

# Conceptual Development of a Transformable Chair Using TRIZ

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## Abstract

There is increased sophistication in the field of transformable furniture which will acquire less space with minimum weight. This applied research was done to develop a transformable chair which would satisfy various needs of people. The study of existing models was carried out and survey was conducted to understand the voice of the customer. Concept generation tool (here TRIZ) was used to generate various concepts. Newer concepts were modeled in SOLIDWORKS. Customer feedback for the newly modeled concepts was carried out to narrow down our choices to only single concept. After choosing the concept, Golden ratio was applied to it and the results were analyzed.

**Key words:** Concept generation, TRIZ, Forced decision, DARE analysis, Product development, Pugh Matrix, Concept Scoring, Golden Ratio, Transformable Chair.

## I. INTRODUCTION

Chair is a widely consumed product over the world for different type of applications like in domestic, industrial, educational deeds to name a few. There is increased sophistication in the field of transformable furniture which will acquire less space with minimum weight. When the chair is not required for seating, the user can fold it and easily carry it away.

City life requires people to get creative in the furniture they buy and lay out. Most of the people go out for outing are in need of many things like a table, a chair, a coffee cup holder, relax chair, sometimes a bed alike thing to name a few. These things demand much space independently to take them along with them. Hence people expect to carry anything transformable from one shape to the other with them.

There is a beautiful concept known as the Golden Ratio or Devine Proportion available in the nature and it is widely used by designers. It is often symbolized using Phi ( $\phi$ ), after the 21st letter of the Greek alphabet. The value of  $\phi$  is rounded off to 1.618. It is widely said that any product which fits into this famous golden ratio is eye pleasing and eye-catching. This divine ratio is used by many because of its visible lure of the human eye. One of the important objectives of the new product development is how that particular product looks. According to designer's language how the feel of the product is more important. If the product fits in the Divine Proportion the product will be an eye grabber,

which is an important dimension for a product. It is not an easy task to fit any product into this ratio, it requires a lot of calculations and it is time consuming, but still very efficient way to develop a new product. This ratio can be used as an effective tool in product life cycle development in any industry.

## II. LITERATURE SERVEY

As the part of the literature survey, the following patented models were studied. Along with the following models the conceptual models which are available in the market, with the help of internet, were followed.



Fig 1

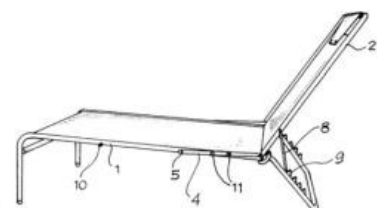


Fig 2

0 532 474 A1 – Bed transformable into armchair, patented on September 7, 1992



Fig 3

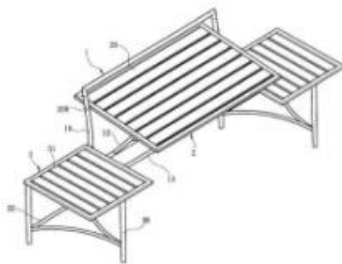


Fig 4

US 8,550,547 B1 – Transformable Chair Equipped with a Movable Deck, patented on October 8, 2013



Fig 5

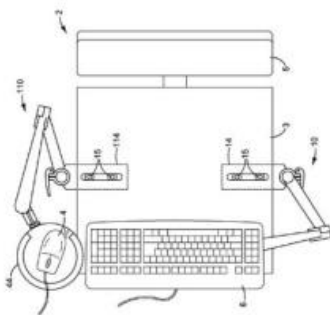


Fig 6

US 2011/0031785 A1 – Chair Arm Transformable into a Work Surface, patented on February 10, 2011, EP 2



Fig 7

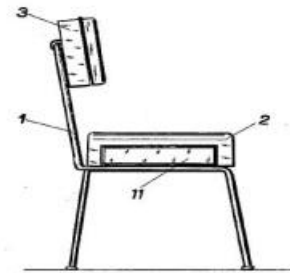


Fig 8

110 049 A1 – Combined Hair-Dressing Table and Chair, patented on April 15, 2009

### III. RESEARCH METHODOLOGY

Literature survey was done to understand the existing models and technology used in them which included study of Patents. To develop the transformable chair following methods were adapted. First basic customer survey was conducted (with 105 participants) to understand the requirements of them and prioritization of the requirements was done. Table 1 shows the list of features that customers are looking in transformable chair. There are various concept generation tools available; out of those TRIZ was selected for this applied research. With the help of the TRIZ tool hand sketches were made implying this principle. Some of the selected sketches were modeled using SOLIDWORKS. For the selected modeled concepts concept scoring with the help of Pugh matrix was carried out. Only one model was then chosen and detailed modeling was performed. Golden ratio was then put into practice for that chosen model.

#### A. Customer Survey on Chair

Customer survey was conducted to rate the various attributes ranging from 1 to 5.

Table 1 Voice of the Customer (Here total number of participants were 105)

Sr. No.	Requirements	Description
1	Ease of Handling	The chair should be easily carried away from one place to the other
2	Design of Product	Product should be aesthetically pleasant and sound in design
3	Ease of transformation	It should be easily transformed from one shape to the other with less efforts
4	Compactness	It should be in a such feasibly small size that after folding it does not seize too much space
5	Comfort	Product should have a higher level of comfort
6	Weight	The chair should be light in weight

*B. Front Burners from the customer requirements*

The Prioritization of customer requirements is done to determine relative importance of each feature. It is done in two stages. Forced Decision is a chart that allows a team or an individual to systematically identify, analyze and rate the strength of relationship between sets of information. Table 3 shows the FD analysis of the transformable chair. In this matrix according to the customer feedback the attributes are compared and they are assigned with either 0 or 1 rating. It is done for all the attributes and finally they are summed up. The priorities are ranked from higher level to the lower level.

Table 2 Attributes and their rating from Survey

Designation	Features	Rating
A	Side Table	1.17
B	Cup Holder	4.70
C	Arm Rest	3.20
D	Extending Neck Support	2.47
E	Foot Rest	3.47

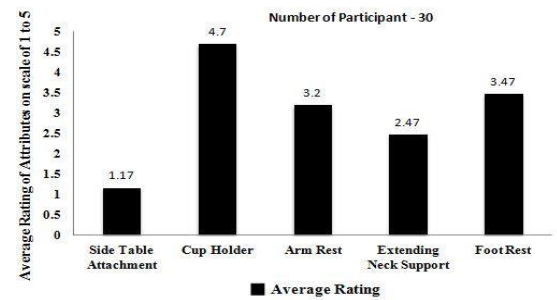


Fig 9 Rating of features based on Survey DARE stands for Decision Alternative Ratio Evaluation.

Table 3 shows the DARE analysis done. This analysis is done to calculate the degree of importance of one factor when compared with the adjacent factor. The attributes are arranged according to their ranks, developed from the FD analysis. It is used to understand how much one attribute is in lead than the adjacent attribute. It is determined how much more important that item is to the item that is directly below in priority ranking.

*C Concept Generation Tool (TRIZ)*

There are many tools available and used for the generation of concepts in new product development, but no single method is best. These tools are used to foster the ideas from the functionalities identified, also sometimes developing concepts for each function and then combining them. Concept generation tools are TRIZ, Six Thinking Hats, Brain Storming, Concept Fan, Cause and Effective Analysis to name a few.

Here for this research we have followed the TRIZ tool to develop the concepts. TRIZ (A Russian acronym: Theoria Resheneyva Isobretatelskehuh Zadach). It is the theory of inventive problem solving. TRIZ is based on two basic principles – 1. Somebody, sometime, somewhere has already solved your problem or one similar to it. Creativity means finding that solution and adapting it to the current problem. 2. Don't accept contradictions. Resolve them.

TRIZ theory uses a systematic approach to solve any problem from a common base. That method is eligible to transfer solutions from a field of science and technology to another one. A typical pattern used in TRIZ is first Identify our specific problem, second translate it into the TRIZ specific problem, third find out TRIZ general solution and finally translate that into out

general solution. TRIZ methodology uses the abstraction of the problem, based on a model that provides a range of problem

Table 3 DARE analysis (In the table T stands for Total; C for Cumulative; and W for weightage)

FUNCTION DESCRIPTION				T	C	W (%)
B	1.35			1.35	3.968	31.14
E	1	1.08		1.08	2.939	23.06
C		1	1.29	1.29	2.722	21.36
D			1	2.1	2.11	16.56
A				1	1	7.84
<b>Total</b>					12.7395	100

solving principles from which comes out the better solution. The TRIZ methodology shows that the suitable solutions come out when the designer can overcome the compromises generally accepted as inevitable constraints. The theory is based on 39 engineering parameters to be considered in the design stage, thus carry out a matrix with 39 rows and 39 columns. In that matrix the intersection of a parameter with the remaining 38 gives rise to inventive principles. These principles are 40 and usually overcome the contradiction and solve the problem. They are simple, obvious and not debatable.

*D Applying TRIZ*

For my work we have chosen Productivity versus Device Complexity. This means that the factor to be improved here is productivity and the worsening factor is device complexity. After observing the matrix, the matrix gives us 4 principles – Equipotentiality (12), another dimension (17), and Mechanical Principle Replacement (28) and Intermediary (24). For our model we have chosen principle number 12.

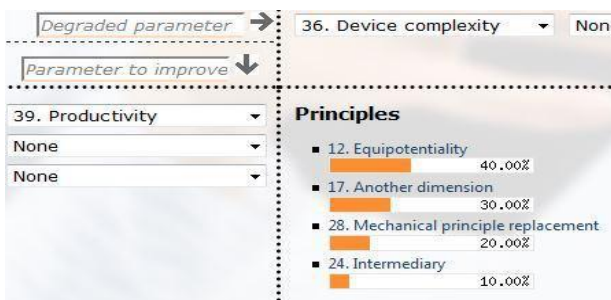


Fig 10 TRIZ Calculation (courtesy: [http://www.time-to-innovate.com/en/steps\\_matrix](http://www.time-to-innovate.com/en/steps_matrix))

Equipotentiality (40%) - In a potential field, limit position changes (e.g. change operating conditions to eliminate the need to raise or lower objects). Concept 2 and Concept 5 had been developed using this principle.

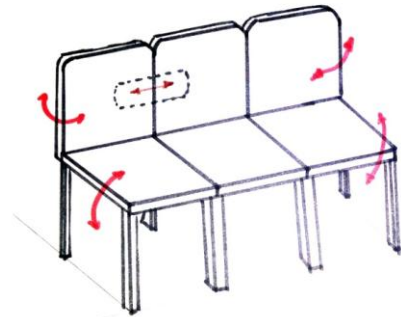


Fig 11 Isometric View of Concept 2 (This model, the chair can be transformed into the shape of a bench whenever required.)

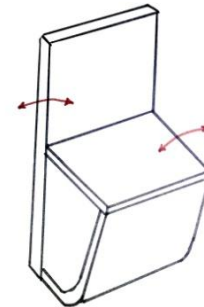


Fig 12 Trimetric view of Concept 5 (In this concept, chair can be transformed into a table top, also into a bed alike thing with very minimum efforts. Also finally it gets hold of less room)

Another Dimension (30%) - To move an object or system in two- or three-dimensional space. Concept 1 falls in this category of principle. This concept was built up using another dimension principle.

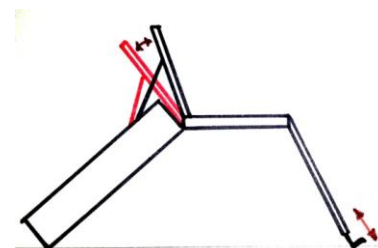


Fig 13 End View of Concept 1 (Here in this concept the chair can be transformed into the relax chair and a bed. Plus it has given provision for a foot rest cum coffee cup holder.)

Mechanical Principle Replacement (20%) - Replace a mechanical means with a sensory (optical, acoustic, taste or smell) means

Intermediary (10%) - Merge one object temporarily with another (which can be easily removed). For building up Concept numbers 3 and 4 this principle was used.

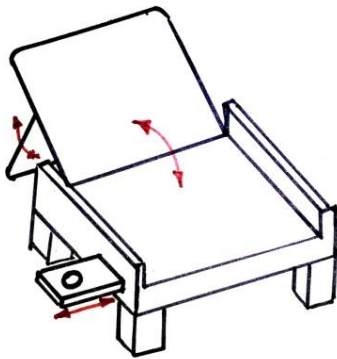


Fig 14 Isometric View of Concept 3(This chair can be transformed into a relax chair and a bed, also holds a coffee cup holder. It occupies less space and easy to handle)

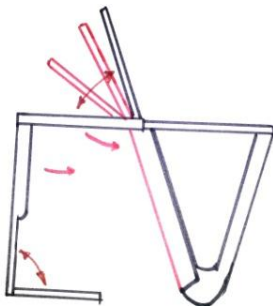


Fig 15 End view of Concept 4(Concept number 4 is being schematically represented in fig 7. It has an aesthetically pleasant shape, and can be transformed into a table top from the shape of a chair)

*E. Pugh method (Concept screening)*

The Pugh Matrix is a type of Matrix Diagram that allows for the comparison of a number of design candidates leading ultimately to which best meets a set of criteria. It is used for concept scoring .We are now in need of selecting best 3 concepts from above concepts to narrow down our choices. Here one concept is chosen as a yardstick concept. The rest concepts are the compared with this reference concept against stated attributes. For each comparison the concept is evaluated as being better (+), the same (S), or worse (-) than the yardstick concept. Table 5 shows the Pugh Matrix calculations.

Table 4 Pugh Matrix (C stands for Concept number)

DESIGN ALTERNATIVES	C1	C2	C3 (REFERENCE)	C4	C5
<b>ATTRIBUTES</b>					
Cup Holder	+1	-1	S	S	+1
Comfort	-1	+1	S	+1	+1
Handling	-1	-1	S	+1	+1
Portability	-1	+1	S	+1	+1
Aesthetically Pleasant	-1	+1	S	+1	+1
Cost	+1	+1	S	+1	+1
Space Required	+1	-1	S	-1	-1
Ease of Operation	-1	+1	S	-1	+1
Complexity	+1	-1	S	-1	-1
Total (+)	4	5	0	5	7
Total (-)	5	4	0	3	2
Total (s)	0	0	9	1	0
Net Score	-1	+1	0	+2	+5
Rank	V	III	IV	II	I
Carry on?	No	Yes	No	Yes	Yes

*F. Modelling of concepts using SOLIDWORKS*

From the concept screening process we have selected 3 concepts i.e. Concept 2, Concept 4, Concept 5 according to their nets scores. So these concepts have been modelled in SOLIDWORKS.

Concept 1



Fig 16-a and 16-b Concept 1(Here chair can take shape of a bench where instead of one man now 3 people can seat)

Concept 2

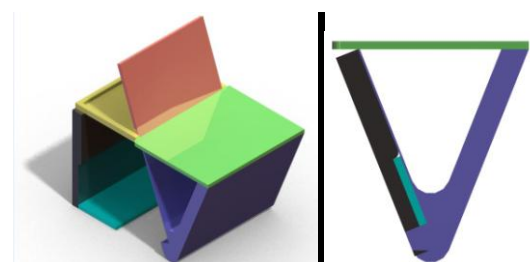


Fig 17-a and 17-b Concept 2(In this concept the chair can be transformed into a shape of a table top which can hold many things, also it has a very compact shape and an aesthetically pleasant design)

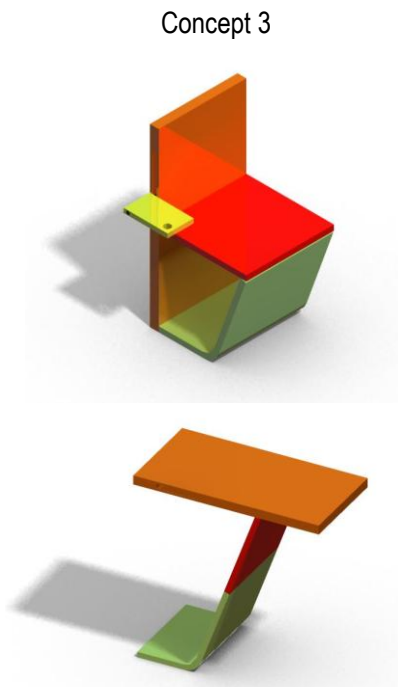


Fig 18-a and 18-b Concept 3(In this modeled concept, a chair can be transformed into a table, also can be used as a coffee cup holder, and can be used for relaxing purpose)

*G. Feedback on Developed Concepts*

Another survey was conducted to get the reviews from the people on the three different concepts generated. The participants were asked to rate the concepts and provide suggestions to improve the design. Ratings for these 3 concepts were obtained from the survey. Fig 11, Fig 12 and Fig 13 shows the data. The results of the survey show that concept 3 is the best concept among the three followed by concept 1 and concept 2 respectively (Fig 14).

*H. Pugh method- Concept scoring*

Three concepts were selected and it became indispensable to select the best concept in order to develop it into physical product. This was done by concept scoring method. In this method, weightage for each criterion was assigned according to DARE analysis results. The ratings for each feature for every concept were taken from results of survey. The scores were determined by the weighted sum of ratings for each concept (Table 5).

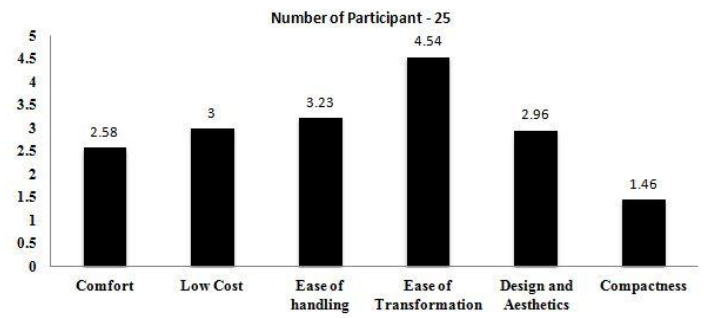


Fig 20 Rating for Concept 1

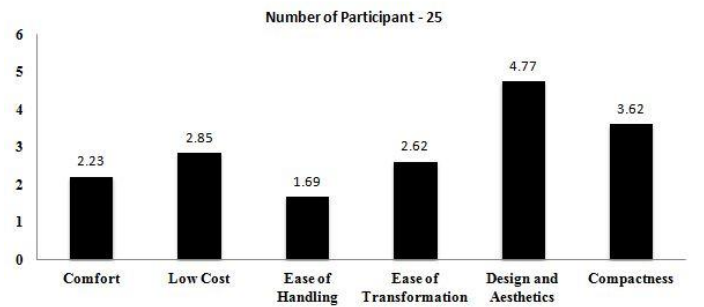


Fig 21 Rating for Concept 2

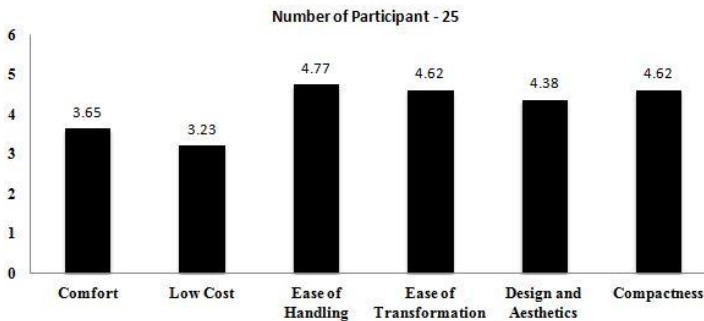


Fig 22 Rating for Concept 3

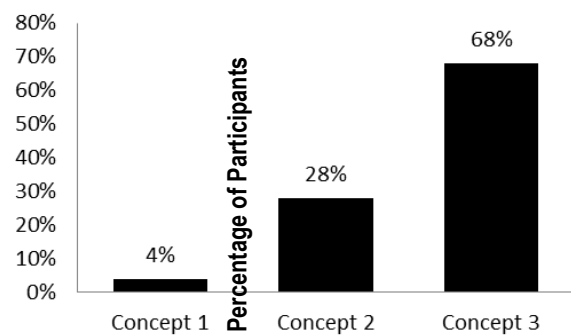


Fig 23 Selection of Concept.

Table 5 Concept Scoring (W stands for weight; R stands for Rate)

Attributes	Concept 1			Concept 2		Concept 3	
	W	R	W%	R	W%	R	W%
<b>Ease of Handling</b>	31.14	3.2	0.9964	1.6	0.498	4.8	1.488
<b>Ease of Transformation</b>	23.06	4.6	1.06	2.6	0.599	4.6	1.06
<b>Compactness</b>	21.36	1.4	0.307	3.6	0.768	4.6	0.983
<b>Design &amp; Aesthetics</b>	16.56	3.0	0.4968	4.8	0.794	4.4	0.728
<b>Comfort</b>	5.52	2.6	0.1435	2.2	0.121	3.6	0.198
<b>Low Cost</b>	4.32	3.0	0.129	2.8	0.121	3.2	0.138
<b>Net Score</b>			<b>3.132</b>			<b>2.901</b>	<b>4.554</b>
<b>Rank</b>			<b>II</b>			<b>III</b>	<b>I</b>
<b>Carry on?</b>			<b>No</b>			<b>No</b>	<b>Yes</b>

### I. Application of Golden Ratio

The following figures show the model with and without application of golden ratio.

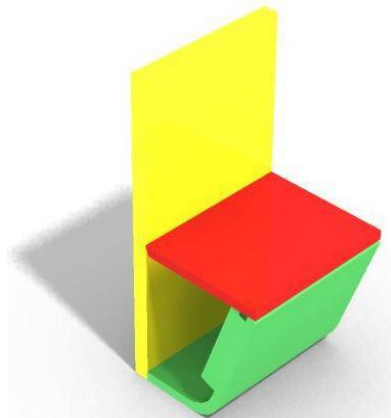


Fig 24 Isometric View (Without Golden Ratio)

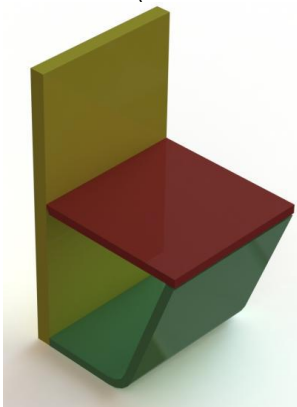


Fig 25 Isometric View (With Golden Ratio)

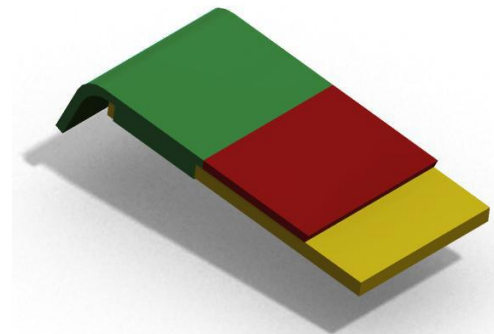


Fig 26 Isometric View (Without Golden Ratio)

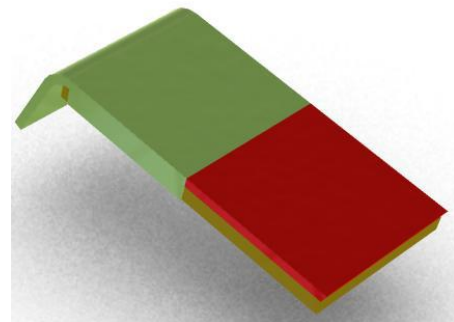


Fig 27 Isometric View (With Golden Ratio)

From the above figures it is clear that the model implying to the golden ratio is more aesthetically pleasant and eye catching that the one not fitting into the golden ratio.

## IV. RESULTS AND DISCUSSION

We have selected concept number 3 as the best concept. It now needed to be developed. Before any future operations on this concept this concept is needed to be modeled. The modeling of the same concept was done in SOLIDWORKS. Also the part list is shown below.

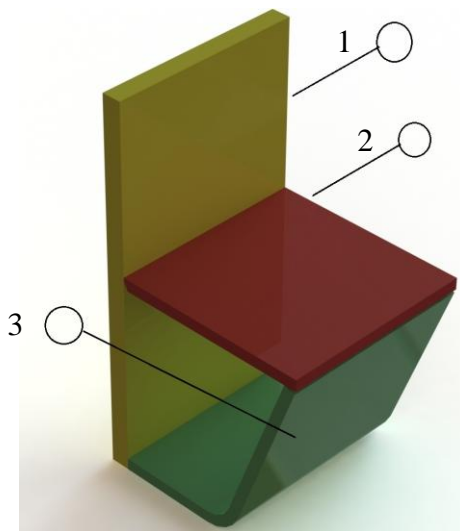


Fig 28 3D model of Concept 3

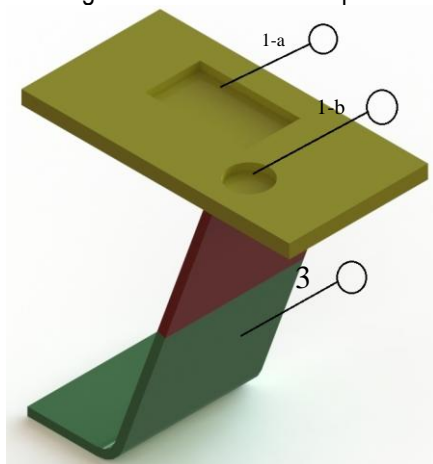


Fig 29 3D model of Concept 3



Fig 30 3D model of Concept 3

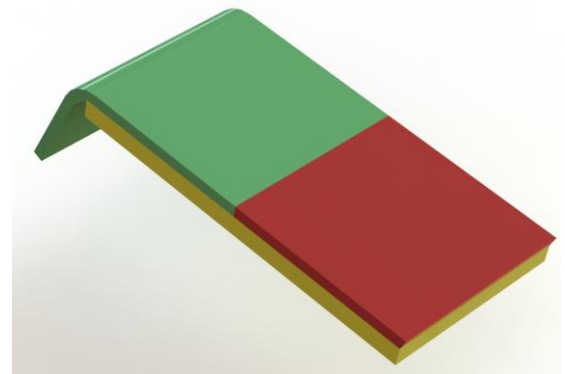


Fig 31 3D model of Concept 3

Table 6 Part List

Part No.	Part Name	Quantity
1	Back Rest/ Table	1
2	Seat	1
3	Base	1
4	Prop up	1

## V. CONCLUSION

A step by step procedure for any new product development is described in this paper. Various decision making methods like FD analysis, DARE analysis, and Pugh matrix were studied. It has been learned that the feedback from the customers play a vital role in developing new concept. Also concept generation tool (TRIZ) was studied in this applied research paper. A very old and rarely used theory of Golden ratio was also briefly discussed here which can be used as an effective tool in new product development. It has been learned that the feedback from the customers play a vital role in developing new concept.

A transformable chair was developed here, which can be used as a table, a coffee cup holder, also can be used for lying down purpose. And also it had been learned that it acquires less space when fully folded and can be easily carried away from one place to the other.

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