ISSN 2634-095X (ONLINE)
& 2634-1395 (PRINT)

JOURNAL OF MULTIMEDIA ART DESIGN & EDUCATION

MADE 2022
VOLUME 2
ISSUE NO. 1

EDITED BY
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STEPHEN D. PRIOR

Published by: JLP Publishing
London, United Kingdom
email: madejournal@gmail.com
www.madejournal.uk

ISSN: 2634-095X (Online)
ISSN: 2634-1395 (Print)

ISSN 2634-095X (Online); 2634-1395 (Print)

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ISSN 2634-095X (Online); 2634-1395 (Print)

International Journal of Multimedia Art, Design and Education

Prof. Siu-Tsen Shen

Editor-in-Chief

A warm welcome to the third edition of the International Journal of Multimedia Art, Design and Education (MADE), an open-access resource dedicated to publishing high quality, peer-reviewed research papers in all areas of design research.

The recent COP26 climate summit in Glasgow has focussed the world's attention on the subject of global warming and the resulting impact of not keeping to the 1.5 °C goal.1 Rising sea levels, floods and storms, surface temperatures of 50 °C, drought and wild fires causing further carbon emissions have already arrived.2

The natural world is under attack as never before, and we humans are all responsible for this. The science is largely undisputed, however, the means to fix the problem is challenging, expensive and controversial.

We are at a tipping point, whereby inaction may well result in a situation beyond our capability to rectify it. Semantic arguments about "phase down" or "phase out" of coal power does not help. We need to be bold, agile and rapid in our collective actions if we are to avoid disaster. We can all make small changes to our lives, and design can help support this. Whether this is changing our diet, moving to electric vehicles, using bio-fuels or moving to a more sustainable future, we can do this!

Our Editorial Board consists of leading design researchers and practitioners from all over the world, all of whom have proved willing to contribute their valuable time to the development of this new journal. To reach the widest possible audience, the journal will be published both online and in print. The online version will be open access, freely available for anyone, anywhere to download, read, distribute, and use, with proper attribution of authorship, for any non-commercial purpose. A printed version of the journal will also be available at cost.

The journal aims to provide an international forum for exchange of ideas and findings from researchers across different cultures, by encouraging research on the impact of cultural factors on design theory and practice. The journal also seeks to promote the transfer of knowledge between professionals in academia and industry. To help make our vision a reality, we invite you to submit your best work to the MADE Journal and to encourage your colleagues to do the same.

In these turbulent times, we all have a responsibility to use design tools to boost economic growth and provide opportunities to the younger generation. These are our future leaders, and together we can overcome the current challenges of Covid-19, recession and geo-political tensions in the world.

Acknowledgements

The third issue of MADE was only possible due to the hard work of the three contributors. Each of the contributors went through an

extensive revision/review process, which resulted in works of excellent quality. The reviewers in the various disciplines spent countless hours on top of their already busy schedules to ensure the works included are of the highest quality. The MADE executive committee not only had the goal of creating this journal, but also served a large role in determining the initial format and general guidelines for the journal. They had online meetings to discuss deadlines, submission, and their careful consideration helped the editorial board avoid a number of pitfalls we could have encountered with this issue. They were also charged with the difficult task of selecting the cover design from an impressive set of submissions. I also need to acknowledge the work of Assisting managing editor, Sin-Yi Guan, who spent hours discussing policies, formatting, and any other number of other details about the journal with me.

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Prof. Siu-Tsen Shen
January 2022

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Growing Green, Benign by Design (Part 2 of 3)

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The project is an attempt to cover the aspects of production and application of materials from renewable sources, for sustainable product development. The paper is divided into three parts describing the role of renewable materials in the past, present and future.

The first part, named Chemurgy, places the topic in a historic perspective. The word Chemurgy was introduced in the thirties to describe a branch of chemistry which dealt with the application of natural raw materials, especially from farm products. As a result of agricultural over-production and the advent of the economic depression, American farmers were in search of new outlets for their produce.

Industry (especially the newly created automobile industry) on the other hand, was in great demand of materials. One of the important car manufacturers at the time was Henry Ford. He was a Chemurgist, whose vision it was to grow cars from the soil. His cars included many components from renewable materials, such as gluten or soy plastics and used alcohol for fuel, which was gained from vegetables. Presently, cars in Brazil use alcohol for fuel, extracted from sugar cane.

Two of the most important chemurgic plants were soy and hemp, the latter of which was banned in 1937. The two plants (both originate from Asia) were cultivated on a large scale, primarily for non-food purposes. Many important discoveries had been made, which found wide application still in use today.

The chapter concerned with current development consists of two parts, i.e. renewable materials and sustainable ways of production. The part about renewable materials is divided into five areas of consumer application. Of particular interest to industrial designers are natural fibers and bioplastics. In the area of natural fibers, the PLATO manufacturing process seems a promising development.

The technique upgrades wood or plant fiber to make it more strong, more light-weight and more resistant to rot. Plant fibers which have been treated are finding application in the car industry. Moving on to bioplastics, the first generation of bioplastics, which still contained some synthetic material, has been superseded by a generation which is totally biodegradable. Most bioplastics, which are currently available, are designed to be thermoplastic, to be processed by conventional industrial machinery. A particularly interesting development is the production of a plastic like Biopol (Poly-hydroxy-butyrate), by plants instead of bacteria.

The second part of this paper is about methods of production. There is a shift noticeable towards the utilization of transgenic plants or bacteria to produce materials. Biotechnology assists in the improvement of production efficiency and product quality. An example of this is corn and potato which have been modified not to produce amylase, so the process of starch extraction has become easier and cleaner.

The third part begins with an assessment of the developments towards sustainability, including economical, technical, social, and ecological aspects.

In the race towards a sustainable future, there are two scenarios, i.e., Aquafication and Prosumerism, put forward for consideration. Presently, agriculture for industrial purposes does hold the promise of sustain ability. However, if it were to be applied on a grand scale, it would pose two major problems in the near future, i.e., a shortage of fresh water and a shortage of land.

There have been successful attempts in transplanting bacterial genes into plants, which enables them to be salt-tolerant. This way, it would be possible to shift agriculture for industrial purposes to sea (aquafication). The plants would be grown on the sea surface and its industry would make use of the natural forces readily available for its energy needs, like wind-, water- and solar power.

Alternatively, in a cocooning society (F. Popcorn), with working at home becoming more common and leisure time increasing, self-sustainability will become a possibility. The prosumer household, (producer/consumer, A. Toffler) will be self-sufficient in all its needs, like consumer goods, food, cosmetics, medicine, fuel, clothing, etc. All these goods will be "grown" through the application of fast-growing plants.

To test the feasibility of this concept I have conducted several experiments. For example, Giant Jersey Cabbages have been grown into shapes, suitable for furniture application. Tree-free furniture from local resources will become a possibility. Similarly, bottle gourds have been grown in moulds which have taken on geometrical shapes for packaging purposes.

Some other experiments have been carried out with "dead" natural materials. One example is that of mussel shells, (a waste material from the seafood industry) which I have applied into building materials. Another example is the fiber of the Loofah gourd which has been compressed into shapes for shock-resistant packaging or other purposes.

Keywords **–** Benign-design, bio-based design, bio-based materials, bio-design, ecological design, green design, green technology, renewable materials, sustainable product development (s.p.d.).

Relevance to Design Practice **–** This research probably has the most relevance in concept stage of product design, in choice of sustainable materials and greener production techniques. But it may also influence the designer's awareness and responsibility of the impact his product will have on the environment.

Part 2: Current development (in materials from renewable sources)

Material fields

The approach taken for this topic is from a designer's standpoint, by choosing five user fields where renewable materials are being applied, rather than starting a dictionary of renewable materials which would be a more botanical or scientific approach.

This section is divided into two parts. The first part 'material fields' is about renewable materials, the second part 'engines of production' is about manufacturing processes. Besides areas common to designers,

I have also included other areas of sustainable development like cosmetics and fuel. This is because the third chapter covers these areas in which the prosumer is self-sustaining.

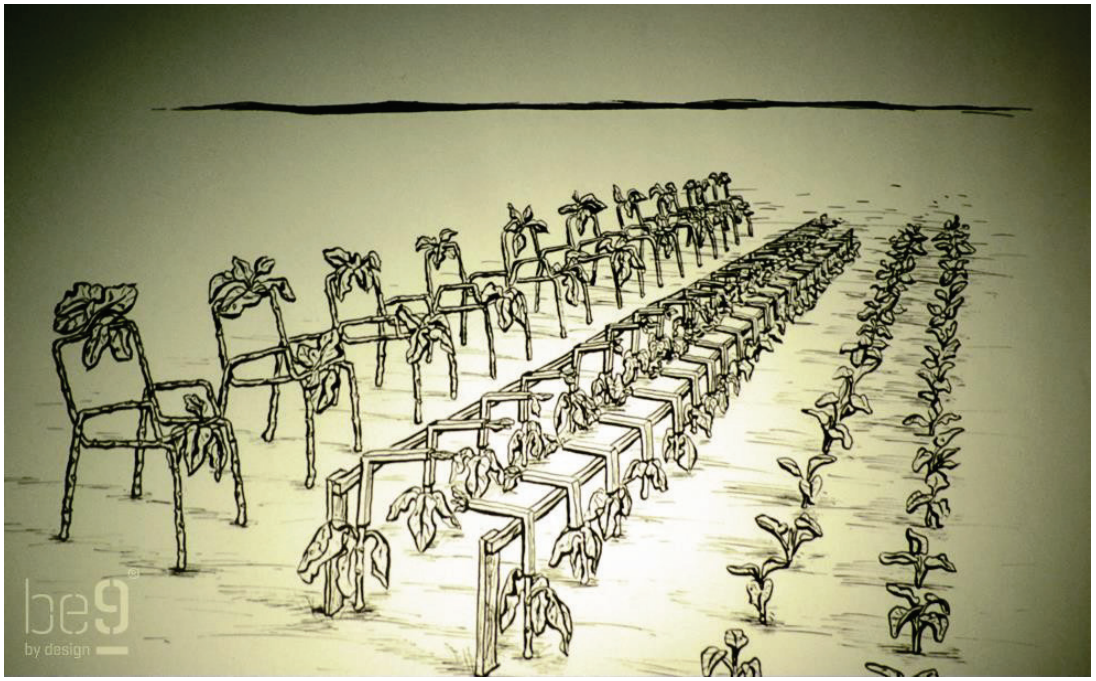

Figure 1: Walking stick cabbage field (by author).

An introduction

As said in the former paper, after W.W. 11 the emphasis was laid on the petro-chemical industry rather than on agriculture for industrial purposes, in a chase to materialize the American dream. At the end of the sixties people began to worry about its toll on the environment. They reverted to basics and nature. There was a revival of use of natural materials. The name chemurgy was changed to biochemical engineering. In the nineties there is a renewed concern for the environment and subsequently interest arose for the use of renewable materials. Perhaps this is a reaction to the results of the Rio de Janeiro Summit, held in 1992. In the Netherlands a new name appeared for agriculture for industrial purposes i.e. “Agrificatie”.

ISSN 2634-095X (Online); 2634-1395 (Print)

Figure 2: Pioneered in Russia in the 30's, rubber tyres made from Dandelions (Taraxacum kok- saghyz). Continental has developed a modern car tyre "Taraxagum".

Agricultural crops for non-food purposes are grown mainly for their fibers, oils and carbohydrates. These materials find non-food appliance in quite different areas. However, there are two large areas of opportunities, i.e. composites (fibers) and disposables (bioplastics). For both areas there is a search for the ideal bulk material which can compete with and offer an environmentally sound alternative to petrochemical or tropical wood products, as the case may be.

In the bio-technological area there is a general shift noticeable from the way in which materials are being produced. Presently, bacteria are applied as the engines for production of bioplastics, even genes are being transplanted into plants for higher production. In effect, there is a growing concern towards the (ab)use of nature for human exploitation. There are heated debates about the ethics of transgenics and cloning.

Home - building materials

This area includes a range of natural based materials used for constructional or cosmetic purposes in the home. As this area is rather extensive, a choice has been made and it is far from complete.

Cellulose based fibers

In the past 7,000 years around 2,000 plants have been used to produce natural fiber. Different parts of plants are used for fiber production, including bast, leaf, seed, or fruit fibers. There are mainly three marketing areas for fiber crops i.e. paper, textiles and building- composite materials, the last one of which is relatively new. Plant fiber holds several advantages over artificial fiber including their strength and their ability to stretch.

Figure 3: Bleached pinecone chips with a bio-based binder (by author).

Cellulose (C6 H10 O5) is the world's most abundant polymer. The structure is quite like starch but very complex. A team of researchers in Japan have synthesized cellulose, which can lead to a whole range of cellulose-based designer polymers in the near future. Plants derive their rigidity from the way component glucose molecules of cellulose are joined. There is a distinction noticeable concerning the source of renewable fibers, i.e. agricultural waste fibers mainly from food crops and fibers which are intentionally grown for non-food application. These fibers intended for technical application are so called Agri fibers.

Waste source fibers

In North America, agricultural waste fibers like bagasse, cereal straw, corn stalks, cotton stalks, kenaf, rice husks, rice straw and sunflower hulls and stalks, are used for composition panels.

However, the quality of these panels are inferior to those made of wood. But blends with wood will improve quality. There is a OSB (oriented strand board) available which consists of such waste materials. Along with wood chips the waste is pressed together under high temperature, so there is no need for glue. Cereal straw can include straw from wheat, rye, barley, oats and rice.

Straw can be used in fiber board, and for cardboard and paper products. Corn cobs were used in the production of the first nylons.

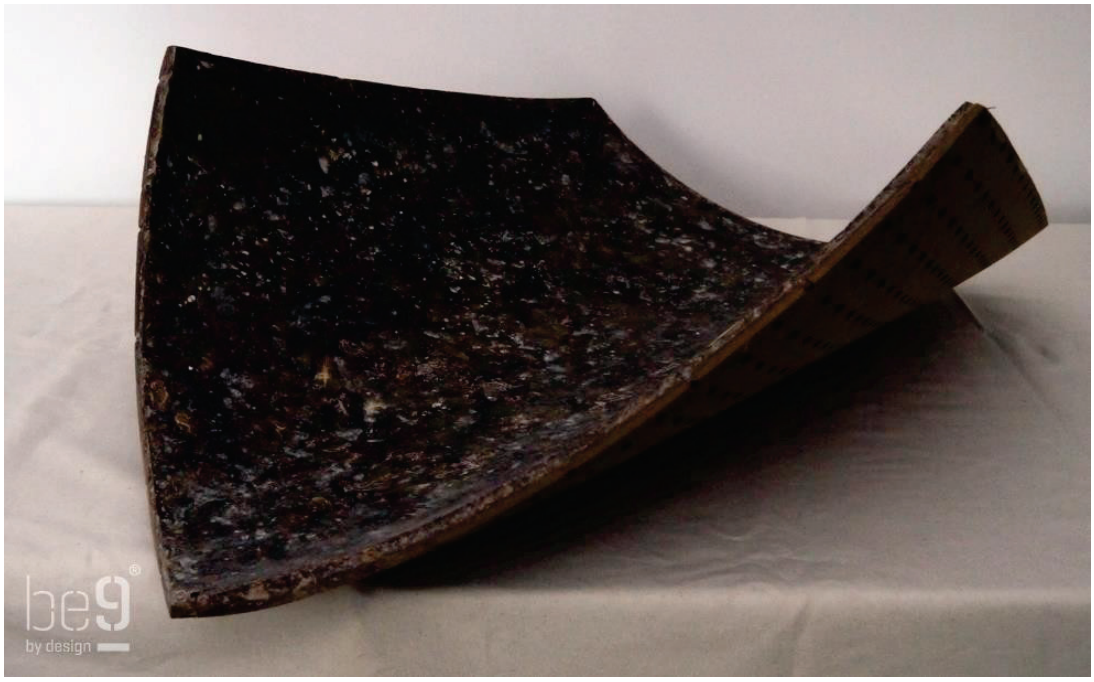

Figure 4: Bowl made of chips from Larch cones and a bio-based binder (designed by author).

Rice husks and coffee husks are agricultural residue, which is made into particle board in India. In India, particle board is made from bagasse without addition of a binder. Bagasse is the residue fiber remaining when sugarcane is pressed for sugar extraction. Abaca are banana leaves which are applied into roof board. It is an alternative for the asbestos material. By the development of a machine which removes the fiber from leaves more efficiently, pineapple (Ananas cosomus) fiber can now be commercially gained from the plant, whereas in the past it was simply burned. Resinous residue can easily be cleared from the fiber, after which it can be spun. One possible application is that of reinforcement for concrete. Nearly 50 billion coconuts are harvested each year, of which only 3-8% is recovered for collection of fibers. Coconut fiber, or Coir, is known to be strong and durable and has long been applied in domestic products such as mats, carpets, brushes, and as filler for mattresses and furniture. However, recent new areas of application seem to offer new opportunities, e.g. geotextiles (mats for waterworks, earthworks, etc.), insulation materials, shock-absorbent packaging materials (also in combination with natural rubber), in technical appliances as a dust-filter (Cocolok), humidifiers, etc.

Agri fibers

Biomass can be defined as anything which grows from seeds, water, soil, sunlight and fertilizer. It is predicted that Agri fibers like hemp will eventually replace synthetic fibers like glass- and carbon fibers in composite materials.

In the Netherlands research is being done on these fibers, at ATO-DLO, in conjunction with industry, to establish or modify their properties. Parallel to this some Agri fibers are also researched for possible technical and commercial significance in the paper industry. Especially hemp is being investigated. Some fibers like flax and hemp are nearly pure cellulose and contain a minimum of lignin. Agri fibers have many good properties which compare favorably to synthetic or ceramic fibers. The fibers are light, strong, flexible, non-toxic, cheaper, and even the energy put into the production can be returned by incineration. Besides, moulds show less signs

of wear when natural fibers are applied. Areas of application are as reinforcement for bioplastics or other materials like cement, geotextiles, or as insulation.

Figure 5: Table made with pinecone chips and a bio-based binder (by author).

Composition panels made from agricultural fibers are divided into several categories, including low density insulation board, MDF (medium density fiber board), hardboard and particle board. Binders may be synthetic thermosetting resins or modified naturally occurring resins like tannin or lignin, starches, thermoplastics or mineral. Ruckstuhl is a producer of natural fiber carpets, which include jute, flax, coir, sisal, wool and horse hair and even paper thread. A selection of fibers grown for industrial purposes is described below: (See also the article on transport further along).

Hemp

Hemp (Cannabis Sativa) originates from China and has been cultivated there since long before 4,000 BC. The strength of the fiber is 25% greater than that of flax. It has two different qualities of cellulose i.e. bass fiber which is of very good quality and wood fiber which is of less quality and contains more lignin. Hemp is, amongst other things, processed in a variety of insulation products, geo-textiles and light-weight panels.

Figure 6: Hemp fiber door panel for the BMW i3.

Flax

Flax (Linum Usitatissimum) has been traditionally grown for linen in the textile industry and its oil (linseed oil) has been applied in linoleum. Flax has been and still is applied into fiber board similar to chipboard. Other applications could be panels for facades, ceiling panels, parts for window frames, reinforcement in concrete, or insulation/ soundproof panels instead of glass wool or rockwool. One major advantage of flax is that there is no need for a binder because it contains hemi-cellulose and pectin.

"Platonic love"

At Ceres B.V. in Wageningen the durability of flax fiber is being improved by a process called PLATO. The fibers are light-weight and are more resistant to decay. (the process of PLATO is described further along the chapter in the article about wood).

Elephant grass

Elephantgrass (Miscanthus senensis giganteus) is a fast-growing voluminous crop which originates from China. Potential applications are in geotextiles, thatched roofs instead of reed and in paper products as its fibers are similar to those of wood.

Figure 7: Elephant grass from the garden with a bio-based binder pressed into blocks (by author).

Jute

Jute is a strong, non-polluting and absorbent fiber. Jute is traditionally applied in food packaging, as woven sack material, carpets, furnishing and bags. However, some segments like potato sacks have been partially taken over by synthetic materials. So other applications are being looked into.

One option is composites, like jute mats in combination with synthetic resins for window panes, using a process called pultrusion.

Figure 8: Chair made from pinecone chips and Jute and a bio-based binder (designed by author).

Bamboo

Bamboo is split into slices and glued together for parquet floors. The floors are very durable and can compete with tropical hard woods. An advantage of using bamboo is

that it only takes 4-5 years to mature in order to be applied in floors. There are other products based on bamboo available in China like plywood, fiber- and particle board, composites and even veneer.

At the Technical University in Eindhoven research is being done on bamboo as a cheap construction material. A social housing project was begun in Costa Rica in the late eighties. In Kyoto, Japan, a center was established after the war, for the development of bamboo building materials.

Figure 9: Bamboo bookcases (designed by author).

Loofah gourds

Loofah gourds have been grown on an industrial scale on Sardinia in 1992, as part of an EU funded experiment. Further research will conclude whether it would be worthwhile to increase production for industrial application in sound / warmth insulation panels.

Horsehair and coir fiber

Horsehair and coir fiber is mixed with natural rubber and applied padding in the upholstery industry. The latter one is also used in filters (cocoloc). Other tropical fibers include kenaf, sisal, mauritius hemp, kapok, ramie, rattan and datepalm.

Natural composites

Composites are combinations of materials. Natural based material composites are made up of natural fibers and a natural binder. Bioplastics are dealt with in the next piece about disposables and packaging. Sometimes, fibers are pressed together by pressure and heat and an additional binder can be left out. Nature produces complicated ready-made composite materials also, for example wood or bamboo. Man-made composites in general are still child's-play in comparison.

Wood

Wood is one of the foremost natural composites. There is an ever-increasing demand for durable wood. However, the supply of tropical wood cannot continue at this pace and chemically treated wood isn't doing the environment any good either. One option is to up-grade the wood of local, fast-growing low-grade trees.

"Fair and square"

A Japanese scientist has invented a process by which tree stems turn into square logs. In a specially designed micro-wave oven, the logs are cooked to around 100 degrees Celsius after which they are pressed into a square shape, using minimal pressure. When the logs cool down, they keep their new shape. The strength of the wood is improved, and the density is increased. Using this process, cheap, low quality wood can be upgraded. Ordinarily, about 50% of timber would be lost in the sawmill. Crooked trees which would otherwise be wasted, can also be of use now, as they can be straightened.

Figure 10: Poplar chair (designed by author), Poplars grown into poplar plywood.

"To platonise" (the word has been admitted as a new word in Dutch dictionaries). At Shell Research a process had been developed, called PLATO (short for Providing Lasting Advanced Timber Option). Wood which has not been dried is heated till 200 degrees Celsius for about 30 minutes. At this stage the water evaporates, and the wood is like paste, so it can be pressed into any shape.

Afterwards it is heated till about 180 degrees Celsius which hardens the wood.

The process upgrades low quality wood, whereby the larger cellulose molecules are left intact, and the smaller ones are destroyed or form larger molecules. The resulting wood is rot-proof, less moisture absorbent and much stronger. The wood handles the same as before though. Cr&dO is commercializing the process with some financial aid from the Dutch state. An experimental manufacturing plant has already been built. The process is being exploited by Plato-Hout B.V. in Wageningen and they hope to produce commercially in 1997.

Bamboo

Bamboo has been the major construction material in the orient. Bamboo is the common name given to about a thousand varieties of woody grasses (Gramineae). Some varieties grow as fast as one meter per day. Bamboo has many good properties and therefore many applications.

"Bamboozle"

In the quest for compatibility to industry,

square bamboo is being grown in Japan. Usually Moso is selected and used because of its thickness. A rectangular frame consisting of two halves is placed over the bamboo shoot. When the shoot has reached the top of the frame, the frame is simply slid up. The square bamboo is cut down between October and December of the year it has been formed. Lengths of square bamboo are very much sought after and are quite expensive. They usually find application in Japanese homes as an ornamental post for the tokonoma -the most important part of the living-room.

Man-made composites

Imitation of nature seems to be an option to reach strong designed structures in materials. Bionics or biomimetics is the art of copying living designs which are known to be mechanically optimized. At the Centre of Biomimetics at the University of Reading scientists are for example researching the structure of coconut shells, for crash helmets.

"Biomimetics"

C. Mattheck has studied the mechanism of adaptive growth in biological load carriers (like trees and bones) and has incorporated his findings into a program called CAO (Computer Aided Shape Optimisation) which is a tool for engineers and designers.

Natural composites grow to strengthen themselves. When the load is increased on a branch, it will gradually become stronger. The tree will self-optimise by growth. During this process it will create a state of constant stress. It will restore its optimum state by attachment of more material at overloaded points. In trees only the outermost growth ring adapts to mechanical loading by reactive growth. Also these composites are able to restore themselves. Following the principles from nature, he has redesigned and improved the common steel screw.

"Products alive"

Schliekelmann predicts that our dead, man-made composites may one day grow stronger under pressure. Imagine a bridge which improves its own construction according to an increase in traffic. After all, growth is an electro-chemical process, the basics of which are known to us.

Disposables & packaging

Until 1900, natural materials were applied in almost every product. The first generation of plastics weren't petroleum based but were made of casein or modified cellulose. As dealt with in the previous chapter, there were also applications of gluten and soy based plastics in the automotive industry. In the present consumer society there is a growing need for disposables and packaging which are biodegradable. Natural fibers, bioplastics or a combination of the two (composites) can be applied in both areas.

Figure 11: Fast food packaging, Albumen and gelatin (designed by author).

Trays and containers

Flax, coir, jute or hemp fiber is pressed into shapes for vegetable or fruit trays without the addition of binders. The lignin present is mostly sufficient. A granulate called Fasal made by IFA in Austria is being marketed. It's made of wood chips, crushed corn and natural resins. It is thermoplastic and biodegradable. Sometimes large leaves like banana leaves are enough to serve as packaging material. There are even orange peels which have been pressed into square shaped containers and dried.

Paper and cardboard products

Hemp has a higher yield per acre compared to trees. The fibers are longer, which results in a high- quality paper. The paper resists decomposition and yellowing as it ages does not occur. Because of its low lignin content bleaching can be done without chlorine. Hemp paper can also be recycled more often because of its longer fibers. Teabags, tissues, carbon paper, quality paper made from Agri fibers. Elephant grass is a fast-growing plant which reaches 3-4 meters in height. The structure of its fibers are similar to those of wood. So the obvious application is in the paper and cardboard industry. Straw is also a fiber which is used in the paper and cardboard industry, particularly in Denmark and Britain. The fibers of Kenaf (Hibiscus cannabinus L) are easily extracted and bleached and can serve as pulp for newspaper production. When it is combined with recycled paper it can upgrade it.

Bio pulping involves fungi to convert wood chips to paper pulp, which means a considerable reduction in energy and pollutants normally associated with paper production.

"Paper chase"

Zeneca, Shell Research and Nippon Paper Industry are working on genetically modifying lignin in paper pulp trees. This way lignin will be easier to remove from cellulose, which makes paper making less energy and chemical intensive. Nippon Paper Industry is also researching eco-bleaching by white fungi.

Shock-absorbent packaging material

Any cellulose based fiber can be turned

into a foam material like hemp or elephant grass.

Cocoloc is a composite consisting of coir bound by latex used for packing delicate products. Straw is also applied as shock-resistant material.

On Sardinia, an experimental project was started in 1992, to see whether loofah gourds were suitable to be grown in this Mediterranean climate. The reason for this experiment, which was funded by the European Union, was that loofah as a fiber source, could have many non-food applications the most important of which is shock-absorbent packaging material for delicate products. The fruit consists of 60% cellulose, 29% hemicellulose and about 11% lignin. One cubic meter of loofah weighs around 10 kg which is about the same as polystyrene foam. By compression or heat the fruit can obtain any shape. It can also be combined with various other materials from natural sources.

Bags

Bags of linen, cotton or jute are very common.

Biopolymers

Biopolymers, or bioplastics, are biodegradable by biological processes through microbes as bacteria or fungi. They are very suitable for short life-span products, such as packaging or disposables.

However, some bioplastics are also perfectly suited for longer life application. Biopolymers are often more heterogeneous than synthetic ones and their structure offers greater opportunities of modification.

Figure 12: Golf tees, sand and gelatin (designed by author).

They are sometimes seen as an outlet to get rid of agricultural surpluses. Most bioplastics can be modified to suite industrial processes for petroleum-based plastics. They can be applied as coatings, produced as foams, or injection moulded, etc.

Starch

The properties of the different sources of starch vary in strength, transparency and flexibility. For instance, pea starch produces a stiff and strong plastic. On the other hand, potato starch leads to a less strong but flexible

plastic. Potatoes contain around 20% starch. Potato starch is generally more expensive than wheat starch but is of better quality. Starch forms a good barrier to oxygen but absorbs moisture. There are several crops which are grown for starch production. Some of the important ones are corn in the United States, potato and wheat in Europe, tapioca and rice in Asia.

Figure 13: Starch peanuts.

"Corny"

At a corn flakes factory in America a material was produced by accident which looked much like polystyrene packing peanuts. It was expanded and was flexible. With a little modification Eco- foam (National Starch) was born. It has been commercially produced since 1991. The Dutch company Avebe produces potato starch in Holland, wheat starch in France and Sweden and tapioca starch in Thailand. There are mainly two groups of commercial starch products i.e.:

Expanded starch

The most common way to produce expanded starch is like the technique used for baking wafers developed by Biopack of Austria. The doughy mix in the mould is baked in an oven. As the water evaporates, a foam-like material is left. Loose-fill and trays can be produced this way.

Usually, additives are included such as puffing agents like Guar.

ISSN 2634-095X (Online); 2634-1395 (Print)

Figure 14: Starch flowers expanded in microwave (designed by author project with Avebe).

Thermoplastic starch

To be applied as a thermoplastic material, starch needs an agent like glycerol. This substance makes it possible for starch to melt, and makes it more flexible. It is colourless and has no scent. It is available for about 3ECU/kg. It can be extruded into film or sheets, or injection moulded using conventional machinery. Avebe offers a starch product called Paragon which expands in the microwave. Of the two components in starch amylase and amylopectin, amylase is of no use to the starch industry. Splitting starch costs a lot of energy and produces a lot of waste.

One of the disadvantages of potatoes is their weight. It is therefore not worthwhile to extract potatoes outside a certain radius from the starch factory.

Because of the hydrophilic and low mechanical properties of starch there are only a few areas of application. Warner Lambert in America was the first company to come up with starch as a bioplastic. At K'92 a plastics fair held in Düsseldorf they introduced Novon, made from corn and potato starch, which was applied in golf tees, loose-fill and as bin liners. In America, Cargill manufactures a line of corn-based cutlery and plates. In Belgium de Ster produces starch cutlery for passenger airlines. In the Netherlands biodegradable trays made of starch are produced by Suntray in Helmond. Biopack in Austria also produces expanded starch products. Lyckeby Biopack, founded in 1991, a Swedish/Austrian company, provided the disposables for the Lillehammer Games in Norway in 1994. Hamburger boxes and french fries' trays were made of pure starch. Plates however, were provided with a coating of cellulose, vegetable oil and natural resin.

The cutlery was made from corn starch imported from America. Cornstarch bin liners were also provided. From the beginning of 1993, the Austrian MacDonalds serves certain meals on starch plates. Lozer produces trays for German chocolates. Biotec produces sheet material which is thermoplastic and can be moulded. Novamont-Feruzzi in Italy produces

compostable bags, films for wrapping, loose-fill, cotton swabs, nursery pots and diapers from

"Designer spuds"

Researchers in Holland have come up with a genetically modified potato which only makes amylopectin. Already a similar modification was applied to corn in the United States for starch production. Mater-Bi starch. Biros made of Mater-Bi, consisting of 50-80% starch and the rest of synthetic materials. However, there are 4 grades being produced by this company, one of which is purely natural, the others have a certain synthetics content.

Other products which are being produced include capsules and several other medical products, diapers, tampon applicators, ear swabs, seed coating, abattoir aids, (vegetarian) dog bones, toys, candle sticks and ornaments for churches, fireworks rocket tips, shotgun shells, (starch)clay pigeons, fishing lures, golf-tees, trays for candy or biscuits, paper clips and windows for envelopes. Starch is biodegradable and can be turned into compost. It is also easily separated from synthetic plastics. At incineration starch emits no toxic substances and dissolves into water and carbon dioxide.

PHA / PHB

In 1929 it was discovered that bacteria produced polyester as a reserve. This group of materials which consists of many variations, is known as PHA. The material is gained by the process of fermentation. The material has good properties, such as high resistance to water and it can be applied in most industrial processes like extrusion and the production of films.

Figure 15: Biopol: biodegradable bioplastic PHB (Polyhydroxybutyrate).

ICI Zeneca was producing one of these plastics, named Biopol, commercially from sugar. Biopol is now being produced by Monsanto of Italy. It produced in a variety of plastics with different melting points varying from 136 to 162 degrees centigrade.

In 1990, the German cosmetics brand Wella introduced a biodegradable bottle made from Biopol produced by ICI. The manufacturer made an experimental batch of 200,000 bottles. The plastic is commonly applied as a coating mostly on paper products.

A problem though was the relatively high price of Biopol (in 1990, it cost 8x as much as conventional plastic bottles).

There is quite a low output of bio-polyester compared to the level of input of food like glucose or starch on which the bacteria feed. For every kilo of Biopol 3 kilos of sugar is needed and the process is quite slow. The bacteria store PHB within their cell walls, up to 90% of their total weight. To harvest the bioplastic the cell wall has to be ruptured, without damaging the plastic. This is quite a delicate procedure as the plastic is destroyed at temperatures above 70 degrees and an acidity of higher than pH value 8. A solvent was used but proved too expensive. The bacteria can also feed on fossil fuels. At Zeneca bacteria fed on natural gas. ATO-DLO has also done research with these bacteria but they feed on vegetable oils, like rape seed oil. The advantage is that it is cheaper and they claim a bigger production of PHA. Even more important is the diversity of vegetable oils. Interestingly, the diet and general conditions influence the properties of the eventual plastic. PHB has a high melting point and can with stand steam. It can be applied in diapers, coffee cups and cutlery. Also pens and disposable razors have been produced. In 1989, it was discovered that plants could be used for the production of speciality chemicals and polymers. These products were being produced by bacteria, but plants should increase their yield considerably.

"Plastic plants"

At the Michigan State University in East Lansing researchers have succeeded in having a plant produce a plastic similar to Biopol, by transferring the genes of the bacteria to this plant. Arabidopsis was engineered to produce granules of PHB and survives whilst storing it like the bacteria do. Similarly in Stanford at the Garnegie Institution mustard plants were injected with genes to make PHB. Most plants when dried could provide around 20% plastics besides their "natural" products. The discovery was sold to Monsanto in St. Louis.

Poly lactic acid

Lactic acid is a solid at room temperature. There are 2 types i.e., D-lactic acid obtained by the action of bacteria on meat extract and L.lactic acid from the fermentation of sucrose by bacteria. A mix of the two is obtained from sour milk. Bacteria act on lactose in milk and excrete lactic acid.

Figure 16: Cat casket made from bioplastic including PLA and wax. The lining is non-woven hemp.

Pure lactic acid was synthesized in 1913 for the first time. Copolymerization produces polymers with a wide range of properties. These thermal polyesters are biodegradable and can be processed using the conventional melt processing technology. In Holland, Purac and Hycail produce this material. Due to high costs, mainly because of the price of sugar, it was initially applied in medical products only. However, in the United States poly lactic acid was being produced cheaply by using waste from potatoes or whey. This new Biolac process has been patented and is marketed by a Japanese company Kyowa Hakko.

Lactic acid polymers have a long shelf-life but can be considered moisture sensitive as they degrade slowly. This may vary between six months and 20 years. Poly-lactides are high quality plastics.

There is also a transparent variety available. Biolac is the common name for this polymer. Due to high prices the application was limited to medical products, but recently these prices have dropped. However, scientists have demonstrated the process for converting potato waste to lactic acid. Other types of food waste like cheese whey, fruit, corn, grain or sorghum would be interesting for the production of bioplastics *48. Application for packaging is a possibility when a long shelf- life is required. Film, trays and boxes are suitable applications. Transparent cups have been produced. A combination with other materials is also possible.

Casein

Milk proteins like casein are presently applied into light sensitive paints for televisions and in certain glues for attaching beer labels. In the past, casein or whey was applied as plastics in combs and buttons and was processed into yarns for clothing items like ties. It was often used as a substitute to imitate ivory or tortoise shell.

Figure 17: Some Casein-based bioplastic products from the early 20th century.

Inulin

The polymer inulin (produced by chicory a blue-flowered plant) does not dissolve in water nor in many chemicals, so it might be an interesting material for cosmetics packaging. A sugar company in Holland (CSM) has begun a factory to produce inulin

from chicory.

Gluten

Found in corn and wheat, gluten is a vegetable protein. It can be chemically or enzymatically modified in order to be applied for non-food purposes. The production of wheat gluten is still growing but the demand stays stable. So there is room for industrial application too. The price can compete with other plastics. TNO in Holland has researched its possibilities and found it could be made thermo-plastic so it can be industrially processed. It can be extruded into fibers, films or tubes. It can also be used as a granulate for injection moulding or used in vacuum film.

The material breaks down within 24 hours at room temperature by addition of an enzyme (5%), so it can be called biodegradable. Some applications include bioplastics, packaging materials, biodegradable coatings, glue, slow-release materials and heart valves.

Gelatin

Gelatin is made from bones and hides and is applied into certain paper products like bank notes and capsules.

Figure 18: Jelly pen made from gelatin, felt, alcohol-based ink (designed by author).

Agar

Agar-agar is the gelatinous extract of seaweed or algae. American scientists have discovered a way to develop a solid which is lighter than air and is based on agar. The agar is dissolved in water and an organic solvent is added together with an emulsifying agent. The gel sets and is freeze-dried. The material could be applied as insulation packaging or slow-release capsules.

Chitin

Chitin occurs in exo-skeletons of anthropoids and in the walls of fungi. It is similar in structure to cellulose. In Japan, the shrimp industry is quite large and the many peels are a waste product. Scientists have succeeded in making a semi-transparent film for packaging, from a combination of chitin and cellulose. The material has good properties such as moisture resistance and good biodegradability. The researchers were working on making the film transparent.

Vegetable oils

Plastics, coatings, paints. cosmetics, detergents and lubricants are some of the products made from vegetable oils. Bicarbonic acid are supplied by microbes and applied into plastics. Crambe oil produces a kind of nylon, which is an excellent base for durable light-weight components for the aviation or marine industry. Some important oil producing crops include rapeseed, soybean, sunflower and castor. From castor oil small substitute body parts (like testicles) are made.

Figure 19: Jelly pen with vegetable oil-based ink (designed by author).

Transport

As seen in chapter 1 on chemurgy, natural materials have been applied in car parts right from the start.

Car materials

Following in the footsteps of Ford half a century earlier Mercedes has introduced a car, the E-class, which includes interior panels made from flax and sisal fiber. (Although the formerly East German made Trabant's bodywork was also made of flax fiber). Interior parts like door panels, dashboards, rear shelf, sun vizors, sound-proof / isolation material, roof and dashboard upholstery, seat upholstery and carpets.

Figure 20: A-class Mercedes Benz.

But even reinforcement in wheel arches and bumpers are possible applications for natural fibers. The Smart car and the A-class cars will include flax fiber reinforced parts instead of glass fiber ones. In Holland, KIEM, is designing an interior for Volvo Car, which will probably include platonised flax fiber parts. This material has the advantage of being moisture- resistant, lightweight, sound-proof and more safe than glass fiber. In Holland a truck is being developed, the body work of which will be consisting of unto 80% renewable materials. The weight is expected to be reduced by up to 1,000 kg.

Figure 21: Modern Soy-based foam seat for the Ford Mustang.

Some innovative processes have been developed like pultrusion by which fibers with binders are dragged through a mould to produce profiles. Other processes are injection moulding, or conventional press techniques. It has been proven that natural

fibers are indeed an improvement technically, when compared to glass fiber. Flax fiber is very light weight, so when applied in a significant quantity it could safe quite a bit on petrol consumption. Under the bonnet flax could be applied as a reinforcement fiber in brackets and hoses. But flax fiber can also be applied in exterior components like car bumpers. I suppose the use of natural fiber with use of natural binders or without binders is limited to interior use. However, when a suitable natural binder which is water-resistant is found, perhaps the outer body work will be sustainable as well.

The prospects of polylactic acid seem promising. The properties are quite similar to ABS plastic so it might be applied into car bumpers or other products which need to withstand wear. (for further information about fibers, see The home).

Fuel

Fossil fuel reserves will almost certainly be depleted in the 21st century. On top of this, the exponential growth of car use world-wide results in an increase of carbon dioxide emissions. As discussed in the chapter about chemurgy the diesel engine was originally designed to run on bio- fuel. However, it was decided to opt for fossil fuel as sources seemed endless and was relatively cheap to attain. The consequences of this decision are all too clear a century later.

Biomass can be used in several ways to produce energy:

- Incineration or vaporisation
- Oil from biomass
- Fermentation: bio-ethanol

"Timber!"

Because of petrol fuel restrictions, in war time France there were cars on the road that burned timber for fuel. Service stations sold wood for the gazogène or *"gazos"*.

Figure 22: A Gazo truck running on timber for fuel in war years.

Incineration or vaporisation

One method is to burn or vaporise the matter. By incineration, heat and electricity can be gained. By vaporization also methanol can be extracted which has many applications in the chemical field.

Nowadays, some fast-growing plants are especially grown as a source of energy such as hemp or elephant grass. Agricultural waste can also be used such as straw. In Sweden a generator was designed for maximum output (95%) of energy called the Biocomb-cyclon-burner.

In Britain an experiment has been conducted in which seaweed was grown in tanks, dried and burned to produce electricity. The carbon dioxide which is produced is redirected into the tank which speeds up growth of the seaweed. However, without government help it will not be able to compete with the cheap fossil fuels.

Oil from biomass

Rape seed is especially grown for bio-fuel in Europe and contains about 45% oil. In the EEC in 1988 5.2 million tonnes was produced. The EU have decided to keep these fuels free from tax. The emission of carbon particles which can cause cancer is more than halved. Also the carbon dioxide which is produced is absorbed by the rapeseed so the ecological chain is closed. Another advantage is that spilled biofuel is bio-degradable. Shell has developed a process (Hydrothermal Upgrading) by which about 40% oil is gained from the biomass, but it's even possible to use household organic refuse or agricultural waste material. This could make the fuel cheaper and is the cheapest green alternative to using fossil fuel.

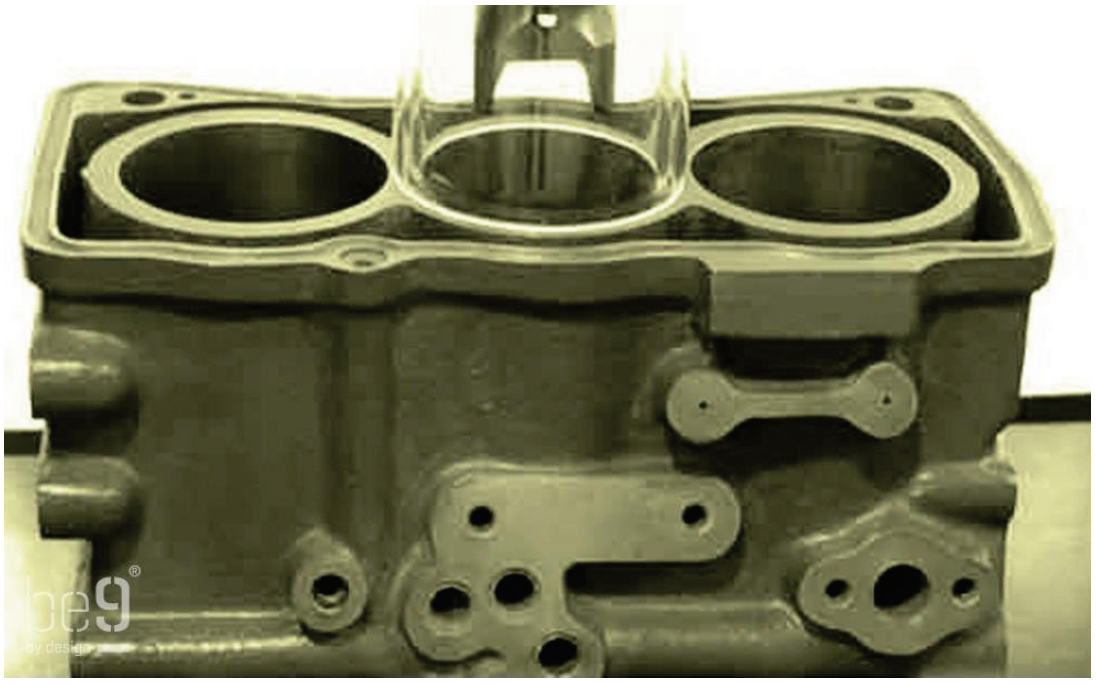

Figure 23: A modern Elsbett 3-cylinder car engine designed to run on strait vegetable oil.

The Elsbeth-engine was specially designed to run on vegetable oils but is very similar to the ordinary diesel engine. This engine enables the farmer to be self-sustainable if he grows his own fuel. Amongst other car manufactures Volkswagen is supplying a diesel engine which is also suitable for biofuel, but the fuel is not readily available yet. It is quite easy to adapt a conventional diesel engine to suit biofuel. However, the engines life span might decrease by about 2%. In Japan an experimental ceramic engined car (Isuzu) has been tested. The engine is lighter and can withstand more heat than a metal one and is therefore more efficient.

Oil extracted from biomass, has been proven economically worthwhile. But the main problem associated with this biofuel is the amount of space it takes to supply enough fuel for consumers.

Fermentation: bioethanol

As seen in the previous chapter, Ford was experimenting with alcohol derived from vegetables as a fuel for his cars. Usually *"dry"* crops are used for burning and *"wet"* crops like potato or sugar beet are used for fermentation. In Brazil corn, sugarcane and sugar-beet are grown for the extraction of alcohol. This country is the largest producer of bioethanol (12 billion litres a year). In Britain genetically modified bacteria increase the production of ethanol by about 30%. In a research report for the EU it was concluded that it was not really worthwhile to extract alcohol from plants as there was as much energy needed to recover the alcohol.

In Stockholm, Sweden, there is an experiment being conducted involving city busses running on cheap Spanish wine. Permission was granted by the EU to use five thousand tonnes of surplus wine for fuel purposes. So in the near future our cars may have ceramic engines running on wine or rapeseed oil, and have their body work and interior made up of natural fiber and bioplastics.

Cosmetics, detergents & medicine

A lot of cosmetics ingredients from biological origin, have a healing effect as well. Herbs and natural oils often contain substances which can cure. The classic ingredients for detergents and some cosmetics were sand, soap and soda.

Figure 24: Cosmetics packaging using modified bottle gourds (by author).

Plant oils, herbs and weeds

Today, about 15% of all detergents are plant based. Often natural materials like flax or coconut oil are applied. Flax can be grown

locally and needs little fertilizer or pesticides. Plant based cosmetics take less energy than those from fossil oils.

Hemp oil extracted from hemp seeds is known to assist the body's natural ability to heal. It contains essential fatty-acids and vitamins. Also soap and shampoo is made of hemp. Jojoba oil is currently the new economic wonder oil for the cosmetics industry. Besides being used in food, herbs are extensively being grown and applied in cosmetics and holistic medicine. One interesting product is a pillow filled with herbs and spices to ward off insomnia and cheer the soul. In holistic medicine old recipes are being consulted and there is a revival in the herbs industry. New, alien or forgotten herbs are being grown, for example Ginseng is being cultivated in Holland.

Industry

The Bodyshop sells many plant-based cosmetics for which sometimes special (trade-not aid) production projects are started, mostly in third world countries. Ecover a brand in detergents makes products based on vegetable oils or whey which are completely biodegradable. In the first years there was a growth in turnover of more than 400%.

Opportunities

Sometimes rare and even endangered species of animal or plant are exploited by drugs companies for a special chemical they produce. With the help of biotechnology, the desired product can be provided locally, in larger quantities and without threatening endangered species.

By the conventional method, genetically engineered bacteria produce the antibodies in fermentation vats. This is expensive because sterile conditions are needed. In another process genetically modified plants generate antibodies in their leaves. A big disadvantage of this method is that the antibodies have to be extracted immediately.

"Growing medicine"

In Germany botanists of the Institute for Plant Genetics and Culture in Gatersleben have discovered a cheap way to grow antibodies in seeds and store them indefinitely. The researchers used the tobacco plant but are now experimenting on the pea plant. The main problem however, for large scale production of antibodies will be its extraction from the peas. Perhaps it will be possible in the near future to pick your own antibodies.

At Mogen in Leiden (Holland) potatoes have been engineered to produce the human protein and serum albumin. The production by potatoes is cheaper than at the chemical industry.

In France a team of researchers at INCERM have succeeded in genetically modifying certain plants like rape seed, tobacco and corn for the production of human blood. The plants produce amino acids in their leaves, which form the basic structure for hemoglobin. After its extraction, iron is added.

Early next century it might be possible to produce pure blood cheaply on an industrial scale, by applying plants for its production.

Clothing

"Denim returns"

Presently in France (the country of origin of Denim jeans, named after the indigo colour

process developed in the city of Nîmes), coloured cotton (shades of yellow, green and brown) will be cultivated in the wine-region of Languedoc-Roussillon, thanks to research and development results at CIRAD. The cotton plant has been modified to endure the changeable European climate.

Traditionally, many natural fibers have been applied in the textile industry, such as cotton, silk, wool, and linen. the production of silk is described in the following article engines of production. Viscose and rayon fiber are made from wood fiber but are chemicals and energy intensive.

Cotton

Cotton has a bad reputation, but it remains the most important textile fiber. “Ordinary” cotton is yielded with the help of defoliate chemicals which rids the plant of its leaves.

Pesticides and insecticides are often used. The cotton is bleached and coloured, made shrink- and crease-resistant and softened which involves a lot of pollution and energy. However, there is organic cotton being produced with natural colours, described further along in opportunities.

In recent years though, since the Eco-fashion trend had started, fibers have been applied from uncommon sources such as weeds. Alternative natural fibers are often far superior to and more environment-friendly than cotton.

Hemp

Hemp fiber is stronger, longer, more lustrous and absorbent compared to cotton fiber. Hemp textile regulates temperatures very well, so keeping the wearer warmer in the cold and cooler when it is hot. Clothing made from hemp fiber has proved to be exceedingly popular in Germany and the United States. However, the fiber is too thick to be processed in existing spinning and weaving machinery. But in the near future we can expect hemp T-shirts. Hemp fiber is currently being used in jeans clothing. The original jeans made by Levi Strauss in 1850 were also made of hemp (canvas).

Peat

Amazingly enough, clothing items, covers and pillows are being made from peat. Peat is basically plant fiber which has been pressed together by age. Often peat is combined with fibers like silk or wool and spun to fiber.

Figure 25: Peat casket (designed by author).

Milkweed

Similarly, milkweed is considered a nuisance as a weed, but it is currently being grown by the Natural Fiber Corporation in America to be applied in covers and pillows.

Pineapple

Pineapple fiber is spun and woven into clothing. Thanks to the development of a new machine with UN funding fiber can be gained from the plant's leaves. The fiber seems to have good moisture regulating properties and improves the quality of the air.

"Blue genes for blue jeans"

Genetic engineers at Agracetus plan to transplant genes from an indigo plant to cotton plants for the production of blue cotton. The genes would be engineered in such a way that they would be active only in the cotton fibers, so only the cotton boll would turn blue. The colouring of cotton is polluting for the environment and requires energy. Indigo was the original pigment to be used before a cheaper, synthetic alternative was found.

Industry

In the seventies a new concept (in which Archizoom from Italy was involved), for the production of garments was developed. This involved a machine which knitted tubes instead of flat sheets. A garment normally consists of a series of tubes. Several companies like Esprit have marketed Eco-fashion made from organic cotton, which is not dyed, linen, wool or other natural fibers. The demand for organic cotton exceeded the supply. There are companies emerging specializing in the field of hemp or peat fashion.

Opportunities

Besides these new fibers there are some positive developments in the traditional fiber like wool and cotton as well. Natural coloured wool is available nowadays, sometimes from more exotic animals than the common sheep. The American Churro sheep can yield four different kinds of wool simultaneously. In America, Sally Fox has succeeded to create machine-spinnable coloured cotton (browns and greens), by crossing several varieties of

cotton. She is also working on improving the fiber quality in other colours. Her coloured cotton is now being spun by commercial machines and woven into shirts, jackets, sheets and socks for major clothing companies.

There are two American companies: Agracetus and Calgene, which are researching cotton to improve the quality of its fiber. The fiber is being engineered to be stronger, longer, finer, warmer wrinkle-free and even pre-coloured.

Engines of production

An introduction

It seems most production and processing of renewable materials for industrial purposes is still relying on energy intensive, conventional methods. Especially bioplastics are designed or modified to meet the requirements of industrial processes. For example, starch is modified by the addition of glycerine, which raises its melting point. However, there are processes being applied from other areas like the food industry. Sometimes completely new ones are applied, which have been specially designed to process natural materials, such as pultrusion. With the advent of biotechnology, we may have arrived at a transitional stage. Desirable materials can be produced by the transplantation of alien genes to rapid replicators like bacteria or plants. The following piece explains several options of manufacture.

Insect living factories

Insects have been cultivated throughout history as living factories, producing materials for man. Three examples are silk moths and lac lice and the honey bee.

Silkworms

The production of silk(beta-keratin), or sericulture originated in China, around 3000 B.C. Of the four hundred different types of moth, there are two varieties which are most common for silk production, i.e. Bombyx mori and for wild silk, Antheraea pernyi, which is not domesticated. The silkworms feed on Mulberry leaves and produce cocoons from which silk fiber is taken. Silk yarn is produced by the reeling of cocoons, which float in a tank filled with hot water.

Lac lice

The Kerria lacca is a small parasitic insect which is cultivated in India for the production of shellac. They secrete a resinous substance on branches. They are tiny and it takes several million to produce one pound of lac. Shellac was applied as isolation material for electrical equipment, in varnish and in the manufacture of gramophone records.

Honeybee

The bee is of course a well-known example. It has been cultivated for thousands of years for its products, like honey, queens jelly and wax.

Bacterial trans mutators

Bacteria of course have been used in the past in various processes for food production, such as dairy products. Bacteria are also known to clean polluted soil or water by breaking down chemicals. The Kuwait desert was very polluted by oil spills as the result of the war. The cleaning up of the oil in the sand was difficult and not making much progress involving complicated and expensive

machinery. However, in 1995 there were wild plants with yellow flowers growing on the polluted soil. A biologist went to investigate and found the roots to be completely free from oil contamination. This was because of bacteria in the root which feed on oil. Actually, the bacteria feed on nitrate-nitrogen after which the oil is broken down into carbon dioxide and water. Since its discovery the plant has been spread to other parts of the desert.

But researchers in Japan have come up with another method by applying bacteria straight to the soil. This way it works quicker and better, as the polluted sand is turned into fertile garden soil. But there is a problem i.e. the bacteria can't stand the high desert temperature. Fertilizer is mixed into the sand and water cools the mixture. So, the Kuwait desert is cleaned up and is turned into a fertile agricultural area, by the work of bacteria. As shown in the chapter about bioplastics it had been discovered early this century that bacteria can produce plastics. Today it is being commercialized as Biopol initially by Zeneca, now by Monsanto.

Only recently it has been possible to transplant genes from one organism to another. Once the genes are identified which are responsible for the making of a desirable material or substance, they can be transplanted into bacteria for high production. The bacteria produce a pulp of the material.

"Alchemist bacteria"

Bacteria are even applied in extracting gold from rocks. These bacteria feed on iron sulphate (pyrite) leaving gold.

Two interesting examples where bacteria are involved as a means of manufacture are described below:

Silk

Spider's silk is much stronger in comparison to the strongest man-made fibers like Kevlar. Several Universities in America and even the U.S. Army (since the late sixties) have been experimenting with transferring genes responsible for making silk in spiders into bacteria. The bacteria produce large protein molecules which are similar in structure as silk. The bacteria make silk pulp, from which it can be shaped into any form. Basically, the bacteria are cultured in water at around body temperature and fed on a diet of amino acids.

"Bullet-proof vests of silk"

In theory a scaled-up net of silk could catch a fighter-jet in midair. One application could be that of bullet-proof vests.

By inserting genes into micro-organisms, researchers have been able to express, or produce essentially identical molecules. In fact, any material can be tailor-made using this method. Other proteins which are interesting are elastin, collagen, alpha-keratin.

Mother of pearl (nacre)

Researchers of the University of Washington are trying to identify the proteins which are responsible for forming nacre (a protective inner layer in shells) such as in abalone. This material is twice as strong as any ceramic. If they succeed the gene will be found and can be transplanted into the bacterium Escherichia coli. The bacteria will produce the proteins in sufficient quantities.

Scientists have also researched and mimicked the principal of nacre, which is to

deflect pressure through its many layers. The resulting material is very tough and could find application in rotor blades for jet engines.

"Nacre coatings"

Perhaps it will be possible to provide products or objects with a nacre coating by immersing them in a solution of the proteins and necessary ions.

"Bioplastic plants"

Researchers at the Garnegie Institute have successfully transplanted a gene, which makes proteins from which bacteria produce PHB, into mustard plants. They say that in the future most plants will be suitable for the production of plastics. Besides growing their "normal" products, they will also provide a harvest of plastic. The plants contain about 20% degradable plastics once dried. Monsanto Co. bought the rights and it is believed that in about five years or so the first products from genetically modified plants will be commercially available. This development will reduce the costs greatly for this biodegradable plastic.

Power plants

Woods have been the engine for civilization from the start. The cultivation of plants goes back a long way, but cultivation on an industrial scale for non-food purposes probably began in colonial times with the development of plantations, for natural rubber for instance.

For the first time, plants are being used as hosts for alien material production. The reason being is that plants can produce materials in large quantities, without much attention and at low costs. As seen in the previous chapter, a plastic similar to Poly hydroxybutyrate (PHB) or Biopol, which was being produced by bacteria, can now also be produced by plants. Besides, material production, other substances can be produced by plants using similar techniques. For example, antibodies can be grown in huge quantities and stored indefinitely if they are produced in the seeds.

Nano assemblers

Perhaps the disadvantage of living engines is that they eventually die and have to provide for successors. Although my research is about biological processes, I want to include nanotechnology because it could also apply to biological materials.

The well-known physicist R. Feynman mentioned in 1959 the application of small machines to build smaller machines. The smallest machines would be able to assemble atoms.

Nanotechnology (nano - one billionth) involves building materials on a molecular level. Atoms which are the smallest parts of matter, are selected and assembled into molecules, by small machines. These machines, which resemble robotic arms, are themselves made up of molecular parts containing several thousands of atoms. Each assembly step is a chemical reaction.

The process is basically the same as the growth of a tree. Just as the self-replicating molecular machinery of a seed can make a tree, so a properly programmed replicating assembler will be able to make a tree, so a programmed replicating assembler will be able to make a micro-computer or a full-sized car. This way it is possible to build designer molecules to any specification.

"Diamond-fiber composite"

In theory, carbon atoms could be assembled in a certain way to produce diamond- fiber composite. (Diamond is the strongest material known to man). It would be possible to create a virtually indestructible and light-weight product. The material can be assembled directly into the shape of the eventual product so there is no waste material. (K. Eric Drexler).

In conclusion

In the field of materials from renewable sources, there are mainly two areas interesting to designers, i.e. bioplastics and natural fibers. In the area of bioplastics, the so called first generation, which mostly contained a certain percentage of non-biodegradable materials, has been largely replaced by a new generation of bioplastics, which are completely biodegradable. Due to price reduction in recent years, through scale enlargement, bioplastics are gradually becoming competitive. The application of bioplastics is generally limited to the field of disposables and packaging and the medical field. One particularly interesting development, although it still is in an experimental stage, concerns the production of a plastic similar to Biopol, by plants.

In the area of natural fibers, the PLATO process seems an interesting development. It basically involves a change in the structure of wood or plant fiber, brought about by cooking the matter. The resulting material is lighter, stronger and more durable than the original. Natural fibers are finding sustainable application particularly in building materials, in the paper industry, in eco-fashion, as an energy source and most recently in the car industry. Projects like the one on Sardinia involving the large-scale cultivation of Loofah gourds are a good initiative. In the case of production processes, I feel the processing of natural materials is still in a transitional stage. Presently, the material has to be modified to meet the specifications suitable for industrial processing. However, there are processes being developed specifically for dealing with natural materials, like pultrusion.

One big step further is the production by biological processes, such as the application of bacteria or plants as rapid replicators for materials. Biotechnology will assist in the improvement of production efficiency and product quality. An example is corn and potato which has been modified to produce no amylase, so starch extraction has become easier and cleaner.

Remarks

Of all renewable sources, I think the waste source is often being discarded. A lot of natural materials waste from the food industry for example, which is normally burned or buried, could be applied into products. I find the concept of applying plants or insects for the manufacture of parts or complete products fascinating. Imagine consumer goods being grown instead of being manufactured. In this area I have done some experiments, the results of which are to be found in the next chapter.

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ISSN 2634-095X (Online); 2634-1395 (Print)

College Students' Responses to the Card-Based English e-Picture Book Creating Activity (CEePBCA)

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The purpose of this study was to investigate the voices of 22 college students (F: 17; M: 4; Unknown: 1) about a Card-Based English e-Picture Book Creating Activity (CEePBCA) in an undergraduate English classroom in Taiwan. The main research question was: How did college students respond to the CEePBCA from the perspectives of all the participants, gender and TOEIC score respectively? The sources of data included an anonymous questionnaire and the participants' written reflection papers. The results of the study indicated that (a) the CEePBCA could benefit the participants in English acquisition and critical thinking development, regardless of gender and English proficiency, (b) the activity was able to help the participants boost their critical thinking more than English acquisition, (c) similar were both female and male participants' attitudes toward the activity in both English acquisition and critical thinking development, (d) the activity benefited both female and male participants in critical thinking development more than in English acquisition, (e) the activity could help both the participants with TOEIC score 700 or more and those with less than TOEIC score 700 in critical thinking development more than in English acquisition, and (f) the activity was a little more beneficial for the participants with less than TOEIC score 700 in English acquisition than those with TOEIC score 700 or more, whereas the activity was more beneficial for the latter in critical thinking development than the former. The participating students' written reflection papers also backed up the results obtained through the questionnaire.

Keywords – Taiwan, college students, English acquisition, critical thinking, Card-Based English e-Picture Book Creating Activity (CEePBCA)

Relevance of design practice – The paper addresses the voices of AFL students about a Card-Based English e-Picture Book Creating Activity (CEePBCA) in an English classroom in Taiwan. The results of the current study can contribute to the theory, research and practice of language teaching and learning, especially e-picture-book creating and learning.

Introduction

Traditional teaching is convenient, economic and time-saving (林/Lin, 2015), but it tends to be teacher-centered in the classroom (Bergmann & Sams, 2014). The teacher's lectures, the main role of teacher-centered teaching, easily make students dull, inactive (林/Lin, 2015), inattentive, and sleepy. Also, traditional teacher-centered learning focuses on rote memorization and continuous repetition, which provides students with limited skills (黃/Huang, 2018). In the teacher-centered classroom, teachers are providers of knowledge and students are passive receivers (Emaliana, 2017; Serin, 2018), and the former who hold all the answers (Roche, 2015) help the latter get standard answers (Emaliana, 2017; Serin, 2018). Such teachers may have low motivation to innovate their courses (Emaliana, 2017). In particular, teacher-centered English teachers usually lecture specific textbooks, focusing on the analysis of grammar and sentence structures (Acat & Donmez, 2009). Besides English acquisition (especially grammar and reading), students in the teacher-centered classroom may have few opportunities to develop their critical thinking.

However, in the learner-centered classroom, students can realize what they have learned and increase their sense of responsibility (Serin, 2018) in a less apprehensive classroom (Paul, 2003). The learner-centered learning theory has caused the authorities' and English teachers' attention because it focuses on learners' interests and abilities in four skills (listening, speaking, reading, and writing), argument, comparison, analysis, creativity (Moqaddam, 2016), and imagination.

One important goal of education is to help students increase their learning motivation and their ability to think and create (王/Wang & 邱/Chiu, 2018), which the Card-Based English e-Picture Book Creating Activity (CEePBCA) in this current study can reach by involving an interaction between students and their teacher in class and even between students and students in small groups. Plus, little research was done on the voices of college students about the CEePBCA. Thus, the purpose of the current study was to investigate college students' responses to the CEePBCA in an English classroom. Six research questions were produced to motivate the study as follows:

1. How did undergraduates respond to the CEePBCA in terms of English acquisition?
2. How did undergraduates respond to the CEePBCA in terms of critical thinking?
3. How did male and female undergraduates respond to the CEePBCA in terms of English acquisition respectively?
4. How did male and female undergraduates respond to the CEePBCA in terms of critical thinking respectively?
5. How did undergraduates with TOEIC score 700 or more and those with less than TOEIC score 700 respond to the CEePBCA in

terms of English acquisition respectively?

6. How did undergraduates with TOEIC score 700 or more and those with less than TOEIC score 700 respond to the CEePBCA in terms of critical thinking respectively?

Literature Review

The teacher-centered teaching tends to emphasize students' prompt outcomes while the student-centered teaching focuses on students' learning process (Paul, 2003). Traditional teaching of English is more teacher-centered than modern education nowadays. The teacher-centered English learning, such as Grammar-Translation Method (GTM) (Brown, 2007) increases students' higher pressure than the student-centered learning, such as The Silent Way (SW) and Total Physical Response (TPR) (Brown, 2007). The vital mission of modern teachers is to teach students the skills which can help them think critically (Kochiyama, 2016) and differently. Roche (2015) demonstrated that "critical thinking is a very empowering realization" (p. 42) for students to understand what they have learned or done in an anxiety-free classroom.

Picture books can supply students with a wealth of chances for language input and interactive discussion so that teachers had better choose picture books suitable for students by considering their interests (Kochiyama, 2016) and their language proficiency. Ellis and Brewster (2002) proposed that the use of children's literature could help students to learn language, cultures, and thinking. As well as vocabulary and sentence structures, students can learn "the rhythm, intonation and pronunciation of the language" (Kochiyama, 2016, p.38) by reading aloud, involve themselves in meaning creating (Mourão, 2009), and build their positive values and attitudes toward life (Ghosn, 2002).

Schemata are definitely essential but not a sufficient source to stimulate students' critical thinking development (Lai, 2011). Students' dispositions also of much importance, including fair- and open-mindedness, flexibility, a respect for different ideas, and willingness to cooperate with others, among others (Lai, 2011). The current world requires that people should have diverse abilities such as critical thinking and problem-solving skills (Ghazivakili et al., 2014). Critical thinking is essential in any scholastic curriculum and should be developed throughout the subjects (Shaheen, 2016). Thayer-Bacon (1998) stated that critical thinking can increase individuals' problem-solving skills. Critical thinking plays an important role in any educational setting (Lloyd & Bahr, 2010; Shaheen, 2016), such as language teaching. Though Shirazi and Heidari (2019) made a conclusion in their research study that critical thinking had no significant relationship with academic achievement, Fero et al. (2010) stated that critical thinking plays an important role in academic achievement.

Wang et al. (2010) investigated 52 college students' responses to two assignments in a Children's Literature class. These two assignments were "English Picture-Book Creating" (EPBC) and "English Puppet Show DVD Creating" (EPSDC). Two research questions are: (a) how did the college students relate the "English Picture-Book Creating"

(EPBC) to learning about picture books and critical thinking? and (b) how did the college students relate the "English Puppet Show DVD Creating" (EPSDC) to learning about children's literature and critical thinking? Collected data consisted of a 6-point Likert scaled questionnaire, the instructor's reflection notes, the participants' final papers, the course blog postings, the participants' picture books, and their English puppet show DVDs. The results of the study showed that the participants tended to agree that (a) they broadened their knowledge of picture books and developed their critical thinking in the EPBC activity, and (b) they broadened their knowledge of children's literature and boosted their critical thinking in the EPSDC activity.

Wang et al. (2015) explored the voices of 119 Applied Foreign Languages (AFL) freshmen (F: 100, M: 19) about the Grammar-Related e-Picture-Book Creating (GRePBC) in an English Grammar class. Two research questions are: (a) how did the AFL freshmen respond to Grammar-Related e-Picture-Book Creating (GRePBC) from the perspective of English grammar acquisition? and (b) how did the AFL freshmen respond to Grammar-Related e-Picture-Book Creating (GRePBC) from the perspective of critical thinking? Collected data included a 6-point Likert scaled questionnaire, the participants' reflection papers, and their e-picture-books. The results obtained from the research study indicated that the GRePBC was helpful for the participants to increase their English grammar power and critical thinking development.

Sun (2016) explored the voices of 80 Taiwanese college students with low to intermediate level English competency about three teaching modes from the perspectives of vocabulary acquisition and word retention. The three modes for three classes respectively are picture-book reading-only (PRO), picture-book reading plus vocabulary instruction (PRVI) and picture-book reading plus reading-based collaborative output activities (PRCOA). Two post-tests were used to measure the students' vocabulary acquisition and word retention respectively. The results of the present study showed that (a) the PRVI class increased their vocabulary power more than the other two classes, (b) the PRCOA was the best mode for vocabulary retention, and at the same time for vocabulary acquisition and retention.

Wang et al. (2020) explored the impact of the Recycling English Songs/Lyrics Activity (RESLA) on 15 Taiwanese college students' (F: 13; M: 2) English acquisition and critical thinking development in an English class. Two research questions were (a) how did the college students respond to the RESLA from the perspective of English acquisition? and (b) how did the college students respond to the RESLA from the perspective of critical thinking? The resources of data included a six-point Likert scaled questionnaire and the students' written reflection papers. Two crucial results obtained from the research study were the college students tended to agree that (a) the RESLA was helpful in increasing their English acquisition and developing their critical thinking, and (b) the RESLA helped them to develop their critical thinking more than English acquisition boost.

The above literature review shows that several course activities were helpful to intense learners' English acquisition and increase their critical thinking development. In the current

study, English acquisition includes vocabulary power, listening ability, speaking ability, reading ability, and writing ability; critical thinking involves creativity, imagination, respecting different ideas, cooperation, peer relationship, and communication skills.

The definition of creativity selected for the current study is *"an ability to generate novel ideas [and produce new objects] after continuously assembling, selecting, assessing, and connecting existing knowledge and/or prior experiences"* (italics in original, as cited in Wang, Armstrong, Wu, Wen, & Wang, 2015, p.3); that of imagination selected for the current study is *"an ability to form a vivid mental image of what has been studied and/or experiences"* (italics in original, as cited in Wang, Armstrong, Wu, Wen, & Wang, 2015, p.3).

Methodology

The purpose of the current study was to explore college students' attitudes toward the Card-Based English e-Picture Book Creating Activity (CEePBCA). This section addresses nature of the class, participants, the teaching activity, and data collection.

Nature of the Class

In this English Teaching Tool Design course, students took two class periods (100 minutes) every week. The aims of the elective course were to help students (a) know well some teaching materials and strategies, (b) enhance their enthusiasm in English teaching and learning, (c) sharpen their critical thinking/reading skills, (d) boost their technology literacy, and (e) increase their ability to choose and even produce English (e-)materials and/or tools suitable for readers or users.

Participants

The AFL (Applied Foreign Languages) college students, taking the course in English Tool Design offered in a national technical university of Southern Taiwan, were recruited to be the participants of the present study. The class size was 31 (F: 24; M: 7), but 9 of them did not rate the questionnaire because they were absent from the class either on the rating day or in the previous week. As such, twenty-two questionnaires (F: 17, 77%; M: 4, 18%; Unknown: 1, 5%) (see Table 1) were collected. Moreover, the number of the participants with TOEIC score 700 or more was 12 (55%), and that of those with less than TOEIC score 700 was 6 (27%), but 4 participants did not write down their TOEIC score records.

Table 1. Demographics of participants rating questionnaire.

Questionnaire	Valid							Invalid				Total		
TOEIC score	700+		700−		U[b]			700+		700-				
Gender	F	M	F	M	F	M	U	F	M	F	M	F	M	U
	10	2	4	2	2	0	1	1	0	0	0	**17**	**4**	1
Total	**12**		**6**		3			1		0		**21**		1
	21							1				**22**[a]		

[a] The class size was 31, but only 22 students rated the questionnaire.
[b] U: Unknown

Card-Based English e-Picture Book Creating Activity (CePBCA)

The Card-Based English e-Picture Book Creating Activity (CePBCA) was done in Weeks 3 and 4 (i.e., 4 class periods in total) of Spring Semester in 2019 as follows:

Step 1: The class was divided into five groups, with three to eight people each. Each group was delivered a round box of cards, with a picture on both sides each, by their instructor. Among the cards, each group selected ten to fifteen or more cards to create a team e-picture book. (About 15 minutes)

Step 2: Through computer, each group was required to type one or two sentences based on the picture of each card on the same PPT page. They were encouraged to look up new words in various dictionaries via smart phones and classroom computers. (About 80 minutes)

Step 3: After finishing their e-picture books, all the groups uploaded their e-picture books on the e-campus. Their instructor discussed with each group and revised their sentences together page by page. (About 40 minutes)

Step 4: After revising the sentences with their instructor, each group took time to rehearse their story. (About 20 minutes)

Step 5: After rehearsals, each group role played their work in the front of the classroom. (About 20 minutes)

Step 6: In the end, each student was required to rate the questionnaire (see Appendix A), sign a consent form (see Appendix B) and complete their reflection papers about the whole course activity based on the given questions (see Appendix C). (About 30 minutes)

Data Collection

The sources of data collection for the current study included 22 questionnaires, 22 short reflection papers, and five card-based English electronic picture books. Each of them is discussed and addressed below.

Questionnaire

The questionnaire (see Appendix A) used in Wang et al.'s study (2020) was appropriate and chosen for the current study. The questionnaire included two parts: Part 1 consisted of 12 items and Part 2 was a space for the participants' free comments. Of the 12 items, item 12 (Don't rate item 12, or your questionnaire will be invalid) was designed to exclude the questionnaires rated by any

absent-minded participants.

The questionnaire and a consent form (see Appendix B) were completed by 22 participants after all the teams role-played their works in class. The class size was 31, so the return rate was about 70% (22/31). The number of the valid questionnaire was 21 (see Table 1), because one female student with TOEIC score 700 or more rated item 12. Thus, the validity of the collected questionnaires was 95% (21/22).

Short Reflection Paper

At class in the 30 minutes of the last class period in week 4, 22 students were required to complete their short reflection papers, together with mind-maps, reflecting on the teaching activity and then posted their papers on the university e-campus. In total, 22 reflection papers for the current study were collected.

Students' Works

In total, five card-based English e-picture-books were posted on the university e-campus respectively. Furthermore, these five stories were combined into an e-collection and posted on the e-campus, and the e-collection was printed to be a paper collection (see the contents in Picture 1). These five stories were briefly described as follows:

1. The Adventure of a Thief: The title of the e-picture-book obviously suggests a thief's adventurous fantasy.
2. Who Was the Winner?: A young and pretty girl dreamed a dream in which a wizard used magic liquid to turn the other three opponents into pigs and won the girl's heart.
3. The Tragedy: The main female character was cheated by a handsome and rich, but married, millionaire and then she decided to take revenge on the man.
4. Ben's Poor Day (see Picture 2): Several bad things happened to Ben in one day, such as breaking his arm, suffering from diarrhea, and losing his apartment and father in a fire.
5. A Woman with Her Pet Pig: A woman bumped into her pet pig on a rainy day; she was scared and cried loudly, recalling the first and warm time when she had met it.

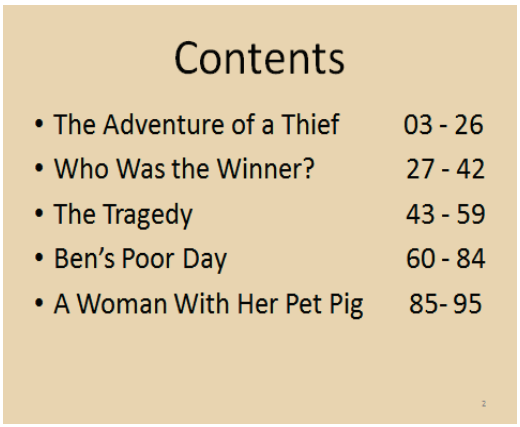

Figure 1. Contents.

Figure 2. Ben's Poor Day.

Findings/ Results and Discussion

The purpose of the current study was to explore the voices of college students about the Card-Based English e-Picture Book Creating Activity (CEePBCA). The following results and discussion are produced to answer the main research question: How did college students respond to the CEePBCA from the perspectives of all the participants, gender and TOEIC score respectively?

Overall (All the Participants)

The results of Tables 2 and 3 indicated that all the participants tended to agree with the positive impact of the CEePBCA on their English acquisition and critical thinking development. Furthermore, the comparison between the results of Table 2 and those of Table 3 indicated that the teaching activity benefited the participants in critical thinking development (average mean value=5.48) more than in English acquisition (average mean value=4.91). The result was also supported by the fact that each mean value of items 1-5 (5.33 – 5.55) in Table 3 is higher than any of items 6-11 (4.52 – 5.14) in Table 2.

English Acquisition

Table 2 shows the results of the English acquisition section of the questionnaire. All the participants tended to agree with the impact of the CEePBCA on their English acquisition ability. In comparison, participants estimated that this activity helped them most in increasing their vocabulary power (item 1: 95.24%, M=5.14), speaking ability (item 3: 95.24%, M=5.00), and writing ability (item 5: 95.24%, M=5.05), followed by reading ability (item 4: 90.47%, M=4.86), whereas participants estimated that this activity helped them least in increasing their listening ability (item 2: 85.72%, M=4.52). The average mean value of items 1 to 5 is 4.91 ((5.14+4.52+5.00+4.86+5.05)/5).

Table 2. The results of all the participants' responses to English acquisition. (n=21).

Rating	Item	1 Vocabulary Power	2 Listening Ability	3 Speaking Ability	4 Reading Ability	5 Writing Ability
StA + A + SoA[a]	n	20	18	20	19	20
	%	95.24%	85.72%	95.24%	90.47%	95.24%
StD + D + SoD [a]	n	1	3	1	2	1
	%	4.76%	14.29%	4.76%	9.52%	4.76%
All	M	5.14	4.52	5.00	4.86	5.05
Average Mean				4.91		

[a] StA + A + SoA= Strongly Agree + Agree + Somewhat Agree;

StD +D + SoD = Strongly Disagree + Disagree + Somewhat Disagree

Note: The percentage was rounded up from the second decimal point.

Critical Thinking

Table 3 shows the results obtained following the analysis of the critical thinking section of the questionnaire. The results indicated that all the participants tended to agree with the effectiveness of the CEePBCA on their critical thinking development. In comparison, participants estimated that this activity helped them most in developing their creativity (item 6: 100%, M= 5.33) and imagination (item 7: 100%, M= 5.48), respecting different ideas (item 8: 100%, M= 5.48), and increasing their communication skills (item 11: 100%, 5.55), followed by cooperation (item 9: 95.24%, M= 5.52) and peer relationship (item 10: 95.00%, M=5.50). The average mean value of items 6 to 11 is 5.48 ((5.33+5.48+5.48+5.52+5.50+ 5.55)/6).

Table 3. The results of all the participants' responses to critical thinking (n=21).

	Item	6 Creativity	7 Imagination	8 Respecting different ideas	9 Cooperation	10[b] Peer relationship	11[b] Communication skills
StA+A + SoA[a]	n	21	21	21	20	19	20
	%	100%	100%	100%	95.24%	95.00%	100%
StD+D +SoD[a]	n	0	0	0	1	1	0
	%	0%	0%	0%	4.76%	5.00%	0%
All	M	5.33	5.48	5.48	5.52	5.50	5.55
Average Mean				5.48			

[a]StA + A + SoA= Strongly Agree + Agree + Somewhat agree;

StD +D + SoD = Strongly Disagree + Disagree + Somewhat Disagree

[b]One female participant with TOEIC score 700 or more did not rate items 10 and 11.

Note. The percentage was rounded up from the second decimal point.

Gender

The results of Tables 4 and 5 indicated that both male and female participants tended to agree that the teaching activity helped them in critical thinking development and English acquisition, but benefited both males and females in the former more than the latter.

English Acquisition

Table 4 shows that this activity benefited male participants (average mean=5.10) and female ones (average mean=4.88) similarly in

English acquisition. In particular, 100% of the male participants tended to agree that this activity helped them increase their vocabulary power, listening ability, speaking ability, reading ability, and writing ability (items 1-5: M=5.50, 4.75, 5.50, 5.00, and 4.75 respectively). Over 90% of the female participants tended to agree that this activity helped them increase their vocabulary power (item 1: 93.75%, M= 5.08), speaking ability (item 3: 93.75%, M=4.94), and writing ability (item 5: 93.75%, M=5.19). Interestingly enough, the female participants' mean value (5.19) in writing ability was higher than male participants' (4.75), which resulted from the fact that female participants rated item 5 "strongly agree" (n=6) and "agree" (n=5) and male participants rated item 5 only "agree" (n=3) and "somewhat agree" (n=1).

Table 4. The results of gender's responses to English acquisition. (F=16, M=4). [b]

	Item	1 Vocabulary Power	2 Listening Ability	3 Speaking Ability	4 Reading Ability	5 Writing Ability
n % StA + A + SoA[a]	Female	15 93.75%	13 81.25%	15 93.75%	14 87.50%	15 93.75%
	Male	4 100%	4 100%	4 100%	4 100%	4 100%
n % StD + D + SoD[a]	Female	1 6.25%	3 18.75%	1 6.25%	2 12.50%	1 6.25%
	Male	0 0%	0 0%	0 0%	0 0%	0 0%
Mean	Female	5.08	4.44	4.94	4.75	5.19
	Male	5.50	4.75	5.50	5.00	4.75
Mean difference		-0.42	-0.31	-0.46	-0.25	+0.44
Average Mean	Female			4.88		
	Male			5.10		

[a] StA + A + SoA= Strongly Agree + Agree + Somewhat agree;

StD +D + SoD = Strongly Disagree + Disagree + Somewhat Disagree

[b]One student did not click the gender box.

Note: The percentage was rounded up from the second decimal point.

Critical Thinking

Table 5 presents that this activity benefited female participants (average mean=5.51) and male ones (average mean=5.38) in critical thinking development.

In particular, 100% of the male participants tended to agree that this activity helped them increase their creativity, imagination, respecting different ideas, cooperation, peer relationship, and communication skills (items 6-11: M=5.00, 5.25, 5.25, 5.50, 5.75, and 5.50 respectively). Moreover, 100% of the female participants tended to agree that this activity helped them increase their creativity, imagination, respecting different ideas (items 6-8; 5.44, 5.50, and 5.50 respectively), and communication skills (item 11: M=5.60). About 94% of the female participants tended to agree that this activity helped them increase their cooperation (item 9: 93.75%, M=5.56) and peer relationship (item 10: 93.75%, M=5.47). Interestingly enough, the male participants' mean value (5.50) in cooperation was lower than female participants' (5.56) (item 9: 100% vs. 93.75%), which resulted from the fact that male participants rated item 9 "strongly agree"

(n=2) and "agree" (n=2) and female participants rated item 9 "strongly agree" (n=11), "agree" (n=4), and "somewhat disagree" (n=1).

Table 5. The results of gender's responses to critical thinking. (F=16, M=4). [b]

	Item	6 Creativity	7 Imagination	8 Respecting different ideas	9 Cooperation	10[c] Peer relationship	11[c] Communication skills
n %	Female	16 100%	16 100%	16 100%	15 93.75%	14 93.75%	15 100%
StA + A + SoA [a]	Male	4 100%	4 100%	4 100%	4 100%	4 100%	4 100%
n %	Female	0 0%	0 0%	0 0%	1 6.25%	1 6.25%	0 0%
StD + D + SoD [a]	Male	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Mean	Female	5.44	5.50	5.50	5.56	5.47	5.60
	Male	5.00	5.25	5.25	5.50	5.75	5.50
Mean difference		0.44	0.25	0.25	0.06	0.28	0.10
Average mean	Female	5.51					
	Male	5.38					

[a] StA + A + SoA= Strongly Agree + Agree + Somewhat agree;

StD +D + SoD = Strongly Disagree + Disagree + Somewhat Disagree

[b]One student did not click the gender box.

[c]One female participant with TOEIC score 700 or more did not rate items 10 and 11.

Note: The percentage was rounded up from the second decimal point.

TOEIC Score 700

Before graduation, the AFL participants of the current study are required to gain TOEIC score 700 or more to pass their graduation threshold criteria set up by their department. That is the reason why the participants were divided into two groups based on their graduation threshold criteria in the study, with one group who had TOEIC score 700 or more, and the other group who had less than TOEIC score 700.

The results of Tables 6 and 7 indicated that both the participants with TOEIC score 700 or more and those with less than TOEIC score 700 tended to agree that the teaching activity helped them in English acquisition and critical thinking development, and the teaching activity benefited the two groups in critical thinking development more than in English acquisition. Furthermore, the teaching activity benefited the participants with less than TOEIC score 700 in English acquisition more than those with TOEIC score 700 or more, whereas the teaching activity was more beneficial to the latter than the former in critical thinking development.

English Acquisition

Table 6 shows the results obtained following the analysis of the English acquisition section of the questionnaire. Results indicated that the participants with TOEIC score 700 or more and those with less than TOEIC score 700 tended to agree with the effectiveness of the CEePBCA on their English acquisition. Overall, the teaching activity benefited the participants with TOEIC score 700 or more (average mean=4.80) in English acquisition a little less than those less than

TOEIC 700 (average mean=4.93). Comparatively speaking, the teaching activity benefited the participants with TOEIC score 700 or more in boosting their reading ability (item 4: 91.67% vs. 83.33%; M: 4.50 vs. 5.17) and writing ability (item 5: 100% vs. 83.33%; M:5.33 vs. 4.33) more than those with less than TOEIC score 700; the activity benefited the latter in increasing vocabulary power (item 1: 100% vs. 91.67%; M:5.33 vs. 4.92) and listening ability (item 2 :100% vs. 75.00%; M:4.67 vs. 4.33), and speaking ability (item 3: 100% vs. 91.67%; M:5.17 vs. 4.92) more than the former. Interestingly enough, the TOEIC-score-700-or-more participants' mean value (4.50) in reading ability boost was lower than the less-than-TOEIC-score-700 participants' (5.17) (item 4: 91.67% vs. 83.33%), which resulted from the fact that the former rated item 4 "strongly agree" (n=2), "agree" (n=3), "somewhat agree" (n=6) and "somewhat disagree" (n=1), whereas the latter rated item 4 "strongly agree" (n=3), "agree" (n=2), and "somewhat disagree" (n=1).

Table 6. The results of the responses to English acquisition from the participants with TOEIC scores. (700 or more=12, less than 700=6). [b]

	Item	1 Vocabulary Power	2 Listening Ability	3 Speaking Ability	4 Reading Ability	5 Writing Ability
n % StA + A + SoA[a]	700+	11 91.67%	9 75.00%	11 91.67%	11 91.67%	12 100%
	700−	6 100%	6 100%	6 100%	5 83.33%	5 83.33%
n % StD + D + SoD[a]	700+	1 8.33%	3 25.00%	1 8.33%	1 8.33%	0 0%
	700−	0 0%	0 0%	0 0%	1 16.67%	1 16.67%
Mean	700+	4.92	4.33	4.92	4.50	5.33
	700−	5.33	4.67	5.17	5.17	4.33
Mean difference		0.41	0.34	0.25	0.67	1.00
Average Mean	700+			4.80		
	700−			4.93		

[a]StA + A + SoA= Strongly Agree + Agree + Somewhat agree;

StD +D + SoD = Strongly Disagree + Disagree + Somewhat Disagree

[b]Two female students and one male student did not write down their TOEIC scores.

Note: The percentage was rounded up from the second decimal point.

Critical Thinking

Table 7 shows the results obtained following the analysis of the critical thinking section of the questionnaire. Results indicated that the participants with TOEIC score 700 or more and those with less than TOEIC score 700 tended to agree with the effectiveness of the CEePBCA on their critical thinking development. Overall, the CEePBCA benefited the participants with TOEIC score 700 or more (average mean=5.56) in critical thinking more than those less than TOEIC 700 (average mean=5.17). All the TOEIC-score-700-or-more participants (100%) tended to agree with all the statements of questionnaire items 6-11 (M=5.50, 5.50, 5.50, 5.75, 5.55, and 5.55 respectively, while all the less-than-TOEIC-score-700 participants (100%) tended to agree with the statements of questionnaire items 6-8 and 11 (M=4.83, 5.17, 5.17, and 5.50 respectively. Comparatively

speaking, the teaching activity benefited the TOEIC-score-700-or-more participants more than the less-than-TOEIC-score-700 ones in boosting their creativity (item 6: 100% vs. 100%; M:5.50 vs. 4.83) and imagination (item 7: 100% vs. 100%; M:5.50 vs. 5.17) and respecting different ideas (item 8: 100% vs. 100%; M:5.50 vs. 5.17) and cooperation (item 9: 100% vs. 83.33%; M:5.75 vs. 5.00) and peer relationship (item 10: 100% vs. 83.33%; M:5.55 vs. 5.33), and communication skills (item 11: 100% vs. 100%; M:5.55 vs. 5.50).

Table 7. The results of responses to critical thinking from the participants with TOEIC scores. (700+: 12, 700−: 6). [b]

	Item	6 Creativity	7 Imagination	8 Respecting different ideas	9 Cooperation	10[c] Peer relationship	11[c] Communication skills
n %	700+	12 100%	12 100%	12 100%	12 100%	11 100%	11 100%
StA + A + SoA[a]	700−	6 100%	6 100%	6 100%	5 83.33%	5 83.33%	6 100%
n %	700+	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
StD + D + SoD[a]	700−	0 0%	0 0%	0 0%	1 16.67%	1 16.67%	0 0%
Mean	700+	5.50	5.50	5.50	5.75	5.55	5.55
	700−	4.83	5.17	5.17	5.00	5.33	5.50
Mean difference		0.67	0.33	0.33	0.75	0.22	0.05
Average mean	700+	5.56					
	700−	5.17					

[a]StA + A + SoA= Strongly Agree + Agree + Somewhat agree;
StD +D + SoD = Strongly Disagree + Disagree + Somewhat Disagree
[b]Two female students and one male student did not write down their TOEIC scores. 700+:TOEIC score 700 or more; 700− : less than TOEIC score 700
[c]One female participant with TOEIC score 700 or more did not rate items 10 and 11.
Note: The percentage was rounded up from the second decimal point.

Qualitative Support (Short Reflection Papers)

The above-mentioned quantitative results were supported by such qualitative data as the quotations from the 22 participants' reflection papers and their mind maps. The following excerpts and mind maps were shown based on the alphobetical order serially.

Male Student A showed that the teaching activity benefited him the most in writing skill, imagination, and friendship. In his mind, their instructor was a helper who revised their work with them in class. His comments are as follows.

> (***Male Student A***) We created our work by brainstorming, we talked a lot and discussed, [and then we] typed in. The most [helpful] skill I learned was writing skill, thank[s to our] teacher's guiding [by which] we could correct our work. And it also improved my imagination to complete the story. My crew and I [had] already [been] good friends, so it made our friendship stronger.

This activity helped Male Student B increase his speaking ability and use correct grammar. Plus, this activity allowed him to respect his teammate's ideas and helped him enhance his imagination. He said:

> (***Male Student B***) We learn how to listen [to] other teammates' suggestions, and how

to make the story smoothly. We also learn how to use the right grammar and speak correct pronunciation. Making a story also let us use our imagination. All of our stories are very interesting and funny.

Through this activity, Male Student C learned a lot in critical thinking development, including communication skills, cooperation and peer relationship. He said:

(***Male Student C***) In the process, I offered some ideas to my teammates…. Owing to this activity, we learned how to make [our] communication well and also improved our cooperation and peer relationship.

As well as writing and speaking abilities, Male Student D thought that this activity was beneficial to him in boosting communication skills and respecting different ideas. He said:

(***Male Student D***) In this activity, we inspire our imagination to create stories with limited pictures. I think this is a good exercise for my writing skills. It also trains my speaking skills. Communicating with the team [members] when working in division of labor, everyone has different ideas; some controversy also occurred …, but we all communicate well [with one another]. This event has benefited me a lot.

Female Student A showed that they created their team e-picture book with happiness in the interesting and meaningful activity via respecting different ideas and good commination, and that increased their friendship. Also, this activity encouraged her to think and imagine. She said:

(***Female Student A)*** In my opinion, this activity is funny and really meaningful. I learned a lot from it. For example, it helped me to think faster, and broaden our imagination. It also made our team connect our relationship; this activity needs lots of communication skills; when we have different ideas, it's important that we have to respect others, so that we could finish the work with happiness.

Per se Female Student B, this activity could benefit her in writing and vocabulary power. Aside from logical thinking, she learned the importance of cooperation and respecting others' ideas in a group. She said:

(***Female Student B)*** I learned many things from this activity. For English acquisition, I learned how to collect all ideas and writing a whole story with my classmates. Also, I learned many [words] I have never seen before. In this activity, I think "respecting different ideas" and "logical thinking" are important to us. "Respecting different ideas" from other classmates is the part of teamwork. During discussion, we had many ideas but we couldn't put [them] in the same story. So, we need to respect others first and make a decision together. "Logical thinking" is the key point to organize a story line. I learned how to think logically by this activity because I have to arrange the timeline of the story.

The following quotation and Mind-map 1 showed that this activity was creative and useful for Female Student C to learn English and develop critical thinking. As well as vocabulary power and grammar, she increased her communication ability and developed her creativity and imagination in the process of creating their team e-picture book. She also suggested that the teaching activity be employed to stimulate children's creativity.

(***Female Student C***) This is a very creative and useful activity. At the beginning, I think it will be a tough [task]. But as we start to do this, I find that this card-based e-picture-book [creating] activity lets us brainstorm, learn more new vocabulary and discover our unique idea. I recognize that I am also a [person] of creativity and imagination and have a sense of accomplishment. Moreover, our team members [are] not only good at communication [but] also have the great organizational capabilities. We put all of ideas together, and create the one and only story. I like this kind of activity; it can stimulate imagination and gain the summary ability. Moreover, if we want to be a teacher in the future, it may be [a] good sample and a useful method to train children's creativity.

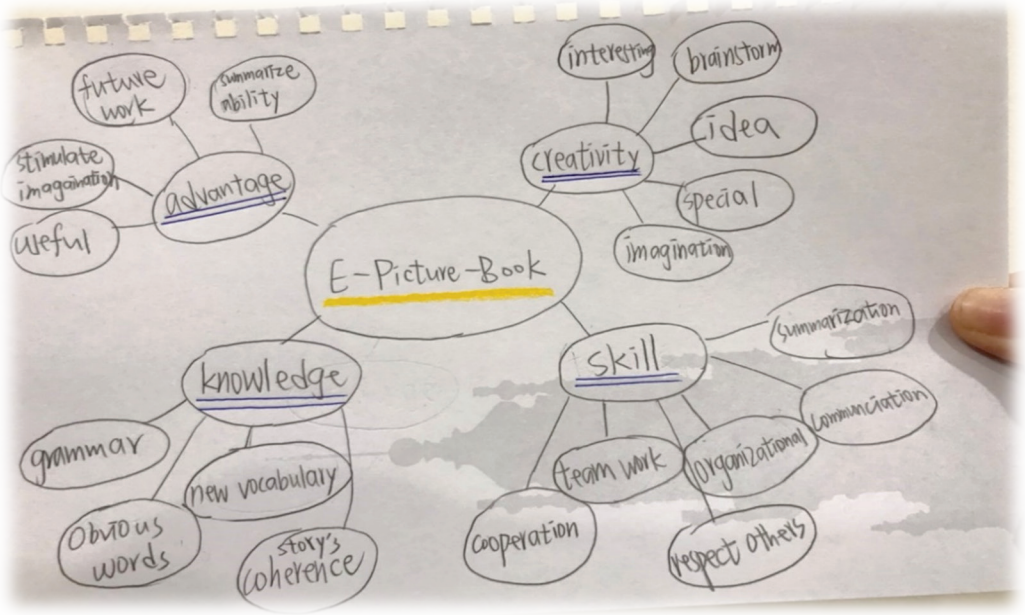

Figure 3. Mind-map 1 by Female Student C.

In this activity, Female Student D learned cooperating with her unfamiliar classmates and respecting their different ideas, and thereby she made friends with them and boost her communication skills. The following quotation is backed up by Mind-map 2. She said:

(***Female Student D***) We need to cooperate with others and listen to others' opinions. It impressed me a lot. Also, this activity gave me a chance to contact the classmates who I seldom talked [with] in class. Cooperating with new friends makes me braver to talk [with others] and enhance my communication skills.

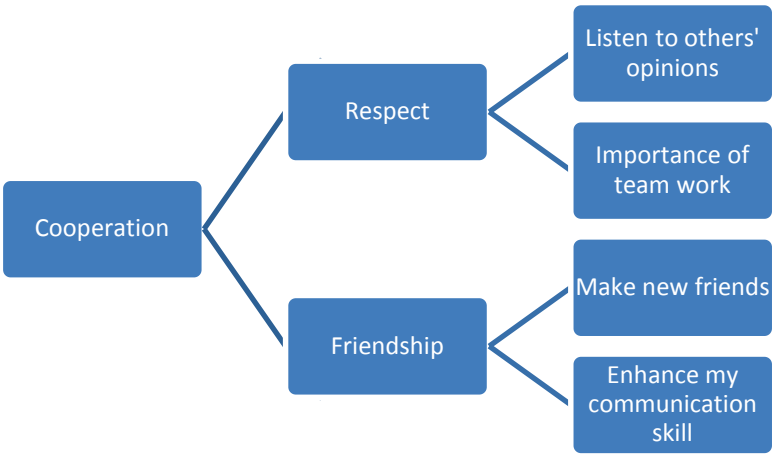

Figure 4. Mind-map 2 by Female Student D.

Conclusion

The purpose of the current study was to explore AFL college students' perceptions of the Card-Based English e-Picture Book Creating Activity (CEePBCA). The results of the current study indicated that AFL college students tended to agree with the effectiveness of the teaching activity in their English acquisition and critical thinking development, regardless of gender and English proficiency. Plus, the quantitative results were supported by the qualitative data (students' reflection papers along with mind-maps and students' English e-picture-books).

Some approaches to English teaching and learning are designed to increase learners' English acquisition and nurture their critical thinking development, which can be reached by the CEePBCA in the current study. The length of the course activity is flexible, depending on the learners' English proficiency and their critical thinking development.

Traditional teaching may easily bore students, because they are pure receivers lacking sense of participation in class. Without paying attention to their teachers, the students tend to use cell phones, read irrelevant books, watch YouTube, play video games, sleep and chat during class. Therefore, to avoid the weaknesses of this teaching model, teachers have to rack their brains to design activities to have their students involve themselves in the classes. Other interested teachers can implement this activity, CEePBCA, in their own classes such as language acquisition and English children literature. However, the students in such classes had better equip themselves with the ability to make sentences, which can make the activity keep going well. The students can be encouraged to use more difficult vocabulary, various phrases and different sentence patterns in the activity if their English proficiency is high enough.

In the process of creating English e-picture books, students can increase their ability in vocabulary, grammar, and sentence making; they can develop their imagination, creativity, cooperation, communication skills; they can expand their minds and learn to respect different thoughts; they can explore various themes and new perspectives and thereby enlarge knowledge. In the process of sharing English e-picture books, students can increase their ability in vocabulary, listening,

speaking, and reading; they can learn different themes, perspectives, and knowledge.

If time permits, the students can role play other groups' picture books, which can help the students practice listening and speaking more. On the other hand, each team can have more time to create their works. Female Student E thought that this activity was interesting and enjoyable but its length was too short for her team to make their work satisfying. She said,

> (***Female student E)***: The Card-Based [English e-picture-book] creating activity was interesting but the time to create was too short. Maybe the story we created could be more complete if we got more time to use. This is my first time to create a story based on cards picking, so I really enjoyed this activity.

Two limitations may skew the results of the current study: (a) small was the sample size, 22. (b) the gender ratio between men and women is imbalanced. The first limitation implies that the results of the current study cannot be generalized to other groups of people. The second one may skew the result that male and female attitudes toward the teaching activity. For the future research, the participants can be recruited from a larger population of AFL college students, non-AFL college students, senior high school students, and so on.

Note: This paper was presented at The 38th International Conference on English Teaching and Learning. Wenzao Ursuline University of Languages, Kaohsiung, Taiwan, July 23-24, 2021.

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Appendix

Appendix A: Questionnaire

Department/Grade: _____
Gender: □ Male □ Female □ Other

Use the following response categories. Please circle the numbers (6, 5, 4, 3, 2 or 1) in the boxes. Many thanks!!
6: Strongly Agree (St. A) 5: Agree (A) 4: Somewhat Agree (So. A)
3: Somewhat Disagree (So. D) 2: Disagree (D) 1: Strongly Disagree (St. D)

Part I

	Card-Based English e-Picture Book Creating Activity (CEePBCA) was useful to _____.	St. A.	A.	So. A.	So. D.	D.	St. D.
	English acquisition						
1	increase my vocabulary	6	5	4	2	2	1
2	increase my listening ability	6	5	4	3	2	1
3	increase my speaking ability	6	5	4	3	2	1
4	increase my reading ability	6	5	4	3	2	1
5	increase my writing ability	6	5	4	3	2	1
	Critical thinking						
6	stimulate my creativity	6	5	4	3	2	1
7	stimulate my imagination	6	5	4	3	2	1
8	learn to respect different ideas	6	5	4	3	2	1
9	increase cooperation	6	5	4	3	2	1
10	increase peer relationship	6	5	4	3	2	1
11	increase communication skills	6	5	4	3	2	1
12	**Don't** rate item 12, or your questionnaire will be invalid	6	5	4	3	2	1

Part II: Free Comments

In particular, if you rate some items **3 or below**, please write down the item number(s) and explain why in English or Chinese. Your responses will do the researcher(s) a huge favor. Many thanks!!!)

Source: Wang, C.-H., Thomson, G., Chen, Y.-S., Peng, S.-Y., Wang, E.-H., Chin, J.-K., Cheng, M.-Y., Chen, Y.-R., Huang, S.-C., & Wu, T.-Y. (2020). College students' responses to the Recycling English Songs/Lyrics Activity (RESLA). Journal of National Formosa University, 35(1), 1-21.

Appendix B: Consent Form

Human Subject Form

(March, 2019)

Department/Year: _____ Student ID No. _____ Name: _____

I, _____, freely consent to allow the instructor, XXX, Professor in the Department of Applied Foreign Languages (AFL) at National XXX University (NXU), and his co-researchers to use our team works, class pictures, my reflection paper together with mind map(s), and relevant data in their research study about English acquisition, critical thinking, technology literacy, and so on.

I understand that there is no physical and/or psychological harm anticipated as a result of participation in the research study. I have the right to withdraw personal data at any time. Any question that I have about the study can be addressed to the researcher(s). I understand that I may have access to the results of the study if I request it. Furthermore, I understand that any information I provide for the research study will NOT be used against me in any way.

Date: _____.
Signature: _____

Source: Wang, C.-H. (2003). *Self-Guided bibliotherapeutic experiences related to identity issues: Case studies of Taiwanese graduate students in American university settings*. UMI.

Appendix C: Questions for short reflection paper

Short Reflection paper

March, ____, 2020

Department/Year _____; ID N_____; Name: _____; Grade: __

Q1. How did you create your (team) work in the Card-Based e-Picture Book Creating Activity (Ce-PBCA)? What did you learn from the (Ce-PBCA), especially from the perspectives of English acquisition (e.g., four skills and vocabulary), critical thinking (e.g., creativity, imagination, respecting different ideas, cooperation, friendship/peer relationship, and communication skills), technology literacy, and so on? Draw one or more mind-maps to summarize your reflection points.
Q2. Any other comments?

ISSN 2634-095X (Online); 2634-1395 (Print)

Brand Logo and Visual Puns: The Design Imagery of NGO Logos

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In the face of changes in the information generation and other factors, many NGOs are beginning to make changes in the way they approach branding. While many recent logos design studies have extensively illustrated the trend toward simplicity, visually relevant design of logos is in some ways related to complexity. In this study, 200 university students were invited to conduct a semantic difference experiment through intentional sampling. By using SPSS analyzed the visual imagery perceptions of the 43 subjects who used visual puns to design the logos. 16 sets of semantic adjectives were dimensionally reduced through exploratory factor analysis (EFA), and the relationships between the constructs were analyzed through multiple linear regression models (MLR). The results of the study revealed that: (1) the visual imagery of NGO logos designed with visual pun could be categorized into four factors: "design feature", "brand recognition", " Figurativeness ", and "personality dimensions". (2) The design feature and personality dimensions of the logos designed with visual pun will affect the viewers' brand recognition of the NGO, among which the design features will have a greater impact.

Key words **–** visual pun, logo design, NGO.

Relevance to Design Practice **–** This study has new implications for the visual pun in logo design and offers more possibilities for redesigning the same kinds of logos.

Introduction

With the release of the United Nations (UN) Sustainable Development Goals (SDGs), the SDGs have not only become a trend for countries and researchers around the world but have also proven that non-governmental organizations (NGOs) are becoming more relevant to people (Hege et al., 2018). Many recent studies in the social science have pointed out the long-standing problems of NGOs, including underfunding, distrust of new people, credit problems, and transmission of organizational ideas. In fact, many NGOs are

beginning to transform themselves in the direction of branding (Garg et al., 2019; Iwankiewicz-Rak & Mroz-Gorgon, 2017).

As the face of a brand or organization, the logo must have simple and powerful shapes and lines to accurately and quickly convey the message to the viewer and allow the target audience to understand the meaning and value of the brand (Xu et al., 2017; Wang et al., 2018).

The combination of logo and visual puns is a paradoxical phenomenon, as the definition of logo must be purely shaped according to most current criteria (Pittard et al., 2007; Bossel et al., 2019). Visual pun is the combination of two or more elements that allow the eye to add interest to the size, shape, and color of what it sees through its own experience. Depending on the viewer's point of view, different images are seen and interpreted differently, which is often used in painting, animation, and logo design (Nick, 2019).

How to strike a balance between the fun of visual puns and the functional communication of logos and combine the advantages of both to create logos that meet the psychological expectations of consumers, this study starts with NGO logos and visual puns, and focuses on the following objectives: (1) To understand the perceptions of the test subjects on the visually relevant design of the NGO logo through the semantic difference method. (2) Through factor analysis, the experimental scale was refined to obtain the design factors of visual bicorrelation signs, and to examine whether the factors affect each other.

The parent source of the sample in this study was the 2020 list of the top 500 NGOs in the world, legally purchased through NGO Advisor, a credible evaluation organization in the field. Due to the Covid-19 epidemic and the redesign of the brand logo, the sample was limited to the period after September 2020, and any logo changes made before or after that date were excluded from this study. In addition, this study focuses on the visual imagery of visual punctuation logo design. To avoid interfering variables, the logo images used in this study were removed from the color features and displayed in black and white gray scale.

Literature review

non-governmental organization (NGO)

It is an organization that is not affiliated with any governmental entity and is not established by any state. NGOs are usually non-profit organizations that are funded by private fundraising and corporate sponsorship. Usually, these types of organizations want to be independent from the law to maintain their independence and cooperate with corporations to obtain corporate funding. It is difficult to distinguish between NGOs and NPOs, as the former resort to the government to change the status quo, while the latter use the power of the organization itself to change the status quo.

NGOs have in recent years taken the route of development towards branding (Garg et al., 2019; Iwankiewicz-Rak & Mroz-Gorgon, 2017). The brand image does affect the support and resources people invest in the organization and even some organizations are developed in a corporate model (Joachim & Schneiker, 2018).

Lloyd (2017) conducted semi-structured interviews with branded NGOs in the South African country. The study examined the strategies, models and branding experiences of these successful branding NGOs, while also confirming that funding and trust issues among NGOs remain intractable today.

Compared to the insights on this logo in the past five years, some scholars have already started to look at NGOs in Taiwan from a branding perspective 13 years ago. The study by Yeh and Liao (2008) focuses on the image quality of NGO logos and brands and the perceptual quality of the organizations. The researcher used the then newly established NGO "Legal Aid Foundation" as a case study to study the image and perceptual quality of the whole NGO. The main research method used in this study was a questionnaire survey. The researcher used literature research to develop the questionnaire structure and questions, and conducted exploratory factor analysis to extract the factors specific to this study by using the questions contained in the three dimensions of "corporate image", "brand image", and "brand awareness".

In the spirit of science, the study connects NGOs with brands. The results of the study revealed that the strength of association of the NGO brand logo with the general public has a correlation with their assessment of the brand image. There is a positive correlation between the two. It was also found that people's association with the brand actually affects their image imagery and causes their own perceptions in terms of quality.

Visual pun

In rhetoric, a pun is a phrase that has two meanings, one that looks like it is saying "this thing" and the other that is saying "that thing", using one sentence to describe two things. "Puns are often used in the fields of literature, advertising and linguistics. It is mainly used to deepen people's impressions and to make something that would otherwise be boring and humorous; according to the Merriam-Webster Online Dictionary, pun refers to multiple meanings. The single word may be traced back to the Italian puntiglio (subtle point, argument).

It is one of the One of the creative methods often used in the field of logo design. In order to get the most concise result, the designer usually selects two or more different symbols according to the purpose of image recognition, and defines the signified with the two most similar elements for integration.

The new meanings that emerge from the combination of the new symbols and the original symbols are often used by those in the advertising field to capture the audience's attention, and sometimes these new things turn into a guessing game that uses metaphors to construct marketing by involving the audience (Van, 2018).

However, in the design of visual puns, the age of the viewer must be considered, as some puns must be learned to be appreciated. Visual puns can even be combined with metaphors, exaggerations, allegories, and parables to create even more visual effects (Forceville, 2020). If visual puns are used properly in design, they can not only add interest to the target, but also

trigger the resonance and interaction between the puns and the audience.

Logo

The logo is not only for consumers to recognize the brand, but also to establish uniqueness and differentiate itself from other similar brands. The strategy of image symbols is to strategically plan and execute the symbolic system to establish the specific style and characteristics of the brand through these symbols to differentiate the brand from the competitors. A brand logo is a way to communicate with a target group and to communicate a message. Foroudi et al. (2017) define the composition of corporate brand logos as the following four components: (1) name of the company; (2) color; (3) design; and (4) font direction.

The shape of the logo is an attractive feature, for example, the roundness or angle of the logo, the symmetry of the logo shape, the sense of variation and even the rules applied in the logo design are enough to influence the consumers' attitude and imagination towards the product (Jiang et al., 2016; Bettels & Wiedmann, 2019). As for the complexity of logo shapes, in mature brand corporate logos, "complex" shapes are more easily recognized by consumers than "simple" ones; on the contrary, "simple" logo shapes are more easily recognized by consumers than "complex" ones.

This is a departure from the previous assertion that logo design must be simple and slick, which may be attributed to changes in time and cultural trends, and that brand awareness increases as the brand gains exposure, with complex brand logo design having a more active role in this process; a simple brand logo design has only short-term benefits compared to a complex brand with long-term exposure benefits (Van, 2016; Van & Das, 2016). In fact, there is a negative relationship between the symmetry of the logo and the excitement level of consumers. Instead, a logo with a sense of change can drive consumers' emotions, which in turn leads to association and consumption of the company (Bajaj & Bond, 2018; Luffarelliet al., 2019). The study by Stancu et al. (2021) examines the relationship between consumers' personality dimensions of brands and brand logo design. A study was conducted with 60 consumers on 14 retailers' brand logos.

After analyzing the data through logistic regression and algorithms, the study found that there was an interdependent relationship between the two. When the logo design was complex, consumers were more influenced by the dimension of brand personality and were able to perceive the brand attitude positively. The study found that when receiving messages from brand logos, consumers associate them with messages based on their own past experiences, so they can suggest messages related to brand attitudes through the manipulation of logo complexity. However, experts have not yet received a reasonable explanation for the cause of this implication.

Okamura and Ura (2019) published a study on shape preference of squares and circles in the 21st Century Psychology issue. The researcher validated the CMT model based on the previously proposed CMT, which has two factors, the original concept, and the target concept. The study was conducted using an online questionnaire with 100 male and 100

female office workers, for a total of 200 respondents. In recent years, research on logos has focused on logo redesign and logo design features. In a study by Bresciani and Del Ponte (2017), it was noted that logo design can help consumers judge the image of a brand and affect their attitude towards the company. The research method is to use Multiplepicture sorting to divide the logos into two groups. The results for color were different depending on the cultural background of the consumers. Machado et al. (2014) studied the preferences and reactions of consumers from different countries and cultures regarding the "imageability" of logo design. The study was conducted in two countries, Portugal and Spain, using 48 sets of logos. The study found that the image of the logo has a strong influence on the preference of consumers from different countries and cultures, and can affect consumers' emotional evaluation of the brand. It is also found that among the "imagery" of logo design, figurative logos are more likely to be liked by consumers, and in particular, logos designed using real things in nature are more effective and are not limited to specific types of logos.

Methodology

The research framework of this study is shown in Figure 1. In addition to exploring the design imagery of the visual pun design logo, the factors extracted from the exploratory factor analysis will be used to understand the elements of visual pun applied to the logo design of the NGO brand. Based on the results of the factor analysis, the components of the visual pun design will be explored in a multiple regression analysis, and the extent to which the factors influence each other.

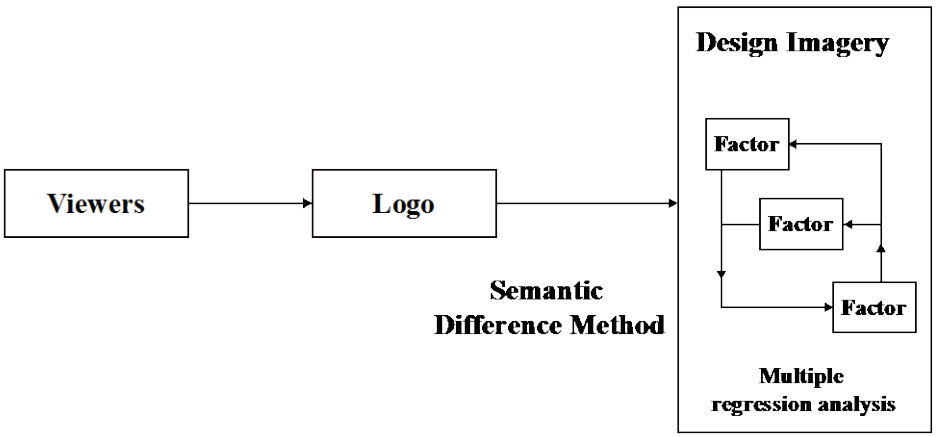


Figure 1. Research framework.

Semantic Differential

Based on the definition of visual pun, this study conducted three focus group interviews with design professionals on the sample, with a total of 15 participants, detailed basic information of participants is shown in Table 1. A total of 43 visual pun concept logos were selected. After cross-referencing, those logos that were

selected for a total of three times as the tested samples, and the samples that met the characteristics of visual pun logos were selected as follows Figure 2, For the number of times the logo was selected, can be seen in Appendix 1.

Table 1. Basic information of study sample screening members.

Sessions	Gender	Age	Educational Background	Design Experience
1	Male	26	Postgraduate students	7
	Female	24	Postgraduate students	7
	Female	24	Postgraduate students	3
	Female	23	Postgraduate students	6
	Female	23	Postgraduate students	9
2	Male	26	Postgraduate students	7
	Female	23	Postgraduate students	5
	Female	25	Postgraduate students	6
	Male	23	Postgraduate students	5
	Female	22	Postgraduate students	5
3	Male	26	Postgraduate students	7
	Female	23	Postgraduate students	8
	Male	28	Postgraduate students	5
	Female	25	Postgraduate students	8

In this study, 132 sets of semantic adjectives were collected based on studies of related semantic difference experiments (Qiu, 2008; Wu, 2004; Hem & Iversen, 2004). After eliminating 10 groups of similar, vague, and repetitive adjectives, a total of 122 groups were selected. The selection was made through a questionnaire survey of 36 students with design backgrounds, and the basic information of the participants is shown in Table 2.

The participants were mainly 2nd year university students in the graphic design course, of whom 16 were male and 20 were female, 33 were 2nd year university students, 1 was a 1st year master's student, and 2 were 2nd year master's students. The participants selected the adjectives that they thought were applicable to their own sample logos by using a projector to project the sample logos on the screen while rotating the sample through the paper questionnaire. A total of 16 sets of adjectives were selected for each projection for about 1 minute, and the most frequently selected adjectives that were suitable for this study were filtered out as shown in Table 3.

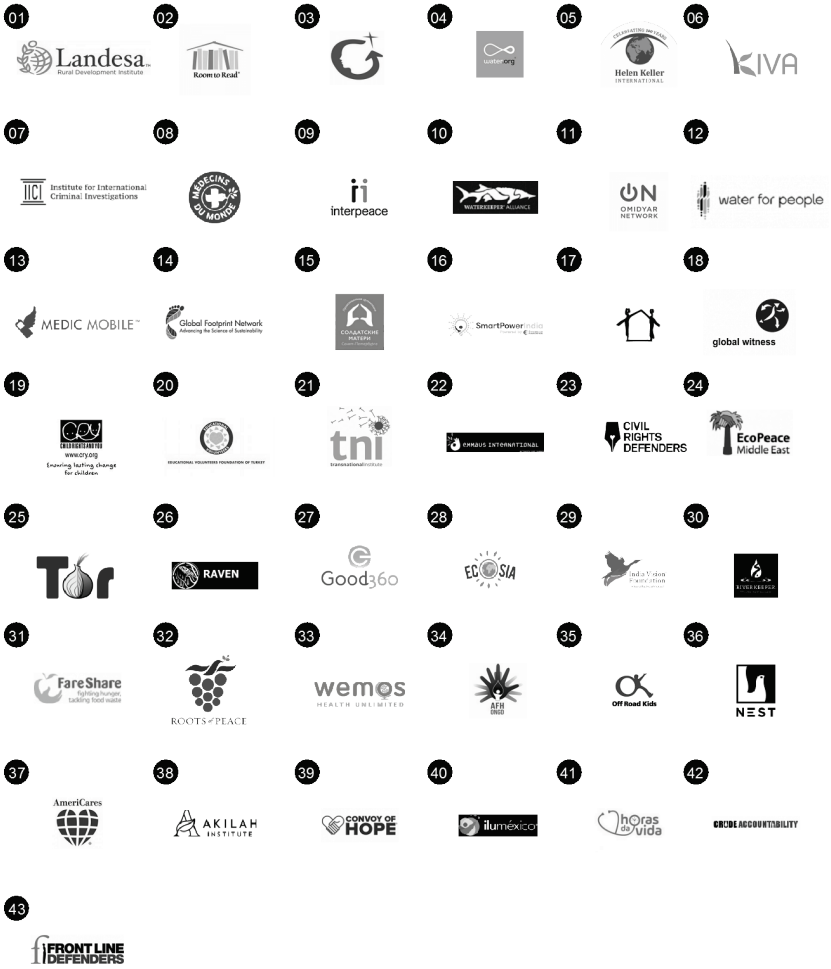


Figure 2. Sample of semantic difference experiment.

To avoid over-specialization of the adjective vocabulary, the adjective scales were screened by young Chinese experts to exclude the more difficult words for the youth group, the basic information of the experts is shown in Table 4 below.

Since the study of psychologists Takahashi et al. (2016) confirmed that the semantic difference scale can be used for behaviors that cannot be measured by biological abilities, such as mental perception, attitude, and intention, and the study of Stoklasa et al. (2019) indicated that the semantic difference scale is superior to the Likert scale in psychological studies, the scale design in this study Therefore, in this study, the semantic difference scale will be used for the construction of the experimental scale.

Table 2. Semantic adjective selection participant profile.

Variables	Number of people
Male	16
Female	20
2nd Year of University	33
3rd year of University	0
4th year of university	0
First Year of Master	1
Second Year of Master	2

Table 3. Results of semantic adjective selection.

Semantic Adjectives for Experimentation			
Bold - Conservative	Lively - boring	Simple - Complicated	Personalized - Public
Abundant - Poor	Casual - Discreet	Round and smooth - sharp	Rational - Emotional
Coordinated - abrupt	Eye-catching - mediocre	Designed - Systematic	Professional - Amateur
Abstract - Figurative	Regular - mutated	Easy to read - hard to understand	New - Old

Table 4. Basic information of Chinese experts.

Gender	Age	Expertise	Awarded Experience
Female	26	Youth Literature Scriptwriting for theatre	Taipei Literature Award -the Excellence Award.

Results

Research Participants

The test subjects came from two schools, Fu Jen Catholic University and Chinese Culture University. The visual imagery experiment was conducted during class time, and the participants were selected for their ability to complete the entire scale on their own. The collected semantic scales included three invalid questionnaires, one blank questionnaire, and two apparently random questionnaires; 200 valid questionnaires were returned, with a return rate of 99.85%, The basic statistics of the test subjects are shown in Table 5. There were 200 subjects, of which 40 were biological males and 160 were biological females, with 145 subjects (72.5%) aged 20-24 years and 55 (27.5%) aged under 19 years. The largest number of respondents were in their third year of college, with 90 (45%), followed by 45 (22.5%) in their first year of college, and a small number of respondents were in their

fourth and fifth year of college. A small number of respondents were in their fourth and fifth year of college (and above) and were extended graduates of the Liberal Studies program, with 32 (16%).

Table 5. Basic statistics of experimental subjects.

Variables	Category	Number of people(N=200)	Percentage
Gender	Physiological male	40	20%
	Physiological female	160	80%
	Other	0	0%
Age	Under 19 years old	55	27.5%
	20 to 24 years old	145	72.5%
	25 to 29 years old	0	0%
	30 to 34 years old	0	0%
	Over 34 years old	0	0%
Grade	University First Year	45	22.5%
	University 2nd year	33	16.5%
	University 3rd year	90	45%
	University 4th Year	26	13%
	University 5th Year	6	3%

Semantic scale results

Based on the visual imagery evaluations of 43 logos by 200 young subjects in the formal experiment, the average ratings of the 16 adjective scales were compiled. The top three visual pun marks with the highest and the bottom three visual pun logos in the 16 sets of adjective scales will be analyzed for design imagery.

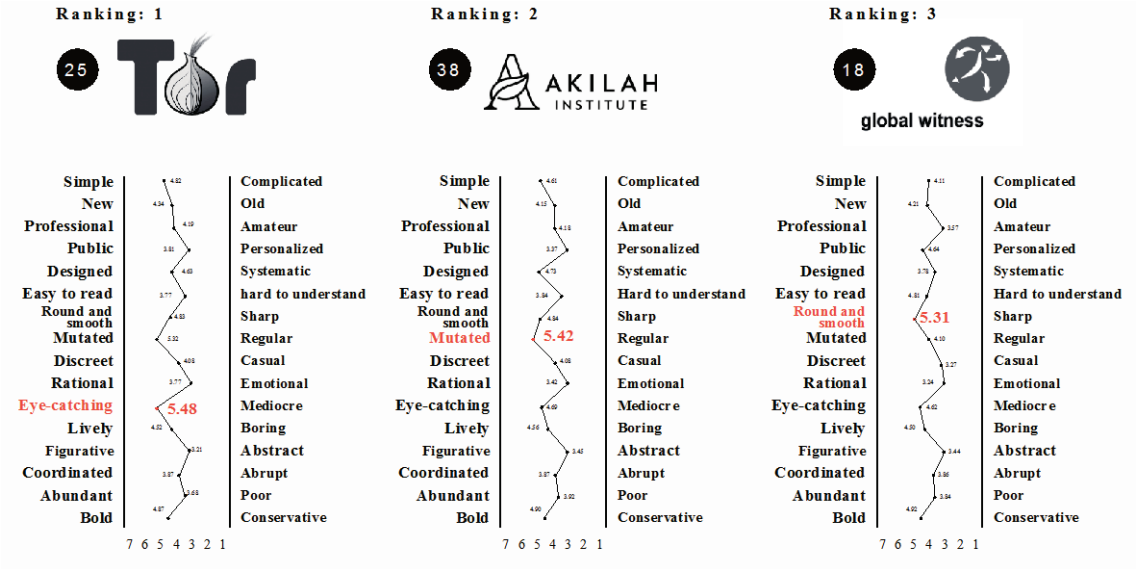
When the scales in the selection were repeated, they were selected downward until all three sets of scales were different, and the top three highest rated positive adjective scales were selected. The top three highly rated signs on the positive adjective scale can be seen in Table 6, among the 16 adjective sets in the formal experiment, the positive visual imagery term that received the highest average rating was logo 25 "eye-catching", with an average of 5.48. logo 25 is from The Onion Router organization. Often referred to as "The Onion" in Taiwan, the organization has been working to protect the privacy and transparency of what people do online, and advocates for the right of all humans to use the Internet freely. The most famous contribution is that it was used as an important browser tool in the 2010 Arab Spring, and the O in the organization's logo was directly replaced with an onion, so that viewers would see the onion as an O.

Without affecting the meaning of the word itself, it is easy for viewers to understand that the organization is "Onion". Although the design does not use too many techniques or metaphors, it has become the most eye-catching symbol in the visual experience of young people.

The second highest rated scale was “mutated", which appeared in Logo 38, with a mean rating of 5.42 and a standard deviation of 1.04, indicating that respondents from the younger age group were consistent in their assessment of whether the visual imagery of the logo was more regular or more mutated.

The logo is AKILAH, a non-governmental organization dedicated to the promotion of women's higher education in East Africa, emphasizing that the members of the organization can be highly integrated with women's leadership and future career development, and its logo is a combination of the letter "A" and a leaf. The sense of variation in logo design is more exciting to consumers than symmetrical and regular design logos, which is the same argument as Bettels and Wiedmann (2019).

Table 6. Highest semantic evaluation of the top three logos.



The third rated adjective is “round and smooth", which appears in logo 18, with an average rating of 5.31 and a standard deviation of 1.00. Again, this shows that among the 43 visually punctuated logos designed by young people, this logo is the smoothest in terms of visual perception.

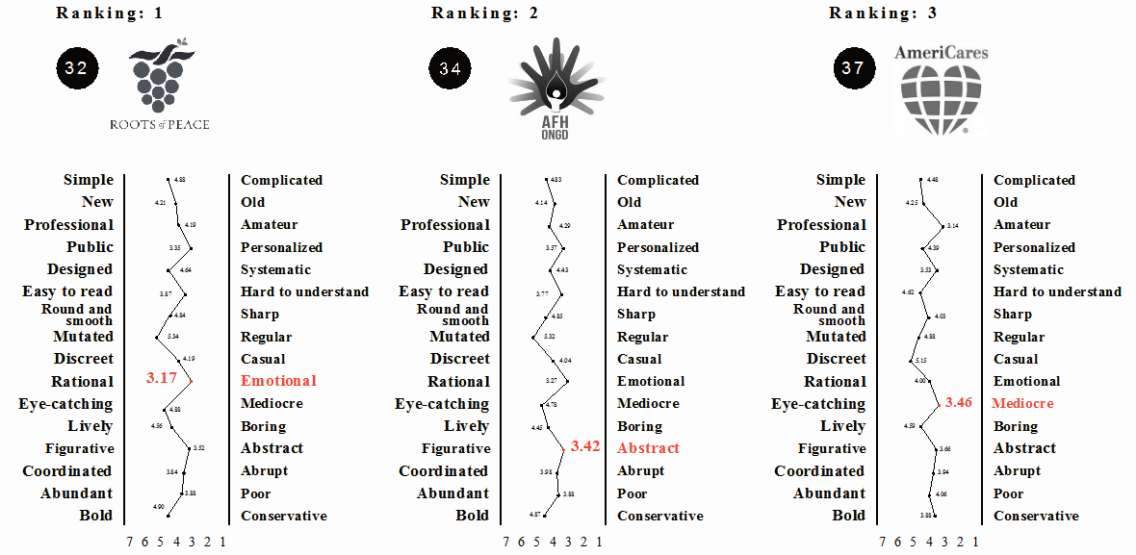
As can be seen in Table 7, among the 16 adjective scales in the formal experiment, the three adjectives that received the lowest mean ratings (indicating that the visual imagery was more skewed towards the other end of the scale) were “emotional", "abstract", and “mediocre”. The adjective "sensual" was rated at 3.17 and appeared in the sample logo32 with a standard deviation of 1.24. In the larger experiment, the respondents' responses were less discrete, indicating that the young respondents were more emotional in their perception of the visual imagery of the logo.

The logo is Roots of Places, an organization dedicated to helping the desolate lands that have experienced war through agricultural technology reform, and fostering agriculture in the region to improve the living standards of these people. In the logo, the dove symbolizing peace is used as the root of the grape, which has the image of peace and food, and the meaning conveyed by the logo is in line with the organization's development philosophy, making people feel a more emotional logo design.

The second lowest negative adjective was "abstract", which received a mean rating of 3.42, with a standard deviation of 1.54, indicating a greater dispersion between the abstract and figurative visual perceptions of the logo. The logo is the Association for Empowering the Hondurans (AFH), whose main activity is to improve the lives of

Honduran families by providing them with technical and economic support in their daily activities or specific business models, and by promoting agricultural, educational, and socio-economic development activities.

Table 7. Lowest semantic evaluation of the top three logos.



The logo is designed in such a way that the white color in front looks like a person holding a water drop and a candle flame full of hope, while the object at the back looks like a light and a palm. It is true that the visual perception is not so direct that people can feel a qualitative image, presumably because the image of the logo is less clear than other visual pun logo, so the scale of the logo in the average evaluation is in the direction of abstraction.

The "mediocre" adjective scale is the third lowest in the negative vocabulary, with a mean score of 3.46, while the sign to which it belongs is the sample sign 37, with a standard deviation of 1.37. This shows that the dispersion of respondents' answers is in the middle, which means that not all of them consider the sign to be mediocre.

The organization is AMERICARES, a health-oriented NGO that helps poor families and people affected by disasters to recover from them by changing their behavior in the use of medical supplies and medicines. The logo is based on a love heart with white lines cut at equal intervals, which has the visual image of the earth. It is assumed that the logo is most mediocre in terms of visual perception because of the cut lines and the symmetrical design of the left and right.

Table 8. KMO and Bartlett's test results.

KMO & Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.846
Bartlett's Test of Sphericity	Approx. Chi-Square	96729.412
	df	120
	Sig.	.000

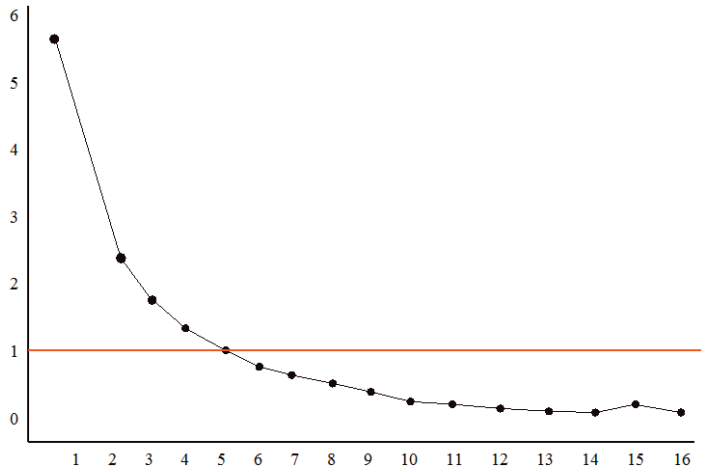


Figure 3. Factor scree test.

Table 9. Factor Loading Plot.

Rotated Factor Matrix[a]				
	Design Feature	Brand recognition	Figurativeness	Personality Dimension
Abundant - Poor	0.843			
Bold - Conservative	0.818			
Eye-catching - Mediocre	0.810			
Designed - Systematic	0.799			
Easy to read - Hard to understand	0.798			
Lively - Boring	0.722			
Coordinated - Abrupt	0.644			
Professional - Amateur		0.866		
Personalized - Public		0.766		
New - Old			0.830	
Abstract - Figurative			-0.734	
Regular - Mutated			0.617	
Casual - Discreet				-0.834
Simple - Complicated				0.624
Rational - Emotional				-0.613
Round and smooth - Sharp				0.582
Extraction Method: Principal Axis Factoring.				
Rotation Method: Varimax with Kaiser Normalization.				
a. Rotation converged in 5 iterations.				
Eigenvalues	4.852	2.276	2.127	2.085
% of variance	30.322	14.226	13.295	13.031
% of total variance	30.322	44.548	57.843	70.874

Exploratory Factor Analysis

The results of the experiments are shown in Table 8, where the fitness level of the samples was 0.846. According to the principles of fitness, a value above 0.9 is optimal, a value between 0.9 and 0.8 is a good fitness level, 0.7 to 0.6 is barely, and 0.6 to 0.5 is not recommended for subsequent analysis. Data with a fitness of 0.5 or less are not suitable for factor analysis at all. The fitness of this study reached 0.846, i.e., in the good range, and the fitness of the formal experiment was also higher than the pre-test, i.e., the data obtained in the formal experiment were suitable for the subsequent factor analysis.

The approximate chi-squared check statistic of 96729.412 with a degree of freedom of 120 and a significance p-value of 0.000, which is less than 0.05, rejects the null hypothesis H0, indicating that the variables

between the formal experiments are suitable for subsequent factor analysis.

Factor Extraction

The statistical method was used to extract common factors using Principal Component Analysis, and Varimax was used as the factor spindle. In the steep slope of the formal experiment, there were five factors with eigenvalues above 1, but after the fourth factor, the scree test began to level off, and the eigenvalue of the fifth factor was 1.00, which was not very meaningful if it was included in the factors (See Figure 3).

Table 9 shows the data obtained from the formal experiments, which were statistically analyzed by principal component analysis, and the matrix of the axes after the factors were axed by Varimax. The explanatory variance of the four factors is 30.322(%), 14.226(%), 13.295(%) and 13.031(%), and the total cumulative explanatory variance is 70.874(%), which exceeded the minimum standard value of 60(%). The 16 groups of adjectives are divided into four factors after the adjustment of the spinning matrix. The first part of the factors is composed of sevem groups of words, including "Abundant - Poor", "Bold - Conservative", "Eye-catching - mediocre", "Designed - Systematic", "Easy to read - hard to understand", "Lively - boring", and "Coordinated - abrupt", this named as "design feature" according to the vocabulary contained in the first factor and the relevant information obtained from the literature. The second factor is composed of two groups of terms, including "Professional - Amateur" and "Personalized - Public", according to the literature, Ye and Liao (2008), who used the same concept of branding to study the logo design of NGOs as the subject and medium of this study. In this study, the concept of brand image is proposed, and this study invokes this concept with minor modifications and names the factor as "brand recognition".

The third factor consists of three sets of terms in the test scale, "New - Old", "Abstract - Figurative", and "Regular - Mutated", according to the characteristics of the terms included. According to Machado et al. (2012) and Machado et al. (2014), the abstract and figurative aspects of logo design have been completely studied and defined, and named as "Figurativeness".

Table 10. The logo factor scores some statistics.

Logo NO.	DesignFeature	Brand recognition	Figurativeness	Personality Dimension
1.00	0.17	0.26	- 0.15	- 0.02
2.00	0.16	0.32	- 0.19	- 0.11
3.00	0.17	0.49	- 0.27	- 0.16
4.00	0.15	0.55	- 0.25	- 0.05
5.00	0.03	0.53	- 0.26	- 0.20
6.00	0.22	0.26	- 0.14	- 0.07
7.00	0.11	0.19	- 0.22	- 0.05
8.00	0.08	0.15	- 0.09	- 0.12
9.00	- 0.06	- 0.09	0.03	0.02
10.00	- 0.03	- 0.09	0.07	0.04
11.00	- 0.05	- 0.08	0.09	0.06
12.00	0.01	- 0.01	- 0.01	- 0.04
13.00	- 0.03	- 0.09	0.07	0.04
14.00	- 0.04	- 0.09	0.05	0.02
15.00	- 0.04	- 0.10	0.05	0.04
16.00	- 0.03	- 0.09	0.04	0.00
17.00	- 0.05	- 0.10	0.06	0.06
18.00	- 0.03	- 0.11	0.05	0.02
19.00	- 0.05	- 0.11	0.04	0.02
20.00	- 0.05	- 0.07	0.05	0.05
21.00	- 0.04	- 0.09	0.05	0.01
22.00	- 0.07	- 0.09	0.01	0.04
23.00	- 0.03	- 0.09	0.07	0.04
24.00	- 0.05	- 0.09	0.03	0.00
25.00	- 0.05	- 0.09	0.06	0.05
26.00	- 0.05	- 0.11	0.02	0.03
27.00	- 0.04	- 0.09	0.07	0.06
28.00	- 0.09	- 0.05	0.04	0.02
29.00	- 0.02	- 0.10	0.05	0.00
30.00	0.00	- 0.09	0.04	0.00
31.00	- 0.04	- 0.08	0.06	0.03
32.00	- 0.04	- 0.11	0.06	0.04
33.00	- 0.03	- 0.06	0.04	0.01
34.00	- 0.05	- 0.10	0.06	0.06
35.00	- 0.05	- 0.07	0.06	0.07
36.00	- 0.05	- 0.09	0.07	0.06
37.00	0.03	0.00	- 0.06	- 0.08
38.00	0.04	- 0.09	0.07	- 0.02
37.00	0.03	0.00	- 0.06	- 0.08
38.00	0.04	- 0.09	0.07	- 0.02
39.00	0.05	0.05	0.04	- 0.01
40.00	0.00	- 0.04	- 0.02	- 0.09
41.00	- 0.04	- 0.10	0.07	0.05
42.00	- 0.02	- 0.08	0.08	0.05
43.00	- 0.04	- 0.06	0.04	0.01

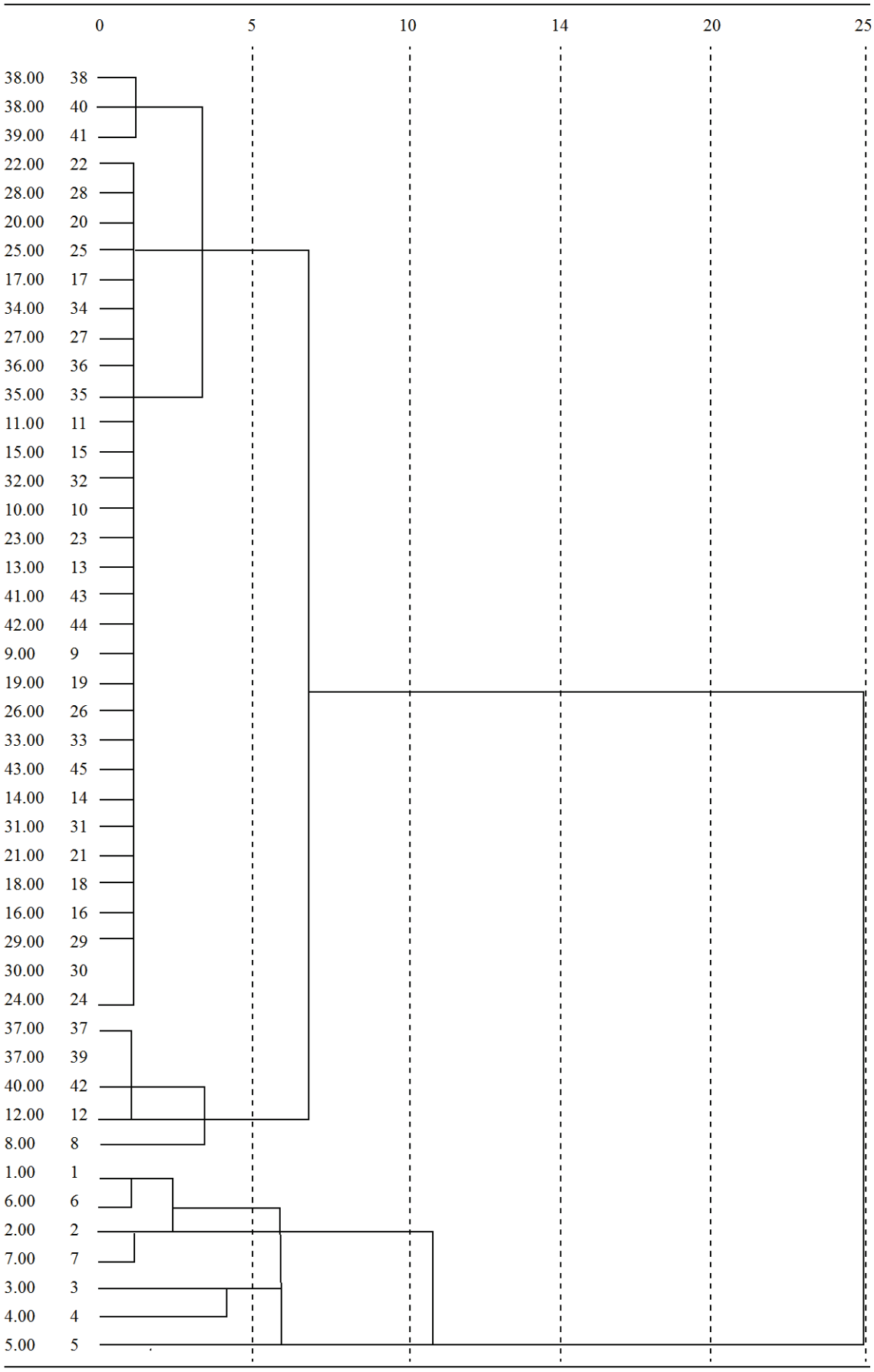


Figure 4. Cluster analysis tree plot.

Because the researcher has contributed to the research on logo design and repeatedly confirmed the meaning and suitability of figurativeness in new research, this study named this factor as "Figurativeness". The fourth factor consists of four sets of original terms: "Casual - Discreet", "Simple - Complicated", "Rational - Emotional", and "Round and smooth - Sharp". This study named this factor as "personality dimension" based on Stancu and Constantin's (2021) study on the complexity of logo design, consumer perception and brand personality dimension.

Hierarchical cluster analysis

To allow the same group of similar logos to be discussed together, the mean scores of each logo on the four factors were transformed as shown in Table 10, and then a hierarchical cluster analysis was conducted. To facilitate the understanding of the clustering, this study chose to use tree diagrams for the analysis instead of using icicle analysis. The clustering approach was based on inter-cluster linkage as the main method, and the measurement interval was performed by squared Euclidean straight-line distance, and the clustering results are shown in Fig. 4.

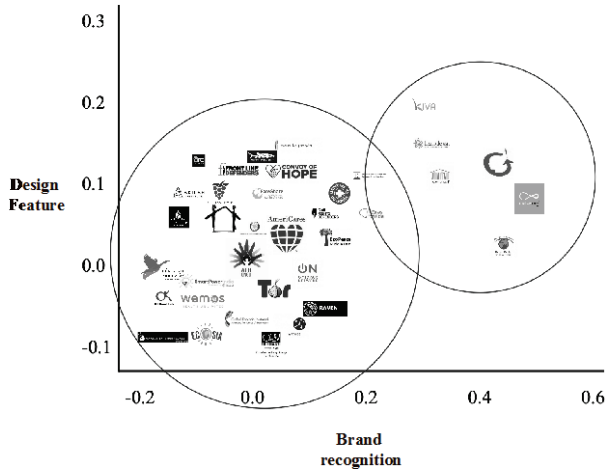


Figure 5. Factor 1 and 2 cluster analysis plot.

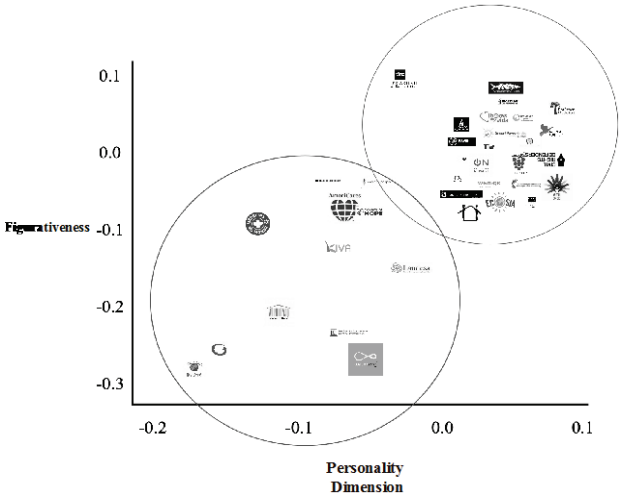


Figure 6. Factor 3 and 4 cluster analysis plot.

hen clustering at 10, the 43 marker samples will be divided into 5 clusters; at 15, they will be divided into 2 clusters; and at 20, they will also be divided into 2 clusters. Although there is no specific method to cut out the distance for cluster analysis, the researcher basically relies on the objective perspective to cut out the sample distance. In the scattering diagram, it is obvious that the samples are divided into two clusters, so the distance15 is used for the hierarchical clustering.

After the hierarchical cluster analysis, the logos were placed in order according to the quadrant coordinates (x,y), Figure 5 and Figure 6 show the distribution of the four factors, and it can be found that the sample is clearly divided into two groups.

In Figure 5, the first group of logos is slightly underperformed in terms of "design feature" and "brand recognition", while the other group of logos has a relatively higher performance. IN Figure 6, the features of "Figurativeness" and "Personality Dimension" of the first group of logos are also less obvious than the other group of logos.

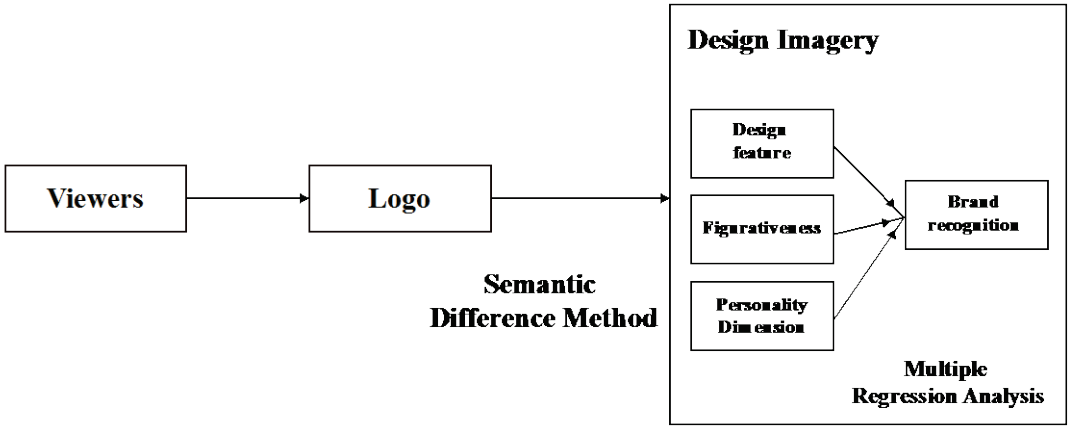


Figure 7. Revision of the research framework.

Multiple regression analysis

After integrating the scale data recovered from the formal test, the four factors obtained through factor analysis were used to name the four constructs based on previous research related to NGOs, logo design imagery, etc. (Van, 2016；Van & Das, 2016；Bresciani & Del Ponte, 2017；Sharma & Varki, 2018；Stancu et al., 2021). The three components of "design features", "Figurativeness" and "personality dimensions" were used as independent variables and "brand awareness" was used as a dependent variable to conduct multiple regression analysis to understand the degree of influence of each component and the component with the greatest influence on "brand recognition", and to modify the structure of this study based on the results (see Figure 7).

The structure of this study was derived from factor analysis, the correlation coefficients between the factors were not higher than those between the factors and the variables within the factors, since the questions with high correlation with each other were formed into one factor in the process. However, in some cases, if the correlation coefficients of the factors and variables are only slightly

different from the variables in the group, and thus sorted to the next factor, the high correlation coefficients may still cause the problem of collinearity between the factors. Therefore, before exploring the constructs of factor analysis, it is necessary to confirm that there is no collinearity in the constructs to avoid reducing the explanatory power of the regression model

With "brand recognition" as the dependent variable, all the components of "design feature", " figurativeness" and "personality dimension" were significantly correlated, with 0.316 for "design feature", 0.153 for "figurative" and 0.240 for "personality dimension", respectively (see Table.11). In Table 11, when "brand recognition" was used as a dependent variable, all the components of "design features", " figurativeness" and "personality dimensions" were significantly correlated, with 0.316 for "design features", 0.153 for "figurativeness" and 0.240 for "personality dimensions" respectively.

Moving on to Table 12, this is a summary of the regression models generated from the multivariate regression analysis using the forced input method.

Table 11. Correlation coefficients for each factor.

Correlations

Pearson Correlation	Design feature	Brand recognition	Figurativeness	Personality dimension
Design feature	1			
Brand recognition	0.316**	1		
Figurativeness	0.439**	0.153*	1	
Personality dimension	-0.017	0.240**	0.304	1

**.Correlation is significant at the 0.01 level(2-tailed).
*. Correlation is significant at the 0.01 level(2-tailed).

Table 12. Summary table of "Brand recognition" regression model.

Model Summary

Model	R	R Square	Adjusted R Square
1	0.743[a]	0.694	0.662

a. Predictors: (Constant),Figurativeness, Design feature , Personality dimension.

Table 13. "Brand recognition" regression model F checklist.

Anova[a]

Model	Sum of Squares	Mean Square	F	Sig.
Regression	0.717	0.239	12.431	0.000[b]
Residual	3.770	0.019		
Total	4.487			

a. Dependent：Brand recognition
b. Predictors：(Constant),Figurativeness, personality dimensions, design feature.

The R-squared value is 0.743 and the adjusted R-squared value is 0.694, indicating that the regression model generated by the three independent variables in this study can explain a total of 69.4%. The adjusted R-squared value of 0.662 was used in this study, considering the number of independent variables and the determination of the inflation coefficient due to the sample size.

Using the significance checklist of the regression model, the calculated F-value is 12.341, with a significance p-value less than 0.001, rejecting the need for no hypothesis. Therefore, it can be inferred that the R-squared value of this regression model in the parent is not zero, i.e., at least one of the three constructs can provide explanatory power to this model. This means that this "brand recognition" regression model is statistically significant and therefore this model has predictive power (see Table 13).

Table 14. Regression model coefficient margin check statistics.

Coefficients[a]

Model	B	β	t	Sig.
1 (Constant)	0.776		1.198	0.232*
Design feature	0.286	0.323	4.422	0.000***
Figurativeness	-0.010	-0.007	-0.092	0.927
Personality dimensions	0.465	0.246	3.740	0.000***

a Dependent：Brand recognition

***p<0.001,**p<0.01,*p=<0.05

Table 14 shows the individual regression coefficients of the three dimensions. The T-values of "design feature" (x1) and "personality dimensions" (x3) are 4.422, 3.740, and salience are less than 0.001, both of which reject the hypothesis of needing no hypothesis; the T-value of " figurativeness" (x2) is -0.092; the p-value is 0.927>0.05, so the hypothesis of needing no hypothesis cannot be rejected.

In this study, the Beta (Standardized Coefficient) value was used to determine which of the three components had the greatest influence on "brand recognition", and "design feature" had the greatest influence at 0.323.

The F-value of the three factors in this study was 12.431, with a significant p-value of less than 0.001, which rejects the hypothesis. Therefore, it means that the factors of "design feature" and "personality dimensions" affect the brand perception of the NGO logo designed by visual pun approach.

Model Reliability Check

In order to check whether the "brand recognition" regression model of this study is consistent with the three majors assumptions of linear regression, the Shapiro-Wilk normality check was first performed with the Unstandardized Residual of the model, as shown in Table 15. According to this normality test, H0 and Ha are assumed to be normal and non-normal respectively, and the significance

of the model is 0.665>0.05. The assumption of H0 cannot be rejected, which means that the normal distribution of the "brand recognition" regression model cannot be rejected. The basic assumption of linear regression is that the dependent variable and the self-variable must have a linear relationship, and the residuals are plotted as a normal probability diagram in Figure 8.

According to the characteristics of the normality diagram, a residual of 45 lines means that it is obeying the normality distribution, the "brand recognition" regression model in this study obeys the assumption of linear regression for the normality distribution, as can be inferred from Table 15 and Figure 8.

Table 15. Regression model standing checklist.

Normal calibration

Unstandardized Residual	Kolmogorov-Smirnov [a]		Shapiro-Wilk	
	Statistic	Sig.	Statistic	Sig.
	0.036	0.200*	0.994	0.655

*. This is a lower bound of the true significance.

a. Lillefors Signifiance Correction

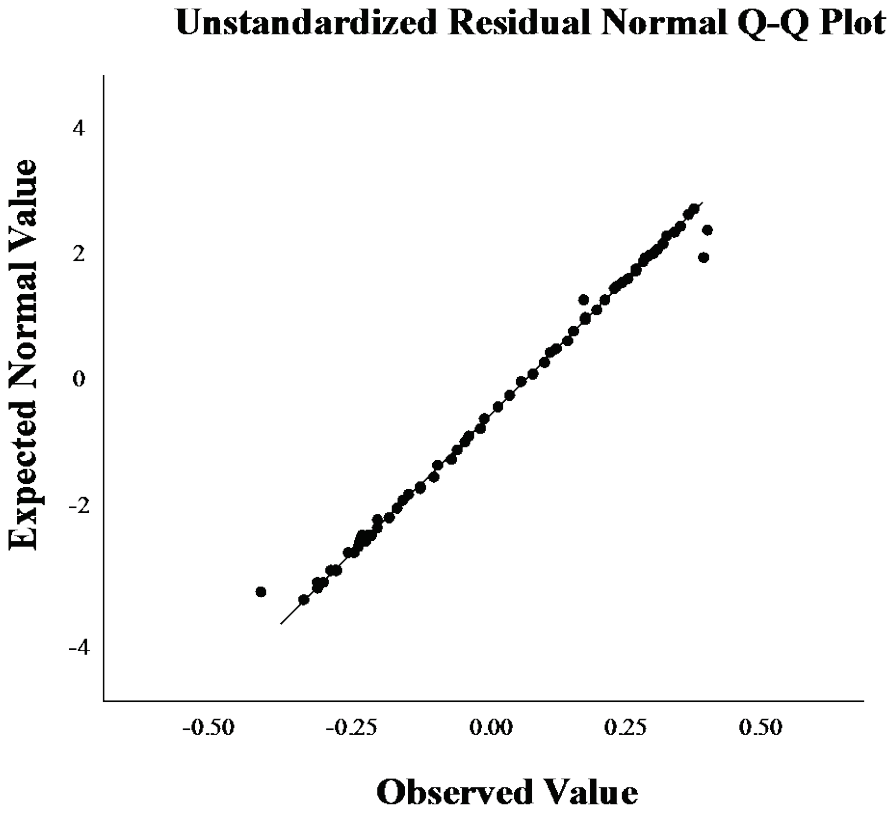


Figure 8. Regression model unstandardized residuals Q-Q plot.

Table 16. Regression model error item independence checklist.

Model Summary

Model	R	R Square	Adjusted R Square	Durbin- Waston
1	0.743[a]	0.694	0.662	1.842

a. Predictors: (Constant),Figurativeness, Design feature , Personality dimension.

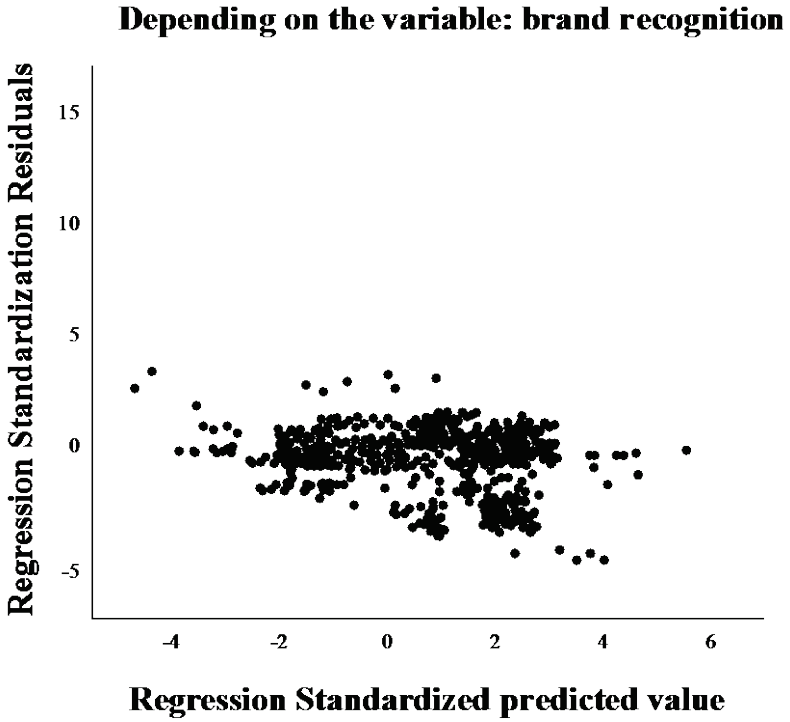


Figure 9. Regression model homogeneity scatter plot.

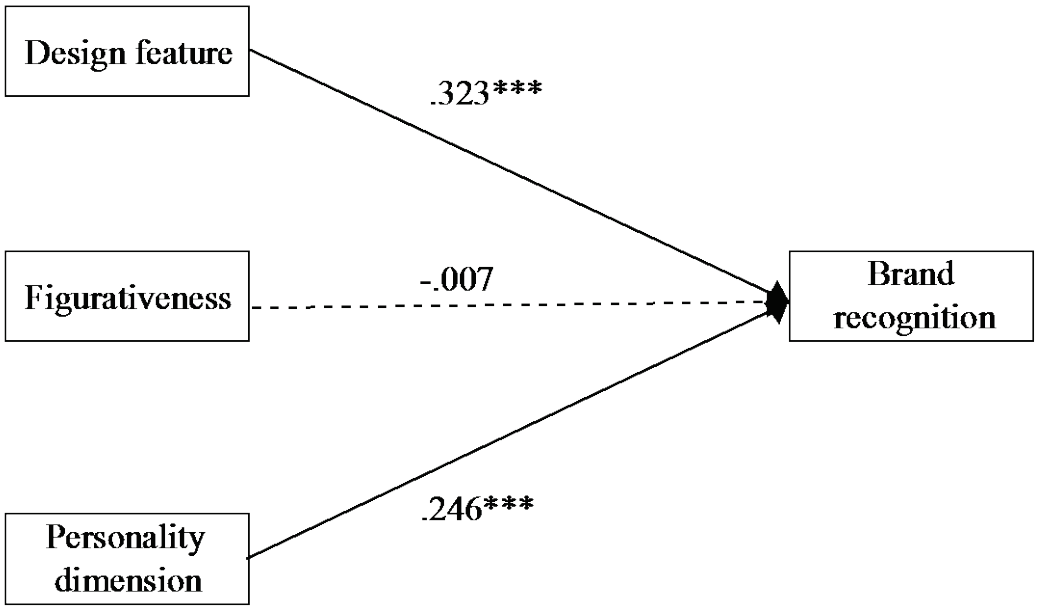


Figure 10. Influence on "brand recognition" regression pattern.

assumptions of linear regression, the Shapiro-Wilk normality check was first performed with the Unstandardized Residual of the model, as shown in Table 15. According to this normality test, H0 and Ha are assumed to be normal and non-normal respectively, and the significance of the model is 0.665>0.05. The assumption of H0 cannot be rejected, which means that the normal distribution of the "brand recognition" regression model cannot be rejected. The basic assumption of linear regression is that the dependent variable and the self-variable must have a linear relationship, and the residuals are plotted as a normal probability diagram in Figure 8.

According to the characteristics of the normality diagram, a residual of 45 lines means that it is obeying the normality distribution, the "brand recognition" regression model in this study obeys the assumption of linear regression for the normality distribution, as can be inferred from Table 15 and Figure 8.

independent variables of the model itself. After the multivariate regression analysis, the extent to which "design feature", " figurativeness" and "personality dimension" affect users' "brand recognition" of the NGO is shown in Figure 10 , and both "design feature" and "personality dimension" have significant effects. This means that when users view the NGO logo designed with visual puns, the visual features of the brand logo and the association of personality dimensions will change the viewer's perception of the brand, with the visual features of the logo having a greater impact, The impact of " figurativeness" on brand recognition is not significant, which means that the design of logo shape will not affect the change of brand recognition of users. The explanatory power of this regression pattern is 66.2%, and the expansion coefficient is below 2, so there is no co-linearity in this regression pattern.

Conclusion

At the beginning of the study, it is clear from the literature that in recent years, many NGOs have started to operate along the lines of corporate branding, and there have been studies on the association between NGO logos and brand images from a branding perspective in domestic studies, Perhaps the relevance of NGOs to our lives is an inevitable trend for the future. Likewise, past research, both domestic and foreign, has revealed many of the current key issues in this field. Many international NGOs are currently facing the biggest problems of lack of trust from people who have not encounter them, lack of publicity, and lack of reputation. The most important part of visual communication design is to communicate through design. Therefore, this study selects the visual imagery of logo design for NGOs and uses visual correlation as the main direction of logo design.

This study conducted an exploratory factor analysis on the experimental recovered data in an attempt to standardize the elements that influence the viewers' visual imagery of visual pun logo design, the 16 sets of bipolar adjective scales were divided into four components: "design feature," "brand recognition," " figurativeness," and "personality dimension" based on a review of domestic and foreign literature (Ye, R.Tsubaki and Xiangfan Liao, 2008; Machado et al. 2012; Machado et al. 2014; Stancu & Constantin, 2021).

According to the relevant literature, the brand image of NGOs affects people's resource allocation to the organization (Joachim & Schneiker, 2018). As well as logos have an impact on factors related to the image of brands and products (e.g., Van, 2016; Van & Das, 2016; (Jiang et al., 2016; Bettels & Wiedmann, 2019; Bajaj & Bond, 2018; Luffarelliet al., 2019; De Reales-Avil.s & Rivero, 2018; Stancu, 2021; Del Ponte, 2017; Sharma & Varki, 2018). Through factor analysis, this study divides the viewers' focus on logo design imagery using visual punctuation design into four aspects, and in terms of "design feature," when using visual pun design logos, eye-catching imagery is not an overly exaggerated shape feature for young viewers, but rather a simple and streamlined way to create more visual punctuation. The most eye-catching design for the young people. From the " figurativeness " point of view, according to the brand organization's different business strategies, the imagery of the logo design will also be different goals. If the young people want to have a concrete feeling for the organization and the logo, and then carry out visual pun design, it is recommended to retain the original shape characteristics of the pun material, if the outline characteristics are removed in the past, the design imagery will be abstract.

The focus of the study is on an extremely specific category, namely "NGOs", and therefore the generalizability of the findings is easily questioned, although in recent years the relevant literature has pointed out that many NGOs are gradually starting to operate their organizations as brands and companies, and even suggested that the brand image of NGOs affects people's image and resources devoted to the organizations. It is suggested that future researchers can explore similar issues in other categories to demonstrate that the findings of this study are relevant to a wide range of contexts. However, this study is an exploratory study and it is hoped that the results can be applied to a wide range of groups and that the characteristics of the student groups can reflect a certain degree of homogeneity and test the expected effects. For this reason, many studies related to signs, imagery, and cognition have been conducted with student groups as subjects. The reason for not selecting social work students, NGO practitioners, and other social workers as the subjects is that, although the students were not selected for the study, they were not selected for the study. The reason for not selecting social work students and NGO practitioners is that although the study is based on NGO logos as the sample, the people who will see the logos are not the only ones. The reason for not selecting social work students and NGO practitioners is that although the study is based on NGO logos, the people who will see the logos are not the only ones. The current problems of NGOs are that they have difficulties in publicity and are not trusted. Therefore, the public is more interested in the design imagery of NGO logos using visual punctuation design. Therefore, the public is more important to the design of the NGO logo using visual punctuation design, and the target audience should be set more widely. If we want to avoid this problem, we can conduct a follow-up study by age To avoid this problem, a follow-up study could be conducted by sampling the age group to eliminate this concern. Since there are few studies on visual puns and logos, this study is a preliminary study on the use of visual puns in logo design,

and through multiple linear regressions, it can be understood that the use of visual puns in logo design does influence the visual imagery of viewers on brand recognition. It is recommended that subsequent researchers divide the study sample into logos with and without visual biconsumer design. The appropriateness of the visual bicollinearity combined with the logo design is further investigated.

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Appendix 1. Statistical table for evaluation of subjects' imagery

Scale	adj1		adj2		adj3		adj4		adj5		adj6		adj7		adj8		adj9		adj10		adj11		adj12		adj13		adj14		adj15		adj16	
No.	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
01	4.55	1.40	4.18	1.29	4.41	1.45	3.93	1.63	4.77	1.45	4.65	1.50	3.36	1.23	3.81	1.19	5.12	1.27	4.62	1.11	4.60	1.84	4.93	1.63	3.84	1.84	4.25	1.17	4.16	1.46	4.44	1.42
02	4.44	1.39	4.18	1.26	4.44	1.41	3.85	1.60	4.65	1.42	4.57	1.45	3.63	1.35	3.94	1.25	5.01	1.31	4.66	1.15	4.61	1.71	4.84	1.59	3.90	1.78	4.35	1.41	4.11	1.45	4.44	1.40
03	4.42	1.57	4.17	1.42	4.64	1.47	4.31	1.40	4.48	1.60	4.44	1.59	3.66	1.48	4.17	1.34	4.81	1.59	4.57	1.15	4.72	1.71	4.83	1.67	4.06	1.87	4.42	1.19	4.21	1.43	4.72	1.34
04	4.41	1.53	4.12	1.34	4.61	1.41	4.15	1.61	4.61	1.51	4.40	1.53	3.91	1.50	3.93	1.22	4.89	1.46	4.79	1.44	4.81	1.77	4.85	1.67	4.19	1.77	4.45	1.17	4.17	1.40	4.74	1.41
05	4.21	1.45	4.75	1.36	4.50	1.30	3.93	1.59	4.45	1.40	4.20	1.51	3.78	1.35	4.27	1.24	4.47	1.53	4.45	1.13	4.80	1.64	4.52	1.66	4.20	1.74	4.38	1.07	4.21	1.36	4.66	1.36
06	4.77	1.44	4.41	1.38	4.45	1.42	3.84	1.65	4.72	1.47	4.59	1.47	3.52	1.41	3.83	1.25	5.03	1.43	4.68	1.22	4.58	4.91	4.91	1.62	3.70	1.87	4.23	1.27	4.38	1.44	4.48	1.39
07	4.42	1.46	4.27	1.30	4.52	1.49	3.85	1.70	4.63	1.46	4.53	1.50	3.51	1.46	3.85	1.37	5.10	1.36	4.68	1.34	4.43	1.75	4.65	1.62	3.65	1.74	4.15	1.26	4.20	1.47	4.35	1.39
08	4.67	1.47	4.05	1.27	4.10	1.41	3.74	1.53	4.62	1.44	4.65	1.49	3.51	1.26	3.91	1.23	5.07	1.32	4.50	1.17	4.62	1.99	4.81	1.52	3.61	1.71	4.24	1.14	4.13	1.46	4.56	1.29
09	4.85	1.54	3.84	1.23	3.86	1.34	3.46	1.53	4.45	1.40	4.55	1.49	3.28	1.26	4.09	1.25	5.28	1.08	4.81	0.92	3.79	1.64	4.59	1.33	3.61	1.55	4.18	0.96	4.09	1.43	4.78	1.01
10	4.90	1.53	3.86	1.23	3.88	1.34	3.41	1.53	4.47	1.41	4.60	1.49	3.27	1.25	4.09	1.24	5.35	1.06	4.85	0.93	3.78	1.62	4.66	1.30	3.59	1.57	4.21	0.94	4.13	1.42	4.82	1.02
11	4.86	1.56	3.87	1.29	3.89	1.38	3.37	1.52	4.40	1.42	4.54	1.51	3.26	1.25	4.07	1.14	5.37	1.05	4.87	1.42	3.77	1.63	4.66	1.33	3.58	1.58	4.17	0.96	4.16	1.43	4.80	1.03
12	4.83	1.50	4.16	1.29	4.28	1.36	4.06	1.68	4.75	1.46	4.60	1.49	3.63	1.37	3.83	1.02	5.05	1.32	4.73	1.00	4.86	1.76	4.83	1.64	3.98	1.87	4.31	1.06	4.06	1.51	4.41	1.45
13	4.89	1.53	3.85	1.23	3.88	1.34	3.41	1.53	4.45	1.41	4.58	1.49	3.27	1.25	4.09	1.23	5.36	1.06	4.85	0.94	3.78	1.63	4.65	1.29	3.59	1.56	4.20	0.95	4.13	1.42	4.80	1.02
14	4.90	1.51	3.83	1.21	3.85	1.33	3.47	1.58	4.51	1.42	4.59	1.52	3.27	1.20	4.11	1.22	5.31	1.11	4.80	0.91	3.82	1.67	4.63	1.33	3.60	1.57	4.20	0.93	4.12	0.93	4.82	0.92
15	4.88	1.54	3.85	1.24	3.87	1.34	3.41	1.43	4.46	1.41	4.59	1.49	3.28	1.24	4.08	1.25	5.33	1.07	4.84	0.94	3.76	1.65	4.64	1.33	3.59	1.56	4.59	0.95	4.10	1.41	4.80	1.12
16	4.90	1.50	3.84	1.19	3.86	1.32	3.48	1.50	4.51	1.40	4.58	1.50	3.27	1.22	4.12	1.24	5.28	1.10	4.78	0.90	3.83	1.66	4.62	1.32	3.61	1.56	4.21	0.95	4.11	1.42	4.78	1.01
17	4.87	1.55	3.87	1.27	3.88	1.36	3.40	1.54	4.45	1.41	4.57	1.52	3.27	1.25	4.06	1.26	5.32	1.08	4.85	0.95	3.77	1.65	4.63	1.36	3.57	1.57	4.19	0.96	4.12	0.92	4.83	0.93
18	4.92	1.52	3.84	1.21	3.86	1.33	3.44	1.55	4.50	1.41	4.62	1.50	3.24	1.24	3.27	1.24	4.10	1.23	5.31	1.00	4.81	0.92	3.78	1.67	4.64	1.33	3.57	1.56	4.21	0.95	4.11	1.40
19	4.87	1.54	3.82	1.21	3.84	1.33	3.46	1.55	4.49	1.41	4.58	1.49	3.24	1.14	3.44	1.24	5.29	1.08	4.81	0.90	3.78	1.68	4.61	1.34	3.59	1.55	4.20	0.96	4.08	1.42	4.79	1.10
20	4.85	1.54	3.86	1.26	3.90	1.34	3.42	1.54	4.42	1.44	4.53	1.51	3.66	1.26	4.07	1.26	5.31	1.08	4.83	0.95	3.80	1.62	4.62	1.31	3.61	1.57	4.18	0.95	4.12	1.44	4.79	1.02
21	4.88	1.52	3.83	1.22	3.85	1.34	3.46	1.56	4.49	1.41	4.58	1.52	3.88	1.66	4.11	1.23	5.30	1.11	4.80	0.91	3.88	1.36	4.61	1.35	3.86	1.56	4.19	0.83	4.12	1.43	4.80	1.01
22	4.84	1.53	4.60	1.34	4.73	1.61	4.25	1.55	4.86	1.61	4.81	1.38	3.70	1.48	3.93	1.48	5.08	1.25	4.35	1.48	4.81	1.51	4.65	1.63	4.05	1.53	4.46	1.15	4.05	1.47	4.05	1.48
23	4.90	1.53	3.86	1.23	3.89	1.44	3.41	1.53	4.47	1.51	4.60	1.29	3.67	1.50	4.09	1.24	5.35	1.06	4.85	0.91	3.78	1.64	4.66	1.30	3.59	1.54	4.23	0.93	4.13	1.42	4.82	0.92
24	4.89	1.51	3.81	1.20	3.44	1.32	3.52	1.42	4.52	1.42	4.57	1.50	3.28	1.24	4.14	1.32	5.24	1.13	4.77	0.90	3.84	1.47	4.59	1.34	3.62	1.34	4.19	0.96	4.10	1.41	4.79	1.02
25	4.87	1.54	3.68	1.12	3.87	1.36	3.21	1.44	4.52	1.42	5.48	1.51	3.77	1.35	4.08	1.23	5.32	1.08	4.83	0.93	3.77	1.46	4.63	1.38	3.81	1.40	4.19	0.88	4.34	1.42	4.82	1.02
26	4.90	1.52	3.88	1.02	3.66	1.22	3.40	1.42	4.58	1.42	4.56	1.33	3.28	1.20	4.10	1.26	5.28	1.11	4.82	1.02	3.87	1.22	4.42	1.34	3.58	1.54	4.23	1.21	4.08	1.44	4.84	1.44
27	4.87	1.55	3.86	1.24	3.84	1.35	3.42	1.54	4.44	1.40	4.57	1.51	3.28	1.05	4.66	1.20	5.36	1.02	4.87	1.21	3.77	1.63	4.64	1.30	3.58	1.77	4.20	1.28	4.23	1.12	4.88	1.22
28	4.80	1.53	3.88	1.05	3.65	1.14	3.88	1.35	4.81	1.11	4.88	1.54	3.30	1.27	4.22	1.16	5.42	1.01	4.98	0.92	3.66	1.55	4.32	1.25	3.46	1.37	4.05	0.94	4.12	1.46	4.84	1.00
29	4.93	1.41	4.94	1.11	4.81	1.44	4.23	1.57	5.10	1.38	4.98	1.35	3.48	1.28	3.91	1.10	5.15	1.35	4.43	1.03	5.18	1.78	5.26	1.62	4.06	1.54	4.58	1.12	4.38	1.49	4.30	1.42
30	4.53	1.51	3.84	1.07	3.88	1.42	3.48	1.05	4.56	1.42	4.66	1.50	3.28	1.24	4.12	1.22	5.32	1.08	4.88	0.90	3.88	1.46	4.68	1.02	3.88	1.06	4.28	0.96	4.22	1.32	4.75	1.03
31	4.89	1.52	3.88	1.32	3.88	1.34	3.46	1.32	4.50	1.44	4.62	1.42	3.27	1.28	4.22	1.23	5.40	1.02	4.83	0.93	3.80	1.64	4.33	1.43	3.62	1.58	4.20	0.95	4.23	1.13	4.82	1.02
32	4.90	1.54	3.88	1.44	3.84	1.32	3.52	1.52	4.56	1.42	4.88	1.32	3.17	1.24	4.19	1.24	5.34	1.10	4.84	0.94	3.87	0.92	4.64	1.33	3.35	1.46	4.19	0.95	4.21	1.32	4.88	1.04
33	4.89	1.49	3.74	1.32	3.89	1.42	3.24	1.50	4.51	1.41	4.57	1.50	3.28	1.66	4.12	1.26	5.27	1.12	4.79	1.02	3.88	1.45	4.32	1.34	3.68	1.08	4.20	1.12	4.23	1.33	4.78	1.01
34	4.87	1.55	3.88	1.28	3.98	1.36	3.42	1.54	4.45	1.41	4.78	1.54	3.27	1.14	4.04	1.06	5.32	1.10	4.85	0.97	3.77	1.65	4.43	1.38	3.57	1.51	4.29	0.98	4.14	1.24	4.83	1.03
35	4.85	1.54	4.86	1.16	3.92	1.37	3.41	1.54	4.44	1.31	4.55	1.49	3.28	1.25	4.08	1.44	5.34	1.05	4.87	1.25	3.78	1.42	4.83	1.23	3.61	1.57	4.27	0.98	4.12	1.43	4.93	1.02
36	4.87	1.55	3.86	1.26	3.68	1.35	3.41	1.53	4.63	1.41	4.37	1.30	3.47	1.35	4.28	1.34	5.36	1.08	4.87	0.95	3.66	1.43	4.44	1.13	3.59	1.57	4.28	0.96	4.43	1.42	4.88	1.32
37	3.88	1.50	4.06	1.19	3.94	1.34	3.66	1.50	4.59	1.44	3.46	1.37	4.00	1.17	5.15	1.22	4.88	0.98	4.03	1.63	4.62	1.40	3.53	1.22	4.39	1.19	4.14	1.37	4.25	1.32	4.48	1.32
38	4.90	1.38	3.92	1.31	3.87	1.31	3.45	1.66	4.56	1.42	4.69	1.26	3.42	1.28	4.08	1.08	5.42	1.04	4.84	0.94	3.84	1.68	4.73	1.30	3.37	1.58	4.18	1.26	4.15	1.41	4.61	1.06
39	4.85	1.48	3.96	1.18	3.97	1.33	3.54	1.35	4.55	1.44	4.64	1.50	3.35	1.29	4.02	1.16	5.27	1.13	4.80	0.99	4.12	1.78	4.81	1.45	3.68	1.69	4.30	1.02	4.18	1.45	4.71	1.11
40	4.81	1.52	3.96	1.27	3.94	1.37	3.45	1.48	4.45	1.38	4.63	1.39	3.39	1.29	4.06	1.24	5.02	1.57	4.61	1.06	3.87	1.45	4.45	1.40	3.67	1.53	4.48	1.03	4.14	1.37	4.64	1.21
41	4.88	1.55	3.85	1.24	3.87	1.35	3.31	1.33	4.46	1.40	4.60	1.48	3.27	1.25	4.19	1.03	5.37	1.05	4.88	0.92	3.75	1.64	4.64	1.32	3.62	1.37	4.20	1.25	4.13	1.43	4.80	1.02
42	4.90	1.53	3.88	1.45	3.92	1.33	3.39	1.53	4.49	1.22	4.63	1.51	3.26	1.22	4.07	1.12	5.35	1.05	4.86	1.14	3.82	1.45	4.68	1.32	3.63	1.49	4.21	1.22	4.14	0.82	4.82	1.13
43	4.86	1.54	3.85	1.25	3.72	1.17	3.43	1.52	4.42	1.22	4.52	1.54	3.33	1.28	4.12	1.23	5.28	1.15	4.83	0.96	3.84	1.15	4.65	1.30	3.60	1.57	4.41	0.95	4.12	1.24	4.80	1.01

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ISSUE NO. 1

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