

# Beyond Flat Pattern: Origami As A Catalyst For Fashion Designers To Enhance Creative Design Skills

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## Abstract

Traditionally, fashion design has been based on flat pattern-making techniques, which convert the two-dimensional pattern pieces to wearable garments. Nevertheless, modern design practice tends to find new solutions that would contribute to creative thinking and exploration of space. This paper explores the possibility of origami-based design procedures as a trigger to improving the creative design ability of fashion designers. The study examines the application of the origami principles of folding to Shingo Sato Transformational Reconstruction (TR) Cutting technique to convert flat pattern systems to complex three-dimensional garment design. An experimental research method based on practice was implemented, in which design experimentation was the major mode of investigation. The study had several phases in which the paper-based origami exploration, reconstruction of patterns by TR Cutting, fabric experimentation, and development of the final garment prototype were carried out. The study explores how the systematic manipulation of manual materials is a process that aids spatial thoughts and creative problem-solving through a systematic recording of folding experiments, as well as pattern segmentation and garment construction. The results show that the origami-based experimentation stimulates designers to leave the traditional pattern systems by enhancing three-dimensional visualisation, rational thinking and exploration of geometry and structure. A combination of origami and TR Cutting allows changing flat patterns into sculptural surfaces of garment items, preserving functionality and usability. In addition, the paper identifies the importance of practical experimentation to enhance spatial memory and innovative design thinking. In general, the study can assist in the advancement of creative fashion design practices by showing how novel creative opportunities can be achieved when using origami principles in the creation of garments. It can also be implied in terms of fashion design education, as the results indicate that the introduction of origami-based spatial experimentation should be accepted as one of the tools for developing advanced design skills.

**Keywords:** Origami, TR Cutting, fashion design, spatial cognition, creative design thinking

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## 1. Introduction

Fashion design has increasingly been based on flat pattern making, where clothes are built up by two-dimensional pattern drafting and completed in three-dimensional constructions. Although this technique has also been central to clothes-making, contemporary fashion practice is being explored by the more creative methods that involve challenging designers to veer away from the traditional pattern systems. The studies carried out in design and fashion education have increasingly emphasised experimental design processes, spatial thinking, and interdisciplinary approaches to support creative development. A combination of new pattern-cutting methods, computer technologies and experimental approaches contributed to the significant increase in the variety of potential ways to build garments and explore them aesthetically.

Pattern cutting and development of the garments are the aspects that contribute to the overall development of the

fashion industry. Studies on garment engineering and pattern design have considered the use of advanced technologies and algorithmic methods to improve pattern development and garment fitting (Wang et al., 2022). Equally, the research in computer-aided design of garments has revealed the possibility of interactive three-dimensional technologies of pattern-making to change the conventional process of garment construction (Liu et al., 2018). However, more recent studies have suggested localisation methods based on graphic coding to enhance the accuracy of the 3D garment patterns development in the apparel industry (Lei & Li, 2022). These advancements mean that the field of fashion design is slowly moving away from the conventional design approaches to the more innovative and technologically aided line of design.

Simultaneously, researchers have acknowledged the significance of experimental pattern-cutting as one of the methods that can be used to promote creativity in

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fashion design. Fashion education literature demonstrated that an alternative to pattern cutting may destabilise the traditional design expectations and encourage creative experimentation among students and designers (Valle-Noronha et al., 2020). Sustainable fashion practises, including zero-waste design approaches to reuse pattern construction in order to minimise material waste, have also been associated with pattern-cutting experimentation (McQuillan, 2019). These possibilities have been further extended with the use of digital tools in the fashion design industry, with designers being able to experiment with garment structures using digital 3D modelling and prototyping (McQuillan, 2020). Moreover, the study contrasting zero-waste design thinking with optimisation methods in pattern cutting also puts emphasis on exploring how experimental methods may also be used to affect both the creative design output and output efficiency (ElShishtawy et al., 2022).

In addition to technological and methodological developments, researchers have given more attention to the influence of design thinking and creative thinking on the design process. Design thinking is commonly perceived to be a systematic method of problem-solving, inclusive of creativity, trial and error, and repetitive creation (Lee et al., 2025). In this model, designers work on exploration, ideation and prototyping to come up with novel designs to complex design problems. Design cognition studies have also indicated that creative design thinking includes cognitive processes and visual perception in interaction with physical activity in materials (Ball & Christensen, 2019).

Design research studies have also pointed out that the creative process is hardly linear and instead is usually iterative and experimental. Creative design process theories explain the way in which designers formulate ideas by going through the cycles of exploration, assessment, and perfecting (Bonnardel et al., 2018). The way in which the cognitive processes of perception, motor interaction and spatial reasoning impact the creative results in design practice has been investigated within the study of design thinking (Gero & Milovanovic, 2020). The results of these studies illustrate the need to incorporate a combination of both the theory and practical experimentation in design education and practise.

In the education of fashion and design, researchers have also discussed the role of learning environments and design briefs in driving the development of students in terms of creativity. It has been indicated by research that clearly written design briefs may act as initiators of creativity, as they may help students to consider new problem-solving approaches and conceptual frameworks (Kapkin & Joines, 2021). Equally, the improvements in digital pedagogy have facilitated development in digital forms of learning like virtual prototyping and electronic textiles, which foster experimentation and an interdisciplinary approach in teaching fashion design (Han et al., 2021). Digital design research also suggests that incorporating interactive learning techniques can be used to maximise cognitive responses and the

development of creative skills among design students (Becker, 2017).

The other significant feature of design research is associated with spatial cognition and spatial memory, as these are the essential skills of designers to use in dealing with complex three-dimensional shapes. Spatial cognition helps the designers to visualise in their mind how the two-dimensional images will be translated into three-dimensional buildings. More recent research has shown that spatial memory is an important tool in spatial design procedures that has a role in the comprehension of spatial relationships and their manipulation by designers in the design world (Wijetunge et al., 2025). Design pedagogy research has also examined how concrete models and practical learning techniques can be used to improve spatial perceptions and geometrical thinking among design learners (Zich, 2023). Physical models enable the designer to be closer to the spatial structures, and the association between conceptual and material experimentation is made stronger.

Origami is the Japanese art of paper folding that has been receiving more and more attention as a technique of investigating space structure and geometric transformation in fields of design. Models created using origami have been implemented in architecture and design education as an instrument in creating three-dimensional thinking and spatial awareness (Escoda Pastor, 2018).

With the use of folding, rotation, and transformation, origami shows how a flat surface can be developed into complex volumetric forms, which can be of great use to designers operating on structural surfaces and the development of new forms. The study of design education is beginning to show that origami learning activities may be of great benefit in enhancing spatial reasoning, creativity and design problem-solving skills. The application of origami as a teaching aid to build its spatial visualisation ability has been highly extended because it requires the learner to think in a way that will change a two-dimensional surface into a three-dimensional object (Zich, 2023). Design pedagogy studies show that learning on origami-based design challenges enhances the reasons in geometry and increases the skills of students in perceiving the structural relationships in space systems (Escoda Pastor, 2018). Likewise, Boakes (2020) found that design projects using origami were found to be much more effective in enhancing the quality of creative thinking and spatial reasoning in students because they prompted them to experiment more and engage in problem-solving through the trial-and-error method. Burns and Vuruşkan (2019) demonstrated in the context of fashion education that the development of patterns based on origami stimulates innovative surface construction and enhances the knowledge of the garment structure among students. These works all point to the fact that origami-based exploration is an effective design tool that is also an effective pedagogical approach to improving spatial cognition and design thinking skills.

Besides spatial cognition, studies have also focused on the effects of the physical environment on design

productivity and cognitive involvement. The research on workplace productivity has shown that physical contact and physical environment can influence the productivity and creativity of people involved in the job concerned with design (Khouidi, 2022). The results also confirm the significance of interactive and practical design operations in arousing creative thoughts.

In general, the literature of the current research points to the increased relevance of experimental design techniques, spatial cognition, and creative pattern development in modern fashion design. Although much has been done concerning digital technologies, sustainable pattern cutting and design cognition, there are not many studies that have investigated how pattern cutting and garment construction procedures can be directly informed by origami-based spatial exploration. Specifically, the combination of the origami principles with the high-tech methods of reconstruction of patterns has not been explored yet in the research of fashion design.

To address these research gaps, this research takes place by examining how creative thinking and spatial reasoning can be improved by using origami design exploration in the practise of fashion design. The study pays particular attention to how the principles of origami folding are applied to Transformational Reconstruction (TR) cutting methods to come up with new garment designs.

The objectives of the study are as follows:

1. To investigate the effectiveness of origami-based folding exploration with advancing spatial thinking and innovative design in the field of fashion design.
2. To explore the ability of experimental methods of pattern manipulation to turn a flat pattern into a three-dimensional garment with a complex structure.
3. To examine how practical experimentation can promote creative thinking and innovation in the design of fashion design practice.

This study seeks to bring out a new set of design techniques to broaden the creative potential of modern-day fashion design by integrating the notion of spatial exploration using origami and experimental pattern-cutting techniques.

## 2. Theoretical Framework

### 2.1 Origami Principles

The art of paper folding, origami is an art form of the Japanese people where a plain sheet of paper is folded into intricate shapes in three dimensions with a systematic pattern. The principles are also a useful base in experimental fashion design since they prompt designers to stop using the conventional flat pattern techniques. This research is guided by four principles, namely folding, transformation, modular structure, and geometric logic. The major process of origami is folding, in which creases are used to manipulate a two-dimensional surface into volumetric forms. Folding has been used to create texture, volume and sculptural surfaces in fashion design, in a way that has challenged the traditional construction of a garment. Transformation is the process of turning a plain sheet

into complicated spatial shapes using a series of folds. Here, the evolution of the design goes through several processes before it gets into its ultimate expression. Modular structure is the repetition of units to form bigger structures. In fashion design, modular thinking is associated with patterned pieces that are applied to create a unified garment pattern. Lastly, the geometric logic is the way the accuracy of an origami fold is managed with the help of symmetry, angles, and proportional cuts. This mathematical argument is used to prove the translation of paper folding to systematic pattern-cutting plans.

### 2.2 Spatial Cognition and the Brain

Spatial cognition is the capability to recognise and to operate on spatial relationships among objects. This skill is important in the design fields, where the two-dimensional plans are to be presented in the form of three-dimensional objects. The parietal lobe is also a key part of the brain associated with spatial reasoning, and it is in charge of determining spatial orientation and relationships among objects, along with the prefrontal cortex, which aids in creative cognition and decision-making. Such activities as folding, cutting, and making models are performed manually, which stimulates the relationships between visual perception, motor coordination, and thinking. Experimentation through origami reinforces these mental activities since designers need to forecast the spatial results in advance, prior to doing the folds.

Designers who work with materials have better visual-spatial skills and creative problem-solving capabilities and contribute to more innovative garment design. From a cognitive science perspective, design thinking is closely associated with the interaction between perception, motor activity, and spatial reasoning within the brain. Neuroscientific studies indicate that spatial reasoning tasks activate regions of the parietal cortex responsible for mental rotation and spatial visualisation, while creative problem solving involves activity in the prefrontal cortex associated with higher-order cognitive functions (Cortes et al., 2023). Hands-on activities such as folding, cutting, and manipulating materials create embodied cognitive experiences that strengthen the connection between visual perception and motor coordination. According to design cognition research, such embodied interaction enhances designers' ability to generate innovative solutions by integrating sensory feedback with conceptual reasoning (Gero & Milovanovic, 2020). Therefore, origami-based experimentation can be understood as a form of embodied design thinking that stimulates cognitive processes responsible for spatial understanding, creativity, and innovation in design practice.

### 2.3 Design Thinking Model

The research project is anchored on a design thinking model that has five steps, which include exploration, ideation, experimentation, transformation, and prototype development. During the exploration, designers experiment with origami folds and space structure.

Design concept generation based on such explorations is known as ideation. The experimental phase is performed to test folding structures by using pattern manipulation and fabric tests. The transformation phase is the TR Cutting methods, which rely on the reconstruction of patterns and translation of shapes based on origami to the garment structures. Eventually, the result of the prototype creation will be a type of wearable clothes displaying a mixture of the principles of folding and the reconstruction of patterns.

### **2.4 Integration of Origami and TR Cutting**

The idea of origami and TR Cutting created by Shingo Sato is a bridge between experimentation with paper and the creation of clothes. Experiments with origami serve as a conceptual source of inspiration, and TR Cutting provides a technical solution to the task of recreating patterns on the dress form. In the process, the experiments involved in the folding of papers are first used in the discussion of the geometric structures. These are then cut into pieces of the patterns that are cut, rotated and stitching of the patterns is done by TR Cutting procedure. This technique provides the designers with an opportunity to deal with two-dimensional designs and apply them to form sculpted surfaces of wearable garments. Through the integration of origami and TR Cutting, designers can venture out of the conventional flat pattern approach to designing and have a spatial, exploratory design process. The integration emphasises the role of manual experimentation and structural thinking in boosting the development of creative design in modern fashion practise.

## **3. Methodology**

### **3.1 Research Design**

This paper uses a practice-based experimental research design that is commonly used in creative disciplines such as fashion, architecture, and industrial design. Practise-based research enables the process of making, experimentation, and reflective practise to be used in the creation of knowledge, compared to the use of theoretical analysis. Within the frames of fashion design, designing clothes and prototypes is a kind of inquiry where new design methodologies and innovative approaches to design can be experimented with.

The study is also presented as a design-led study, in which the design process is presented as the main process of creating insights. The garment is not viewed as a final product but as an object of experimental manipulation of materials and patterns that can arouse the creative thought and space problem-solving in the cognitive process of the designer. The combination of the principles of origami and Transformational Reconstruction (TR Cutting) invented by Shingo Sato becomes the experimental framework according to which the connection between folding, shape manipulation, and creation of the garment in 3D is observed.

The research design is also well suited in exploring the shift between two-dimensional flat pattern approaches to

complex three-dimensional forms because it allows the researcher to test by trial and error and, in the process, of constant reflections during the design process. Through observing every step of the procedure, from paper folding to fabric prototypes, the study supports how the origami-based methods could be used as a catalyst for developing better creative thinking in design.

### **3.2 Research Approach**

The research employs the qualitative design experimentation, and it addresses the form, structure and spatial association with the practical design procedures. This is contrary to the quantitative research methods that rely on numerical data since the qualitative design experimentation relies on visual representation, search of materials and experiential learning.

The paper in this regard analyses how the origami-like folding techniques influence spatial mind, creativity and problem-solving acts of the designer in the creation of the garment. It is about learning how designers to deal with materials and patterns to form something new that is not related to the traditional flat pattern technologies. Qualitative mode will enable the researcher to see how the design concepts evolve, such as the trial and error, structural changes, and creative solutions that arise in the process of experimentation. The study can capture the progress of three-dimensional thinking and the construction of garments through the incorporation of origami principles and TR Cutting techniques to comprehend the application of these techniques and methods.

### **3.3 Materials and Tools**

Various materials and tools were employed to ease the process of the experimental design and to inform the process of translating the principles of origami into the process of garment construction. During the first exploration stage, paper models were employed to investigate geometric patterns of folding and geometric changes of space. The paper gives a versatile and easy-to-study medium for studying the structure of origami since it enables the designers to quickly test their folds, angles, and modular shapes before projecting the idea onto textile materials. Following this, fabrics were experimented to experiment the behaviour of origami-inspired folds in fabric. Unlike paper, fabric possesses such characteristics as flexibility, drape, and elasticity, which define the stability and appearance of folded structures. Different materials were employed, and this enabled the researcher to examine the influences of the material properties on the transformation of the origami practises into wearable. A dress form (mannequin) was borrowed as a three-dimensional surface onto which patterning works were performed, and a test of pattern transformation was performed. The dress form allowed the researcher to obtain both a visual representation of the interaction between the folded structures and human body curves as well as to determine the balance, volume, and shape of the garment.

Besides this, another standard pattern-making equipment like pattern paper, rulers, measuring tapes,

marking tools and cutting tools were utilised to create and recreate patterns using the TR Cutting technique. These instruments allowed the accurate movement of pieces of a pattern and the conversion of matted patterns into sculptures.

### 3.4 Experimental Design Process

The experiment design process was divided into multiple interrelated steps, which slowly adapted the principles of origami to make garment building. The initial phase was the exploration of origami using paper, whereby various folds were experimented on to learn how a geometric structure can be used to create a surface in three dimensions. A differentiation of different folding motifs was done during this stage in order to differentiate forms that might be considered in designing a garment. The second phase dealt with the creation of folding structures where the different origami folds were narrowed down, and the structure of the folded origami structures was examined. Through these studies, the researcher was able to examine how inverted folds, stratified forms, and curving geometries may be utilised to create sculptural effects on a surface.

The third phase entailed the translation of the origami designs into TR Cutting designs. Pattern pieces were cut, rotated and reassembled onto the dress form with the transformational reconstruction technique developed by Shingo Sato in order to produce complex 3D shapes. This technique enabled the folded forms invented on paper to be translated into patterns that could be joined together to form a garment.

During the fourth stage, fabric experimentation was done to test the behaviour of textile materials in response to the replicated shapes. Fabric prototypes were designed to test the durability, flexibility and aesthetic attributes of the folded structures in use in wearable design.

The final step was the creation of a prototype of a garment, which includes the creation of sophisticated pieces of patterns into a complete design. This stage was meant to seek structural balance, aesthetic restraint and functionality without compromising the sculptural essence of the origami principles.

### 3.5 Data Collection

The process and visual documentation of design experiments were used in various types to obtain the data required in this study. Visual documentation was used in capturing every phase of the experiment. There were photographs made to record the stages of paper models, fabric prototypes and finished garment construction. These were images of the structural growth and design change. The conceptual thoughts and structural relationships between folds, pattern pieces, and garment silhouettes were also visualised through design sketches. Drawing enabled the researcher to test the differences and possible alterations and then transfer them into physical models. Pattern diagrams were also drawn to describe the process of reconstruction involved in TR Cutting. These drawings recorded the segmentation, repositioning and reconstruction of pattern pieces to

form the final garment structure. Lastly, the analysis of the general shape of the garments created in the course of the research, surface texture, and complexity of structure was carried out with the help of the photographic records of prototypes. These visual records are a complete reflection of the experimental results and assist in the analysis of the effect the origami-motivated design processes have on the creative thought in fashion design.

## 4. Design Experiment and Process Documentation

### 4.1 Origami Folding Exploration

The origami folding techniques exploration was the first stage of the design process, which involved using paper models. Paper was chosen as the first experimental material since it gives an opportunity to quickly test the geometric structures and gives a clear idea of the way flat surfaces could become volumetric ones. Being light and being able to bend, the paper is especially convenient when it comes to investigating the forms of folding and spatial changes, as well as transferring them to textile products.

In this step, various folding solutions were tried so as to explore the relationship between creases, angles, and layered folds and the creation of sculptural surfaces. These experiments were aimed at finding the folding structures that would be used later in the construction of garments. Via the repeated manipulations on the paper, the researcher noted that repeated folds and structures curved on the paper would create dynamic structures that were extending outwards of a flat surface. The studies showed how geometrical folding could be used to create structure through depth and produce complex textures on a surface.

In addition to the development of visual objects, the phase of life preoccupation with origami was a mental exercise of space perception. The folding experiments meant that the designer had to think in his mind of how to physically manipulate a two-dimensional piece of paper into a three-dimensional shape. This assisted in the concept of visualising space and was arousing the creation of design ideologies with structural reasoning rather than conventional systems of patterns.

### 4.2 Pattern Development Through TR Cutting

Once appropriate folding structures were discovered in the process of exploration of origami, the other step was to convert the structures into garment patterns by applying the Transformational Reconstruction (TR) Cutting technique invented by Shingo Sato. TR Cutting. This is a process of manipulating patterns by simply cutting, rotating and repositioning pattern pieces onto a dress form.

The folding ideas on the origami were understood in this experiment as pattern-parting structural directives. The flat pattern was split into the first geometry parts, which could be rearranged to record the volumetric effects as recorded in the paper models. This reconstruction process involved the rearrangement of pattern pieces, and they were designed to produce dynamic surfaces on the garments.

The structure which consequently occurred was a pattern consisting of a series of triangular and angular pieces that allowed the garment surface to spring outwards and create sculptural folds upon assembling them. This experiment stage was the confirmation of the possibility to apply the principles of origami, the geometrical transformation and the modular structure to the strategies of practical manipulation of patterns. It is as well illustrated in the process as a demonstration of how TR Cutting had managed to bridge the gap between the conceptual folding experiments and the construction of wearable garments.

#### 4.3 Fabric Translation

The experiment proceeded to include the fabric translation phase after reconstruction of the pattern. This was to be done to establish the performance of the origami-inspired design on textiles. Fabric as opposed to paper has attributes such as flexibility, drape and elasticity and this is what will dictate how the folds and structural effects will be reflected on the final garment. Prototypical models in fabric were stitched through gluing the re-patterned overview parts and observing the crafting and deforming behaviour of the material. In this process, the designer considered several aspects such as the stability of the folds, the elasticity of the fabric, and the balance of the structure of the surface of the garment. The pattern configuration was modified through trial and error to ensure that the sculptural folds would not lose their desired shape, but would be able to use the garment as an effective and active one. The outcome proved that textile fabrics can be used to recreate with great effectiveness the structural properties that were first studied in paper prototypes with appropriate pattern reconstructions and material choice.

#### 4.4 Garment Construction

The second step after the fabric experimentation was to create the final garment prototype after determining the structural feasibility of the reconstructed patterns. The pattern pieces were put together to form a complete garment whilst maintaining the sculptural features acquired at the origami and pattern reconstruction phases.

The space between the pattern sections was considered especially well during the construction of the garments. To produce the desired three-dimensional folds and surface textures, the accurate positioning of these segments was a must. The dress was modelled on a dress form to enable it to be observed continuously on the relationship of the folds with the body contours.

The construction process showed that the TR Cutting technique allows designers to design sculptural surfaces without the use of traditional darts, seams, or shaping techniques. Rather, the form of the garment came into being as a result of the strategic placement of the pattern

blocks, which formed volumetric folds and superimposition structures on the surface of the garment.

#### 4.5 Final Prototype Outcome

The final prototype of the garment is the final step in the design process of the experiment. The garment is characterised by a row of sculptural creases that stretches over the surface and develops a dynamic relationship between building, form, and movement. These folds are based on the previously reconstructed pattern segments built or produced in the TR Cutting stage and are based on the principles of geometry investigated in the origami experiments.

The last design is used to show the way in which the exploration, which is done through origami, could inform new ways of creating garments and using the flat materials in order to create a larger spatial structure. The volumetric lines on the surface of the garment cannot have been created by the use of the conventional flat pattern techniques only.

In the design aspect, the prototype shows the possibilities of origami-based designs to use in broadening the creative potential of fashion drawing. The outcome of the experimental process, which led to a visually unique garment, was, in addition, an example of how manual experimentation, pattern reconstruction, and spatial reasoning can be used to trigger creative design thinking. The paper thus shows the importance of combining origami concepts and TR Cutting as another approach to creating innovative clothing designs in modern fashion practise.

### 5. Findings

#### 5.1 Enhancement of Spatial Design Thinking

Among the key research results is that there is an improvement in three-dimensional spatial visualisation capacities at the origami exploration phase. It took the designer many times to reinterpret how a two-dimensional surface could be turned into a form volume to create the process of folding paper into geometric structures. The process enhanced the capacity to mentally visualise the space relationship of folds, surface, and structural lines.

The folding experiments, which were paper-based, proved that origami is a cognitive device for learning spatial transformations. This method of creating a paper structure by manipulating it through predetermined folding patterns allowed the designer to predict what the structure would be like in fabric before making it. It helps in the growth of spatial reasoning, which is very important in the interpretation of two-dimensional patterns into three-dimensional attire. The early origami folding studies were aimed at investigating how geometric folds can be used to convert a flat surface to volumetric structures, as illustrated in Figure 1. Table 1 summarises the skills of space that were developed during the origami exploration stage.



**Figure 1.** Paper origami experiment demonstrating geometric folding exploration and spatial transformation from a two-dimensional surface into a three-dimensional structure

**Table 1. Spatial Skills Developed During Origami Exploration**

Design Activity	Spatial Skill Developed	Design Outcome
Paper folding experiments	Spatial visualization	Understanding of volumetric transformation
Geometric fold manipulation	Structural reasoning	Identification of fold-based surface forms
Sequential folding	Spatial prediction	Ability to anticipate three-dimensional outcomes

These observations suggest that origami exploration can function as a training method for developing spatial design thinking in fashion design practice.

**5.2 Creative Problem-Solving**

The other important result of the research is associated with the importance of the origami experimentation in the design process to facilitate creative problem-solving. The experimental folding phase informed the designer to discover a variety of structural options instead of using a series of established systems of patterns.

Through the process of experimentation with folding sequences, the designer learnt that surfaces can be manipulated to establish dynamic forms of garments.

This discovery entailed a constant adaptation and analysis of design results, which supports the iterative principle of creative design thinking. This process of creating was enhanced even further by the translation of folding experiments into pattern reconstruction. Having applied the TR Cutting technique, the designer managed to recycle the origami constructions in the form of pattern segments which could produce new garment surfaces. The pattern reconstruction step is provided in figure 2 and the origami influenced geometries were converted into pattern pieces in segmented form. Table 2 presents the key creative strategies that emerged during the origami exploration and pattern reconstruction stages.



**Figure 2.** Pattern reconstruction using the Transformational Reconstruction method, showing triangular pattern segmentation used to generate three-dimensional garment surfaces

**Table 2. Creative Design Strategies Observed During the Experiment**

Design Stage	Creative Strategy	Result
Origami folding exploration	Structural experimentation	Generation of new design forms
Pattern segmentation	Concept reinterpretation	Translation of folds into pattern pieces
TR Cutting reconstruction	Iterative problem solving	Development of innovative garment structures

The results demonstrate that origami experimentation supports creative design exploration by encouraging designers to test and refine multiple structural possibilities.

**5.3 Innovation in Garment Construction**

The combination of origami philosophy with TR Cutting resulted in considerable innovation in the methods of garment construction. Three-dimensional shape is normally created in the traditional garment construction using darts, seams, and shaping. Consequently, pattern segmentation and surface manipulation created three-dimensional structures in the experimental method applied in this study.

The pattern pieces rebuilt during the fabric translation stage were joined in order to form sculptural folds over the surface of the garment. The resultant forms brought in new volumetric elements that are hard to arrive at in the traditional flat pattern techniques. The stage of fabric experimentation is shown in Figure 3 with the translation of folding motifs of origami into textiles. Table 3 shows the key structural innovations which can be seen at the stage of garment construction.



**Figure 3. Fabric prototype demonstrating the translation of origami-inspired folding structures from paper experiments into textile material**

**Table 3: Innovations in Garment Construction**

Construction Technique	Structural Effect	Design Impact
Origami-inspired folds	Volumetric surface texture	Enhanced visual complexity
Pattern segmentation	Dynamic garment structure	Moves beyond traditional pattern systems
TR Cutting reconstruction	Sculptural surface development	Innovative garment construction method

These results indicate that the combination of origami principles and TR Cutting can expand the possibilities of garment construction in contemporary fashion design.

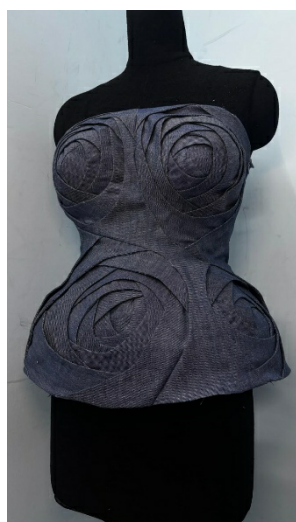
**5.4 Cognitive Engagement in Design**

Experimental process also showed that the process of designing was more cognitive. The relationship between hand-movement, perception and spatial thinking was also very important in the process of coming up with the final garment design.

Physical tasks like folding paper, rebuilding patterns, and working with fabric triggered a feedback loop of physical and visual processes of action and analysis. This interaction made it possible to assess the structural changes as they occurred and make adjustments on the design. The ultimate garment prototype reflects the end

of this cognitive design process. he finished garment illustrates the adaptation of the origami inspired patterns morphology to visualised wearable design, in Figure 4.

The table 4 shows the main cognitive processes of the design experiment based on origami.



**Figure 4. Final garment prototype integrating origami-inspired structural folds into a three-dimensional fashion design**

**Table 4. Cognitive Processes Observed During the Design Experiment**

<b>Cognitive Process</b>	<b>Design Activity</b>	<b>Design Outcome</b>
Visual perception	Observation of folding structures	Identification of structural patterns
Motor interaction	Folding, cutting, and fabric manipulation	Generation of three-dimensional forms
Spatial reasoning	Pattern reconstruction using TR Cutting	Development of sculptural garment surfaces

The results imply that origami-based design experimentation can increase cognitive activity by bridging the relationships between manual activity, visualisation, and spatial reasoning in the design process.

In general, the results indicate that the concept of employing origami principles and applying them to TR Cutting would be very effective in developing the innovation of thinking in space design, exploring creative thoughts, and employing a garment construction process. The experimental process emphasises the importance of the material interaction as a technique of the development of the high-level creative skills in the design of the fashion.

## 6. Discussion

The results of the research prove that the concept of origami and the Transformational Reconstruction (TR) Cutting technique could be very useful to promote creative exploration and spatial thinking within fashion design. The study uses practise-based design process, and experimental folding, pattern reconstruction, and material manipulation to show how new garment structures might be developed by way of. The findings indicate that origami-based techniques are influencing designers to escape the traditional flat pattern techniques and have a more spatial and experimental design process.

Among the most important meanings of this study is that experimentation by using origami helps to improve

spatial reasoning in the process of designing. The experiments to be performed during the first part of the research involved constant mental rotation of the way in which flat items could be formed into three-dimensional shapes. This led to the stimulation of the designer to anticipate space results and manipulate structures as a result of the segmentation of patterns. Similar studies in the past have focused on the linkage between spatial ability and creative output in the design field. Research conducted on the topic of spatial cognition in design education shows that designers who have more powerful spatial reasoning abilities tend to be more creative and innovative in design tasks (Cho, 2017; Suh and Cho, 2020). The conclusions of the current research work are consistent with this view because they indicate that origami-based folding activities can be used as an effective method of enhancing spatial visualisation in fashion design.

The findings also support previous research demonstrating that origami-based design activities contribute to the development of creative design skills. Origami demands designers to experiment using iteration, which involves trial and error folding patterns, assessing and the final outcomes of each pattern. This is much similar to the design thinking process especially in exploration, prototyping and refinement. As evidenced by the educational research, working on origami-based assignments enhances the ability of learners to think in space, reason structurally and be creative in their ideas (Boakes, 2020). These skills are especially valued in

fashion design situations because designers need to keep converting the flat pattern outlines into the three-dimensional garments. The current research confirms the fact that origami experimentation can serve as a good tool at reinforcing these cognitive design skills as well as creating innovative garment structures.

The other observation made during the experiment process is the importance of manual experimentation in spurring creative thinking. The paper emphasises the role of practical activities including folding paper, rebuilding patterns and working with fabric in giving designers an opportunity to develop ideas that otherwise might not be produced by using only drawing and digital modelling. This is consistent with prior studies that have proposed that embodied interaction with materials is important in the spatial cognition and creative problem-solving. According to Clifton et al. (2016), physical contact with spaces and material triggers mental activities that promote spatial reasoning and exploration of the design. On the same note, Cortes et al. (2023) indicate that the level of creative performance is connected to neural activity in the brain areas that relate to spatial cognition. These findings are reflected in the experimental process in this research because they show how manual folding and pattern manipulation motivates the designer to continually review and reconsider the structural possibilities.

The findings also bring to the fore the fact that origami is an efficient conceptual model when it comes to the development of creative design. Folding and geometric logic as well as modular structures were the principles of origami that were used in the creation of new surfaces on garments. Such principles enabled the designer to experiment with a complex structure without losing a distinct geometrical structure. The earlier studies in design education have revealed that design thinking and creativity can be improved through the use of origami-based activities that prompt learners to explore form and structure (Boakes, 2020). On the same note, Burns and Vuruskan (2019) write about the way the folds can be used to assist with the development of patterns and the development of new surface design in fashion education. The current research builds on these concepts by showing how the principles of origami could be used with more sophisticated tools of pattern manipulation like TR Cutting to create sculptural clothing.

The combination of the ideas of origami and the TR Cutting technique of Shingo Sato was critical in the adaptation of the experimental folds into the wearable clothes. Although origami experiments were first done on paper models, TR Cutting technique offered a methodical way of re-creating patterns on the dress form. This enabled the designer to transform geometric folding structures into pattern segments that can create volumetric surfaces upon assembling them. The connexion between origami and making of garments has also been studied in previous practise-based study in fashion design. Choi (2016) proved that the innovative pattern manipulations of the structure of the garments can be extended with the help of the origami-inspired fashion design. The present research is based on this

work, but it adds origami to TR Cutting, emphasising the fact that these two types of approaches can help designers to create complex sculptural forms out of flat materials.

Besides the applicability of the study to practise in fashion design, it also adds to the general knowledge concerning origami as a structure and design approach. Engineering and material science studies revealed that origami-based structures have the opportunity to be used in various fields such as architecture, product design, and engineering systems (Meloni et al., 2021). In these studies, there is an emphasis on the versatility and structural efficiency of origami-based forms. Findings of the current study indicate that the same concepts can be implemented in the area of fashion design to produce clothes which merge both structural and aesthetic novelty.

The implications of this research are more important especially in relation to the education of fashion design and development of creative skills. The classic training on fashion can focus on flat pattern construction that can restrict possibilities of spatial experimentation. With the appearance of origami-based exploration and TR Cutting techniques in the design process, educators may motivate the students to gain a better sense of space and experimental thinking. Studies on design education established that spatial ability is a major factor in design performance, especially when working in the direction of complex three-dimensional designs (Cho and Suh, 2022). In addition, the research on the correlation between visual attention and spatial ability and creativity reveals that designers who practise spatially tasking activities tend to have increased creative production (Suh and Cho, 2021). The current research confirms these results demonstrating how experimentation using origami can be a useful means of education to develop spatial design abilities.

In general, it is emphasised in the discussion that the use of origami principles, spatial cognition, and TR Cutting methods in the process of developing innovative fashion design methods. The latter outcomes of the experiment confirm that exploration by using hands-on folding not only leads to the creation of unique garment structures but also reinforces the cognitive processes of thinking in a creative design. This study offers a model of extending the methodologies of creative practise in the modern fashion design through filling the gap between the paper-based origami experimentation and the garment building.

## 7. Conclusion

The research investigated how origami inspired design experimental could be used as an impetus to improve the capacity of creative design thinking of fashion by incorporating the principles of origami and the Transformational Reconstruction (TR) Cutting technique created by Shingo Sato. The study confirmed that the use of the origami folding techniques has the potential of aiding in the emergence of spatial reasoning, creative exploration, and innovative means of garment construction in the practise of fashion design. The

experiment design procedure that developed through paper-based exploration of origami patterns to pattern reconstruction and fabric prototyping showed the potential of two-dimensional material to be converted into a complex three-dimensional structure of the garments. The research demonstrated that the principles of origami including folding, geometrical reasoning, and structural transformation gives designers novel means of perception of spatial relationships between pattern, surface, and form. These experiments in conceptual folding were further emphasised with the translation of these structures into garment patterns by TR Cutting, which made clear how an experiment with conceptual folding can be translated into a sculptural-surfaced wearable design. In terms of cognition, the study also reveals that manual experimentation was also important in provoking design thinking. Such interaction between the process of moving hands, visual perception, and spatial thinking stimulated the repetition of the problem-solving process and exploration in the design process. The results of these studies indicate that origami-based design methods can be used as an efficient teaching and experimentation tool in the elaboration of sophisticated spatial design skills of fashion designers. In general, the research is added to the accumulating literature on experimental pattern cutting and design thinking in the field of fashion. Combining the principles of origami with the methods of TR Cutting, the research offers another approach to creating new structures of garments, but also helps to stimulate the creative design thinking. Further studies can be conducted on the use of digital design tools, sophisticated materials and computer pattern systems to increase the possibilities of the origami-inspired fashion design.

## References

1. Ball, L. J., & Christensen, B. T. (2019). Advancing an understanding of design cognition and design metacognition: Progress and prospects. *Design Studies*, 65, 35-59.
2. Becker, E. (2017). Design Cognition:: Optimizing knowledge transfer in digital design pedagogy. *Architectural Research in Finland*, 1(1), 93-105.
3. Boakes, N. J. (2020). Cultivating design thinking of middle school girls through an origami STEAM project. *Journal for STEM Education Research*, 3(2), 259-278.
4. Bonnardel, N., Wojtczuk, A., Gilles, P. Y., & Mazon, S. (2018). The creative process in design. In *The creative process: Perspectives from multiple domains* (pp. 229-254). London: Palgrave Macmillan UK.
5. Burns, A., & Vuruşkan, A. (2019). Using origami for creative design and pattern development in fashion education. *Tekstil ve Mühendis*, 26(113), 86-96.
6. Cho, J. Y. (2017). An investigation of design studio performance in relation to creativity, spatial ability, and visual cognitive style. *Thinking Skills and Creativity*, 23, 67-78.
7. Cho, J. Y., & Suh, J. (2022). The architecture and interior design domain-specific spatial ability test (AISAT): Its validity and reliability. *Journal of Interior Design*, 47(2), 11-30.
8. Choi, K. H. (2016). Practice-led origami-inspired fashion design: out of the frame: flight by paper plane. *International Journal of Fashion Design, Technology and Education*, 9(3), 210-221.
9. Clifton, P. G., Chang, J. S. K., Yeboah, G., Doucette, A., Chandrasekharan, S., Nitsche, M., ... & Mazalek, A. (2016). Design of embodied interfaces for engaging spatial cognition. *Cognitive research: principles and implications*, 1(1), 24.
10. Cortes, R. A., Colaizzi, G. A., Dyke, E. L., Peterson, E. G., Walker, D. L., Kolvoord, R. A., ... & Green, A. E. (2023). Individual differences in parietal and premotor activity during spatial cognition predict figural creativity. *Creativity Research Journal*, 35(1), 23-32.
11. ElShishtawy, N., Sinha, P., & Bennell, J. A. (2022). A comparative review of zero-waste fashion design thinking and operational research on cutting and packing optimisation. *International Journal of Fashion design, technology and education*, 15(2), 187-199.
12. Escoda Pastor, C. (2018, May). Origami as a Tool for Three-Dimensional Architectonic Thought. In *Congreso Internacional de Expresión Gráfica Arquitectónica* (pp. 1554-1565). Cham: Springer International Publishing.
13. Gero, J. S., & Milovanovic, J. (2020). A framework for studying design thinking through measuring designers' minds, bodies and brains. *Design Science*, 6, e19.
14. Han, A., Wohn, K., & Ahn, J. (2021). Towards new fashion design education: Learning virtual prototyping using E-textiles. *International Journal of Technology and Design Education*, 31(2), 379-400.
15. Kapkin, E., & Joines, S. (2021). The design brief as a creativity catalyst in design education: Priming through problem statement. *International Journal of Art & Design Education*, 40(1), 126-145.
16. Khoudi, A. (2022). Using noninvasive depth-sensors to quantify human productivity levels in desk-related workspaces. *Journal of Interior Design*, 47(1), 51-65.
17. Lee, J. H., Ostwald, M. J., & Gu, N. (2020). *Design thinking: creativity, collaboration and culture* (Vol. 12). Cham: Springer.
18. Lee, J. H., Ostwald, M. J., & Gu, N. (2025). Introduction: Exploring design thinking. In *Design thinking: Creativity, collaboration and culture* (pp. 1-31). Cham: Springer Nature Switzerland.
19. Lei, G., & Li, X. (2022). A new approach to 3D pattern-making for the apparel industry: graphic coding-based localization. *Computers in Industry*, 136, 103587.
20. Liu, K., Zeng, X., Bruniaux, P., Tao, X., Yao, X., Li, V., & Wang, J. (2018). 3D interactive garment

- pattern-making technology. *Computer-Aided Design*, 104, 113-124.
21. McQuillan, H. (2019). Hybrid zero waste design practices. Zero waste pattern cutting for composite garment weaving and its implications. *The Design Journal*, 22(sup1), 803-819.
  22. McQuillan, H. (2020). Digital 3D design as a tool for augmenting zero-waste fashion design practice. *International Journal of Fashion Design, Technology and Education*, 13(1), 89-100.
  23. Meloni, M., Cai, J., Zhang, Q., Sang-Hoon Lee, D., Li, M., Ma, R., ... & Feng, J. (2021). Engineering origami: A comprehensive review of recent applications, design methods, and tools. *Advanced Science*, 8(13), 2000636.
  24. Suh, J., & Cho, J. Y. (2020). Linking spatial ability, spatial strategies, and spatial creativity: A step to clarify the fuzzy relationship between spatial ability and creativity. *Thinking Skills and Creativity*, 35, 100628.
  25. Suh, J., & Cho, J. Y. (2021). A triangular relationship of visual attention, spatial ability, and creative performance in spatial design: An exploratory case study. *Journal of Interior Design*, 46(3), 11-27.
  26. Valle-Noronha, J., Chun, N., & De Assis B Soares, J. (2020). Failed expectations, successful disruptions: experimenting pattern-cutting from a student-centred learning perspective. *International Journal of Fashion Design, Technology and Education*, 13(3), 238-246.
  27. Wang, Z., Xing, Y., Wang, J., Zeng, X., Yang, Y., & Xu, S. (2022). A knowledge-supported approach for garment pattern design using fuzzy logic and artificial neural networks. *Multimedia Tools and Applications*, 81(14), 19013-19033.
  28. Wijetunge, M. N. R., Gayantha, D. K., & Chandrasekera, T. (2025). Role of spatial memory in spatial design: A systematic review. *Learning and Motivation*, 92, 102166.
  29. Zich, U. (2023). Origami and Descriptive Geometry: tangible models to enhance spatial skills. *Nexus Network Journal*, 25(Suppl 1), 277-284.