.8%) had no preference in material for washing up liquid bottles. The popular choice for material for washing up liquid bottles was plastics (35.6%).

Table 5.86: Material preference for washing up liquid bottles

SPMAT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	2	2.2	2.7	2.7
	yes	2	2.2	2.7	5.5
	no	40	44.0	54.8	60.3
	glass	3	3.3	4.1	64.4
	Plastics	26	28.6	35.6	100.0
	Total	73	80.2	100.0	
Missing	System	18	19.8		
Total		91	100.0		

5.20.9 Environment Friendly Bottle Preference

The majority (74%) expressed their willingness to pay a bit more for the environmental friendly bottles. 24.7 % respondents did not want to pay for this cause as shown in Table 5.87.

Table 5.87: Environment friendly bottle preference in washing up liquid

ENVIRON

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.4	1.4
	yes	54	59.3	74.0	75.3
	no	18	19.8	24.7	100.0
	Total	73	80.2	100.0	
Missing	System	18	19.8		
Total		91	100.0		

5.20.10 Handle and Indentation Preference

The majority (38.9%) liked indented side for washing up liquid bottles followed by 23.6% with no preference as presented in Table 5.88. A substantial number of people (20.9%) did not like handle or indented side and 16.7% chose general handle as their first choice.

Table 5.88: Handle & indentation preference in washing up liquid bottles

HANDLEIN

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	general	12	13.2	16.7	16.7
	no	15	16.5	20.8	37.5
	indented side	28	30.8	38.9	76.4
	no pref	17	18.7	23.6	100.0
	Total	72	79.1	100.0	
Missing	System	19	20.9		
Total		91	100.0		

5.20.11 Impression Preference

Table 5.89 shows that most of the respondents (47.2%) did not like impression in washing up liquid bottles. A large number of the respondents (44.4%) had no preference in this matter.

Table 5.89: Impression preference in washing up liquid bottles

IMPRE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	6	6.6	8.3	8.3
	no	34	37.4	47.2	55.6
	no preference	32	35.2	44.4	100.0
	Total	72	79.1	100.0	
Missing	System	19	20.9		
Total		91	100.0		

5.20.12 Colour Scheme preference

According to the analysis presented in Table 5.90, the half of the respondents did not like colour scheme in washing up liquid bottles. Similar number of people (45.8%) stated that they had no preference on this.

Table 5.90 : Colour scheme preference in washing up liquid bottles

COLSCM

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	2	2.2	2.8	2.8
	yes	1	1.1	1.4	4.2
	no	36	39.6	50.0	54.2
	no preference	33	36.3	45.8	100.0
	Total	72	79.1	100.0	
Missing	System	19	20.9		
Total		91	100.0		

5.20.13 Longer Neck preference

The majority (60%) did not like longer neck in washing up liquid bottles as shown in Table 5.91.

Table 5.91 : Longer neck preference in bleach bottles

NECK

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.4	1.4
	yes	6	6.6	8.6	10.0
	no	42	46.2	60.0	70.0
	no preference	21	23.1	30.0	100.0
	Total	70	76.9	100.0	
Missing	System	21	23.1		
Total		91	100.0		

A good proportion of the respondents (30%) had no preference and only 8.6% opted for neck in washing up liquid bottles.

5.20.14 Trigger Preference

The majority (51.4%) did not like trigger as shown in Table 5.92. Though a substantial number of people (25.7%) opted for trigger in bleach bottles and

Table 5.92: Trigger preference in washing up liquid bottles

TRIGR

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	18	19.8	25.7	25.7
	no	36	39.6	51.4	77.1
	no preference	16	17.6	22.9	100.0
	Total	70	76.9	100.0	
Missing	System	21	23.1		
Total		91	100.0		

proportion of the respondents (22.9%) had no preference on it

5.21 All Purpose Cleaner Bottles- Descriptive Analysis

The descriptive analysis of all purpose cleaner bottles is presented in this section

5.21.1 Geometric Shape Preference

The analysis shown in Figure 5.41 reveals that most of the respondents (28%) liked circular bottles. The second popular choice was rectangular shape and the third was elliptical. A substantial number of the respondent replied no preference in this matter.

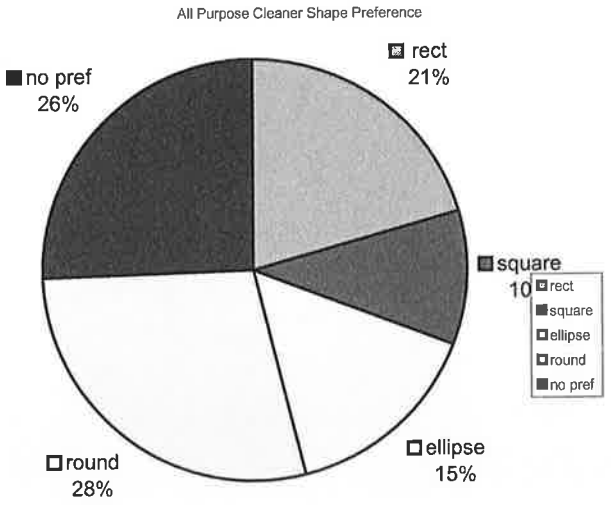

Figure 5.41 : Geometric shape preference in all purpose cleaner bottles

5.21.2 Shape Preference

An analysis was done using SPSS and it was on frequency. From the result presented in Figure 5.42, it is found that the lion share of the respondent 51% liked Shape A. The second popular choice was Shape B with 36% vote and the third popular choice was Shape C with 13% vote. The other two choices in descending order of popularity were E and D,G.

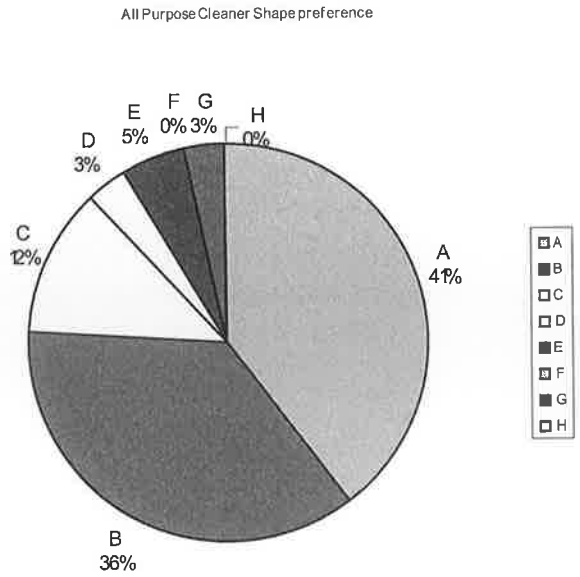

Figure 5.42 : Shape preference in all purpose cleaner bottles

5.21.3 Colour preference

In the colour preference analysis as shown in Figure 5.43, no preference option got the highest responses, which was 39%. Then white got the highest first preference vote along with green, which was 14%. The other colour voted according to the popularity were yellow,offwhite; Blue;orange,blue, skyblue, red.

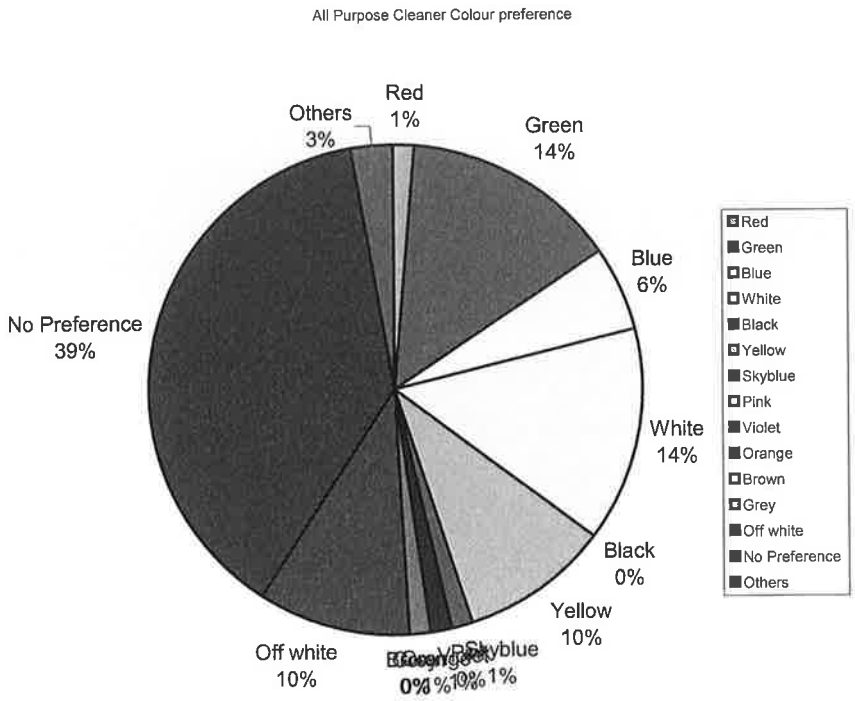

Figure 5.43 : Colour preference of all purpose Cleaner

5.21.4 Transparency preference on All Purpose Cleaner

A descriptive frequency statistical analysis was carried out for transparency preference in all purpose cleaner bottles. The result presented in Figure 5.44 shows that people liked transparent bottles (34%) the most for all purpose cleaner. The second preference of public choice was opaque bottles (29%) and translucent bottle (7%) was the least popular choice. A good number of people (30%) had no preference in this issue.

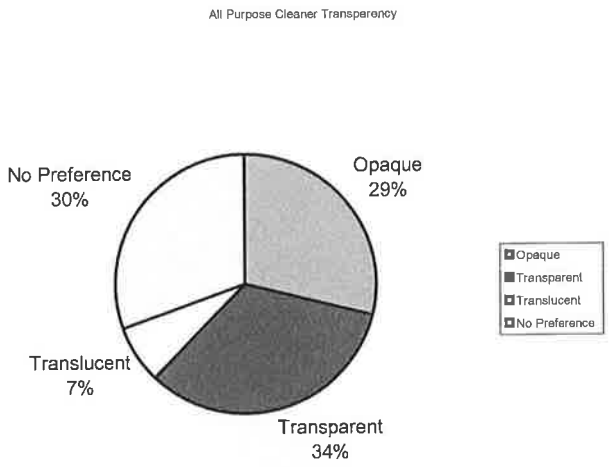

Figure 5.44: Transparency preference in all purpose cleaner bottles

5.21.5 Curvature Preference

The result of frequency statistical descriptive analysis is shown in Figure 5.45. It shows that the majority (34.1%) of the respondents liked curvy shape in bottles of all purpose cleaner. A substantial percentage of people (28.6%) had no preference.

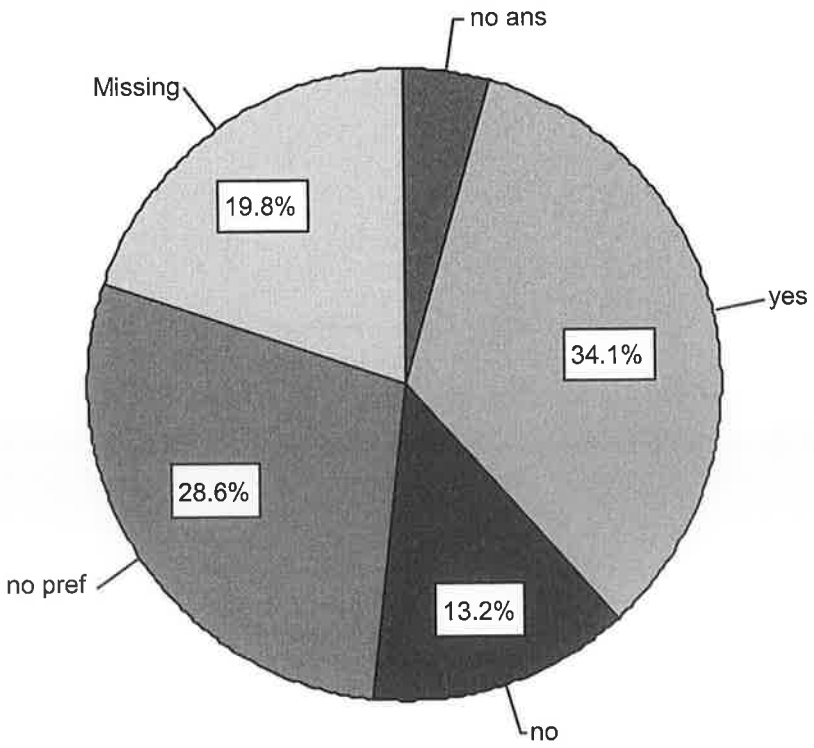

Figure 5.45: Curvature preference in all purpose cleaner bottles

5.21.6 Combination of Colour Preference

The frequency distribution analysis result is presented in Figure 5.46. It shows that the majority (52.7%) did not like colour combination in all purpose cleaner bottles.

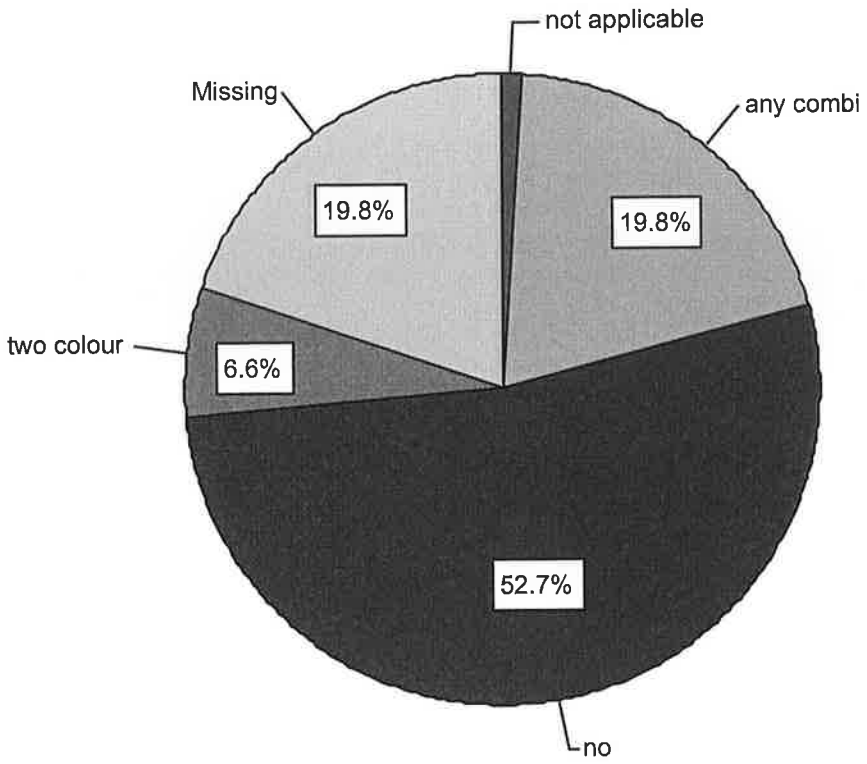

Figure 5.46: Colour Combination in all purpose cleaner bottles

5.21.7 Size Preference

The descriptive analysis on size shows that nearly same percentage of respondents opted for usual and bigger size as shown in Table 5.93.

Table 5.93 : Size preference in all purpose cleaner bottles

SIZE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	12	13.2	16.4	16.4
	usual	29	31.9	39.7	56.2
	smaller	1	1.1	1.4	57.5
	bigger	28	30.8	38.4	95.9
	others	3	3.3	4.1	100.0
	Total	73	80.2	100.0	
Missing	System	18	19.8		
Total		91	100.0		

5.21.8 Material Preference

When asked about special material choice in the survey, the majority (40%) stated that they did not have any preference for special material as shown in Figure 5.47. The popular choice of special material was plastics followed by glass.

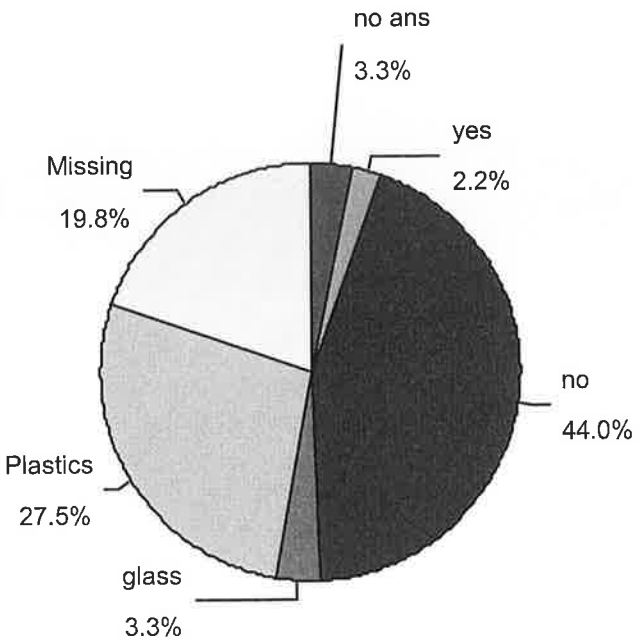

Figure 5.47: Material preference in all purpose cleaner bottles

5.21.9 Environment Friendly Bottle Preference

The survey analysis presented in Figure 5.48 suggests that the majority (61.5%) with a large margin prepared to pay extra money for environmentally friendly product.

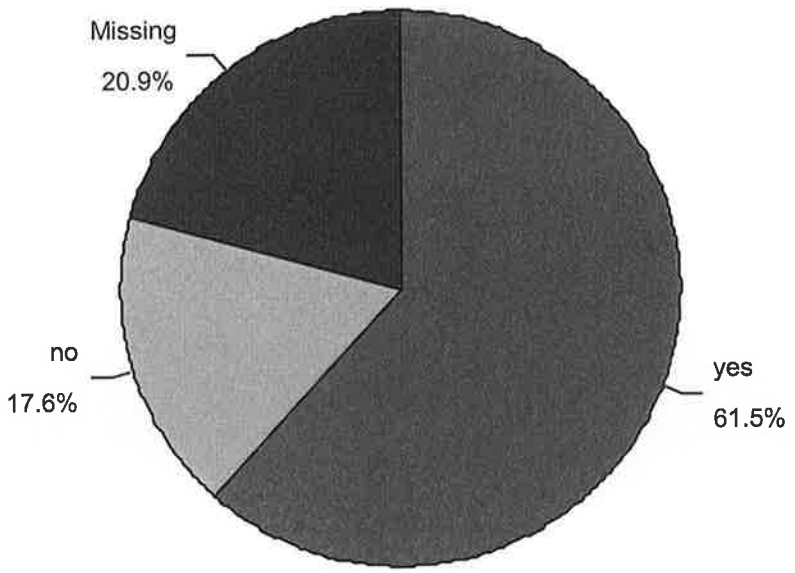

Figure 5.48: Environment friendly bottle preference in all purpose cleaner

5.21.10 Handle and Indentation Preference

The overwhelming/vast majority (61.5%) preferred handle in all purpose cleaner bottles as shown in Figure 5.49. Only 17.6% said they did not like handles.

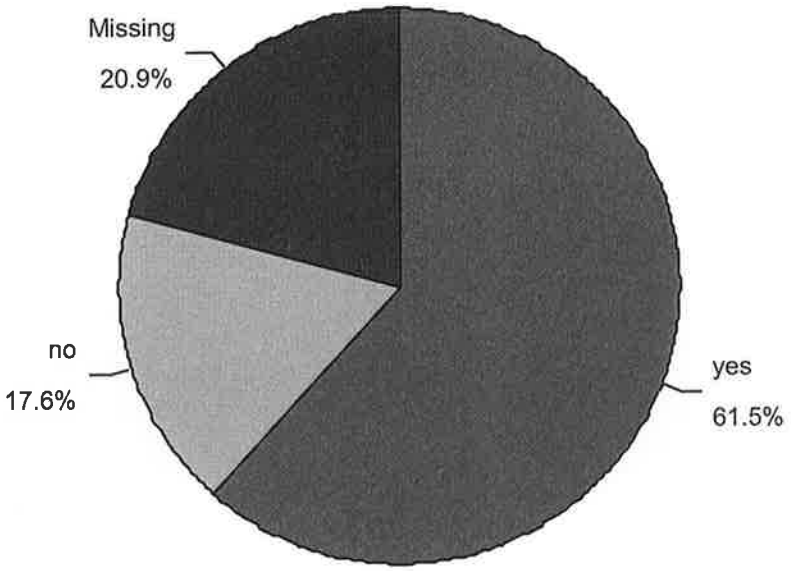

Figure 5.49 : Handle preference in all purpose cleaner bottles

5.21.11 Impression

The majority (39.6%) did not like impression on the all purpose cleaner bottle as shown in Figure 5.50. A small minority (6.6%) liked the impression. Besides, a substantial number of respondents (33%) did not have any preference on this issue.

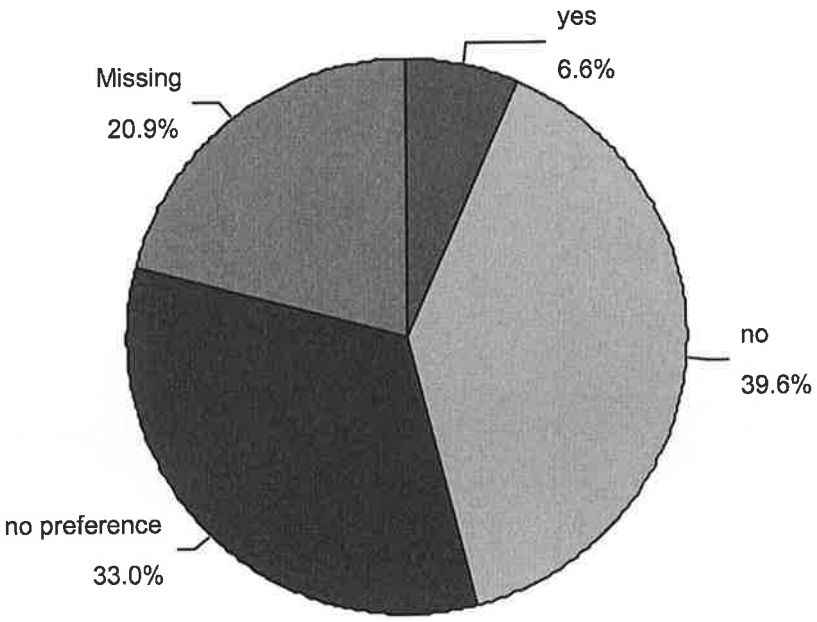

Figure 5.50 : Impression preference in all purpose cleaner bottles

5.21.12 Colour Scheme Preference

The majority of the respondents did not like colour scheme and the second majority opted for no preference as shown in Figure 5.51

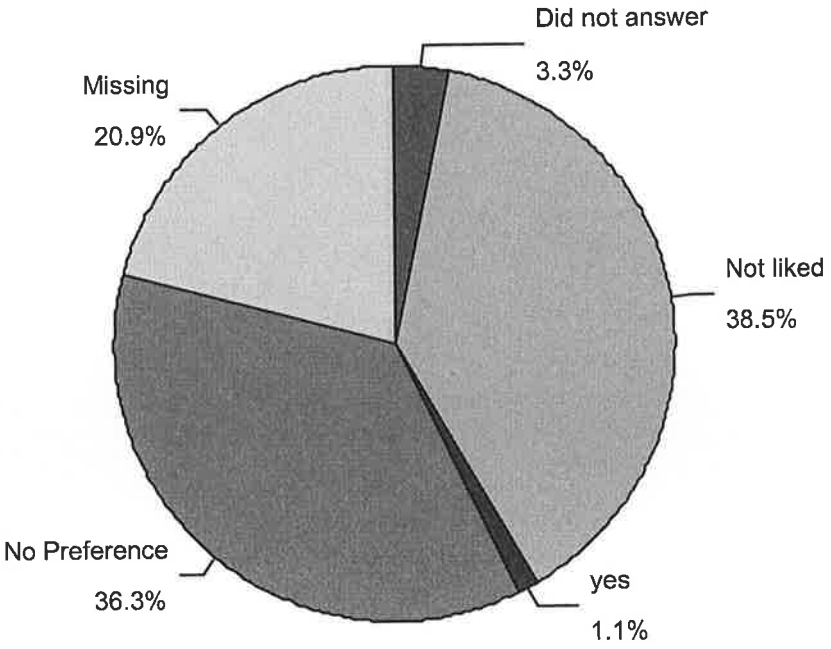

Figure 5.51: Colour Scheme preference for all purpose cleaner bottles

5.21.13 Longer Neck Preference

Nearly the same percentage of respondents opted for longer neck, no option and no preference option as shown in Figure 5.12. The majority (28.6%) did not like longer neck.

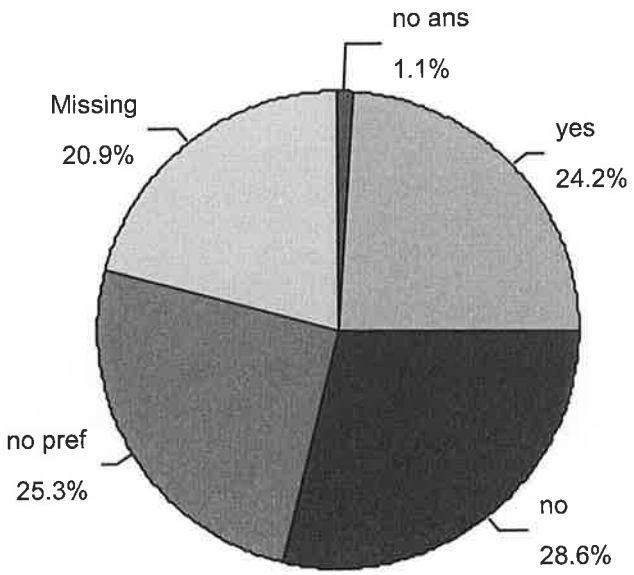

Figure 5.52 : Longer neck preference in all purpose cleaner bottles

5.21.14 Trigger Preference

The analysis result shows that most of the respondents liked trigger in all purpose cleaner bottles (Figure 5.53).

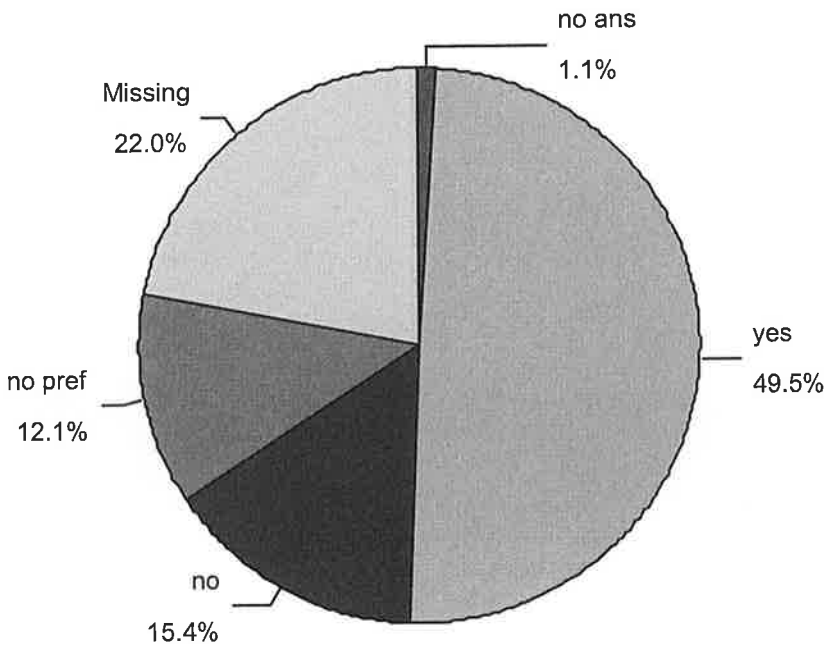

Figure 5.53 : Trigger Preference in all purpose cleaner bottles

5.22 Bleach Bottles - Descriptive Analysis

The descriptive analysis of bleach bottles is presented in this section

5.22.1 Geometric Shape Preference

The analysis shown in Figure 5.54 reveals that most of the respondents (36%) liked round bottles. Rectangle and elliptical shaped bottle came up as the second choice of the respondents. 8% people liked squared shaped bottle.

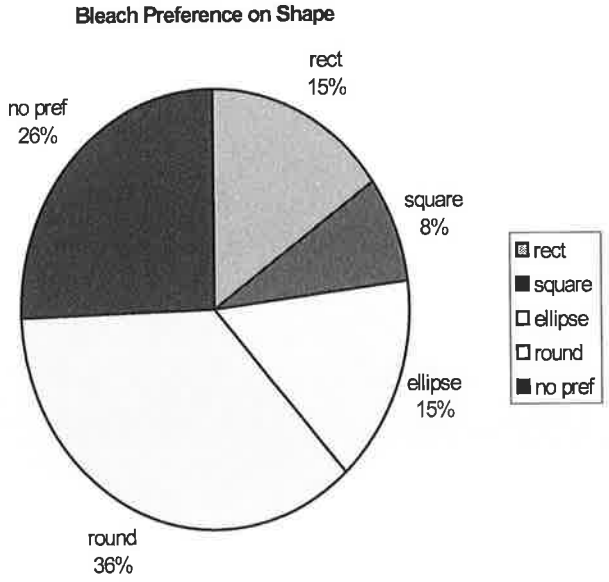

Figure 5.54 : Geometric shape preference in bleach bottles

5.22.2 Shape Preference

Frequency distribution shown in Figure 5.55 points out that the most popular shape was Shape B (44%) . The next three popular choices in descending order were Shape A, C, D. Some shape images did not get response as first choice at all.

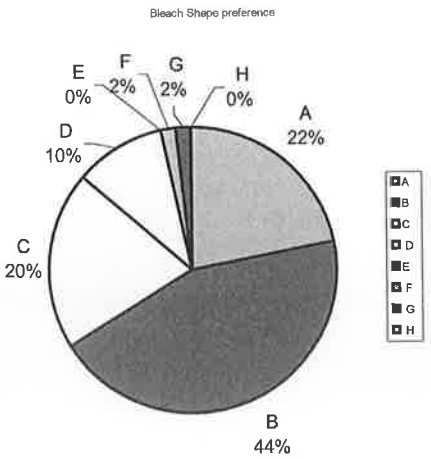

Figure 5.55 : Shape preference in bleach bottles

5.22.3 Colour Preference

The analysis as presented in Figure 5.56 shows that the favourite colour for bleach was Blue(24%). The majority of the respondents (36%) expressed no preference in

this matter. The next three popular colours in descending order were white, green and offwhite.

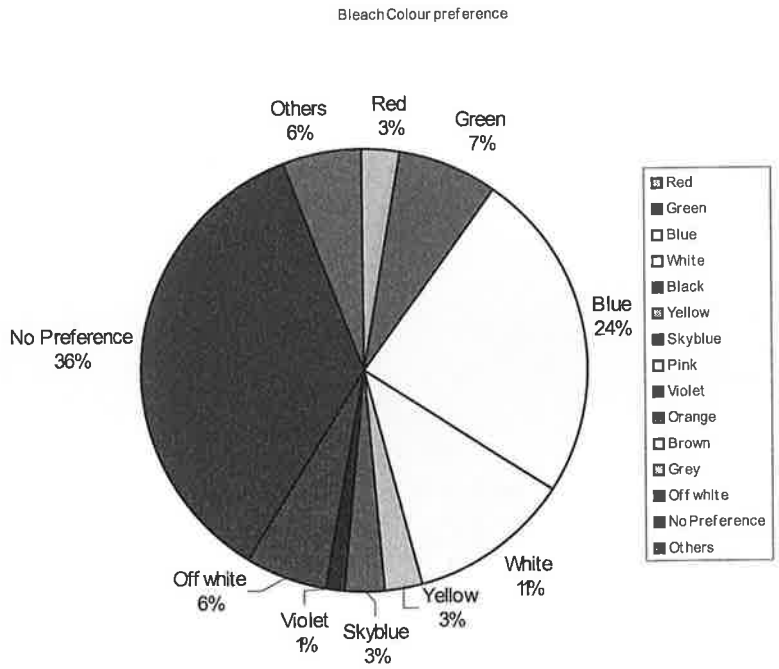

Figure 5.56 : Colour preference in bleach bottles

5.22.4 Transparency Preference

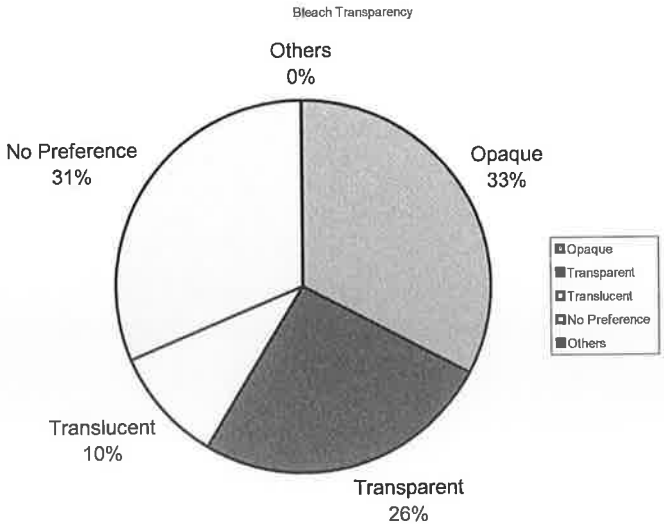

Figure 5.57 : Transparency preference in bleach bottles

The majority of the respondents (33%) liked opaque bottles for bleach as shown in Figure 5.57. 31% opted for no preference.Substantial no of people (26%) liked transparent bottle. The small minority (10%) preferred translucent (10%) bottles for bleach.

5.22.5 Curvature Preference

The analysis shown in Table 5.94 points that the majority (47.2%) opted for curvy section in bleach bottles. 12.5% people did not like the curvy section and 30.6% had no preference.

Table 5.94 : Curvature preference in bleach bottles

CURV

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	6	6.6	8.3	8.3
	yes	34	37.4	47.2	55.6
	no	9	9.9	12.5	68.1
	no pref	22	24.2	30.6	98.6
	others	1	1.1	1.4	100.0
	Total	72	79.1	100.0	
Missing	System	19	20.9		
Total		91	100.0		

5.22.6 Combination of Colour Preference

The majority (64.4%) of the respondent did not like combination of colour as shown in Table 5.95, while the second majority (28.8%) opted for any combination. Only 4.1% preferred two colour combination.

Table 5.95 : Combination of colour preference in bleach bottles

COLCOMB

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	not applicable	1	1.1	1.4	1.4
	any combi	21	23.1	28.8	30.1
	no	47	51.6	64.4	94.5
	two colour	3	3.3	4.1	98.6
	three colour	1	1.1	1.4	100.0
	Total	73	80.2	100.0	
Missing	System	18	19.8		
Total		91	100.0		

5.22.7 Size Preference

The majority (48.6%) liked bigger bottles as shown in Table 5.96. There was substantial preference (30.6%) for usual bottle too.

Table 5.96: Size preference in bleach bottles

SIZE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	11	12.1	15.3	15.3
	usual	22	24.2	30.6	45.8
	smaller	1	1.1	1.4	47.2
	bigger	35	38.5	48.6	95.8
	others	3	3.3	4.2	100.0
	Total	72	79.1	100.0	
Missing	System	19	20.9		
Total		91	100.0		

5.22.8 Material preference

The analysis shown in Table 5.97 reveals that the majority (52.1%) had no preference in material for bleach bottles. Among the selected materials by the respondents, plastic (32.9%) was the top choice.

Table 5.95: Material preference in bleach bottles

SPMAT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	4	4.4	5.5	5.5
	yes	3	3.3	4.1	9.6
	no	38	41.8	52.1	61.6
	Glass	4	4.4	5.5	67.1
	Plastics	24	26.4	32.9	100.0
	Total	73	80.2	100.0	
Missing	System	18	19.8		
Total		91	100.0		

5.22.9 Environment Friendly Bottle Preference

The majority (76.7%) expressed their willingness to pay a bit more for the environmental friendly bottles as shown in Table 5.98. 21.9 % respondents did not want to pay for this cause.

Table 5.98: Environment friendly bottle preference in bleach

ENVIRON

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.4	1.4
	yes	56	61.5	76.7	78.1
	no	16	17.6	21.9	100.0
	Total	73	80.2	100.0	
Missing	System	18	19.8		
Total		91	100.0		

5.22.10 Handle and Indentation Preference

The majority (41.7%) liked indented side on the bottle, while 29.2% opted for general handle as shown in Table 5.99.

Table 5.99 : Handle & indentation preference in bleach bottles

HANDLEIN

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.4	1.4
	general	21	23.1	29.2	30.6
	no	8	8.8	11.1	41.7
	indented side	30	33.0	41.7	83.3
	no pref	11	12.1	15.3	98.6
	others	1	1.1	1.4	100.0
	Total	72	79.1	100.0	
Missing	System	19	20.9		
Total		91	100.0		

5.22.11 Impression Preference

Table 5.100 shows that most of the respondents (47.2%) did not like impression in bleach bottles. A large number of the respondents (43.1%) had no preference in this matter.

Table 5.100 : Impression preference in bleach bottles

IMPRE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no ans	1	1.1	1.4	1.4
	yes	6	6.6	8.3	9.7
	no	34	37.4	47.2	56.9
	no preference	31	34.1	43.1	100.0
	Total	72	79.1	100.0	
Missing	System	19	20.9		
Total		91	100.0		

5.22.12 Colour Scheme Preference

According to the analysis presented in Table 5.101, the majority (48.6%)

Table 5.101: Colour scheme preference in bleach bottles

COLSCM

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	3	3.3	4.2	4.2
	No	35	38.5	48.6	52.8
	No Pref	34	37.4	47.2	100.0
	Total	72	79.1	100.0	
Missing	System	19	20.9		
Total		91	100.0		

Did not like colour scheme. Nearly the same proportion of people (47.2%) stated they had no preference.

5.22.13 Longer Neck Preference

The majority (47.1%) liked neck in bleach bottles as shown in Table 5.102. 30% said

Table 5.102 : Longer neck preference in bleach bottles

NECK

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not answer	1	1.1	1.4	1.4
	Yes	33	36.3	47.1	48.6
	No	21	23.1	30.0	78.6
	No Pref	15	16.5	21.4	100.0
	Total	70	76.9	100.0	
Missing	System	21	23.1		
Total		91	100.0		

They did not like neck, while 21.4% opted for no preference.

5.22.14 Trigger Preference

The majority (42.9%) did not like trigger as shown in Table 5.103. Though a substantial number of people (35.1%) stated their liking for trigger in bleach bottles.

Table 5.103 : Trigger Preference in bleach bottles

TRIGR

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	25	27.5	35.7	35.7
	No	30	33.0	42.9	78.6
	No Pref	15	16.5	21.4	100.0
	Total	70	76.9	100.0	
Missing	System	21	23.1		
Total		91	100.0		

5.23 Guidelines from the Survey

From the survey results, the following observations for aesthetical design of bottles in the targeted products are made:

In general, it is evident that there is significant preference for circular type cross section, off-white and transparent bottle for the targeted products.

For shape, in general the first preference is round (circular) bottles, followed by rectangle and square.

For colour, in general people do not have specific preference, followed by off-white and blue.

In transparency, people in general like transparent bottles followed by opaque ones. For curvature, people in general like curvature followed by no preference.

As to combination of colour, people in general do not like it.

As to material, people in general do not have any preference.

As to cap, people in general like conventional cap.

As to impression, people in general do not like it followed by no preference.

As to colour scheme, people do not like it followed by no preference.

As to indentation and hand position, people in general like indented side followed by general handle and hook.

As to trigger, people in general do not like it.

As to longer neck, people in general do not like longer neck except specific products.

Finally, the following guideline is made for aesthetical design of bottles in the targeted products.

-Circular shape should be selected

-Off white colour should be selected

-Transparent bottles should be selected

5.24 Summary

The second survey conducted among the resident of Dublin city and its suburb were presented in this chapter. At the beginning, survey methods and procedures were described. For this survey, postal questionnaire was the main mode of survey and online survey assisted it. Simple random sampling was used to determine sample size. Later analyses of the survey were presented with pie chart and tables. The findings obtained from this survey and the first survey were used to develop the intelligent design system.

Chapter Six- Simple Material Selection for Bottles (SMSB) Index Development

6.0 Introduction

The objectives of this chapter are to:

- Describe the methodology of creating the simple material selection Index
- Present the index with respect to different products

6.1 SMSB Index

The SMSB index is the abbreviation of 'Simple Material Selection for Bottles'. It gives points to a material on different selection criteria for its use as a bottle or packaging stuff for products. There are many attributes that influence material selection criteria for making bottles for products. The prominent ones based on environmental and economical considerations are:

- Toxicity and Shelf Life (Reaction with the products it contains)
- Cost
- Recycling
- Strength/Density ratio
- Brittleness
- Availability

In this research, three materials were given points based on the above attributes. These three materials were glass, Aluminium and PET plastic. The reason of choosing these three materials was that they are widely used as materials for making bottles.

These materials were first given points independently with respect to the above-mentioned attributes. Then nine products were chosen with which the suitability of each material was studied and points were given accordingly. The products selected were the same products that were surveyed regarding aesthetics attributes. They were: mineral water, soft drink, shampoo, shower gel, cooking oil, all purpose

cleaner, bleach and washing up liquid. In the point system, the higher the point is the better the material for that specific attribute or for any particular product. Different factors were given different weighting to provide a representative simple indication about the selection of material. For instance, PET plastic has higher points on strength by density ratio than glass and Aluminium. It entails that PET plastic is lighter than glass and Aluminium for a required strength and thus easier and more economical to transport. Again, when comparing glass on the aspect of shelf life, it means the possibility of reaction with the materials in certain conditions and time period. Glass got the highest point with soft drink. To get the index of a material independently, average of all the points in different attributes was calculated. Again, here too higher point means the material is superior overall in considering all aspects. Nevertheless, a highest point winner material may not be chosen for a specific due to specific reason pertaining to that product. To cover this aspect, each material was given point regarding its reaction with the ingredients of a specific product and this point may be considered along with independent index of the material.

6.2 Attributes of the Materials for Determining SMSB index

As mentioned earlier, several attributes were considered for determining SMSB index. They will be described in the following paragraphs:

6.2.1 Cost

It is one of the most important criteria for selecting a material for bottles since manufactures have to compete in the market and the major factor in determining competitiveness is cost or price. Therefore, generally the lower is the cost the better and consequently low cost materials were given higher points. Besides, considering its importance, it was given weighting factor of the value 1.2. Here the term 'cost' includes cost of extraction and processing the material to bottle for a product. Table 6.1 lists the cost of three materials covered in this research. It shows that PET plastic is the cheapest among glass, Aluminium and PET plastic. Points were allocated in

Table 6.1 : Cost of materials and subsequent points given in SMSB index [165]

	Cost	Points Given in SMSB index
Glass	5.66 Rs	60
Aluminium	6.87 Rs	50
PET plastic	3.79 Rs	90

the method. Since PET plastic cost was the lowest, it was given 90 points. The full 100 points was not given as a conservative measure of keeping 10 points as tolerance. Aluminium and glass were given 50 and 60 according to their cost relative to the cost of PET plastic.

6.2.2 Recycling

With growing concern of keeping environment safe, recycling has become a key factor in choosing material for bottles. . Therefore, the higher the percentage of recyclable energy a material provides, the higher points it gets in the scoring system. New regulations have made it binding to the manufactures to make the products environment friendly at least to a minimum level. Growing public awareness has also put pressure on the manufactures to take the issue very seriously. At the present consumer dominated market, the manufacturers do not afford to ignore such public pressure. One of the major components of environmental considerations is recycling. Therefore recycling is a major concern on the selection of material. So it was given weighting factor of 1.2 which was the same as cost. Table 6.2 lists the energy saving made by recycled materials of interest and their subsequent ranking / point on this basis. It shows that Aluminium gives the highest amount of energy upon recycling. Following the percentage of saving, glass and Aluminium were given the points same as of their percentage of energy saving. However, PET plastic was given less point than its percentage because it is difficult to recycle.

Table 6.2 Energy Saving upon recycling and Points [166]

	Energy Saving upon Recycling	Points
Glass	33%	33
Aluminium	75%	75
PET plastic	33% but difficult to recycle	20

6.2.3 Availability

If a material is available for a substantial time and with least difficulty in extraction or manufacturing, that material is more likely to be chosen for making of the bottles of a product. Aluminium is basically extracted from bauxite and the current Aluminium reserve is calculated to be sufficient for next 400 years of use [167,168] Besides, Aluminium is light and easy to extract. Therefore it was given 80 points. PET plastic is made from

Table 6.3 Availability and points

	Availability	Points
Glass	abundant	70
Aluminium	400 years reserve, so huge reserve	80
PET plastics	Artificial synthetically produced, so abundant	90

artificially produced polymer and this fact implies it's availability does not depend on reserve. Again it is light and easy to produce. Thus PET plastic was given 90 points. Common glass is sodium silicate and it is available abundantly in sand. But extraction and purification of sand is a bit difficult compared with the other two. Therefore it was given 70 points on availability. Furthermore, availability appears to be of lower importance compared to other factors. Thus it was given weighting factor of 0.5.

6.2.4 Strength / Density Ratio

The ratio of strength and density reflects the weight of the bottle with a material corresponding to a product. In general, higher ratio of strength by density means less weight of the required bottle with the material. So it will be easier and economical for transport. Thus higher ratio is desired and therefore material with higher strength by density ratio was given higher points. Table 6.4 shows strength by density ratio and points allocated for the three materials studied. Since PET plastic has the highest strength by density ratio among them, it was given 90 points. Taking this as the yardstick, glass and Aluminium were given 36 and 62 points respectively. . Later on the calculation of SMSB index, this factor was given the weighting factor of 1. Thus it got importance after cost and recycling.

Table 6.4 Strength/Density ratio and Points [169-173]

	Density g / cc	Strength MPa	Strength/Density ratio	Points
Glass	2.6	50	19.23	36
Aluminium	2.7	90	33.33	62
PET plastic	1.29 to 1.4	55-75	48.51	90

6.2.5 Brittleness

If a material is brittle, much care is required during transport and shelving in the shops. Thus less brittle materials are preferred for making of bottles. Glass is very brittle where as PET plastic is not brittle at all [174]. Aluminium is not that brittle [175]. Therefore, PET plastic was given 90 points on brittleness while glass and Aluminium were given 40 and 65 points respectively. Furthermore, since it appears that brittleness is of lower importance compared to other factors, it was given the weighting factor of 0.75.

6.3 Index of Materials without Considering Interaction with Products

To determine the index of a material, all the points on different attributes are added after applying weighting factor and then divided by the number of attributes. In this way, average point comes up. This average point or score is called SMSB index without considering interaction with products. That means this index is independent of products. In this research, three materials SMSB were calculated. Table 6.5 presents the list of different attributes and corresponding weighting factor. Table 6.6 shows the SMSB index of glass, Aluminium and PET plastic. Here PET plastic topped the table with SMSB index

Table 6.5: Different attributes and corresponding weighting factor

Attributes	Weighting factor
Toxicity and Shelf Life	1.5
Cost	1.2
Recycling	1.2
Strength / Density Ratio	1
Brittleness	0.75
Availability	0.5

Table 6.6: SMSB index of glass, Aluminium and PET plastic

Material	**Total points on five attributes**	**SMSB index**
Glass	212.6	42.52
Aluminium	300.75	60.15
PET plastic	334.5	66.9

of 66.9 followed by Aluminium with 60.15, and the last one was glass with 42.52. In the index, the material that gets high score is supposed to be better in overall comparison for the making of bottles.

6.4 SMSB Index with Consideration of Reactions with Products

In this research, three materials namely glass, Aluminium and PET plastics were considered for the development of SMSB index. Again, nine products were surveyed to gauge public opinions about aesthetic aspects of their bottles. So these nine products were chosen to create another index with three main bottle making ingredients namely glass, Aluminium and PET plastic. To do so, ingredients of these nine products were tabulated and their reactions with the three materials were studied. Since much reaction with the packaging materials like bottles makes the actual product useless, it is considered to be the most prominent one. . Here, consideration of toxicity was also accounted for. Health risk to human beings and other living objects are issues of serious importance. Therefore combination of these two factors was given the highest weighting factor, i.e. 1.5.

6.4.1 Mineral Water

Ingredients of mineral water and their reactions with the three materials are discussed below:

6.4.1.1 Ingredients of Mineral Water

The bottled mineral water contains purified or natural spring water with added or already present / dissolved substances or trace elements [176,177]. The mineral content of mineral water is generally measured by the amount of residue remains when a litre of water evaporated at 180 degree Celsius. The list of mineral includes Calcium, Chloride, Iron, Magnesium etc.

6.4.1.2 Reaction of Mineral Water with Bottle Making Materials

Generally water does not react with the three materials studied. The substances or elements added or available in mineral water is so small amount that they are not in a position to carry out substantial reactions. However, Aluminium is harmful for human health and it may leach into water if kept in store long time and with higher temperature. Hence it is not suggested to use for mineral water bottles and if used, a

protective liner should be provided. Common glass is Sodium silicate and it does not react with water. Thence it is very suitable for mineral water bottles. PET plastic do not react with water in normal temperature. Nevertheless, if stored for a long time and exposed to high temperature, PET plastic might dissolve slightly in water. Therefore, shelf storage life of mineral water bottles with PET plastic is shorter than with glass. Considering all these, points / score was allocated to the three materials as shown in Table 6.7.

Table 6.7: Mineral water and three bottle making materials

	Glass	**Aluminium**	**PET plastics**
Reaction with Mineral Water	almost no	moderate	mild
Points	90	60	80

6.4.2 Soft Drink

Ingredients of soft drink and their reactions with the three materials are discussed below:

6.4.2.1 Ingredients of Soft Drink

Soft drink generally contains water, a sweetener, an acid and an flavour [178]. Other ingredients are additives that varied according to manufacturer and type of soft drinks. Appears below the list of ingredients under main categories [179,180] :

-water- 60- 90 %

- sweetener 7 – 14%

--non diet soft drink use sucrose or high fructose corn syrup (HFCS)

--Diet soft drinks use low calorie sweetener like Aspartame, saccharin, sucralose and acesulfame K

-Acid : normally contains either phosphoric acid or citric acid

-flavour: both natural(e.g. spices, natural extract, vegetable extract, fruit extract etc) and artificial flavourings are used.

-Carbon Dioxide

- Caffeine: in some cola drinks, cola nut is used. It contains caffeine and theobromine. In the rest, artificial caffeine is used.

- Preservatives: generally soft drinks do not spoil due to acidity and carbonation. Nevertheless, in some cases Sodium Benzoate and Potassium Citrate are used. Ascorbic Acid that is also called Vitamin C is used as anti-oxidant.

- Colours: colours are very important as to psychological aspect of taste. Caramel colouring (burnt sugar) gives the look of the cola. In fruit flavoured drinks like Orange Soda, Red 40 and other permitted colours are used.

6.4.2.2 Reactions of Soft Drinks with Bottle Making Materials

Common glass (Sodium Silicate) does not react with phosphoric acid or citric acid. In general, organic acids like the previously mentioned two are weak. Its reactions with others are insignificant. Aluminium's reactions with different ingredients of soft drinks are not significant. Nevertheless, temperature and duration of storage are important factors on determining extend of Aluminium's reactions. If temperature is higher than normal and the product is kept for too long, Aluminium might leach. Aluminium is harmful for human health if taken substantial amount [181]. So if Aluminium is used in making bottles / containers, some sort of lining should be provided for safety and actually in the Aluminium cans used presently for soft drinks have such lining. Furthermore, Aluminium containers should be stored in a cool dry place and disposed of upon expiry. PET plastic do not react with the ingredients of soft drinks if soft drinks are stored between 0 to 4 degree Celcius, which is the recommended storage temperature. Therefore, if stored for a long time and exposed to high temperature, PET plastic might dissolve slightly in water. Taking into consideration of all these, points / score was allocated to the three materials as shown in Table 6.8.

Table 6.8: Soft drink and three bottle making materials

	Glass	Aluminium	PET plastic
Reactions with soft drink	almost no	moderate	mild
Points	90	60	80

6.4.3 Perfume

Ingredients of perfume and their reactions with the three materials are discussed below:

6.4.3.1 Ingredients of Perfume

The basic and major ingredient of Perfume is fragrance creating things that may be derived from nature(e.g. plants), animals or artificially created. Examples of fragrance derived from animals are Ambergris, Castoreum, Musk, Civet etc. Examples of fragrance ingredients derived from plants and other non-animals sources are Amber, Anise, bay leaf, gardenia, moss, oris, ylang-ylang etc. Now a

days in many perfumes, as main ingredients of fragrance are synthetically produced chemicals. Generally they are organic Aldehydes [182]. Some synthetic fragrance ingredients are derived from terpene, benzene, toluene, phenol, naphthalene, etc [183]. Plant extracts are kind of cellulose. Some prominent components of perfume ingredients are cian and acrylo sulphur, boron etc substances in perfume Perfume contains very little amount of organic acid. For preservation, ethanol is used extensively in perfume.

6.4.3.2 Reactions of Perfume with Bottle Making Materials

Perfume's reactions with glass are insignificant. Organic acid are normally weak and don't react with glass. If ethanol has high percentage in a perfume, over time it may react with glass to form sodium ethoxide. Nevertheless, general percentage of ethanol in perfume are not that high, so this possibility could be excluded. Aluminium do not have significant reactions with ingredients of perfume. Boron may react with Aluminium if it has high percentage. Aluminium may leach into the perfume if it is kept for a long time. Aluminium is also considered significantly toxic if got inside human body with substantial amount. Generally people keep perfume for a long time. PET plastic do not react with perfume in general. However, if kept for a long time, it may dissolve into the perfume. Taking account of the above mentioned analysis, the three materials were given points as shown in Table 6.9.

Table 6.9: Perfume and three bottle making materials

	Glass	**Aluminium**	**PET plastic**
Reaction with Perfume	almost no	medium	moderate
Points	90	50	60

6.4.4 Shampoo

Ingredients of shampoo and their reactions with the three materials are discussed below:

6.4.4.1 Ingredients of Shampoo

Shampoo usually contains a number of organic compounds, soap and fragrance. In the packaging of a Pantene Pro Smooth & Sleek shampoo collected from Irish market lists the ingredients as shown in Table 6.10.

Table 6.10: Ingredients of Pantene Pro Smooth & Sleek shampoo

Sodium Citrate	Panthenyl ethyl ether
Hydrogeneted Polydecene	Ammonium lauryl sulfate
Amoonium Polyquaternium-10	Methylisothiazolinone
Parfum	DMDM hydantoin
Hexyl Cinnamal	Sodium chloride
Tetrasodium EDTA	Water
Benzyl Salicylate	Dimethicone
Butylphenyl Methylpropanol	Methylchloroisothiazolinone
Lysine HO	Ammonium xylenesulfonate
Methyl Tyrosiniate HCL	Ammonium laureth sulfate
Linalcol	Cetyl alcohol
Limonene	Cocamide MEA
Citronelol	Trimethylolpropane
Geraneol	tricaprylate/tricaprate
Hydoroxyisohexyl 3-Cyclohexene	Fragrance
Carboxialdehyde	PEG-7M
Histdine	Citric acid
Tocopherol	Panthenol
Sodium benzoate	Disodium EDTA
	Glycol distearate

The other types of shampoo contain almost the same ingredient with small variation or addition of one or two.

6.4.4.2 Reactions of Shampoo with Bottle Making Materials

Shampoo is by and large made of organic compounds. Consequently oxygen from air could not enter easily to the solution. When oxidation is difficult to occur, the solution keeps it properties. There are some inorganic components as well in shampoo. Normally organic and inorganic components do not react. Therefore in normal temperature and when kept air tight, no significant internal reactions occur in shampoo. Calcium and Magnesium components of shampoo might react with glass. Citric acid and other components of shampoo do not have significant reactions with glass. Generally Aluminium does not react with the components of shampoo in normal temperature. Nevertheless, if temperature goes up for some reason, Aluminium may leach. Aluminium is harmful for human health if got inside in significant amount. The same applies to PET plastics as it does not react with shampoo in normal temperature and short time period. However, in high temperature and longer time period, it may react with shampoo. Having considered all these

aspect, glass, Aluminium and PET plastic were allocated points as shown in Table 6.11.

Table 6.11 Shampoo and three bottle making materials

	Glass	Aluminium	PET plastic
Reaction with Shampoo	moderate	much	mild
Points	60	40	80

6.4.5 Shower Gel

Ingredients of shampoo and their reactions with the three materials are discussed below:

6.4.5.1 Ingredients of Shower Gel

Usually shower gel is comprised of soap, fragrance and some organic compounds. The detail description of shower gel ingredients [184] is provided in Table 6.12.

Table 6.12 : Ingredients of shower gel and their functions

Ingredient	Function
Cocamide DEA	Creates foam
Glycerin	Attracts and absorbs water thereby making skin soft
Phenoxyethanol	pereservative
Sodium Cocoamphoacetate	A surfactant that reduces surface tension of a liquid and helps it to spread easily
Dipropylene Glycol	Fragrance carrier
Sodium Benzoate	Control bacteria, yeast and other growths
Sodium Methylparaben	Salt and preservative
Citric Acid	Traps moisture in skin
Tetrasodium EDTA	A chelating agents which acts as a stabilizer, softener or preservative
Polyquaternium-7	conditioner
Disodium Phosphate	preservative
Benzophenone-4	Arometic Ketone
Sodium Laureth Sulphate	Cleaning agent

6.4.5.2 Reactions of Shower Gel with Bottle Making Materials

Shower gel consists of mainly organic compounds. Thence it is difficult for oxygen in the air to enter. Glass do not have significant reaction with shower gel. Aluminium also does not react with shower gel in normal temperature. However, it is a toxic material and might leach if exposed to high temperature. PET plastic normally do not react with shower gel. Nevertheless, shower gel is kept on it for a longer period it may dissolve a little bit in high temperature. To counter this, preservatives are used

in shower gel bottles made of plastics. Considering all these factors, glass, Aluminum and PET plastic were given points as shown in Table 6.13

Table 6.13 : Shower gel and three bottle making materials

	Glass	Aluminium	PET plastics
Reactions with shower gel	almost no	moderate	mild
Points	90	60	80

6.4.6 Cooking Oil

Ingredients of cooking oil and their reactions with the three materials are discussed below:

6.4.6.1 Ingredients of Cooking Oil

Generally most of the cooking oils are vegetable oil that mostly consists of soybean. There are other cooking oils including sunflower oil, olive oil, mustard oil etc. In general, all of these cooking oils' ingredients are fatty acid and low saturated fat.

6.4.6.2 Reactions of Cooking Oil with Bottle Making Materials

Fatty acids are weak acids. Glass does not have significant reactions with cooking oils. Aluminium does not react significantly with cooking oils. Although it may leach if exposed to high temperature. Aluminium is harmful when it gets inside the human body in substantial amount. PET plastic do not react notably with cooking oil. Nevertheless, it may dissolve if temperature gets high and stored for a long time. However normally cooking oils are used almost daily and therefore finish up fast. Table 6.14 shows the points allocated to glass, Aluminium and PET plastics considering all the above mentioned factors.

Table 6.14 : Cooking oil and three bottle making materials

	Glass	Aluminium	PET plastic
Reactions of Cooking oil	almost no	moderate	mild
Points	90	60	80

6.4.7 All Purpose Cleaner

Ingredients of all purpose cleaners and their reactions with the three materials are discussed below:

6.4.7.1 Ingredients of All Purpose Cleaner

Generally all purpose cleaners are made of surfactants, builders, water, colour, fragrance and chelating agents. Table 6.15 lists basic ingredients of all purpose cleaners.

Table 6.15 Ingredients of all purpose cleaner[185,186]

Sodium Hydroxide Butoxydiglycol	Butoxyethanol Isopropyl alcohol

6.4.7.2 Reactions of All Purpose Cleaner with Bottle Making Materials

Sodium Hydroxide, one of the main ingredients of all purpose cleaners, may react with glass. Apart from this, common glass does not react significantly with other ingredients of all purpose cleaners. Aluminium do not react notably with all purpose cleaner in normal temperature. But it may leach at high temperature. Likewise, PET plastic does not react with all purpose cleaner in normal temperature. Table 6.16 shows the points allocated to glass, Aluminium and PET plastic considering all the above mentioned aspects.

Table 6.16 : All purpose cleaner and three bottle making materials

	Glass	Aluminium	PET plastic
Reactions with All purpose cleaner	medium	moderate	mild
Points	50	60	80

6.4.8 Bleach

Ingredients of all bleach and their reactions with the three materials are discussed below:

6.4.8.1 Ingredients of Bleach

Generally bleach contains chlorine based cleaning agent, surfactants, soap and fragrance. A list of ingredients of bleach [187,188] is given in Table 6.17.

Table 6.17 : Ingredients of Bleach

Ingredient	Function
Sodium Hypochlorite	Oxidizing action kills microbes
SODIUM LAURYL ETHER SULPHATE	surfactant
SODIUM HYDROXIDE	
Lemonene (phenylbenzene)	

6.4.8.2 Reactions of Bleach with Bottle Making Materials

Glass reacts with Sodium Hypochlorite. It does not react significantly with other ingredients of bleach. Aluminium reacts with Sodium Hypochlorite. Its reactions with other ingredients of bleach are not significant. PET plastic normally does not react notably with bleach. Lemonene or Phynelbenzene is present in some bleaches and it reacts with PET plastics at high temperature. Generally thicker plastic bottles

are used for bleach due to this reason. The points allocated to glass, Aluminium and PET plastic based upon above information is listed in Table 6.18.

Table 6.18 : Bleach and three bottle making materials

	Glass	Aluminium	PET plastic
Reactions with Bleach	much	strong	mild
Points	40	30	80

6.4.9 Washing Up Liquid

Ingredients of washing up liquids and their reactions with the three materials are discussed below:

6.4.9.1 Ingredients of Washing Up Liquid

In general , washing up liquids consist of surfactants, soap, water and perfume. The label of Fariy washin up liquid lists the following as its ingredients:

15-30% Anionic surfactants
5-15% Nonionic surfactants
Perfume
Geraniol
Limonene

The other sources [189,190] provide the following compounds as ingredients of washing up liquid:

Hexylene Glycol
Sodium Lauryl Ether Sulphate
Cocomidopropyl Betaine
Sodium Laureth Sulfate
Sodium Chloride
Coconut Diethanolamide
Trideceth - 5
C10-16 Alkylamine oxide
Sodium Citrate
Parfum (Limonene)
Glycerol
Chloromethylisothiazolinone / Methylisothiazolinone
Colorant

6.4.9.2 Reactions of Washing Up Liquid with Bottle Making Materials

Glass does not react significantly with washing up liquids. In normal temperature, Aluminium does not react with washing up liquids. However, at high temperature it may leach. PET plastic does not react with washing up liquid in normal temperature.

Table 6.19 Washing up liquid and three bottle making materials

	Glass	Aluminium	PET plastic
Reactions with washing up liquids	nearly no	moderate	mild
Points	90	60	80

Nevertheless, if stored for long time, it may dissolve. Washing up liquids are not kept in store, so this factor might be neglected. Considering all these, points were allocated to glass, Aluminium and PET plastic as shown in Table 6.18.

6.5 Product Specific SMSB Index

Glass, Aluminium and PET plastic were given points according to their reaction or interaction with the selected nine products. Making an average with these point and product independent SMSB index, product specific SMSB index was created as shown in Table 6.20. The material that has higher points for a specific product is supposed to be more suitable for that product than lower points achieving materials.

Table 6.20 : SMSB index specific to products

	Glass	Aluminium	PET plastic
Mineral Water	57.93	65.12	75.75
Soft Drink	57.93	65.12	75.75
Perfume	57.93	62.63	70.75
Shampoo	50.43	60.13	75.75
Shower gel	57.93	65.12	75.75
Cooking Oil	57.93	65.12	75.75
All Purpose Cleaners	47.93	65.12	75.75
Bleach	45.43	57.63	75.75
Washing up liquids	57.93	65.12	75.75

6.7 Summary

The simple material selection for bottles index (SMSB) was developed considering some important factors. These factors were cost, shelf life, brittleness, weight, toxicity and recyclability. Therefore it could be said that this SMSB index combines environmental consideration with some factors affecting distribution and selling of products. In this study, SMSB index was made for three materials, i.e. glass, plastics and aluminium, separately. Product specific SMSB index were also made. The products, which were considered here, were the same products included in the second survey. Thus this index becomes the part of the intelligent design system to help designers with respect to aesthetics and environmental considerations.

Chapter Seven-Programming modules

7.0 Introduction

The objectives of this chapter are to:

- Describe the interface of the Intelligent Design System
- Describe the Aesthetics Advisor module
- Describe Material Index module
- Describe Golden Section ruler module

All the programming modules were developed in this study by using Microsoft Visual basic 6 ™ . The reason for choosing Visual Basic was its simplicity and possibility to link with AutoCAD ™ design software.

7.1 Interface of the Intelligent Design System

The interface of the intelligent design system works as a medium to launch other modules included in the system. The snapshot of the interface is shown in Fig 7.1.

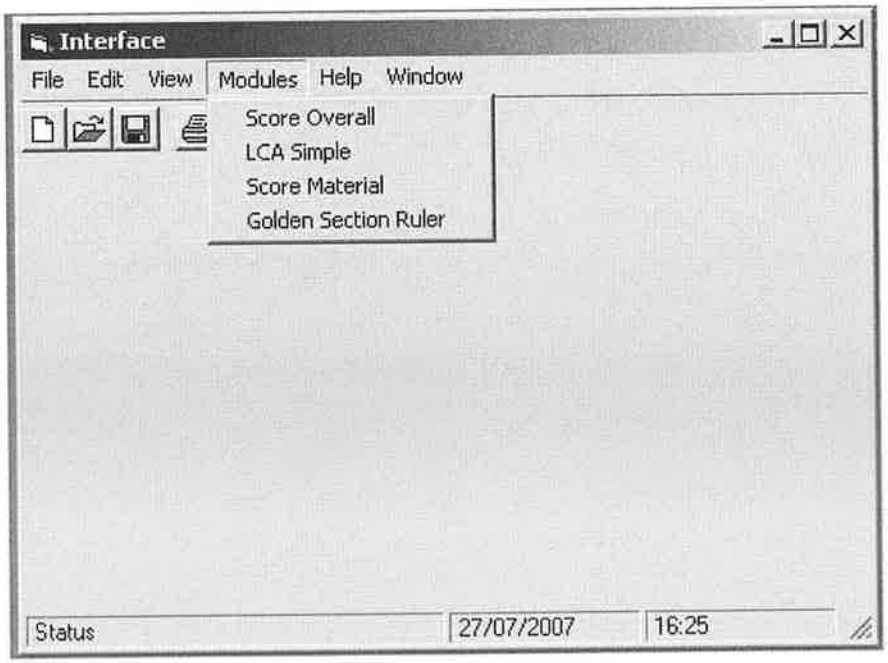

Figure 7.1 Interface of the intelligent design system

The interface contain the basic menu items provided in the most of the windows based application. It has the following menu items:

- File
- Edit
- View
- Modules
- Help
- Window

Modules menu works as a medium or connector to other modules provided in the system. When the user clicks on the *module* menu, the list of available modules come up.The user may select whichever he likes and the respective module window appears. The interface remains available on the background while the user works on the other modules.

7.2 Overall Score and Aesthetics Advisor module

The overall score and aesthetics advisor module was developed to help designers to design product with taking the consideration of aesthetics. A threshold value or minimum value was set by the author to provide a benchmark of the selection. In the following paragraphs, the scoring system and the module are described.

7.2.1 Scoring of Different Attributes in the Aesthetics Advisor Module

The scoring system was built upon the survey results and the other relevant sources of information. As a general principle, the score was allocated proportional to the survey result. For example, 40% people preferred blue colour for mineral water while 50% liked white. Since the scale for each parameter was chosen from 0 to 20, blue colour was given 8 points while white was given 10 points. At the overall output window, an average total score value is displayed. The threshold value was set as 3 for this total average score. Every attribute was also given a threshold value. The threshold value for individual attribute was set to 3. This threshold value signifies that significant preference has been obtained by the choice according to the survey.

7.2.2 Description of the Overall Score & Aesthetics Advisor Module

The snapshots of the Aesthetics advisor module are shown in Fig 7.2 to 7.14. This module comes up when clicked from the menu *modules* in the interface of the intelligent design system. In the front page of the Aesthetics Advisor module, there are two command buttons. At one instance, either of the two may be pressed. If products button is hit, another form with a list of products pops up. When a product is chosen, different forms containing relevant aesthetic attributes (e.g. size,shape, colour, cap, transparency, material, colour combination, handle etc).

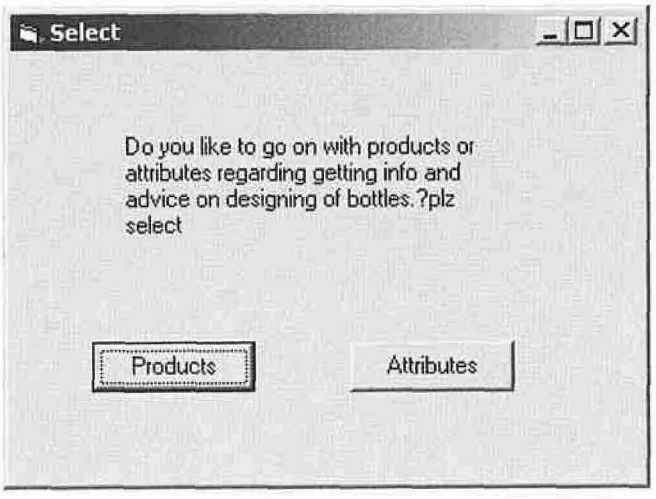

Figure 7.2 : Selection of products or attributes form

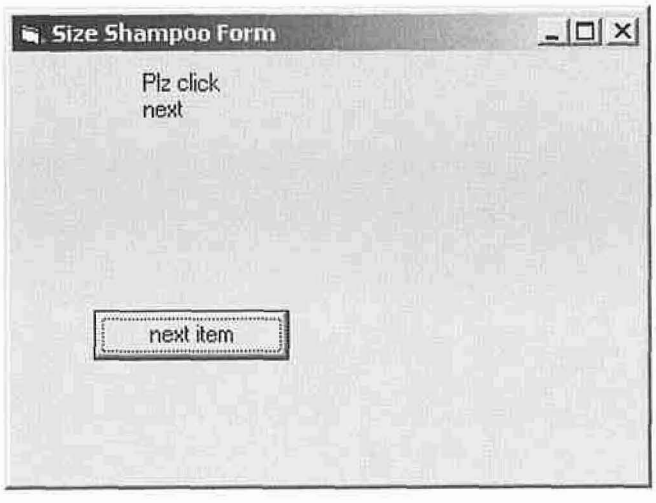

Figure 7.3 : Size form

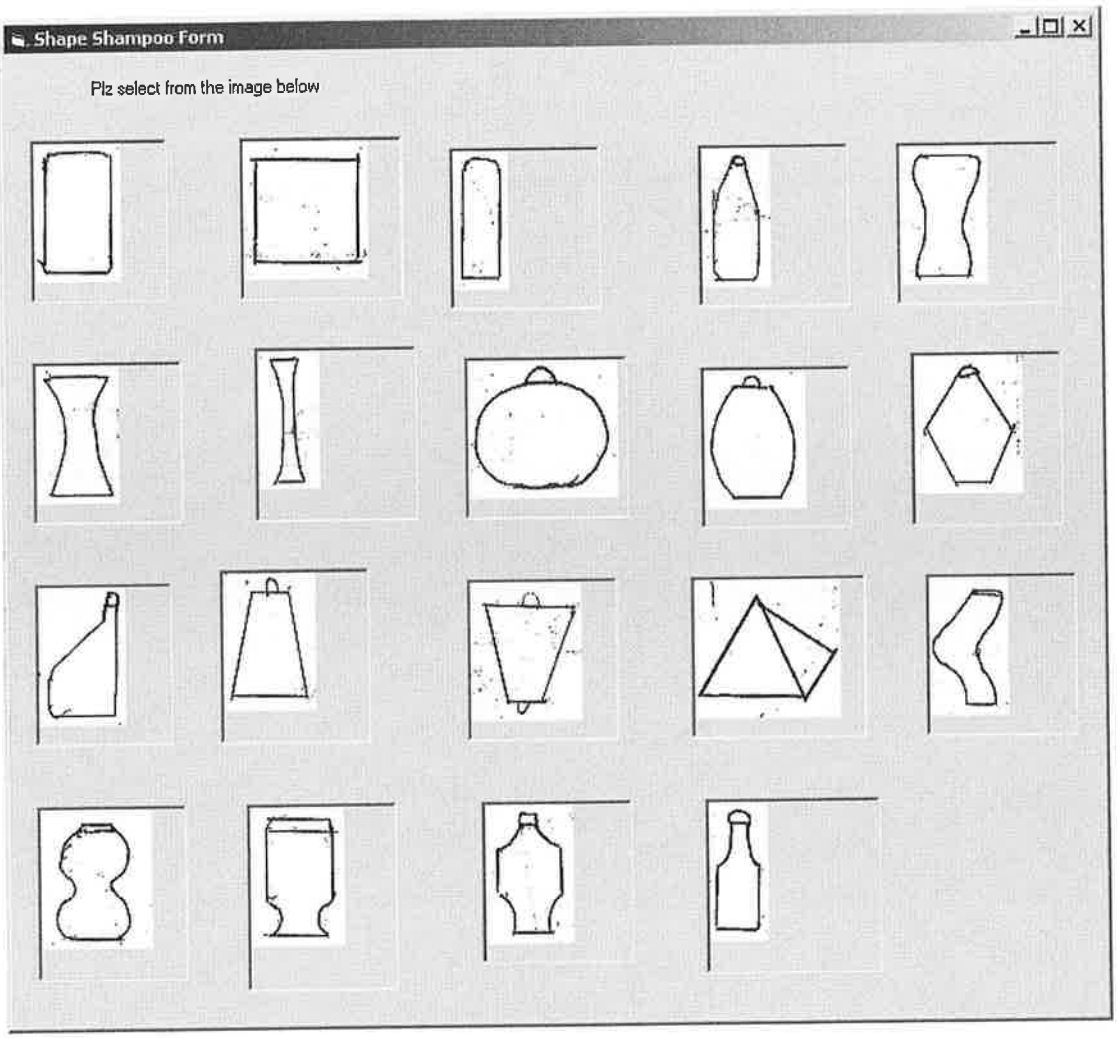

Figure 7.4: Shape selection form

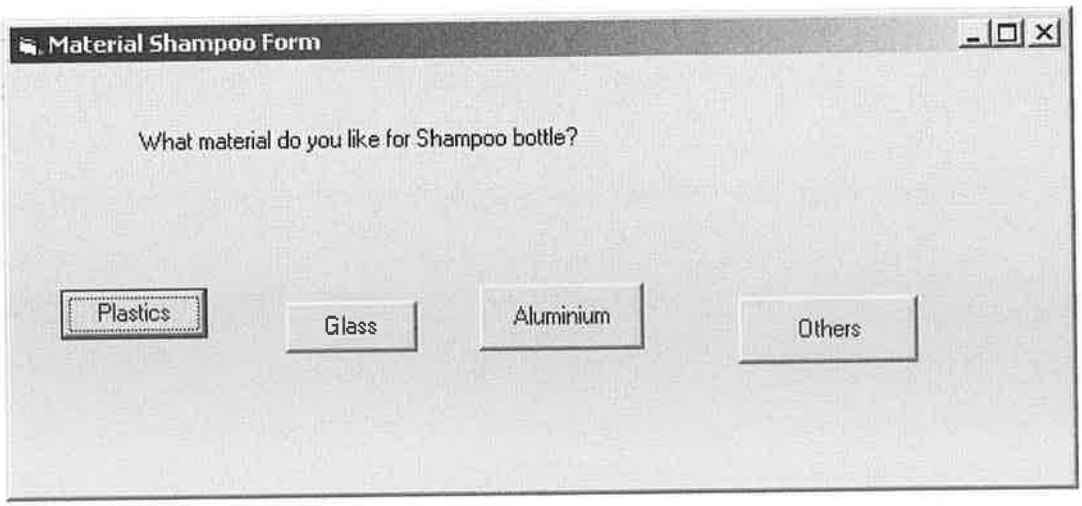

Figure 7.5 : Material selection form

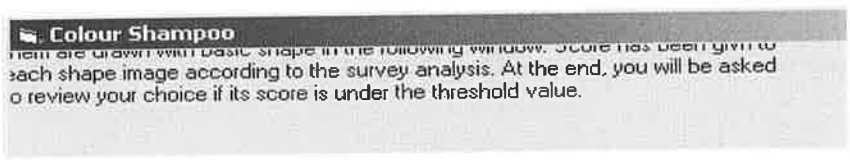

Figure 7.6 : Filler information in between the transition of two windows

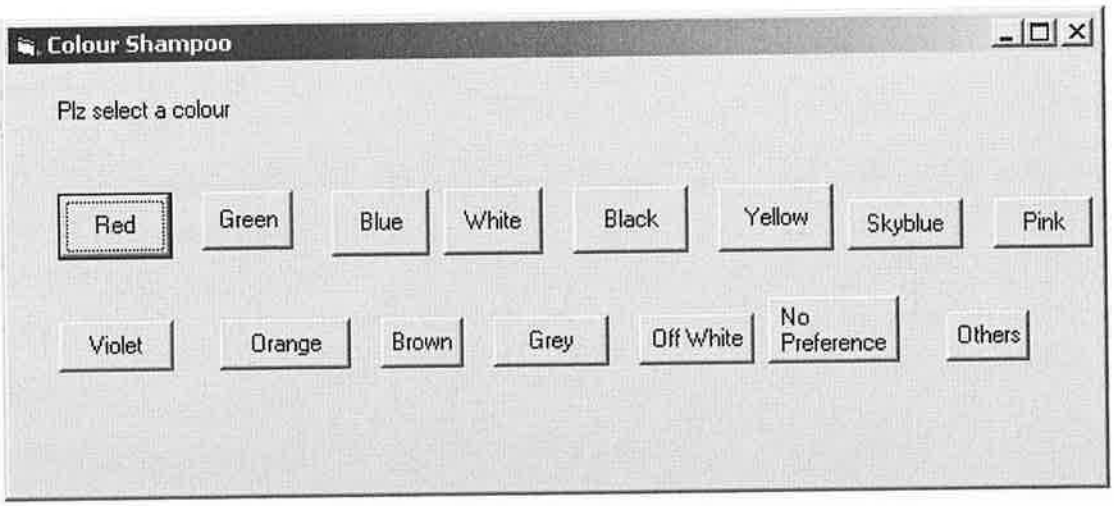

Figure 7.7 : Colour selection form

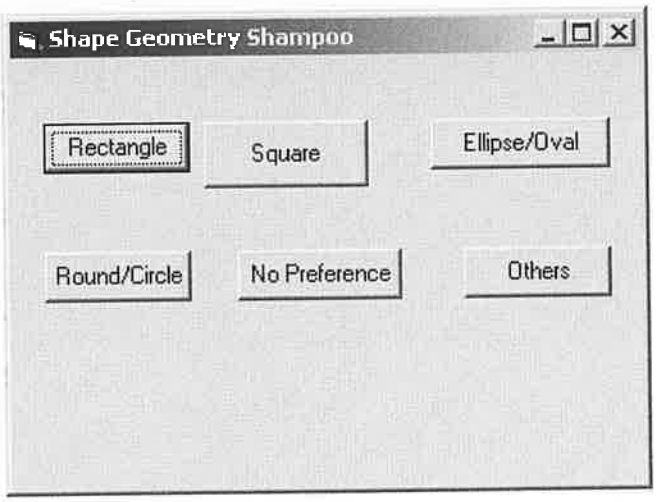

Figure 7.8 : Geometric shape selection form

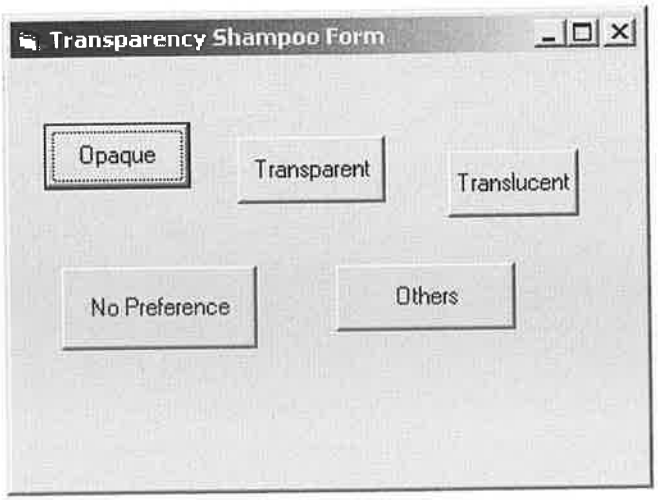

Figure 7.9 : Transparency options form

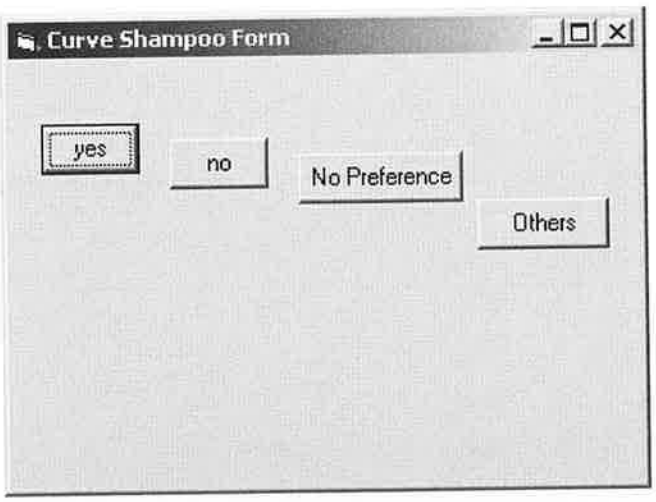

Figure 7.10: Curve form

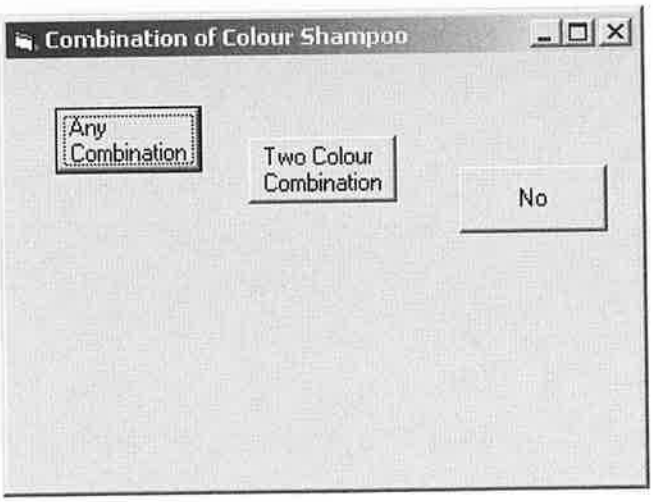

Figure 7.11: Combination of colour form

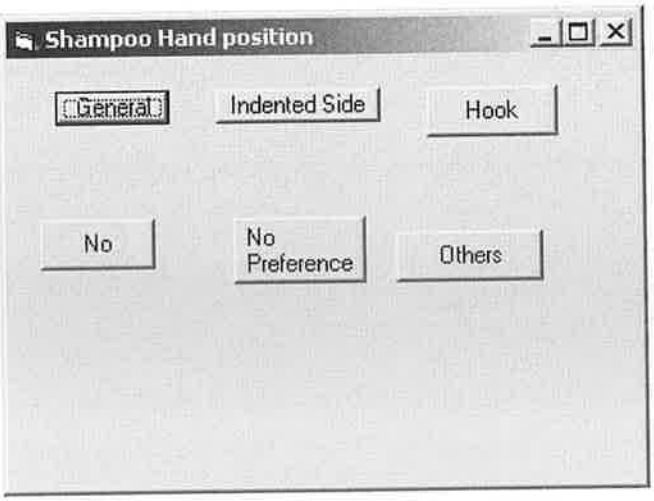

Figure 7.12: Hand-position and Indentation form

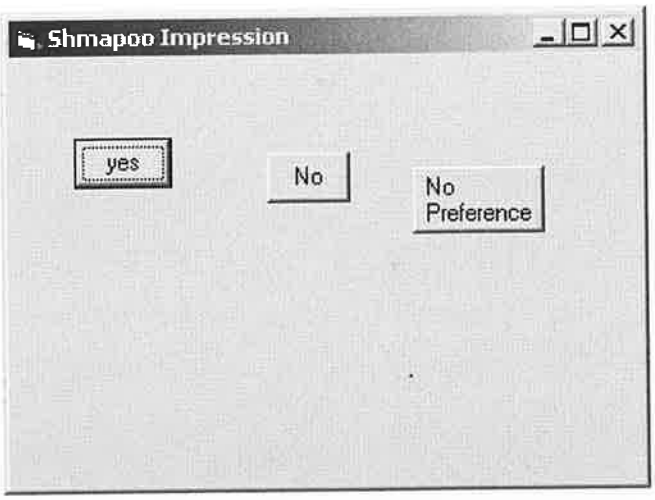

Figure 7.13: Impression form

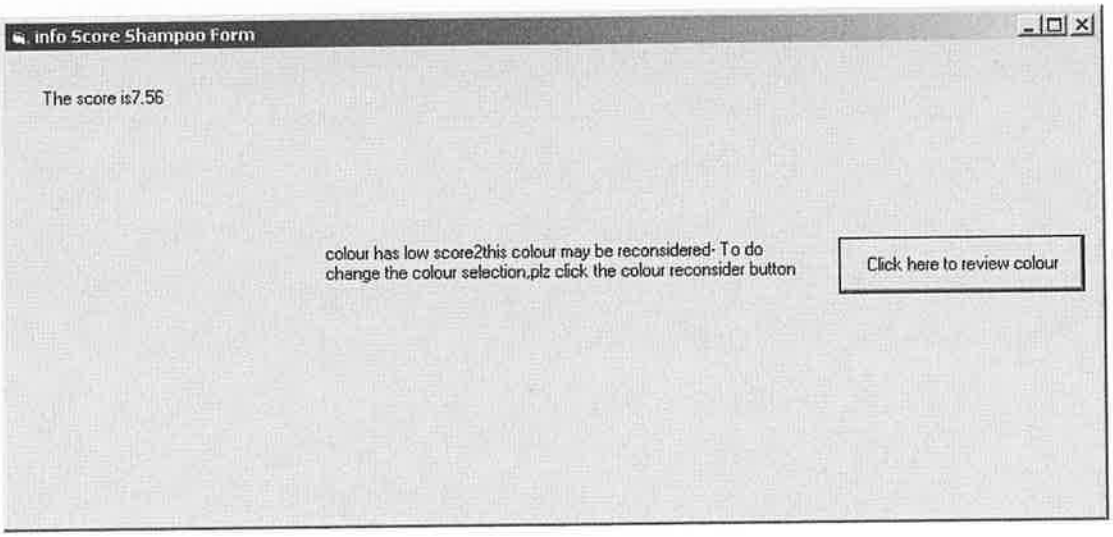

Figure 7.14: Final output screen

come up one after another. In between the transition of two forms, a filler window appears displaying information of the attribute coming in the next form and instruction regarding the next form. When the user goes through all available attributes in the module by selecting his choice, a total average score appears at the total score window at the end. If the score is less than the threshold value, the user will be asked to consider reviewing his choice. The user also gets reviewing option of the specific attribute if the user selection on that attribute falls below the threshold value set for the individual attribute. In the beginning, if the user selects attributes button , a form appears asking to select an attribute. When an attribute is pressed, another form appears. It shows general information regarding that attribute with respect of design of bottles. Also, it asks the user whether he wants to find out information and advice of a specific product bottle with respect to that attribute. If the user selects this option and hits the command button, a form appears with a list of

products' names. When a product's button is pressed, a form of that product appears. It asks the user to choose a option provided on the attribute selected at the beginning. For example, if the user selects colour attribute at the beginning and later mineral water, then a form that contains colour option's for mineral water bottles appears. Upon the selection of choice of that attribute, a score appears specific to that product. If the score for the selected is not greater than the threshold value, the user will be prompted to review his choice. Likewise the user could get judgement on his selection by way of the score for different attributes and different products.

7.3 Simple Life Cycle Analysis Module

With simple life cycle analysis module provided in the intelligent design system, the user could get a primary idea about the environmental impact from his selection of material, manufacturing procedure, transport and end of life cycle. Accordingly, the designer could modify his design. The arbitrary threshold value selection procedure and the description of this module are provided in the following paragraphs.

7.3.1 Threshold Eco Indicator Value Selection

To decide the threshold value for the specific product bottle's threshold value, the eco-indicator value for all the possible combinations were calculated. Among these, maximum and minimum values were located. In general, it was decided that the middle value from the maximum and minimum value would be the threshold value. Personal judgement was applied considering environment impact of different combinations of the life cycle of the specific product's bottle. Thus a threshold value was arbitrarily chosen for a specific product. In this selection, the criteria applied was that arbitrarily selected threshold value might be higher or lower than the middle value of the range but the difference o it from the middle value should not be much. . For example, in the case of mineral water bottle made of plastics, the highest and lowest eco indicator value was found 400 and 100. Here the middle value of the range was 250. The chosen arbitrary threshold value for this product was 300.

7.3.2 Description of the Simple Life Cycle Analysis Module

The snapshots of the Simple Life Cycle Analysis Module are shown in Fig 7.15 to 7.17. When the simple life cycle analysis module (LCA) is selected from the menu of the intelligent design system, the first form appears which ask the user to select the product. Upon selection of the product, the next form asks to select a material for this product from a list. When a material is selected, a list of variants of the selected

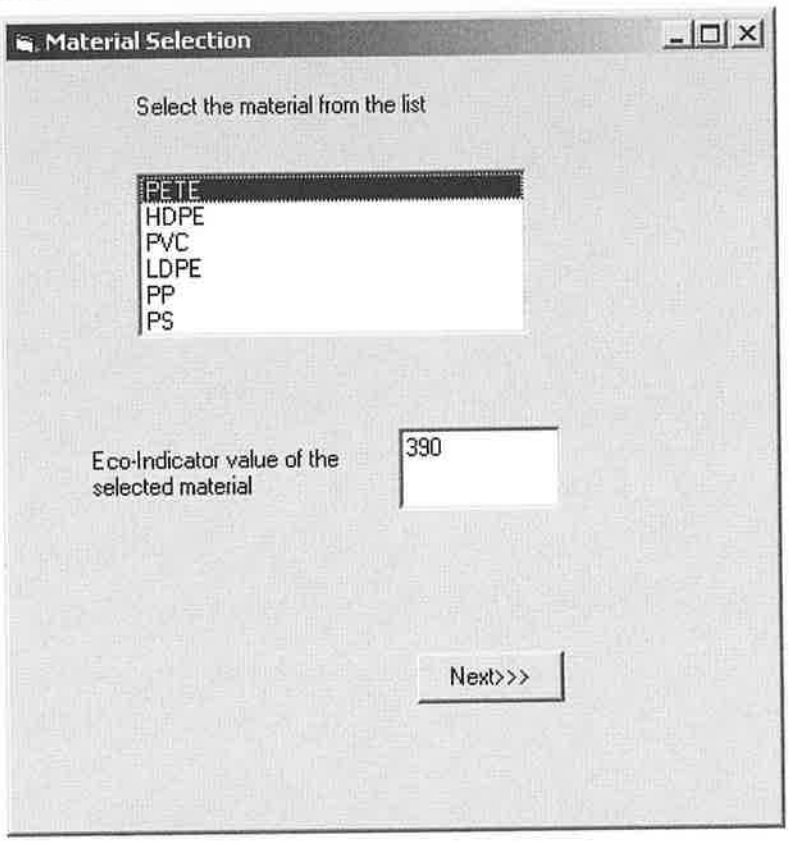

Figure 7.15 : Material selection window of the Simple LCA module

material for the particular product pops up. The user selects one type of the material and corresponding eco indicator value is displayed upon clicking the relevant command button. The next window appears which asks the user to select his choice on transport, manufacturing process and end of life for the product's bottle. Relevant eco indicator values appear as the user selects his options. On pressing the relevant button, the final score window shows up. It gives the total eco-indicator value for the selection of the user. If the total eco indicator value is smaller than the threshold value, the user is prompted to review his selection. . On that page, the user can see all

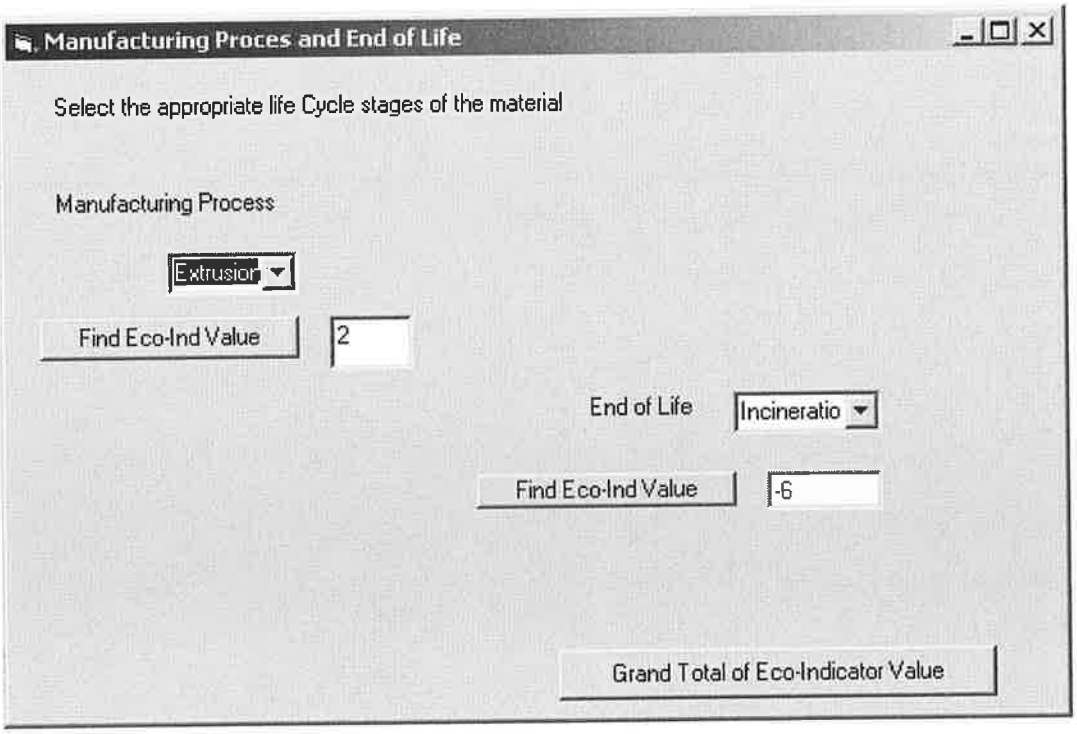

Figure 7.16 : Second form in the simple LCA module

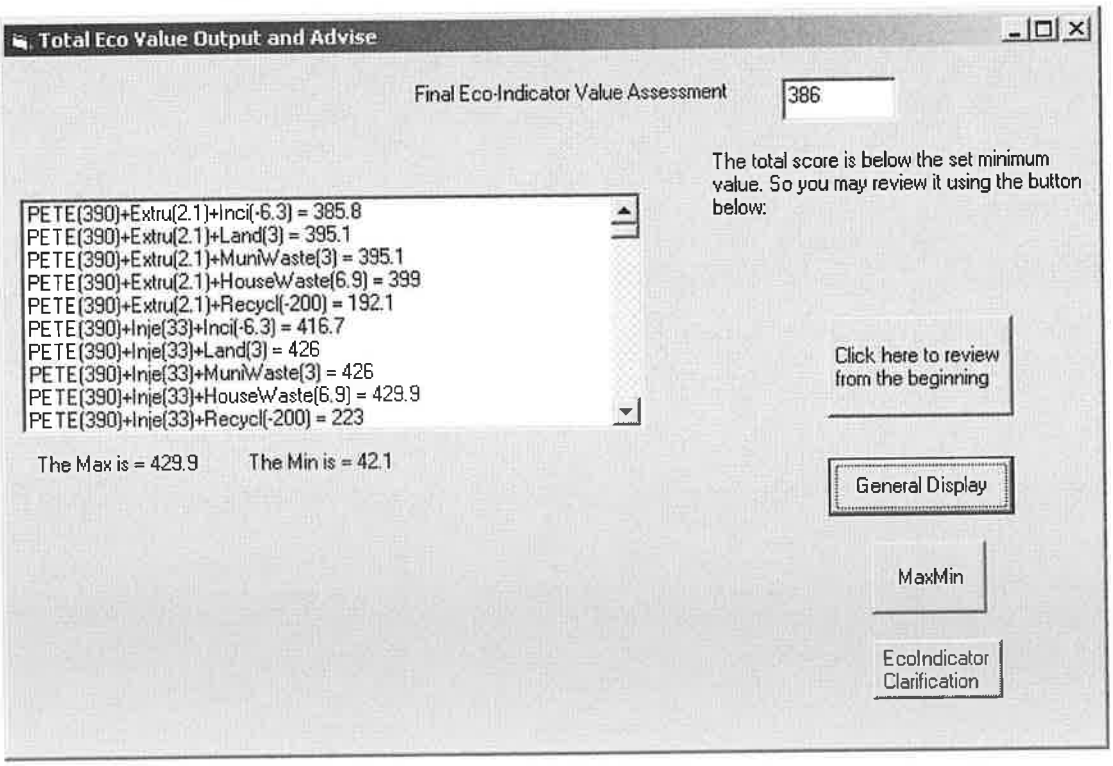

Figure 7.17 : Total eco indicator value and advise form in the simple LCA module

the combinations for different choices and maximum and minimum value among all the possible combinations. This may give useful insight to the designer to decide his options.

7.4 Simple Material Selection for Bottles Index Module

This Simple Material Selection for Bottles (SMSB) index module offers to provide a benchmark to designers on theirs selection of materials while designing a bottle for a specific product. The methodology used in this index was described in a previous chapter of this thesis. This index is arbitrarily made by the author considering some aspects including cost, shelf life, recycling, toxicity, strength by density ratio, and brittleness.

7.4.1 Threshold Value Selection for SMSB Index

The details about the selection of SMSB index were provided in a previous chapter. In the module, a threshold value was arbitrarily chosen by the author to provide a benchmark to designers. The threshold value was selected as 61 for the materials and products combination provided in the module. All the values for the different combinations between the materials and the products were calculated. As a general principle, the threshold value should be the middle value of the range. The maximum and minimum values were found to be 45.43 and 75.75 respectively. The exact middle value was 60.59. After rounding the decimal, 61 was chosen as the threshold value. In this module, only three products and three materials were considered. The products were mineral water, soft drink and perfume. The materials were glass, aluminium and plastics.

7.4.2 Description of the SMSB index module

Like other modules, this module is launched upon being selected from the menu in the interface of the intelligent design system. The first form asks the user to select a material and a product from the list and it shows corresponding SMSB value in the respective text boxes(Figure 7.18). Also, it shows the combined SMSB index for the selected material and the product. When clicked next, the final form appears. If SMSB index falls below the threshold value, the user is prompted to review his choice(Figure 7.19).

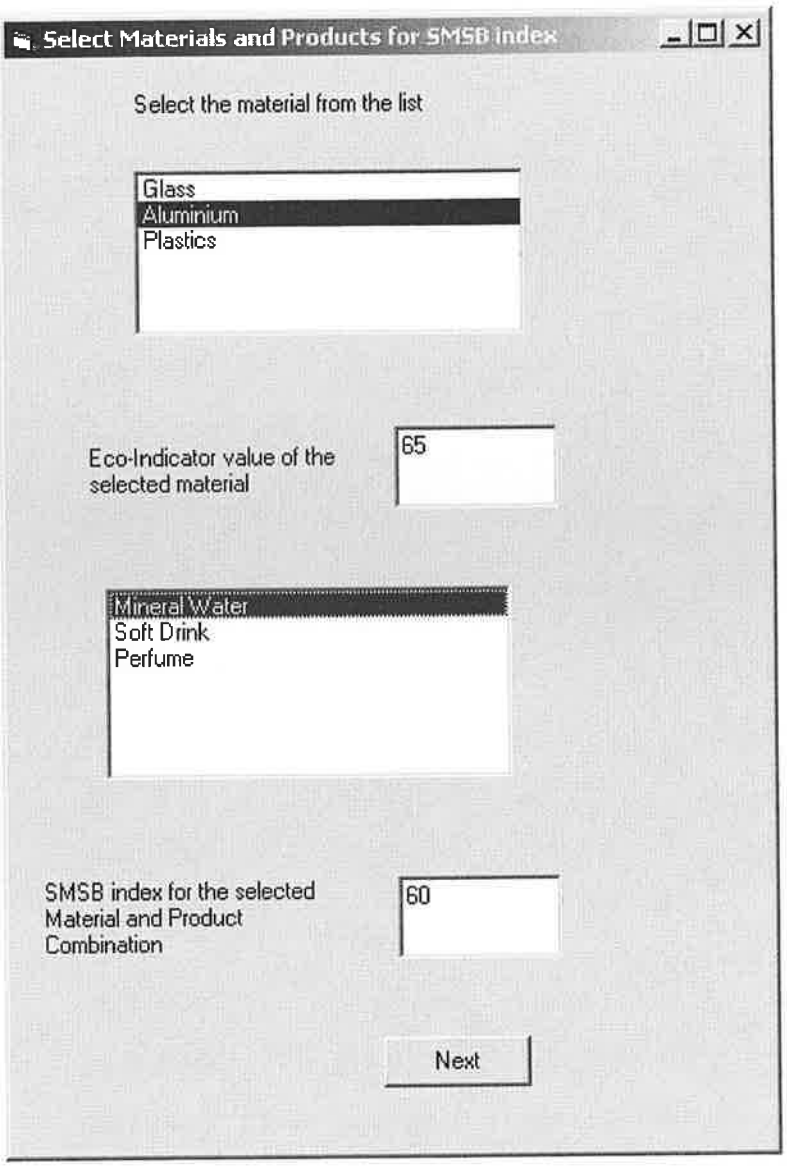

Figure 7.18 : SMSB index module's first form

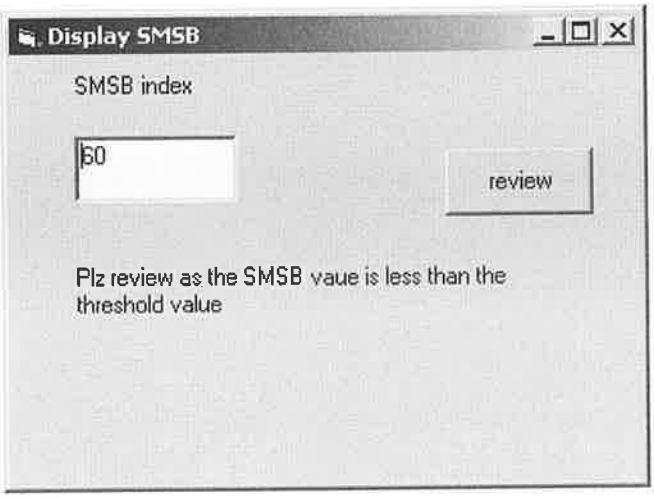

Figure 7.19 : SMSB index module's final form

7.5 Golden Section Ruler Module

The golden section ruler is an aid to the designer to see whether any design meet with the golden section ratio. It is mentioned in some literature that golden section ratio ensures aesthetically pleasant design. A description of the golden section literature was given in the literature review section at Chapter 2. This module is accessed from the interface of the intelligent design system. From its *modules* menu, when this golden section ruler module is pressed, a form shows up. It asks the user to press the command button to locate the image of the design(Figure 7.20). Upon clicking the command button, a small window comes up asking the user to specify

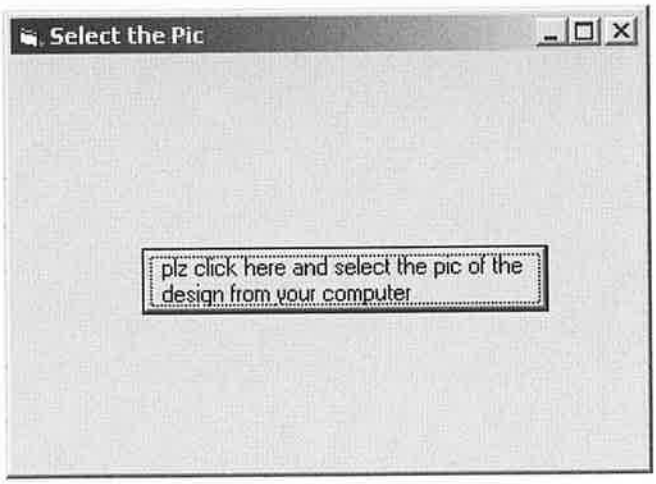

Figure 7.20 : First form in the Golden Section Ruler module

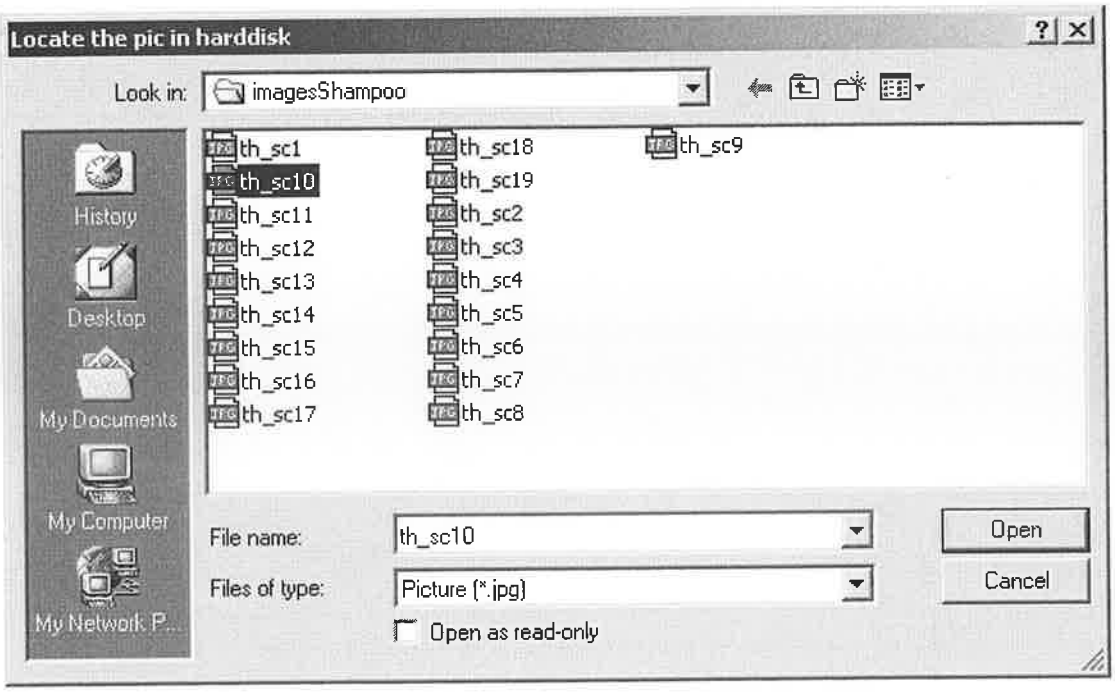

Figure 7.21 : Windows screen to locate the image of the design

the location of the image in the hard disk or any external drive (Figure 7.21). After the image is being located, it is loaded in the next form. Now the user first clicks a point inside the image what he wants to be the reference point for measuring golden section ratio (Figure 7.22). Then the user clicks two more points. These two points could not be the only the one side of the reference point. That is, if one point is on the top of the reference point, the other point should be in the bottom side of the

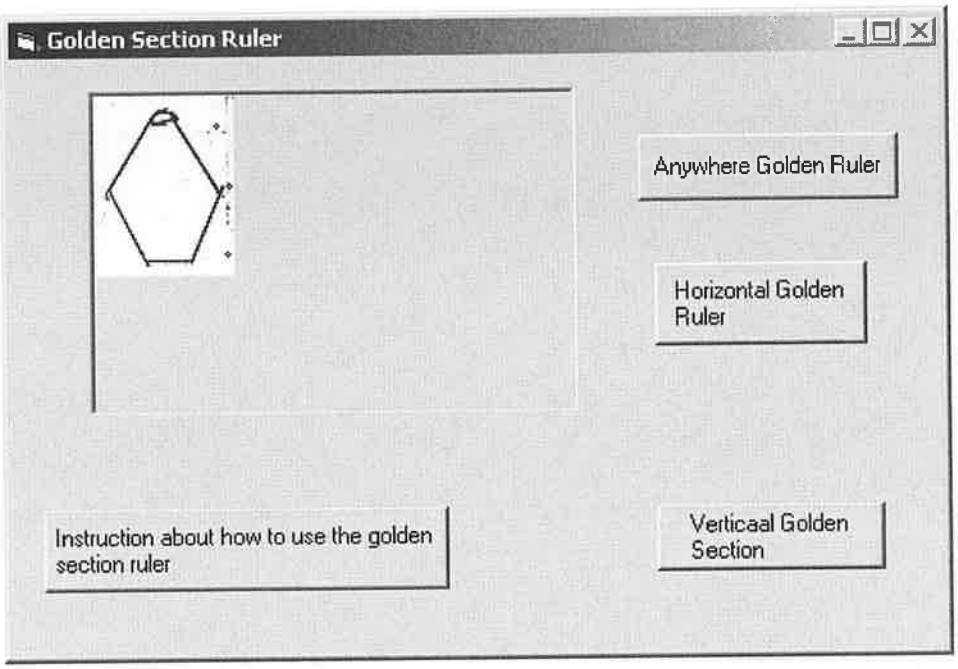

Figure 7.22: Points selection in the Golden Section Ruler

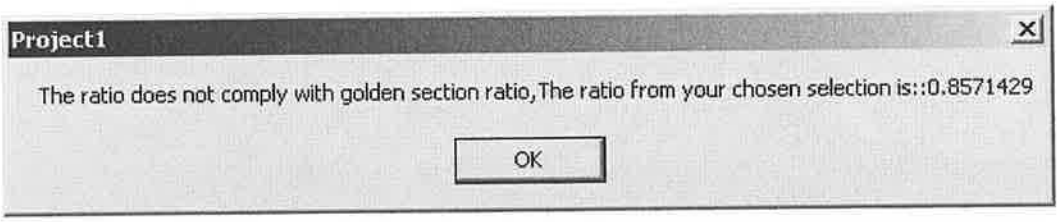

Figure 7.23: Message box informing about the golden section ratio of the selected points

reference point. This instruction could be invoked by clicking *instruction about how to use the golden section ruler* command button. When all the three points are selected, the user are provided with three options of measuring golden section ratio. He could use only one or two or all three option to verify whether the selected three points in the image meets the golden section ratio. When the user clicks on any of these command buttons, a message box appears stating whether the selection meets the golden section ratio (Figure 7.23). The user may checks golden section ratio of

different segments of the image of the design one after another in the same procedure mentioned above.

7.6 Summary

This chapter started with the introduction of the interface of the intelligent design system. The overall score and aesthetics advisor was then illustrated followed by simple life cycle analysis module. After that, the simple material selection index module was depicted. All these three modules have been assigned with the threshold value for their respective field by the author. Such threshold values would work as a benchmarks and help the designers to effectively and easily consider aesthetics and environmental aspect in their designs. At the end, the golden section module was presented. It provides instant notification about the golden section ratio for the selected section. In several literatures, it is mentioned that maintaining golden ratio in design improves acceptability in terms of aesthetics. It is hoped that all these modules in general will be a simple and useful aids to designers for considering aesthetics and environmental factors in design of bottles or containers.

Chapter Eight- Conclusions

8.0 Introduction

The objectives of this chapter are to:

- Summarise the research work performed.
- Present final conclusion from the research work done.
- Provide some suggestions for future work.

8.1 Conclusions of the thesis

This research work was intended to develop an intelligent designs system incorporating consideration for aesthetics and environment.

An extensive literature survey was carried out at the start of this research. It has been found that designers have difficulty in considering aesthetical attributes due to its subjective nature. Different viewpoints of a single aesthetical attribute have been found. But practically it is almost impossible to produce many variations of a single product to cater the demand of the diverse segments of customers. Therefore it is imperative to find out a general guideline for aesthetical attributes liked by the majority of consumers. However, it is not feasible at the present state of knowledge to provide a generic guideline for all consumer products, as there have not been much research works done and tools devised in the field of design for aesthetics. So some consumer products were selected for this study. The other main focus of the present research was design for environment. Many research works have been going out at the different branches of this field. Though an integrated system that would help designers on considering both environmental and aesthetical aspects has not been fully explored. So it appeared to be a novel approach of research to integrate both of these in a single stand alone intelligent design system.

After investigating different research methods relating to the objectives of the present research, a methodology was chosen. Conducting survey, analysis the data and incorporate the finding into an easy to use computer based module was appeared to be the appropriate methodology to fulfil the objective of the project

Considering different factors of the present study, specific statistical methods and analysis techniques were selected. The survey was chosen to be the medium to collect information. Both online and postal surveys were found to be suitable for this study. For analysis of the data, frequency distribution, cross tabulation and chi-square test were selected.

The first survey was carried out among Dublin City University students and staff. It was an online survey. It was successful and provided valuable information for building the guideline on aesthetic aspects of mineral water and soft drink bottles.
The second survey was conducted among the residents of Dublin city and its suburb. The prime method of survey was postal questionnaire. Online survey method was also used here as a secondary tool. Before conducting the original survey, a pilot survey was commissioned. The findings from these two surveys were used to develop the modules for the intelligent design system.

The simple material selection for bottles index (SMSB) was created to help designers to get an overview of the impact of their selection of materials towards environment as well as some distribution and retailing issues like transport, cost, shelf life. The SMSB index was created for three materials in this study and considering the products included in the surveys. Further materials and products may be included following the same procedure.

The intelligent design system module is made up of four modules:

- Overall Score and Aesthetics Advisor
- Simple life cycle analysis
- Simple material selection for bottles index
- Golden section ruler

All these modules are accessed from the interface of the intelligent design system. The author made arbitrary threshold values for the three modules. The golden section

ratio already exists. All the modules were illustrated with snapshots. It is hoped that these module will give a new easily accessible and fast solution for designers to consider aesthetics and environmental factors related to the bottle's design.

8.2 Thesis contributions

The contributions of this research work may be summarised as:

- Developing an intelligent design system that would incorporate consideration for factors related to aesthetic and environment is a novel idea. It's a simple, easy to system that will enhance the designer's ability to design considering subjective factor like aesthetics and environmental impact.
- The surveys conducted to acquire information regarding public views on aesthetic attributes of some consumer products helped to get an overview of the people's preference of the aesthetical aspects of a product's bottle design. It is emerged that the average preference on any aesthetical attribute differs with respect to different products. It is difficult to make a generalisation of people's average liking for a specific attribute for all products as a whole. Within a specific product, though it is possible to find out the general trend, i.e. liking of attribute by the majority, using surveys and statistical analysis.

8.3 Suggestions for Future Work

The suggestions for the future work extendible from the present research work described in this thesis are as follows:

- The survey regarding public opinion about aesthetical aspects of a specific consumer product should be conducted on a large scale covering all segments of the society or the country or all targeted consumers. Then it will enable designers to understand almost all kind of thoughts regarding aesthetical attributes of a specific product.
- Though it is rather daunting, research initiatives might be taken to formulate some generic rules or guidelines regarding aesthetical attributes that will be applicable to most of the consumer products. For instance, colour or shape liked by the majority in general in different consumer products. In a smaller scale, general guidelines on aesthetic attributes of targeted groups of products may be developed.

- Technology, customer demand, taste etc. have been changing rapidly. So different parameters used in the intelligent design system are required to be updated from time to time.
- Some new concepts of evaluating design like socio-economic impact may be integrated into the design system.
- Finally, it would be beneficial for designers to have every design tool available in a single package. So further research projects may be taken to integrate the intelligent design system developed in this work and other design tools in a single package.

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Appendix A1

Aesthetics in Soft Drink & Mineral Water Bottle
--Questionnaire--

This questionnaire is designed for you to indicate your personal preferences for the product, in this case specifically for soft drink(cola plus lemon-lime drink, juice, energy drink etc) & mineral water bottle, in terms of aesthetical and environmental perspectives. Your response will be used in research currently undergoing in Dublin City University namely 'An Intelligent Computer-aided Design System incorporating consideration for Aesthetics & Environment'. Therefore, it would be highly appreciated and gratefully acknowledged if you could kindly offer some of your precious time to fill out the questionnaire as thoughtfully and frankly as possible.

Please be assured that any information you give will be only used for the above mentioned research purpose. At the end of the questionnaire, we ask for some personal details but those are optional. Yet again, if given, your personal details will be treated with strict confidentiality and will not be supplied to any third party.

Please indicate your response by ticking the appropriate alternative and where required, the relevant information.

1. What shape do you like for the bottle? (please check one)
 Rectangle
 Square
 Ellipse
 Round [Circle]
 Oval
 others (please specify)

2. What special shape attribute do you like irrespective of basic shape? (please check one)
 Curved surface
 Smooth finishing
 Gradual changeover in the surface
 others (please specify)

3. What colour do you like for the bottle? (please check one)
 Red
 Green
 Blue
 White
 Black
 Yellow
 Sky blue/ Turquoise
 Pink
 Violet
 others (please specify)

4. Do you prefer combination of colour? (please check one)
No
Two Colour
Three colour
Any combination
others (please specify)

5. What size do you prefer for the bottle? (please check one)
Small
Medium
Large
others (please specify)

6. Do you have strong liking for any specific material? (please check one)
No
Yes (please mention the name of the material here)

7. Would you pay a bit more for environmentally efficient product? (please check one)
yes
No
others (please specify)

8. What is your preferred weight for the bottle?(please check one)
Light
Medium
Heavy
others (please specify)

9. What is your preference on transpareny of the bottle?(please check one)
Opaque
Transparent
Translucent
others (please specify)

10. What type of cap do you like?(please check one)
Conventional round cap
Sport cap [Pneumatic cap- while drinking, it's pulled up and at closing pushed down]
others (please specify)

Personal Information

11. Gender (please check one)
Female
Male

12. Age group (please check one)
Under 14
14-20 years

21-25 years
26-30 years
31-35 years
36-40 years
41-45 years
46-50 years
51-55 years
56-60 years
Over 60 years

13. Education (please check one)
Primary
Secondary
Third level
Masters
PhD
others (please specify)

14. Occupation (please check one)
Student
Government service holder
Job in private company,org, institute etc.
Business
Agriculture and/or Dairy
Academician
others (please specify)

15. Income Level (please check one)
Below €10,000 euro per annum
€10,000 to €15,000 euro per annum
€15,001 to €20,000 euro per annum
€20,001 to €25,000 euro per annum
€25,001 to €30,000 euro per annum
€30,001 to €35,000 euro per annum
€35,001 to €40,000 euro per annum
€40,001 to €45,000 euro per annum
€45,001 to €50,000 euro per annum
€50,001 to €55,000 euro per annum
€55,001 to €60,000 euro per annum
Above €60,000 euro per annum

Optional Personal Information

16.Name [optional]:
17.Mailing Address [optional]:
18.Telephone [optional]:
19.Fax [optional]:
20.E-mail [optional]:
Please hit Submit button below to send the Questionnaire.
Thanks a Million for Your Time and Kindly Filling Out the Questionnaire!!!!

From: "Abu Raihan Rashid" <abu.rashid2@mail.dcu.ie>
To: "Michael Moriarty" <sueducation@dcu.ie>
Subject: posting req-- online research survey
Date: 04 March 2003 11:34

Appendix A2

Hi:

I am a postgraduate research student in the school of mechanical and manufacturing engineering at Dublin City University. I am currently researching the area of Aesthetics and Environmental considerations in the design of consumer products. The overall goal of this research is to build an intelligent design system which will advise designers on such matters.

As to that research, I am currently doing a survey on the aesthetics of bottles used in Mineral water, soft drink, cooking oil etc. An online questionnaire form has been uploaded at:
http://student.dcu.ie/~rashida2/surveydcu.html

Therefore, it would be highly appreciated if you kindly let my e-mail[that e-mail follows this one] through the allstudents and all staff mailing list of DCU and help me to reach maximum number of DCU students and staffs with the request to fill out the questionnaire.

Best regards,
Rashid
-------my mail requested to be posted follows------
Sub: Aesthetics in Bottle--research survey
Hi All:

Please take a moment to fill out the online questionnaire about aesthetics in Product, in this case on bottles used in softdrink(e.g. cola plus lemon-lime drink, juice, energy drink) & mineral water at:
http://student.dcu.ie/~rashida2/surveydcu.html

Now a brief note about my research-it's on the area of Aesthetics and Environmental considerations in the design of consumer products.
Best regards,
Rashid

Abu Raihan Md. Harunur Rashid
Postgraduate Research Student
School of Mechanical and Manufacturing Engineering
Dublin City University[DCU]
Dublin 9
Republic of Ireland
Tel:+353-1-7005749[office]
Mobile:+353-(0)85-7203259
Fax:+353-1-7005345
E-mail: abu.rashid2@mail.dcu.ie
web: http://www.dcu.ie/mechanical/plist.html

E-mail sent to Allstudents list in DCU by the Students Union

From: "Michael Moriarty" <sueducation@dcu.ie>
To: <allstudents@list.dcu.ie>; <sueducation@dcu.ie>
Subject: [Allstudents] Notice from the Chaplaincy, Motown evening, Surveys and other notices
Date: 04 March 2003 13:11

Ash Wednesday in the Chaplaincy
Hi everyone,

Next Wednesday, 5th of March, is Ash Wednesday, first day of Lent and day of fast and abstinence.
-----Truncated----

Aesthetics in Bottle--research survey
Hi All:

Please take a moment to fill out the online questionnaire about aesthetics in Product, in this case on bottles used in softdrink(e.g.cola plus lemon-lime drink, juice, energy drink) & mineral water at:
http://student.dcu.ie/~rashida2/surveydcu.html

Now a brief note about my research-it's on the area of Aesthetics and Environmental considerations in the design of consumer products.

Best regards,
Rashid

--

E-mail sent to DCU staff Mailing list

Sent: Thursday, March 06, 2003
Subject: Re: [Dcustaff] [Allstaff] Research Survey - Product Aesthetics

Hello

I would be very grateful if you could take the time to fill in the online questionnaire at:
http://student.dcu.ie/~rashida2/surveydcu.html

I am currently carrying out a research project concerned with integrating aesthetic design considerations with CAD (computer aided design). I am a postgraduate research student in the school of mechanical and manufacturing engineering at DCU.

As part of my research I have designed an online questionnaire to determine what aesthetic qualities consumers like about certain products. I am currently examining the qualities of a plastic soft drink bottle.

Thank you for taking the time to support my research.

Regards
Rashid

~~~~~~

Abu Raihan Md. Harunur Rashid
Postgraduate Research Student
School of Mechanical and Manufacturing Engineering
Dublin City University[DCU]
Dublin 9
Republic of Ireland
Tel:+353-1-7005749[office]
Fax:+353-1-7005345
E-mail: abu.rashid2@mail.dcu.ie
~~~~~~

3 December 2005

Appendix B1

Dear Sir or Madam:

Sub: Request to fill out a research survey form regarding aesthetic aspects of bottles

I am a Ph.D. research student in the School of Mechanical and Manufacturing Engineering at Dublin City University. I am currently researching in the area of Aesthetics and Environmental considerations in the design of consumer products under the supervision of Prof. Saleem Hashmi and Dr. Bryan MacDonald. The overall goal of this research is to build an intelligent design system, which will advise designers on such matters.

Please find attached a survey questionnaire, which seeks your opinion about aesthetic aspects of the following bottles/containers- mineral water bottles, soft drink bottles, perfume bottles, shampoo/conditioner bottles, shower gel containers, washing up liquid containers, all purpose cleaner bottles, toilet bleach containers, and cooking oil bottles. A couple of photos and diagrams that may be of help in depicting some features of bottles are provided in the attached sheets. This survey is an important part of my ongoing research and I'll be much obliged if you could spare some of your valuable time on filling out this questionnaire as thoughtfully and frankly as possible. Please be noted any member of your family (e.g. spouse, teenage or adult children, siblings, parents) living in your household could fill in the questionnaire. Having filled out the questionnaire, ***please post it back with the Freepost envelope provided (no stamp is required).***

If you prefer you may fill in the survey form online at:
http://www.survey5.tk

At the end of the questionnaire, some personal details are asked but those are optional. Yet again, if given, your personal details will be treated with strict confidentiality and will not be supplied to any third party.

Thanks a million for reading this mail and filling out the survey form-- your help in my research is gratefully acknowledged!!

Best regards,

Rashid

Abu Raihan Rashid
Postgraduate Research Student
School of Mechanical and Manufacturing Engineering
Dublin City University [DCU]
Dublin 9, Republic of Ireland
Tel:+353-1-7005749[office]
Mobile:+353-(0)85-7203259
Fax:+353-1-7005345
E-mail: abu.rashid2@mail.dcu.ie
web: http://www.dcu.ie/mechanical_engineering/index.shtml

Appendix B2

Questionnaire about your opinion on aesthetic aspects of BOTTLES/Containers

Perfume Bottles/Containers

1. What shape do you like for the perfume bottle/container?
Please number the shapes provided in the attached sheets according to your choice, i.e. write down 1 on the shape you like most, then 2 on your second choice and so on. Besides if you prefer any other shape than those mentioned there, please give a description or brand name or you may draw the shape with a mention of its order in your preference, e.g. suppose you like hexagon shaped container and put it down as your third (3) preference.

2. Do you like curvy section or gradual changeover in the bottle/container?

	Men's Perfume/After-Shave	Women's Perfume
a) Yes		
b) No		
c) No Preference		
d) If anything else please write down (i.e. you may mention the brand name)		

3. What colour do you like for the bottle or the perfume inside the container, e.g. the container is transparent and the perfume's colour is red, thus the container appears red?

	Men's Perfume/ After-Shave	Women's Perfume
a) Red		
b) Green		
c) Blue		
d) White		
e) Black		
f) Yellow		
g) Sky Blue		
h) Pink		
i) Violet		
j) Orange		
k) Brown		
l) Grey		
m) Off-white		
n) No Preference		
o) Others, please write down (i.e. you may mention the brand name)		

4. Do you prefer combination of colour?

	Men's Perfume/ After-shave	Women's Perfume
a) No		
b) Two colour		
c) Three colour		
d) Any combination		
k) Others please write down (i.e. you may mention the brand name)		

5. What is your preference on transparency of the bottle?

	Men's Perfume/After shave	Women's Perfume
a) Opaque		
b) Transparent		
c) Translucent		
d) No Preference		
e) Others, please write down (i.e. you may mention the brand name)		

6. Do you like any kind of impression on the bottle surface, e.g. impression of different leaves etc.? (Please see the attached reference sheets)

	Men's Perfume/After-shave	Women's Perfume
a) Yes If yes, please describe it briefly		
b) No		
c) No Preference		

7. Do you have strong liking for any specific material to be used in the bottle (e.g. glass, plastic, Aluminium etc.)

	Men's Perfume/After-shave	Women's Perfume
a) No		
b) Yes, please mention the name of the material here		

8. Would you be willing to pay a bit more for an environmentally efficient product?

	Men's Perfume/After-shave	Women's Perfume
a) Yes		
b) No		

9. What type of opening/spray system do you like? (Please see the attached reference sheets)

	Men's Perfume/After-shave	Women's Perfume
a) Pump/trigger		
b) Opening/orifice		
c) No Preference		
d) Others, please write down (i.e. you may mention the brand name)		

10. What size of the bottle do you usually buy?

	Men's Perfume/After-shave	Women's Perfume
a) 30 ml or smaller		
b) 31ml to 50 ml		
c) 51ml to 75 ml		
d) 76 ml to100 ml		
e) 101ml to 125 ml		
f) 126ml to 200 ml		
g) Others, please write down here		

11. Do you like specific colour scheme, e.g. changing intensity of the strength of the color?

	Men's Perfume/After-shave	Women's Perfume
a) Yes If yes, please describe it briefly (e.g. brand name)		
b) No		
c) No Preference		

12. Do you put strong emphasis on the design of cap/ lid of the bottle/container?
a) No
b) Yes. If yes, you may write down a few lines about your liking here:
.....
.....
..

Soft Drink and Mineral Water Bottles

13. What shape do you like for the bottle?
Please number the shapes provided in the attached sheets according to your choice, i.e. write down 1 on the shape you like most, then 2 on your second choice and so on. Besides if you prefer any other shape than those mentioned there, please give a description or brand name or you may draw the shape with a mention of its order in your preference.
.....
.....

.....
...

14. Do you like curvy section or gradual changeover in the bottle/container?

	Soft Drink	Mineral Water	
		500 ml	1 to 1.5 litres
a) Yes			
b) No			
c) No Preference			
d) If anything else please write down (i.e. you may mention the brand name)			

15. What is your preference on transparency of the bottle?

	Soft Drink	Mineral Water Bottle	
		500 ml	1 to 1.5 litres
a) Opaque			
b) Transparent			
c) Translucent			
d) No Preference			
e) Others, please write down (i.e. you may mention the brand name)			

16. What colour do you like for the product?

	Soft Drink	Mineral Water	
		500 ml	1 to 1.5 litres
a) Red			
b) Green			
c) Blue			
d) White			
e) Black			
f) Yellow			
g) Sky Blue			
h) Pink			
i) Violet			
j) Orange			
k) Brown			
l) Grey			
m) Off-white			
n) No Preference			
o) Others, please write down (i.e. you may mention the brand name)			

17. Do you prefer combination of colour?

	Soft Drink	Mineral Water	
		500 ml	1 to 1.5 litres
a) No			
b) Two colour			
c) Three colour			
d) Any combination			
k) Others, please write down (i.e. you may mention the brand name)			

18. Do you like any kind of impression on the bottle surface, e.g. impression of different leaves etc.? (Please see the attached reference sheets)

	Soft Drink	Mineral Water	
		500 ml	1 to 1.5 litres
a) Yes If yes, please describe it briefly			
b) No			
c) No Preference			

19. Do you have strong liking for any specific material to be used in the bottle (e.g. glass, plastic, Aluminium etc.)?

	Soft Drink	Mineral Water	
		500ml	1 to 1.5 litres
a) No			
b) Yes, please mention the name of the material here			

20. Would you be willing to pay a bit more for an environmentally efficient product?

	Soft Drink	Mineral Water	
		500 ml	1 to 1.5 litres
a) Yes			
b) No			

21. What type of cap do you like? (Please see the attached reference sheets)

	Soft Drink	Mineral Water	
		500 ml	1 to 1.5 litres
a) Conventional			
b) Sports cap			
c) No Preference			
d) e) Others, please			

write down (i.e. you may mention the brand name)			

22. What size of the bottle do you usually buy?

	Soft Drink	Mineral Water
a) 500 ml		
b) 1 litre		
c) 1.5 litres		
d) 2 litres		
e) No Preference		
g) Others, please write down here		

23. Do you like specific colour scheme, e.g. changing intensity of the strength of the colour?

	Soft Drink	Mineral Water	
		500ml	1 to 1.5 litres
a) Yes If yes, please describe it briefly			
b) No			
c) No Preference			

Cooking Oil, Washing up liquid, All Purpose Cleaner and Bleach Bottles/Containers

24. What shape do you like for the bottle?
Please number the shapes provided in the attached sheets according to your choice, i.e. put down 1 on the shape you like most, then 2 on your second choice. Besides if you prefer any other shape than those mentioned there, please give a description or brand name or you may draw the shape with a mention of its order in your preference.

.....

.....

..

25. Do you like curvy section or gradual changeover in the bottle/container?

	Cooking Oil		Washing up	All Purpose	Toilet Bleach
	1 litre	2 litres			
a) Yes					
b) No					
c) No Preference					
d) If anything else please write down (i.e. you may mention the brand name)					

26. Would you be willing to pay a bit more for an environmentally efficient product?

	Cooking Oil		Washing up	All Purpose	Toilet Bleach
	1 litre	2 litres			
a) Yes					
b) No					

27. Do you like any kind of impression on the bottle surface, e.g. impression of different leaves etc.? (Please see the attached reference sheets)

	Cooking Oil		Washing up	All Purpose	Toilet Bleach
	1 litre	2 litres			
a) Yes If yes, please describe it briefly					
b) No					
c)No Preference					

28. What is your preference on transparency of the bottle?

	Cooking Oil		Washing up	All Purpose	Toilet Bleach
	1 litre	2 litres			
a) Opaque					
b) Transparent					
c) Translucent					
d) No Preference					
e) Others, please write down (e.g. brand name)					

29. What colour do you like for the product? (Please see the attached reference sheets)

	Cooking Oil		Washing-up	All Purpose	Toilet Bleach
	1 litre	2 litres			
a) Red					
b) Green					
c) Blue					
d) White					
e) Black					
f) Yellow					
g) Sky Blue					
h) Pink					
i) Violet					
j) Orange					
k) Brown					
l) Grey					

m) Off-white					
n)No Preference					
o) Others, please write down (i.e. you may mention the brand name)					

30. Do you prefer combination of colour?

	Cooking Oil		Washing up	All Purpose	Toilet Bleach
	1 litre	2 litres			
a) No					
b) Two colour					
c) Three colour					
d) Any combination					
k) Others, please write down (i.e. you may mention the brand name)					

31. Do you have strong liking for any specific material to be used in the bottle (e.g. glass, plastic, Aluminium etc.)?

	Cooking Oil		Washing up	All Purpose	Toilet Bleach
	1 litre	2 litres			
a) No					
b) Yes, please mention the name of the material here					

32. Do you like some sort of handle in bottle? (Please see the attached reference sheets)

	Cooking Oil		Washing up	All Purpose	Toilet Bleach
	1 litre	2 litres			
a) General handle					
b) Indented side helps to hold					
c) No					
d) No Preference					
e) Others Please write down					

33. What size of the bottle do you usually buy?

	Cooking Oil	Washing up	All Purpose	Toilet Bleach
Please write down here				

34. Do you like specific colour scheme, e.g. changing intensity of the strength of the colour?

	Cooking Oil		Washing up	All Purpose	Toilet Bleach
	1 litre	2 litres			
a) Yes If yes, please describe it briefly					
b) No					
c) No Preference					

35. Do you prefer to use a bottle with a longer neck? (Please see the attached reference sheets)

	Washing up	All Purpose	Toilet Bleach	Cooking Oil	
				1 litre	2 litres
a) Yes					
b) No					
c) No Preference					

36. Do you like a trigger on the bottle? (Please see the attached reference sheets)

	Washing up	All Purpose	Toilet Bleach	Cooking Oil	
				1 litre	2 litres
a) Yes					
b) No					
c) No Preference					

Shower gel and Shampoo/Conditioner Bottles

37. What shape do you like for the bottle?
Please number the shapes provided in the attached sheets according to your choice, i.e. put down 1 on the shape you like most, then 2 on your second choice. Besides if you prefer any other shape than those mentioned there, please give a description or brand name or you may draw the shape with a mention of its order in your preference.

.....

.....

..

38. Do you like curvy section or gradual changeover in the bottle/container?

	Shampoo/Conditioner	Shower-gel
a) Yes		
b) No		
c) No Preference		
d) If anything else please write down (i.e. you may mention the brand name)		

39. What is your preference on transparency of the bottle?

	Shampoo/Conditioner	Shower-gel
a) Opaque		
b) Transparent		
c) Translucent		
d) No Preference		
e) Others, please write down (i.e. you may mention the brand name)		

40. Do you like any kind of impression on the bottle surface, e.g. impression of different leaves etc.? (Please see the attached reference sheets)

	Shampoo/Conditioner	Shower-gel
a) Yes If yes, please describe it briefly		
b) No		
c) No Preference		

41. What colour do you like for the product?

	Shampoo/Conditioner	Shower-gel
a) Red		
b) Green		
c) Blue		
d) White		
e) Black		
f) Yellow		
g) Sky Blue		
h) Pink		
i) Violet		
j) Orange		
k) Brown		
l) Grey		
m) Off-white		
n) No Preference		
o) Others, please write down (i.e. you may		

mention the brand name)		

42. Do you prefer combination of colour?

	Shampoo/Conditioner	Shower-gel
a) No		
b) Two colour		
c) Three colour		
d) Any combination		
k) Others, please write down (i.e. you may mention the brand name)		

43. Do you have strong liking for any specific material to be used in the bottle (e.g. glass, plastic, Aluminium etc.)?

	Shampoo/Conditioner	Shower-gel
a) No		
b) Yes, please mention the name of the material here		

44. Would you be willing to pay a bit more for an environmentally efficient product?

	Shampoo/Conditioner	Shower-gel
a) Yes		
b) No		

45. What size of the bottle do you usually buy?

	Shampoo/Conditioner	Shower-gel
Please write down here		

46. Do you like some sort of handle/positioning accessory in the bottle? (Please see the attached reference sheets)

	Shampoo/Conditioner	Shower-gel
a) Hook type thing		
b) Indented sides that helps to hold		
c) General Handle		
d) No		
e) No Preference		
f) Others Please write		

47. Do you like specific colour scheme, e.g. changing intensity of the strength of the color?

	Shampoo/Conditioner	Washing up
a) Yes If yes, please describe it briefly		
b) No		
c) No Preference		

Personal Information (For Statistical Purpose Only)

48. Gender
a) Male
b) Female

49. Age group
a) Under 14
b) 14-20 years
c) 21-25 years
d) 26-30 years
e) 31-35 years
f) 36-40 years
g) 41-50 years
h) 51- 60 years
i) Over 60 years

50. Education
a) Primary
b) Secondary
c) Third level
d) Others, Please specify here.....

51. Occupation

Please write down here:

52. Income Level
a) Below €10,000 euro per annum
b) €10,000 to €20,000 euro per annum
c) €20,001 to €30,000 euro per annum
d) €30,001 to €40,000 euro per annum
e) €40,001 to €50,000 euro per annum
f) €50,001 to €60,000 euro per annum
g) Above €60,000 euro per annum

Optional Personal Information

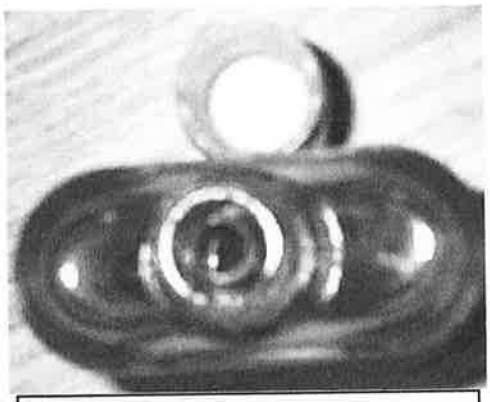
53. Name[optional]:

54. Mailing Address[optional]:

55. Telephone [optional]:
56. Fax [optional]:
57. E-mail [optional]:

Thanks a Million for Your Time and Kindly Filling Out the Questionnaire!!!!

Grip on surface



General opening in a perfume bottle

Trigger in a long-necked container

Impression on surface

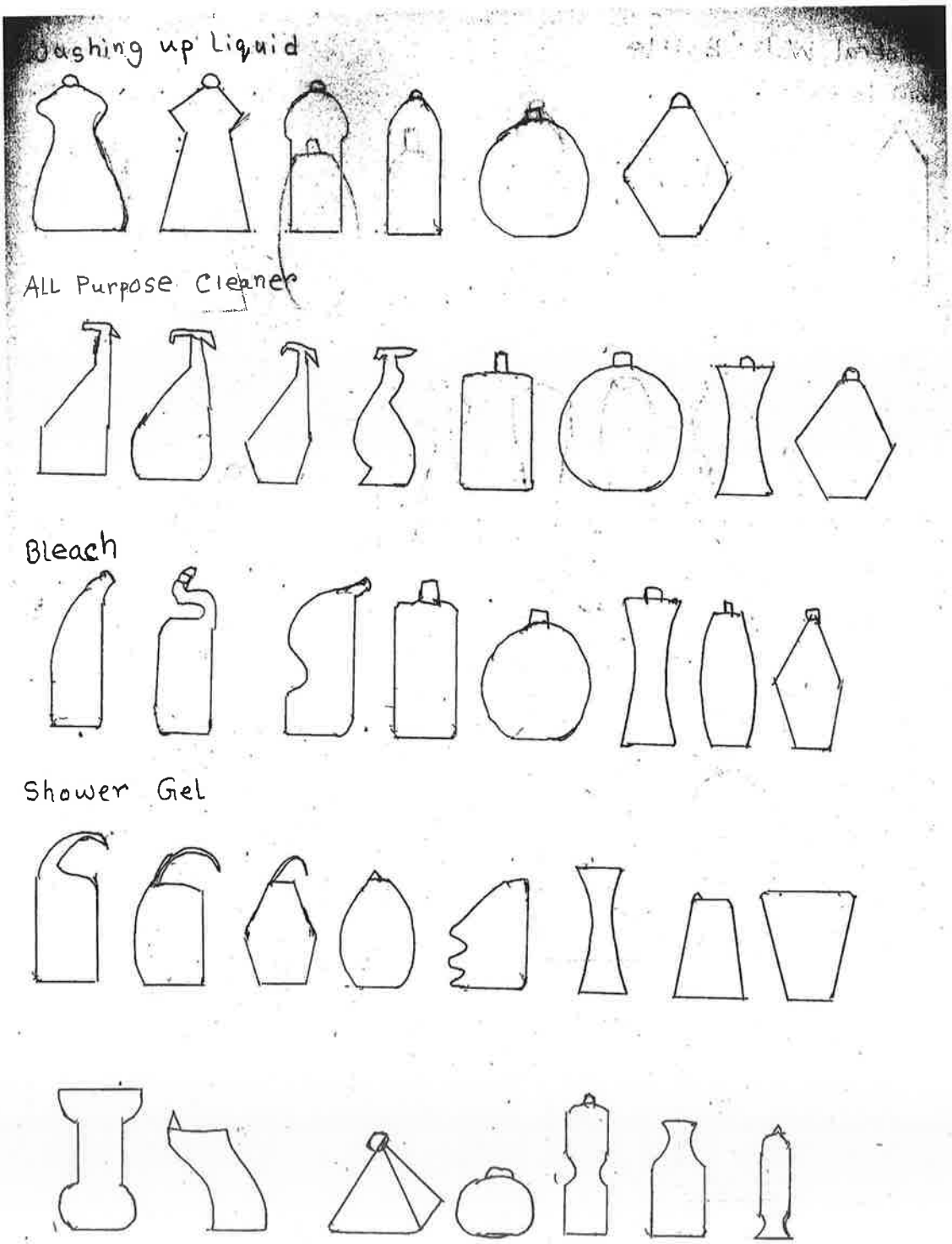
Spray pumped outlet

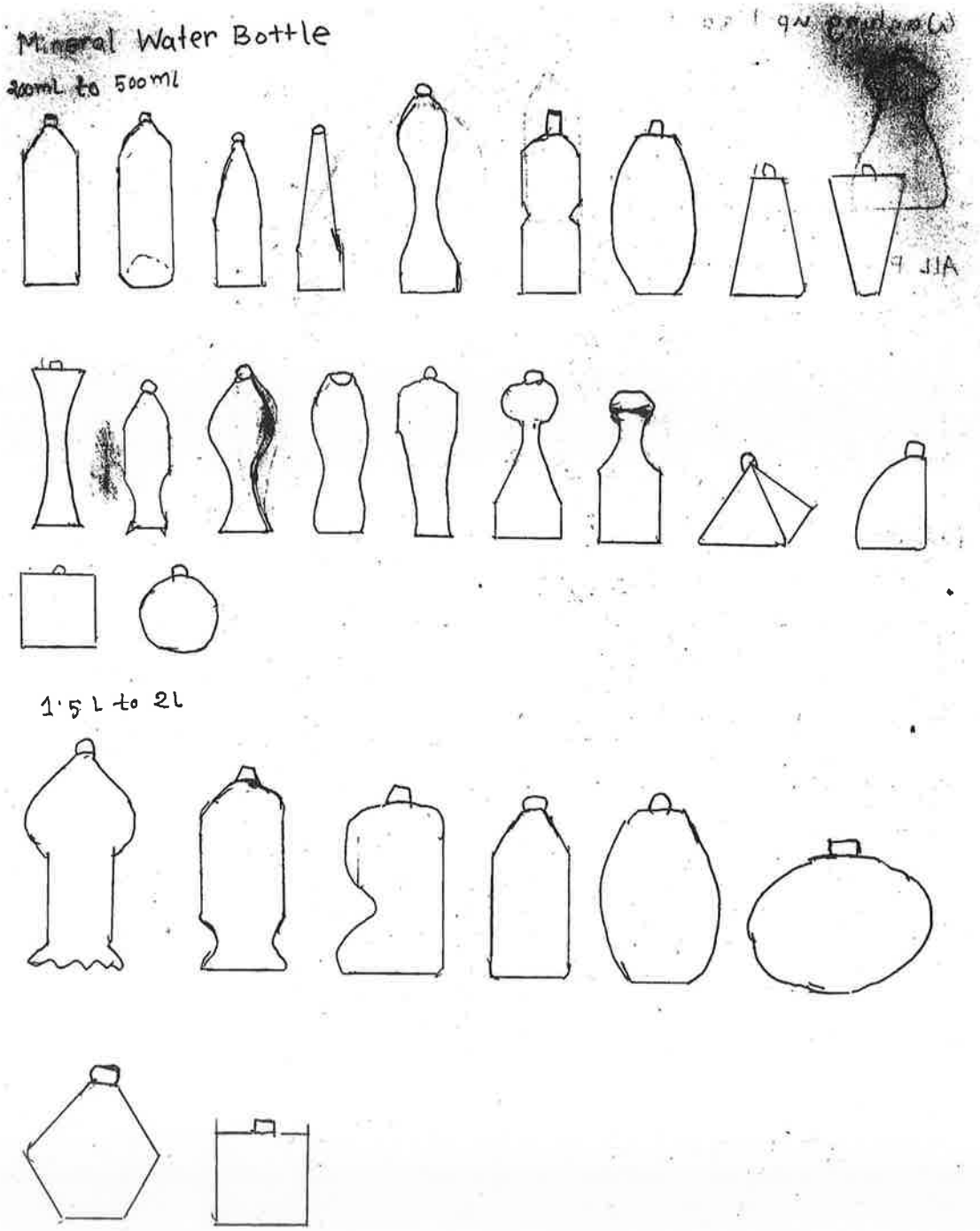
Handle

Hook in a shower gel

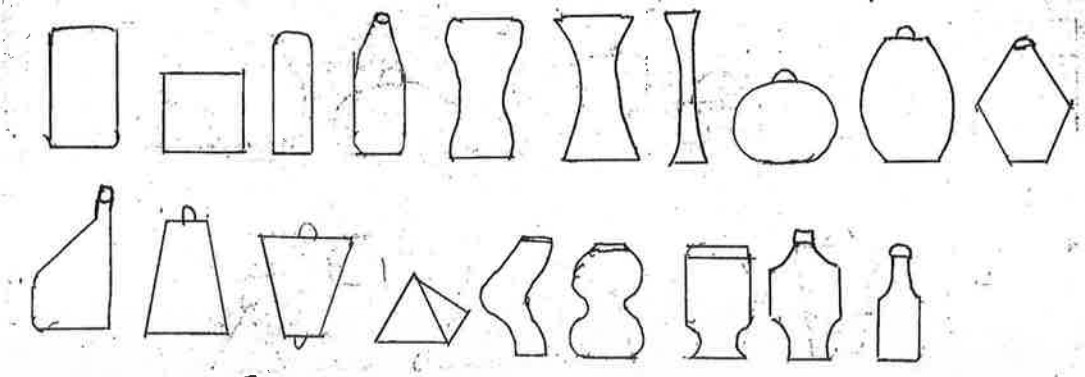
Sports Cap

Appendix B4

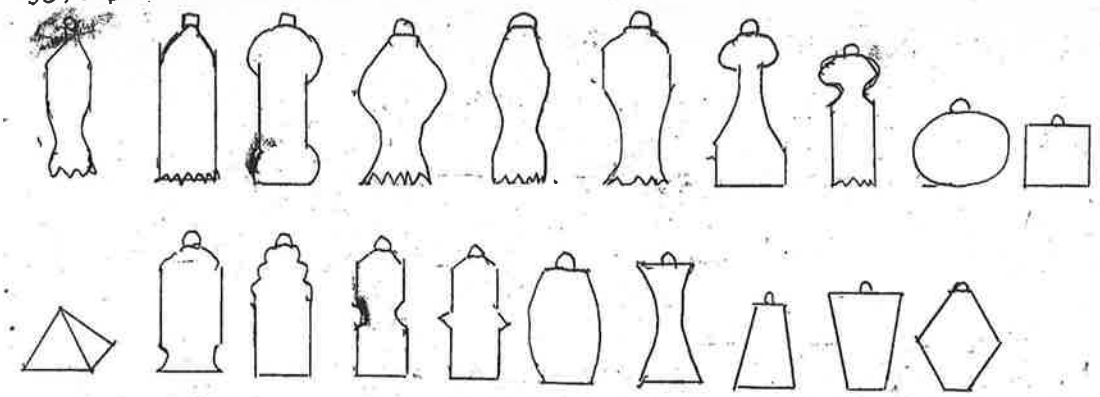



Mineral Water Bottle
200mL to 500ml
1·5 L to 2L

Shampoo / Conditioner

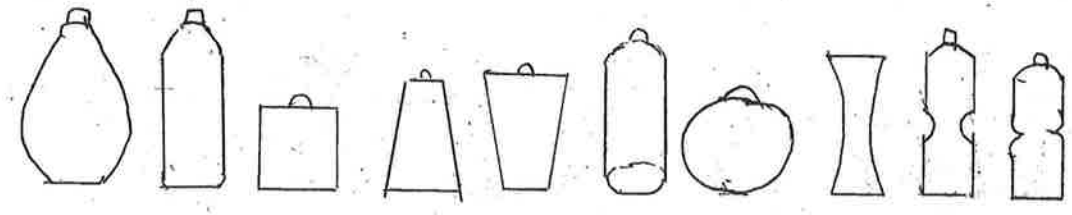


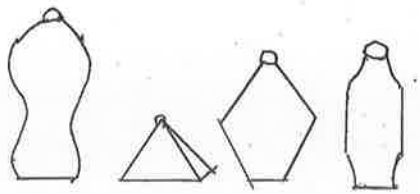
Soft Drink Bottle



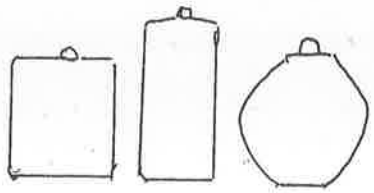
Cooking Oil Bottle

1 Litre

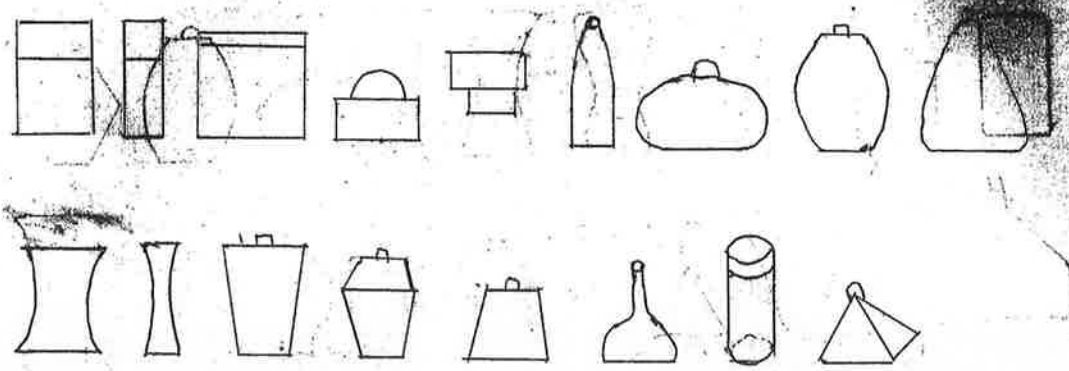




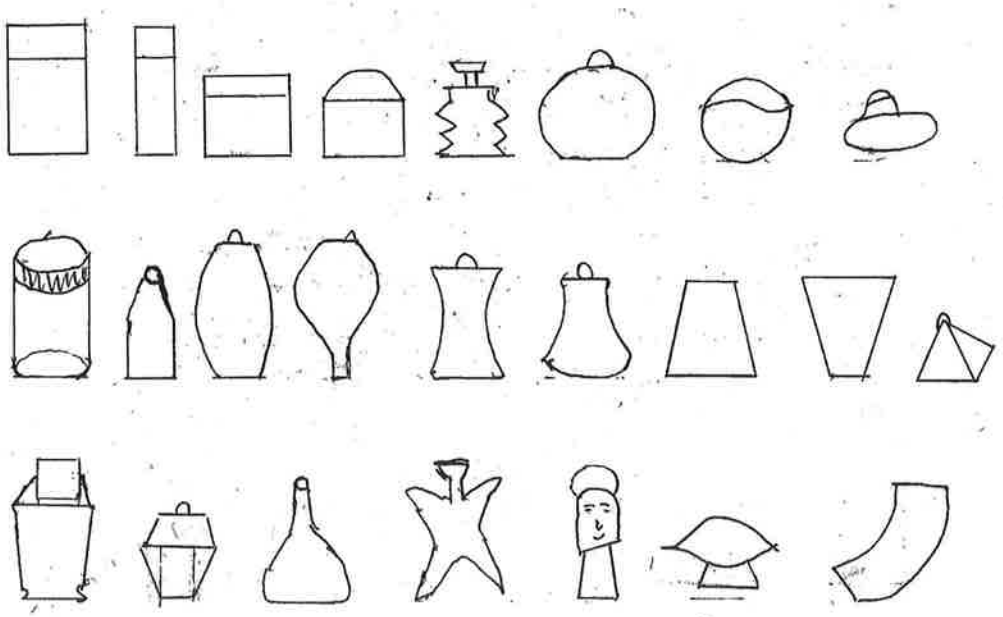
2 Litre Cooking oil Bottle/Container



Men's Perfume/After Shave



Women's Perfume



Appendix C

Chi square analysis of the first survey

Pearson Chi-square

	Gender	Age	Education	Occupation	Income
Shape	0.391	0.372	0.001*	0.000*	0.594
Special Shape Attribute	0.014*	0.001*	0.002	0.001*	0.001*
Colour	0.064	0.005*	0.158	0.000*	0.018*
Combination of Colour	0.664	0.425	0.514	0.002*	0.823
Size	0.000	0.093	0.429	0.066	0.552
Special Material	0.919	0.006*	0.019*	0.235	0.362
Paying for Environment Friendly product	0.694	0.001*	0.001*	0.013*	0.000
Weight	0.081	0.004*	0.000*	0.052	0.014*
Transparency	0.000*	0.000*	0.000	0.066	0.904
Cap	0.073	0.000*	0.000*	0.000*	0.000*

* denotes significance

Likelihood ratio

	Gender	Age	Education	Occupation	Income
Shape	0.387	0.779	0.045*	0.256	0.514
Special Shape Attribute	0.038	0.590	0.683	0.342	0.099
Colour	0.015	0.420	0.506	0.722	0.401
Combination of Colour	0.662	0.917	0.764	0.479	0.847
Size	0.000	0.507	0.687	0.618	0.614
Special Material	0.857	0.044	0.054	0.284	0.634
Paying for Environment Friendly product	0.706	0.002*	0.002*	0.023*	0.001*
Weight	0.072	0.944	0.707	0.967	0.992
Transparency	0.002*	0.186	0.249	0.781	0.947
Cap	0.572	0.000*	0.003	0.000*	0.018

* denotes significance

Reliability Analysis Results

Appendix D

Product	Topic	No of Items	Alpha Value
Mineral Water 500ml	Shape geometric	4	0.61
	Shape	20	0.95
	Colour	13	0.95
	Transparency	3	0.7
Mineral Water 1 to 1.5 Litre	Shape geometric	4	0.71
	Shape	8	0.89
	Colour	13	0.95
	Transparency	3	0.73
Men's Perfume	Shape geometric	4	0.46
	Shape	17	0.9
	Colour	13	0.96
	Transparency	3	0.7
Women's Perfume	Shape geometric	4	0.81
	Shape	24	0.94
	Colour	13	0.95
	Transparency	3	0.71
Soft Drink	Shape geometric	4	0.86
	Shape	20	0.92
	Colour	13	0.92
	Transparency	3	0.70
Shampoo	Shape geometric	4	0.74
	Shape	19	0.74
	Colour	13	0.9
	Transparency	3	0.85
Shower gel	Shape geometric	4	0.65
	Shape	15	0.93
	Colour	13	0.9
	Transparency	3	0.84
Cooking oil 1L	Shape geometric	4	0.83
	Shape	14	0.91
	Colour	13	0.98
	Transparency	3	0.68
Cooking oil 2 L	Shape geometric	4	0.78
	Shape	3	0.06
	Colour	13	0.59
	Transparency	3	0.67
Washing up liquid	Shape geometric	4	0.78
	Shape	6	0.66
	Colour	13	0.91
	Transparency	3	0.55
All purpose	Shape geometric	4	0.87

Cleaner			
	Shape	8	0.84
	Colour	13	0.98
	Transparency	3	0.65
Bleach	Shape geometric	4	0.86
	Shape	8	0.68
	Colour	13	0.96
	Transparency	3	0.69

Appendix E

List of Publications

[1] Rashid, A., Mac Donald, B. J. , & Hashmi, M. S. J., Evaluation of the Aesthetics of Products and Integration of the Findings in a Proposed Intelligent Design System, *Journal Of Materials Processing Technology*, Vol 153-154, 10 November 2004, 380-385.

[2] Rashid, A., & Hashmi, M., Expert System Based Intelligent CAD/CAM: An Overview, Proceedings of *19th International Manufacturing Conference (IMC-19)*, Queen's University Belfast, Northern Ireland, UK, August 28-30, 2002, 35-144.

Poster Presentation

[1] Rashid, A., Mac Donald, B. J., & Hashmi, M. S. J., An Intelligent Computer-aided Design System incorporating considerations for Aesthetics and Environment, *ISIE 2003: International Society for Industrial Ecology's 2nd international conference*, University of Michigan, Ann Arbor, Michigan, USA, June 29-July 2, 2003.