Origami Influenced Furniture

Exploring how Origami, the Japanese art of paper folding, can influence the design of a range of experimental furniture.

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Declaration

I declare that the work in this Thesis is my own work and has not been submitted in part or whole for any other unit.

Anna Radeski

Contents

Acknowledgments

Where to begin….

Firstly, thank you to my wonderful family who have put up with me through the duration of the course, sorry for my abrupt behaviour at times and I can't guarantee it will stop.

Second longest contender would be Andre, three years of love and support, you my boy deserve a medal for standing by me through it all, cheers for everything especially when I was being highly unreasonable.

To all my amazing friends…cheers for being the beautiful people you are.

Marina, thank you for your guidance, support, advice and oh, your office and to all the others who I may have missed, thank you.

Figure 1: Marina's office during the last week

Chapter 1: Introduction

Overview of the study

> **Origami is bringing out, through folding, the shape of paper which is not evident before folding. (Koshiro, 2003)**

Throughout history origami has primarily been used either as a ceremonial device or for entertainment value. However, the Japanese art of paper folding deals with many engineering, construction and design issues that are worthy of exploration and display. Through the research carried out I have found various examples of work where origami concepts have been adapted and applied to the design of both architecture and furniture. However, the list was limited and the pieces I found focussed on certain elements of folding, rather than directly reflecting on the methods of origami.

Therefore, the aim of this study is to thoroughly explore the techniques of origami, investigating the possibilities of using its laws and procedures as a design and construction tool in the production of a range of experimental furniture.

To achieve this aim, this study begins with a review of background literature available on the topic and discusses the methods and outcomes of the experimentations as follows:

Chapter 2 will commence with an analysis of the art of Origami, detailing its history, styles, materials used and rules. A brief investigation of furniture design will follow, highlighting uses and structural and aesthetic requirements concluding with a case study of origami in furniture design, reviewing the work of Enlai Hooi.

Chapter 3 looks at the design approach, presenting the different methods available for researching origami as a design and construction tool and then discusses the process adopted for the study, outlining the methodology undertaken.

Chapter 4 outlines the findings from the experiments carried out in chapter 3 illustrating the pieces designed.

Chapter 5 then draws any conclusions and outcomes detailing the success of the designs in relation to the research question and reviewing the significance of the study. The chapter will also discuss the opportunities for future development of the pieces as well as evaluating the possibilities of other designs.

Chapter 2: Background

As the aim of this study is to explore the possibilities of using origami to influence and even dictate the design of a range of furniture, it is necessary to provide an insight into the art of paperfolding and to define the concepts of furniture design.

The first part of the chapter will examine the art of Origami. By reviewing the history of origami and furthermore deconstructing its techniques and 'rules' the chapter will not only illustrate the notions of the ancient art but will also establish the grounds on which the research methods are based.

Secondly the chapter will look at furniture design as a whole, providing a brief analysis of the structural, aesthetic and usage requirements of a number of unspecific key pieces used by society. In doing so, the chapter will provide a guide to be referred to during the design process.

The background chapter concludes with two case studies reviewing the works of furniture designer, David Trubridge and industrial designer, Enlai Hooi.

Origami

Origami- **the art or process, originally Japanese, of paper folding (The Collins English Dictionary, 2000)**

History

Paperfolding originated in China around the second century A.D. and reached Japan by the sixth century. The name came from the joining of the two terms, ori, 'to fold' and gami, 'paper'. David Engel provides a clear outline of the art of origami in his book 'Origami, from Angelfish to Zen', below is a brief overview of the history of the art.

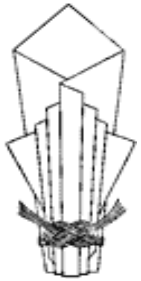


Figure 2: Noshi- ceremonial good luck token

In Japan, sophisticated forms of origami date back to approximately 1200 years ago. The forms possessed both ceremonial and symbolic meanings and as paper was still a rare and precious commodity, paperfolding was an activity only the rich could afford (see figure 2). During the Muromachi period (1338-1573) paper had become inexpensive enough for use by all and it was at this stage that it took on a new ceremonial role, a means of social stratification. Each social class only folded what their group was permitted to. It wasn't until the Tokugawa period (1603-1867) that origami became a status-free form of expression.

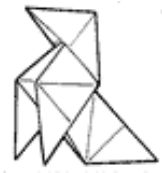


Figure 3: Pajarita (little bird)

Images: Crankshaw, 2003

Paperfolding however was not restricted to Japan. It developed during the same time in North Africa, practised by the Moors and was later brought to Spain when they invaded in the eighth century. The Moors, being Muslims, were not allowed to make representational figures and thus focussed on the principals of geometry with their paperfolding (see figure 3).

It was during the twentieth century that the two components came together, not only as a recreational activity but also as a learning tool. However, the convergence of the two components (as a recreational pastime and a learning tool) still remained on a basic level and the exploration of paperfolding (origami) as an art with a geometric

meaning has only been touched upon lightly. Origami may have become a forum for political and social cause for some avid folders but overall, it is still perceived mainly as a simple art form. Hence the purpose of my thesis is to further this study and illustrate the importance of the art of paperfolding, also known as origami, as not only a 'useless' object art but also a 'useful' object art.

Folding styles- traditional and modern

Traditional designs are thousands of years old. They focus on aspects such as the sequence of the folds rather than the appearance of the completed model. These designs also originate from base folds and generally follow traditional folding styles. (Jackson 1990)

Modern pieces (those originating in the late nineteenth century) have more regard for character than form. The final appearance of these designs is what makes them so amazing. The artistry lies more in the relationship between the paper, the subject and the manipulative finesse of the folder, rather than just the sequence of the fold. (Jackson 1990)

The folding styles of origami, like it's origins, changed and developed over time. Traditionally origami designs were passed down verbally, the first written instructions for folding appeared around 1797 AD. Because none of the folding sequences were ever written down only the simplest of designs were kept. 'Bases', simple and standard folded constructions, are the most straightforward sequence of folds and it was from these that most traditional models were developed and many more are still being developed. Their names came from the most popular models that were created from them. Figures 4 through to 10 illustrate the bases from the easiest (figure 4: kite) to the most complex (figure 10: frog).

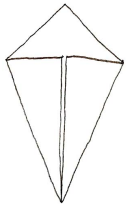


Figure 4: kite base

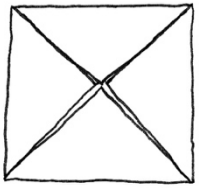


Figure 5: blintz fold

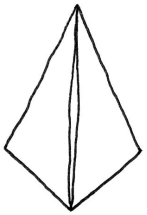


Figure 6: fish base

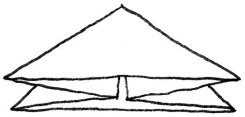


Figure 7: Waterbomb base

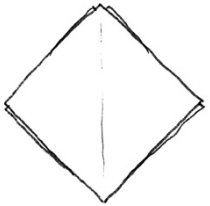


Figure 8: preliminary base

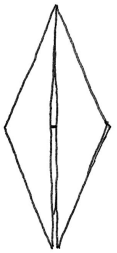


Figure 9: bird base

Figure 10: frog base

Images: Author

However, as time progressed and new methods of recording data came to knowledge, namely writing, so too did the method of passing on sequences. Because steps could now be recorded on paper and referred to at a later date, folds started to become more complex and didn't rely solely on the preliminary bases as a starting point. The folding sequences became as important as the final models. No longer was the challenge to create representational models but rather models, which were as detailed and precise as the actual subject. (Koshiro, 2003)

Not only did the starting point for models develop but so too did the techniques used within the folding sequences and the treatment of folding material. As a result, the concept of purist origami emerged, which established the notions of origami in their simplest form and created parameters for the art, these parameters however were set in modern times and hence they can only be merely considered guidelines and not rules.

Established rules

This area of origami is a difficult subject to deconstruct, as the theory behind the 'rules' is quite sketchy and unrefined. In the true sense there are no rules to origami as it is up to each individual to take from it what they can. For a set of rules to exist they would have to have been written when the art first came about and seeing as folding sequences were not traditionally recorded it is most likely that neither were guidelines, and it is therefore impossible to establish a true set of historic rules. However, if we look at the history of the art it would become apparent that if there hadn't been some guidelines to begin with then, the art of origami would never have come about.

As the name suggests, the concept behind origami is to 'fold paper' therefore, it can be established that two of the initial starting points are the fact that paper is the choice of construction medium and folding the construction method. From this simple idea the following purist rules have been established. These rules deal with origami in its most stripped-back and minimal form and as stated earlier they are not necessarily a true historic opinion.

The central dogma of an origami purist is "One square, No Cuts, No Glue". (Pete Farina 2003)

Purist Standpoints:

The following notions have been discussed by many including David Petty (2003) who like myself feels they are the 'strictest rules' and each folder should decide the extent to which they follow them.

No cuts

This rule illustrates the fact that any effects or details should be created entirely through folding. To allow cutting would also take away from the challenge and purpose of origami with the resulting work being more like kirigami (paper cut-outs). There are questions raised though about this point in circumstances where a slit is actually planned and carried out before the folding to either present new opportunities that would not otherwise be possible or to reduce the complexity of a fold. At the same time, it should also be noted that to reduce the complexity of a folding sequence by cutting, the model would most likely have been folded cut-free before hand.

No glue

This rule came about because of the fact that purists believed that only pieces created from single sheets were viable and in that case, there would be no need for glue. However, many folders who don't follow the single sheet rule also follow this law, believing that there is a better way to join pieces than with glue.

Square start paper

Besides the fact that most traditional models start from a square sheet, the square is the most regular and simple shape.

Only single-sheet, single-colour work qualifies

As purists aim at producing works which are created from the bare minimums the single-sheet/single-colour rule highlights this idea. The single-sheet notion also contributes to the challenging aspect of creating complex models from only single sheets of paper. The single-colour belief falls back on the idea that all effects and detail should be achieved solely from folding.

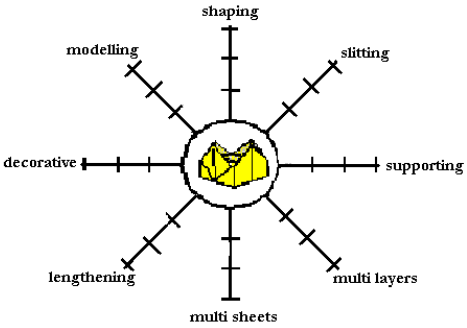


Figure 11: profile diagram of origami

Image: Smith, 2003

Figure 11 (Smith, 2003), illustrates the concept of origami, starting with the purist notion in the centre with a line radiating out for each parameter stated above. The points on the lines illustrate a new modification to the 'rules' and the further out from the centre you go, the less 'origami' the creations are.

It should be noted that there are many different opinions about these rules, however as I stated earlier, they are only a starting point for the folder, and it is then up to each individual to chose what restrictions they apply when folding.

Though there may not be a formal set of rules there are the Ten Commandments of Origami. These points were put together to assist folders and to provide them with some helpful tips. They are as follows:

The Ten Commandments of Origami

1. Choose suitable paper and cut to required form and size
2. Fold paper cleanly and carefully, especially at the small points of corners.
3. Work on a hard surface, so that all folds and creases can be executed with exactness.
4. Exactness is achieved by moving thumbnail sharply along all folds and creases. All subsequent steps are made easier.
5. The greater the exactness of a fold, the more beautiful the finished work.
6. Follow each step carefully in the sequence given.

7. Do not eliminate or skip a step. While folding, it is useful to remember the last completed step and think ahead to the one that follows.
8. Pay attention to all instructions, i.e. Direction of folding, how a form is to be folded together, if it is a fold or crease to be opened up again etc.
9. If origami is new to you, get experience by practicing the basic forms. It is fun to discover how so many different figures are created out of a specific basic form.
10. To gain the most enjoyment from your effort follow all instructions and hints exactly and do your folds and creases carefully and cleanly.

(Falken-Verlag GmbH, 1986)

Materials used

As paperfolding originated from China, naturally so too did the use of paper as the construction medium. The concept of folding paper however was an afterthought as papers main use then was as a writing material. Tsai Lun, a Chinese eunuch is credited to have been the inventor, first producing paper in China in the year 105 A.D. Paper was first introduced to Japan around the sixth century (A.D.) and soon after Origami followed.

Washi is a Japanese handmade paper made from the bark of mulberry and other trees. It is extremely durable and strong and can withstand folding much more than other papers such as machine-made bond paper making it perfect for origami. However, modern folders have not limited themselves to only paper. Other materials used include foil, fabric, metal mesh, plastic sheeting and even filo pastry. Folding with metal mesh and plastic sheeting tends to leave a more permanent model as the folds are not as likely to become weak and the materials have a good memory (when a fold is made it has a better chance of staying in that position and is not easily unfolded, unlike paper). However, it is possible to make paper models (and other weaker material models) more durable and permanent, by coating them in either wax or resin.

Methods for Preserving Models

The preservation of models is more a notion that has come about in modern times. As folding sequences and models became more complex the need to protect them from damage from not only the natural elements but also from humans also increased. This is not to say however that methods to conserve models did not exist in historic times. Waxing is an old method that has been used to preserve artificial flowers (not necessarily origami flowers) by dipping them into molten wax and then allowing them to set. Eric Kenneway (1987, pg 186) suggests this method as one way to preserve folded models. However, as wax will soften with heat and is quite delicate even when set (not in a solid block form but rather in a sheet form as it would be when coating origami models) it can be established that waxing is not a safeguard method for preserving models. Another method suggested by Kenneway (1987, pg 151) is coating models in resin or setting them in a clear resin block. This method is more permanent as the set resin is difficult to melt and extremely strong and durable.

Furniture analysis

Furniture plays an important part of the everyday life of a large proportion of society. Whether it is a chair to sit on, a desk to place things on or a lamp to provide light, these items are required by society to make a space hospitable and usable.

By looking at a number of key items of furniture and focussing on their overall design issues rather than design styles I aim to establish factors which are necessary to each item to make them work as their designers intended. The pieces I have chosen are simple examples of their general categories, in order to illustrate overall shape, structural requirements and uses.

	EXAMPLE	DIAGRAM	BROAD REQUIREMENTS
Seating chair			Needs to bear substantial load Right height for sitting Back support
stool			Needs to bear substantial load Right height for raised sitting
sofa couch			Needs to bear substantial load Right height for sitting Comfort
ottoman			Needs to bear substantial load Right height for sitting or resting feet
Horizontal surfaces dining table			Needs to bear substantial load Right height for eating or working comfortably Durable
coffee table			Needs to bear substantial load Height can vary Durable

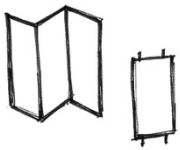
side table			Needs to bear substantial load Height can vary Durable
Bench			Needs to bear substantial load Height can vary Durable
Storage shelving			Needs to bear limited loads Height can vary Durable Shelving size needs to reflect intended usage- therefore can vary
containers			Needs to bear limited loads Durable Sizing needs to reflect intended usage – therefore can vary
Lighting			Needs to provide light Safe for living beings to be around Electrical approval
Screen/Room divider			Needs to bear some load Should provide some privacy/screening Height can vary

Table 1: Furniture Analysis
Images: www.ikea.com
www.freedom.com.au
www.habitat.co.uk

The concept of furniture design and construction is one that has existed for thousands of years. Specialist trades have been created to provide methods and techniques for constructing furniture such as carpentry/cabinet making, upholstery, ceramics, plastics and metal work. It is not to say that other methods do not exist, however the basis of furniture design and construction still revolves around these key elements. Designers generally either have an understanding of a specific material and therefore incorporate its characteristics into their deign process taking into consideration what the material can or can't do or design pieces and then choose and apply materials which they feel will be best suited to their designs. At the same time some designers will manipulate and treat materials so that they can be used for a particular project even if this means forcing the material to do something it does not traditionally do.

As I have decided to focus on origami as a construction method and in general paper as my construction medium, it is the first technique that I will utilize. That is, the concept of designing around the construction medium and being empathetic to its weaknesses and strengths. Two furniture designers that have employed similar design philosophies are David Trubridge and Enlai Hooi. The following section reviews their work and illustrates how a construction technique influences the outcome of designs.

Case Studies

David Trubridge

> **I work within the limits of what I have and know, simplicity and low impact, natural materials and processes, leaving a delicate footprint. (Trubridge, 2003)**

David Trubridge graduated from university with a degree in naval architecture (boat design) and later taught himself furniture making. His designs reflect both his education in boating design as well as his knowledge of timber attained through his studies and his work; David worked as a forester while educating himself in furniture construction.

After attending a presentation by David there were a few key issues he raised that I felt related directly to my study. He felt very strongly about bringing together the two elements of design and craft, stating that 'you learn by doing'. As my study is of an explorative nature this comment exemplified the fact that to understand if my designs would work as furniture pieces, I would need to build them and test them as I went, they would be of no use if only drawn. Furthermore, David talked of materials and processes of construction and how designs should come from the materials they are to be built from. I feel for designs to come from their materials the designer must have a sound understanding of what they are building with, which iterates the notion of design and craft coming together. David himself is a wonderful example of being both a designer and a craftsman.

Figure 12: Figure Table 1996

The two pieces illustrated are very different in their appearance however they both illustrate how a knowledge of a material and construction method affects the design process and hence outcome.

The knees and elbows of the base (figure 12) have been constructed using the forked branches from an elm tree. David used a chainsaw and drawknife to define the shapes while the timber was still fresh and green. This is a prime example of how an in-depth knowledge of a material influences a design.

Now, like 'Figure Table 1996' illustrated how David's understanding of timber contributed to his design and construction process, 'Body Raft' (figure 13), reflects not only David's training in timber but also his Naval Architectural training and boat building knowledge.

Figure 13: Body Raft 2000

Images: www.davidtrubridge.com

Enlai Hooi

With paper, you can only suggest things. Paper tells you what it wants to do. By behaving in a non-plastic way, it only allows certain things to occur. When you try forcing paper to do what it doesn't want to, it creases and buckles, suggesting other possible alternatives. (Hooi, 2003)

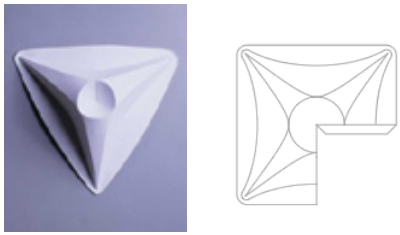


Figure 14: Compression 1

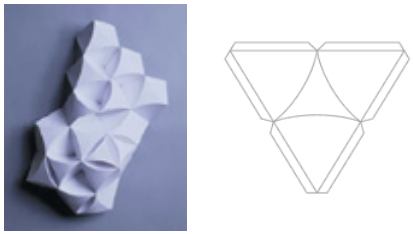


Figure 15: Modular 2

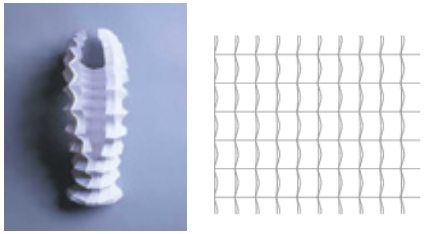


Figure 16: Mechanical 1

Enlai began experimenting with paper during his university days. As paper was readily available at his institute and cost very little, he decided to use it as a medium for exploration. By studying the qualities of paper as he folded and manipulated it, he became aware of key issues that affected its structure such as stress distribution and the tension levels around the folds.

Through his explorations, Enlai began to gain a sound understanding of paper and its characteristics and hence as he experimented, he also designed. Figures 14 through to 16 are all experiments in folding conducted by Enlai. His folding and construction techniques may not follow all, if any, of the laws of origami but they are based on the idea of folding a sheet of material to give it definition and form.

The experiments illustrated deal with issues and concepts that can be applied to future ideas. As with Trubridge, Enlai has taken the skills he has acquired over time, specifically with paper and folding and has used these to create pieces, which are not only influenced by, but also complement, the choice of material.

Figure 18: Shell Three screen

Images: www.enlaihooi.com

The two images on the left (figure 17 and 18) are an example of how Enlai applied his folding experimentations to his design process. His knowledge of how paper works was applied to another material with similar qualities, to construct a screen, which takes advantage of the structural properties that he discovered earlier.

Chapter 3: Design Approach

Fold, repeat…fold, repeat…fold, repeat…fold repeat… (Author, 2003)

Having been introduced to origami at a young age my knowledge of the techniques and methods of paperfolding was quite broad, yet I had not delved deep into the theory behind the styles. After reviewing my background literature and sourcing several instructions for origami models, I began the long process of experimenting in origami. As my quote states, there was much folding and repeating involved. The following chapter outlines the process I took during the course of my study, beginning with the establishment of my guidelines through to the construction of the pieces I designed and encountered.

Establishing my rules

I began my exploration by deconstructing and analysing the concepts of both traditional and modern origami and with the assistance of Smiths diagram that I presented in chapter two, I established a set of 'rules' I would follow during my exploration.

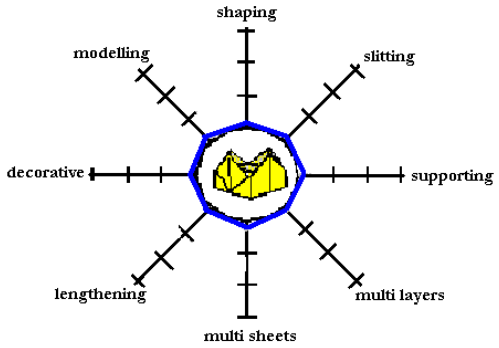


Figure 19: My initial Origami profile illustrated on diagram by Smith

As figure 19 shows I initially decided to stay quite close to the purist notion of origami, working with square, single-coloured sheets of paper and constructing models without the assistance of adhesives or cutting. I chose to work with paper as I felt that as I was only starting my exploration it would be best to work with a material that I had some knowledge of and that was relatively cheap. Paper also presented the notion of using a material, which in its 'normal' state has little structural form but once folded and manipulated gains structural integrity and thus form.

By deciding to work with a square I was providing myself with some boundaries and limitations so that I would be able to focus on a small fragment of the origami world along with the fact that most of the background literature I came across was aimed at folding square's rather than other shapes.

The single colour idea was so not to detract from the folding side of the research. The study was not aimed at ornament and decoration to make the designs usable; it was the folds and hence the pieces themselves that became the 'usable' ornaments.

As for the 'rules' of no cutting or adhesives, I resolved to stick by these for two main reasons. Firstly, because I felt that by cutting the paper I might actually lose some of the strength that

I was attempting to attain and secondly because I thought that exploring the possibilities of creating furniture solely from uncut paper and without the assistant of a joining product would not only be a challenging notion but would also produce quite beautiful and 'clean' pieces.

Paper

Following my initial investigations of paperfolding I began researching the types of paper available. Initially I had in mind a particular paper that Enlai Hooi had found in Japan that was imbedded with glass deeming it waterproof and fireproof, however after meeting with Enlai in Melbourne and discussing the topic with him I came to realise that as I was limited in both time and money, I would have to stick to local suppliers and manufacturers. It was during my meeting with Enlai that he also discussed the possibilities of Tyvek, a polyethylene product that had similar qualities to paper but with the advantages of plastic. I had previously been informed about Tyvek by an acquaintance and with some research found that Spicers Paper Company supplied it.

Through further investigations I came across other 'papers' Spicers supplied that had interesting qualities. The table on the following page presents the papers I sourced from Spicer's along with their characteristics. Though I had found these papers I decided not to begin exploring with them until I was more confident in what I required them to do and hence stuck to plain white bond and cartridge paper for my experiments in folding.

Pageantry	Pageantry is a premium uncoated paper. Pageantry's exceptionally smooth surface produces excellent print results, which are rich and soft without sacrificing details. You can fold it, die-cut it or emboss it. It is acid free for archival life so your message will make an impression that is both memorable and long lasting.
Curious Collection	Full range of uniquely different surfaces and treatments. The family consists of Metallics, Particles, Touch and Translucent, each with their own characteristic and charm.
Polyart	Polyart offers, in unique combination, the qualities of paper linked to the many advantages of plastic. Manufactured from a film of expanded high-density polyethylene, Polyart is resistant to water, oily substrates and tearing. It is suitable for a variety of indoor and outdoor applications that must survive demanding conditions.
Teslin	A synthetic printing sheet, which prints and fabricates like paper, but is durable like plastic. Being waterproof, it can stand up to the elements while holding its shape and delivering fine graphics. Uses include banners, pennants, maps and point of sale materials.
Tyvek	Tyvek has all the printing characteristics of paper but is very strong. It is made of pure polyethylene fibres randomly laid and compressed to form a remarkably tough material that's ideal for all printing applications where durability is of prime importance. Ideal for tags, labels, maps, charts, city plans, manuals, racing numbers, templates, banners and signs.

Table 2: Spicers Paper (www.spicers.com.au)

Exploring origami

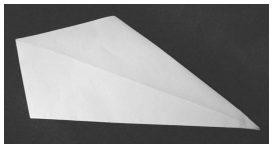


Figure 20: kite base

As previously stated I have been doing origami for a number of years now, therefore I revised what I knew by folding four of the main bases (figures 20-23) to get a better understanding of traditional styles and then continued on to experiment with models created from the bases which may not have carried the same name but used them as a starting point.

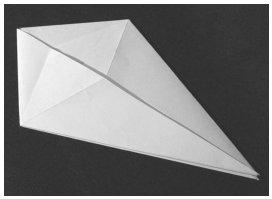


Figure 21: fish base

I then began to look at models, which did not necessarily start from a base fold but rather had their own set of sequences that applied from the onset (figures 24-26). At this stage I also experimented with structural folding where I wasn't actually making specific models but rather dealing with issues of creating strength and form (figure 27). These experiments in folding led me to attempt to create some of my own designs focussing on creating table like objects both on a small and large scale (figures 28-30).

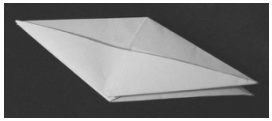


Figure 22: bird base

The following section provides a small example of my experiments in folding, working both with traditional and modern concepts of origami as well as applying the method discussed by Enlai both on his website (www.enlaihooi.com) and when we met. It also illustrates my attempts to create my own folds discussing their weaknesses and strengths and what conclusions I drew as a result.

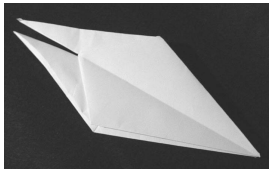


Figure 23: frog base

Images: Author

Single sheet origami

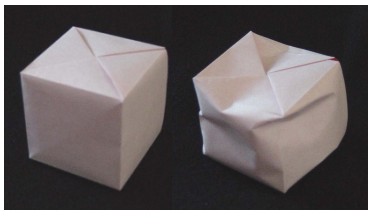


Figure 24: Fujimoto cube

Cube made from a single sheet of paper proves to lack in strength, crushing easily.

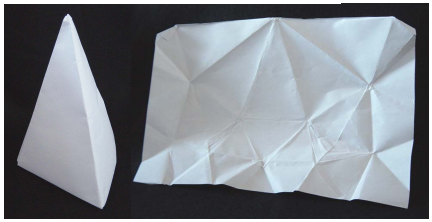


Figure 25: Enlai Hooi method

A pyramid created using the Hooi method where you manipulate a piece of paper, folding and creasing it, noting how it responds and then duplicating those steps which proved positive and refining them to achieve your final model.

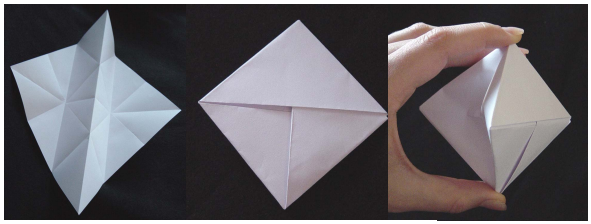


Figure 26: Snap hexahedron

The snap hexahedron proves quite cleaver in its final step of construction where you 'pop' it into shape however for the same reason it becomes weak and buckles easily.

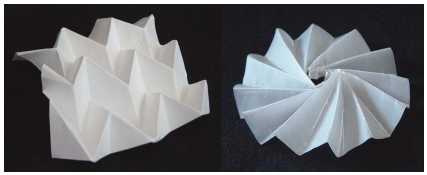
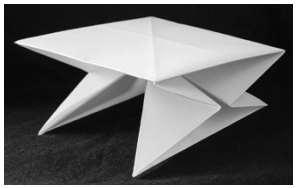


Figure 27: structural experiments

By experimenting with these structural folds, I gained a better understanding of the stress capabilities of paper and how if you are precise in your creasing, strength is better retained resulting in a more durable model.

Images: Author



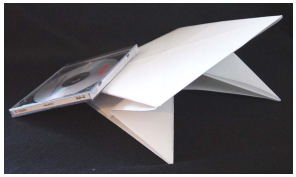


Figure 28-30: own creations

Images: Author

Taking what I had learnt from my experiments I attempted to create a table-like model. Starting off with a small square of paper I chose not to start from a base but rather applied the Hooi method of exploration to the techniques of origami. At a small scale the model appeared successful. However, as I increased its size it began to fail, becoming more like a placemat rather than a table (figures 28-30). At this point I returned to my study of furniture design (table 1, chapter 2) to revise myself of what the necessary requirements of certain pieces were. I had previously forgotten to look at issues of load distribution, tension and strength, all of which are highly important when designing objects that have specific requirements.

By exploring the single sheet method I realised that single sheet origami was lacking in structural integrity to the extents that I required it. Yes, it did hold its own shape when folded but once any weight was applied, the model would fail (collapse). It was at this stage that I decided to look at modular origami. The fact that the small table worked lead to the idea that if a number of small units were joined together then they may prove to be structurally sound.

Modular origami

Investigating modular origami resulted in the discovery of the Sonobe module. Created by Mitsunnobu Sonobe, it is considered by many the origin of modular origami. In his book 'Origami for the Connoisseur' (1987), Kunihiko Kasahara outlines many of the variations of the fold as well as its joining possibilities. From all the background information I sourced I found the Sonobe module was used for the creation of many crystal-like structures that appeared to be quite sturdy (see Figure 31).

Figure 31: Sonobe 'crystal'

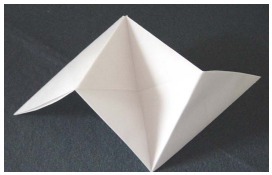


Figure 32: Sonobe module

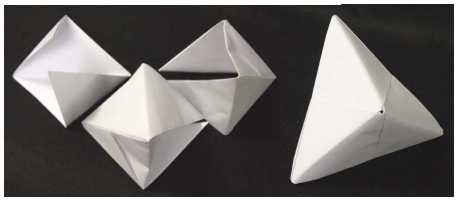


Figure 33: 3 Sonobe modules & hexahedron

Images: 31 Mukhopadhyay, 2003
32 & 33 Author

The way the units joined created pyramid type structures, which proved to be as strong as they looked. I began by attempting to fold one of my single sheet models from the Sonobe modules to see how strength and durability were affected when the number of sheets of paper was increased. I applied the modules to the concept of the hexahedron and the model no longer collapsed under minimal loads (Figures 32 and 33).

I then moved on to experimenting with the modules and testing their strengths and weaknesses. The following section illustrates the process I took during my exploration of modular origami and how I used it to answer my main question 'can origami be used to construct functioning furniture?'

Modular Origami

Exploration

The following figures illustrate my research as to what forms could be created from the Sonobe module and which would create workable units for my purpose of furniture design and construction.

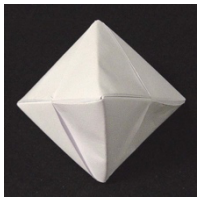


Figure 34:
2 points

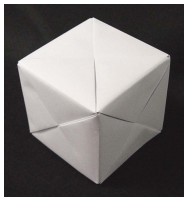


Figure 35:
3 points

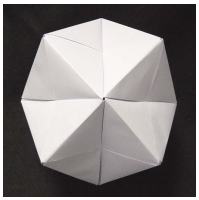


Figure 36:
4 points

Figure 37:
5 points

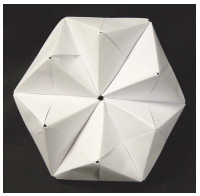
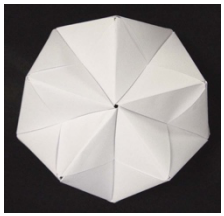
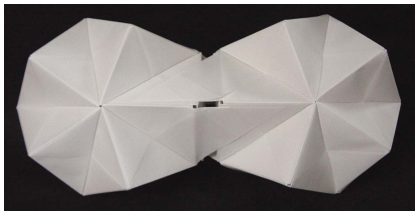
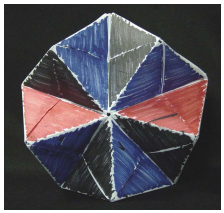


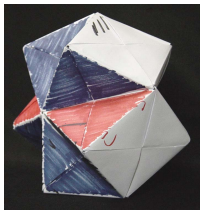
Figure 38:
6 points

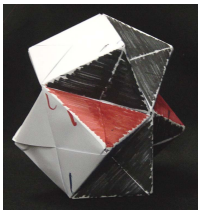
Pentagon (screen system)











Figures 39-43: experiments for screening system

Images: Author

Using the pentagonal units (figure 37-5 points) meant there were flat 'sides' to work with, allowing for a clean join line achieved by slotting tabs into one another. I moved from plain bond paper to a natural trace paper as it held its shape better and thus created a more durable unit. Before moving onto coloured trace papers explored the concept of applying colour after production and the effects that could be created (figures 41-43).

-CUBE (storage system)

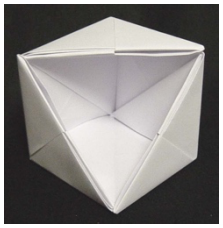
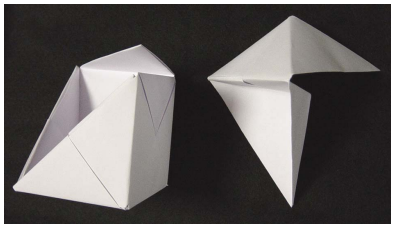



Figure 44 & 45: experiments for storage system and table

Altering the cube unit (figure 35- 3 points) created the basis for the storage system. Further experiments to devise a suitable corner structure resulted in the development of a fold that I was unable to find documented anywhere else.

-CUBE+ (table)

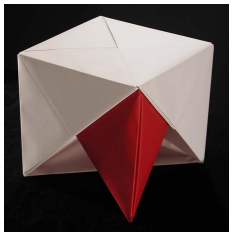


Figure 46: final outcome for table design

By slightly modifying the corner structure from the storage system it served a second purpose and became the leg for the table.

Lean (support object)

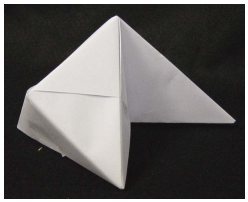
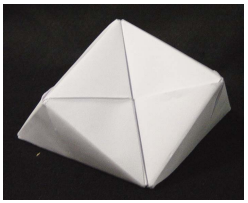
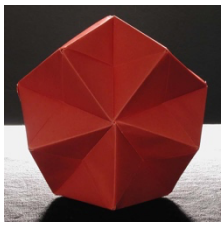
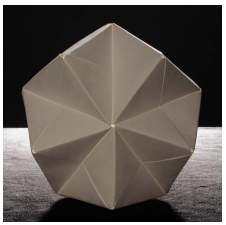
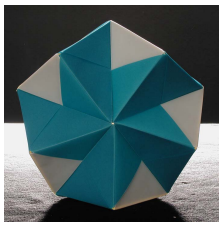



Figure 47 & 48: experiments for support object

Images: Author

Experiments in joining the hexahedrons (figure 34- 2 points) lead to the prototype for 'Lean'.

Exploring paper types in conjunction with origami exploration


Figures 49-52: exploring different paper types for pentagonal units

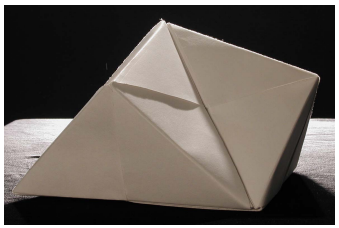
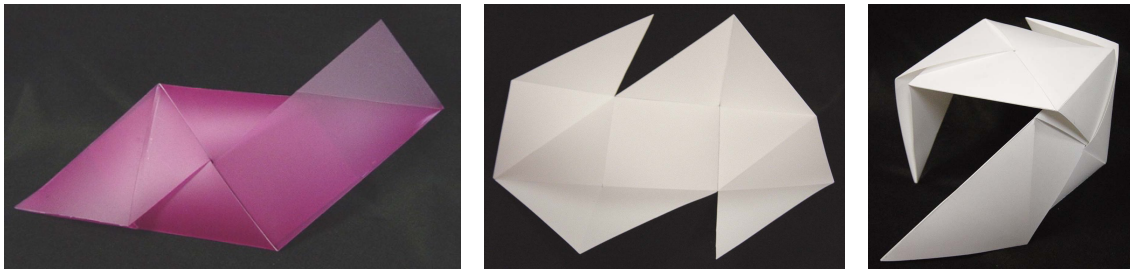



Figure 53 & 54: different paper types applied to 'Lean'

By folding 'Lean' from Teslin paper (figure 54), I was able to realise the possibility of constructing the piece from a medium other than paper. The softness of teslin lead me to explore the possibilities of folding 'Lean' from fabric.

Exploring other materials

As each piece came closer to being finalised the possibilities to create them from other materials also came to light. Therefore, I began to experiment with other mediums, which had similar qualities to paper, in the sense that until they were manipulated and folded, they had little structural integrity. Figures 55 through to 57 on the following page illustrate some of my experiments with plastic sheeting. Unfortunately, the detail and precision of the folds was lost in the translation and therefore I chose not to pursue with plastic sheeting as a construction medium.

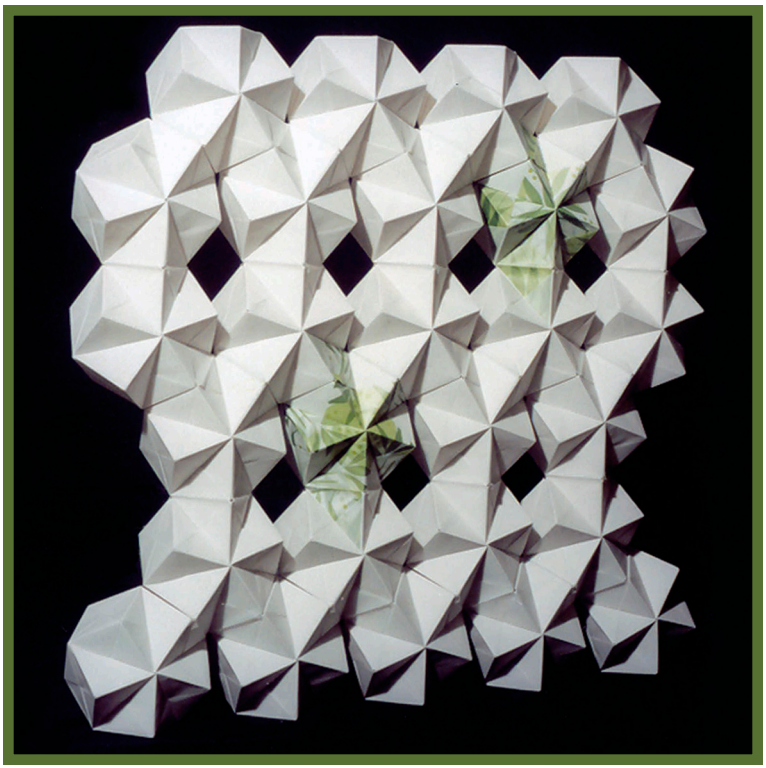


Figures 55-57: Experimenting with plastic sheeting

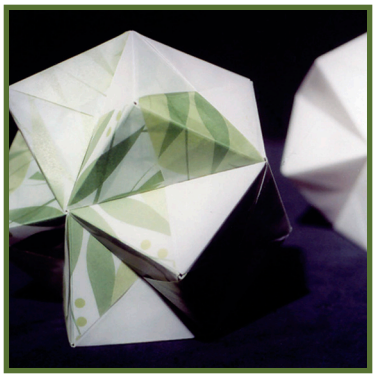
My final selection of materials varied between my pieces. I chose to continue to build 'Pentagon' from trace paper as it provided amazing strength in comparison to the little effort it required to produce neat and precise folds. '-CUBE' the storage system, I constructed from a heavy weight trace as the Sonobe modules were a little larger and the extra thickness in the paper served well to add support. It was also relatively easier to fold thicker paper if the modules required were larger in size. For this same reason I also chose heavy weight trace for '-CUBE+', the table. Furthermore, I researched the idea of coating the tables in a resin so as to waterproof them and increase strength and durability. Finally, my experiment with fabric for 'Lean' turned out to be successful. I chose to use wool felt backed with a heavy weight interfacing that needed to be heated (with an iron) before it could be folded and once cool again it set in shape.

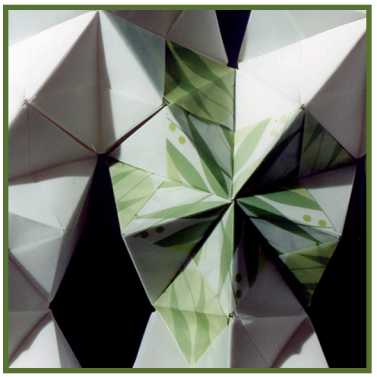
Chapter 4: Design Response

The following pages contain copies of the product cards I designed for each piece of furniture. Each card contains a set of photographs, a brief description of the product, its specifications, the number of Sonobe modules it is constructed from and future production plans for the designs.



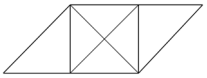
fold pentagon





description
pentagon is a screening system made up of pentagonal units each of which is folded from fifteen sheets of paper. the units are held together by a locking mechanism without the assistance of adhesives

components- each pentagon unit
15 x altered sonobe module

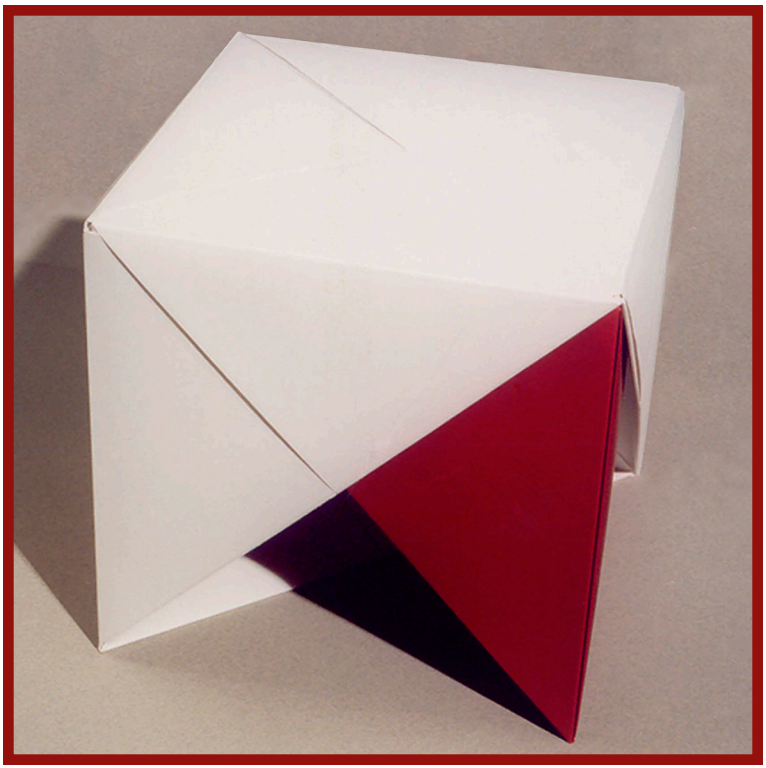


designer
anna radeski

materials
natural trace paper
printed trace paper

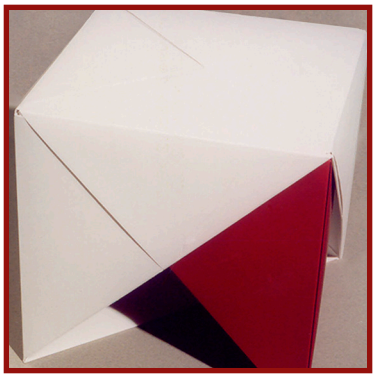
dimensions
individual pentagon units
w 175mm
d 105mm
h 175mm

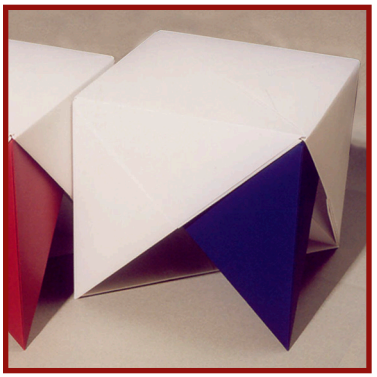
future production
further explore different production methods, such as injection moulded plastic and devise a support system for installing purposes

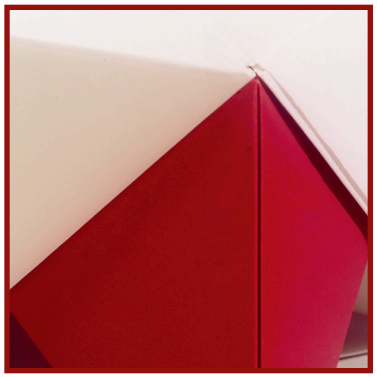


-cube+

fold

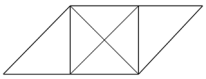






description
-cube+ can be used either individually as a side table or grouped to form a coffee table. each -cube+ is constructed from paper and is then coated in a polymer for added strength and durability

components
7 x altered sonobe module

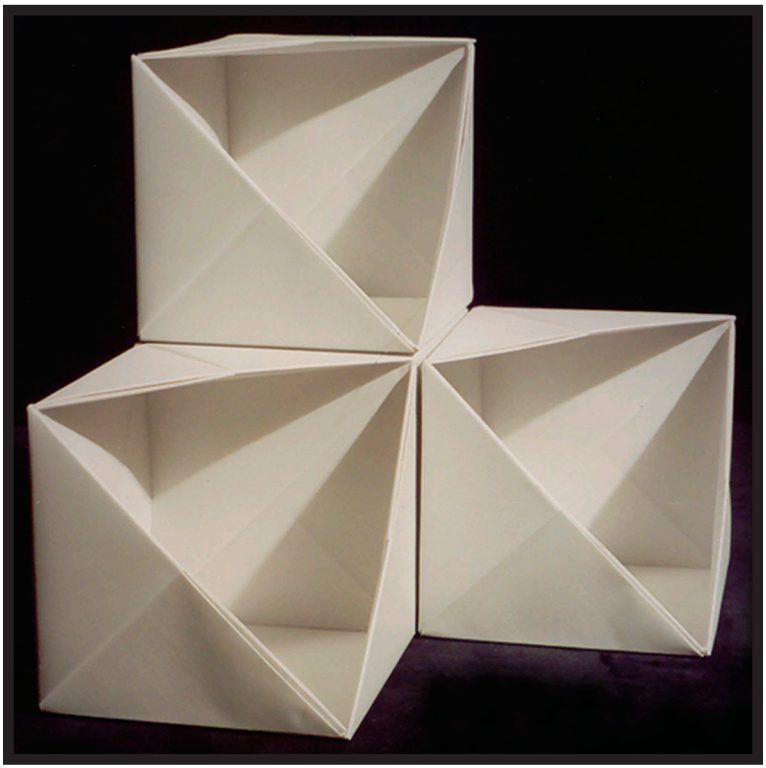


designer
anna radeski

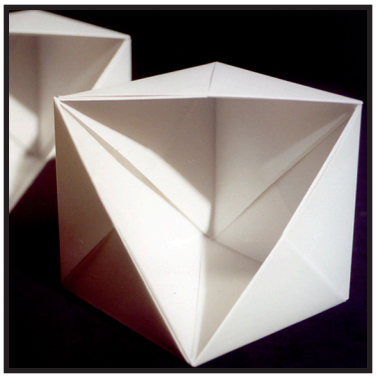
materials
natural heavy-weight trace paper
printed trace paper
polymer coating

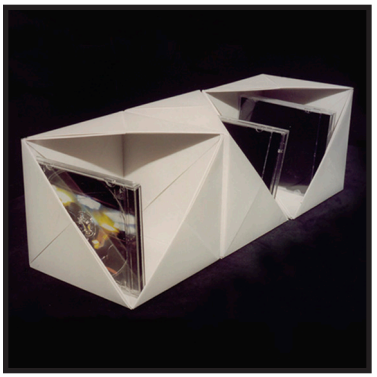
dimensions
w 420mm
d 420mm
h 420mm

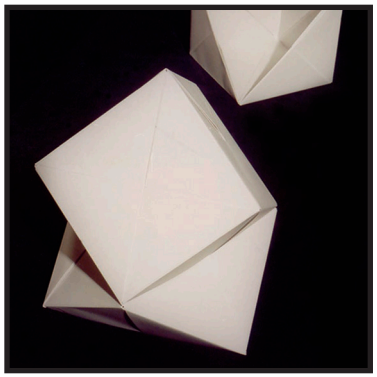
future production
fold from larger sheets of paper and explore different methods of applying the polymer and then move onto different mediums such as timber and metal



fold re-cube

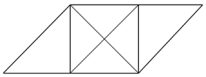






description
-cube can be used either as a stacked storage system or a wall mounted shelving system and is available in mini or maxi. an added feature is the sculptural way the units stack when not being used

components- each cube unit
6 x altered sonobe module



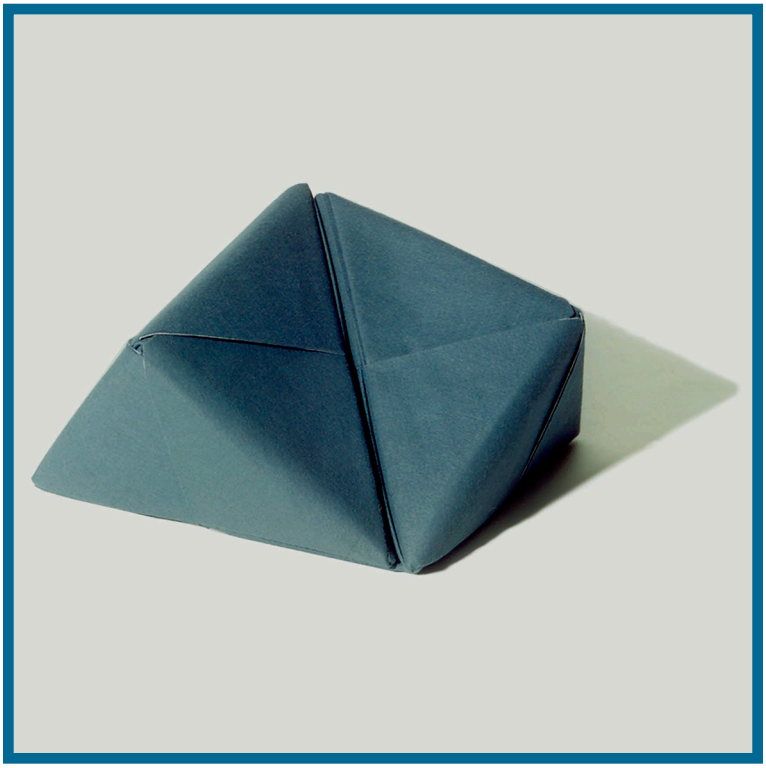
designer
anna radeski

materials
natural heavy-weight trace paper

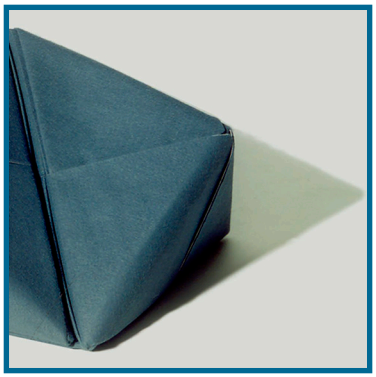
dimensions- individual cube units

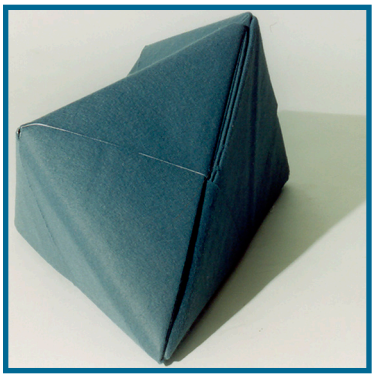
mini	**maxi**
w 150mm	**w** 210mm
d 150mm	**d** 210mm
h 150mm	**h** 210mm

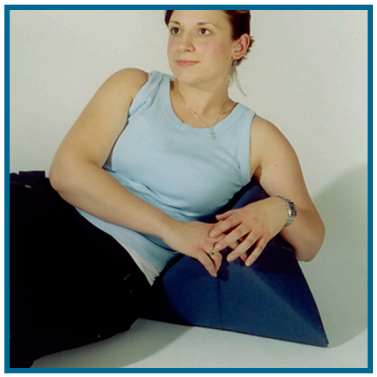
future production
experiment with polymer coatings for the units as well as exploring other construction mediums such as, acrylic sheeting and moulded plastics



fold redd.lean

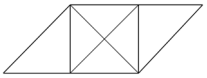






description
lean is a support unit, folded from six sheets of material, available in two sizes, micro (headrest) and mini (back-rest)

components
6 x altered sonobe module



designer
anna radeski

materials
wool felt
heavy-weight interfacing

dimensions

micro	**mini**
w 300mm	**w** 670mm
d 150mm	**d** 335mm
h 150mm	**h** 335mm

future production
better develop how the felt and interfacing are joined and through further research on strength and durability, create a maxi (full body-rest) version of 'lean'

Chapter 5: Conclusion

Have I achieved what I set out to do?

The aim of this study was to explore the possibilities of using origami to influence a range of furniture. Two questions arose from this aim,

1. What were the laws and methods that dictated the Japanese art of origami? and,
2. Could these laws then be used as a design tool and construction method in the creation of a range of structurally functioning furniture?

The study was of a highly explorative nature and thus much of the designing occurred at the same time as the experiments, that is the pieces were the experiments.

In relation to my aim, I feel that I have been highly successful in achieving my goals. I investigated the laws of origami, establishing a set of guidelines to follow and with them I designed and constructed four pieces of furniture all from a folded medium, which in its normal state has no structural integrity, from natural trace paper for the screen system through to felt for the support object. I also built the pieces without cutting the square sheets and without the assistance of adhesives. All the while the pieces function as they were designed to and have provided me with a new avenue of research.

The shapes I created only came about because I chose paper as my construction medium. By choosing the material at the beginning of the design process and then applying construction techniques that have been designed specifically for that material I illustrated how a medium and the strengths and weaknesses it carries can dictate the form and function of the object being designed.

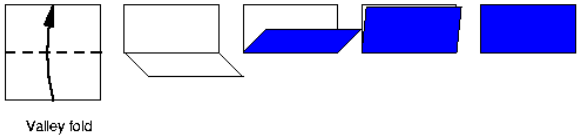
From completing this study, I find that I have achieved what David Trubridge finds so important, bridging the gap between design and craft. My designs, as David would say, have come about because of their construction medium.

Future Development

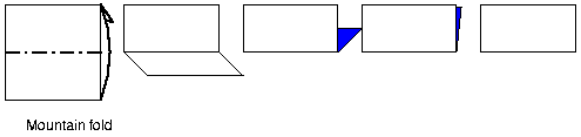
As a follow up to my thesis I would like to continue to develop and refine my pieces so that they are not only experimental furniture rather pieces that could be manufactured on a larger scale. I feel that even though this study focussed on the use of paper and other materials with similar qualities there is the opportunity for me to explore the furniture I have created using different mediums all together. As I stated earlier, these shapes would not have come about if I had sat down with pen and paper and attempted to design them without exploring the possibilities of paper. If I do get the chance to investigate other materials, I would like to treat their explorations in the same manner as I did this study, by attaining a sound understanding of the selected material and responding to its weaknesses and strengths.

Appendix A

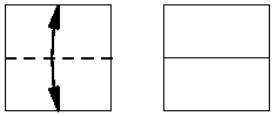
Basic origami folds



Valley fold

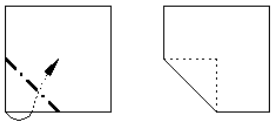


Mountain fold



Fold and unfold: a square with a crease

Turn over



Hidden arrow and hidden paper

Image:
http://origami.kvi.nl/models/basical/symbols/symbols1.

Appendix B

Sonobe Module Folding Instructions

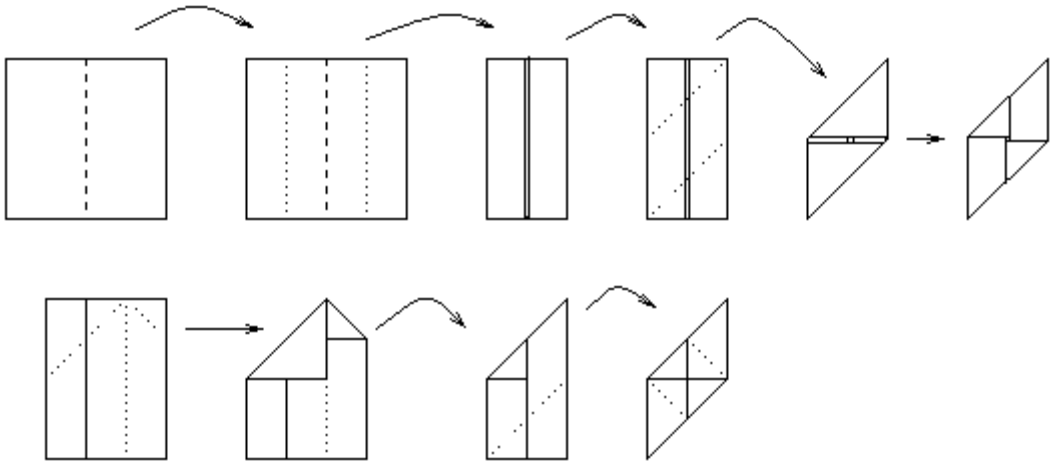


Image: http://hverrill.net/pages~helena/origami/sonobe/

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