Izmir Institute of Technology

The Graduate School

STAGES AND METHODS OF CREATIVITY
IN
AN INDUSTRIAL PRODUCT DEVELOPMENT
(with a case study in bicycle design)

A thesis in

Industrial Design

By

ASLAN RİZA

Submitted in partial fulfillment
of the requirement
for the degree of
Master of Industrial Design

July 1998

We approve the thesis of **Aslan RİZA**

Date and Signiture

.......CAN 98.......
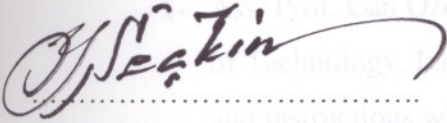
Assist.Prof.Dr. Can ÖZCAN

Supervisor

Department of Industrial Design
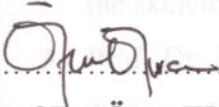
09.07.1998

.......Seçkin.......

Assist.Prof. Yavuz SEÇKİN

Department of Industrial Design
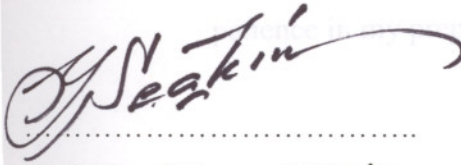
09. 07. 1998

.......Özen Eyüce.......

Assist.Prof.Dr. Özen EYÜCE

Department of Architecture

9.7.1998

.......Seçkin.......

Assist.Prof. Yavuz SEÇKİN

Head of Department

09.07. 1998

ii

IZMIR YUKSEK TEKNOLOJİ ENSTİTÜSÜ
REKTÖRLÜĞÜ

<u>ACKNOWLEDGEMENT</u>

ABSTRACT

This thesis is aimed on researching the creativity process that is concealed in the design process itself. The following chapters will include certain creativity concepts that were filtered out of a variety of processes. There are certain aspects to take into consideration as not only of a creative process but the progressive way of following certain methods of design. The first chapter includes some examples on the blocks that cease the creativity in the design process. Examples will be given to display the way of keeping the continuity of the creative mind. These are methods that designers use in daily life but are not aware of its existence. Processes will be included in the second chapter that will focus on the way of designing and methods of the design process. These methods were included in order to give the creativity process an engineering pull-down and cease it from artistic dispersal. It could be seen that examples given from a bicycle design will be included in all chapters. This is to uphold, and back-up the third chapter. In this chapter the case study of a bicycle design is included. The processes stated in the previous chapters were used in the process of the bicycle design.

ÖNSÖZ

Bu tezdeki amaç, tasarım sürecinde bulunan yaratıcılık sürecini araştırmaktı. Bundan sonraki bölümlerde birçok sürecin, süzgeçten geçirilmiş bir şekilde kavramları dahil edilecektir. Bazı noktalar dikkate alınırken sadece yaratıcı süreç olarak değil bazı tasarım metotlarında bulunan geliştirici yollar aranılacaktır. Birinci bölümde tasarım sürecinde bulunan yaratıcılığı durduran blokların değişik örnekleri verilecektir. Yaratıcı aklın devamını sağlayan yollarla ilgili örnekler verilecektir. Bu metotları tasarımcılar kullanmaktadır ama var oluşundan habersiz bir şekilde kullanmaktadırlar. İkinci bölümde tasarım yolları ve tasarım sürecindeki metotlar üzerinde durulacaktır. Bu yöntemleri dahil etmenin amacı yaratıcılık sürecine bir mühendislik ağırlığı ve artistik yaratıcılığın dağılmasını bir ölçüde geriletmektir. Görülecektir ki bütün bölümlerde bisikletle ilgili örneklere yer verilecektir. Bu da üçüncü bölümde bulunan projeyi desteklemek içindir. Bu bölümde proje ele alınacaktır. Bir önceki bölümlerde bulundurulan metotlar ve süreçler kullanılacaktır.

STAGES AND METHODS OF CREATIVITY IN AN INDUSTRIAL PRODUCT DEVELOPMENT   (with a case study in bicycle design)

INTRODUCTION

Creativity is the utmost importance in a society. Creative people in such an environment build up a civilization. Therefore, work results in development hence power exists. Every living, breathing human being has the potential to be creative. Each human being is a unique individual capable of creating... it comes with the human territory. Man is quite a creative specie. Easily to be seen when looked at the difference between the human being and animals. It leads us to conquer and direct the world with our brain.

All people can be creative, but those who are recognized as being creative have an awareness that others don't. Creative people seem to be able to tune in more to their thought patterns and glean great ideas. People who do not use their creative potential don't know how to do this or aren't even aware it is possible. Creative people can start thinking about something, then forget it. And start thinking about something else while they are still thinking about the previous problem. This is due to the amount of thinking that goes on in the brain itself. It isn't controlled but done unconsciously. With all the "come-and-go-thinking" going on, their brains are still thinking about what could be done to solve the problem. Later on, as life is going on, the person will start thinking about whatever was in mind and his/her brain will inform the mind that it has thought of the problem and has had found a solution for this so that it can be presently solved. Non- creative people don't know that their brains are working for them off-shift they don't know what they don't know.

There are many components that influence the creativity of individuals. This is not to say that people tremendously fluctuate in their creativity day to day and hour to hour; the opposite is often believed - that some individuals are generally more creative most of the time than others. The reasons why some people are more creative, are many, they could be summarized as follows:

a) Without the abilities needed to do the creative act, it is highly possible the individual will be on **duty thinking**. Just because a person has the ability to do

1

something, however, does not necessarily mean that the person will do it. This is why researchers examine people's motives that the individual is in.

b) Without the **motivation** to do so, it is unlikely that a person would complete an act, regardless of the person's abilities. A social role of a person depends on the outer effects that occur in the social group that he or she is in. Certain circumstances show that a person with high thinking potential could be withdrawn from the act just by the social role that he is playing. In the design process there is a positive relationship between intelligence and creativity for the designers whose IQ are less than 130. For IQ's higher than that value, there is no effect of intelligence in the process of creativity in design. This relationship nevertheless goes on for a "so-called" non-creative person, if he is put in a group of people effecting him and pushing him into the deep swamp of creativity then he would start struggling out by using his brain.

c) **Opportunities** in the environment can affect the creativeness of individuals and groups of individuals. So having opportunity of being a suitable person in a suitable place in a suitable time, enhances the creativity of a designer.

d) If a designer ever generates a **novel response** to a problem or challenge, educational technologists convince him in congratulating oneself as being creative. If this is done on a regular basis, every day, then the designer would put himself in the class of "creative people". With practice, the designers ability to generate novel and useful responses to problems and challenges will greatly improve.

e-) **Culture** is another aspect that should be taken into consideration due to the background effect on the designers influences; a good example could be given for the Italian trend. Italians have a very rich history of art leading to designs quite artistic. When Italian designs are researched, it would be seen that the line of expression would be different than other cultures. For instance in the automotive industry they would be said to be creative in the artistic way in designing. The Germans would be said to be good in their accuracy in engines. The British, in their safety for the cabins of cars.

f-) One aspect of a creative personality is the fluency with which the designer generates a number of **new ideas**. Not only does the creative person think of good ideas, but can think of many ideas, explore them, and record them. There are times when creative people feel a need to quantify creative ability. They go to a local psychologist and ask about taking a test to measure there creative ability. But here it should be noted that it is important to recognize that creative ability can be learned, improved upon, and increased over time.

Most (if not all) people are creative to various extents. Some people act on their ideas and others ignore them. Inventors and artists take action on their ideas. How may people have said "I could have done that". The response to that is "Well, why didn't you?" or "Too late...someone else thought of it first". Einstein declares that only 5% of his discoveries depend on creativity and the remaining 95% goes to the big share of work and patience.

That is the whole purpose of creativity training, it is to develop one's ability to generate and implement new ideas. Different people have different levels and abilities of creativity, much like anything else that is a skill. However, everyone can be creative if they want to be. Like other skills, creativity can be developed. Often people will think they aren't creative because they are basing their opinion on a skill they don't have; somebody may express that he is a lousy painter. But that doesn't mean that they can't be creative as a painter, even though they have made a very bad painting. A lack of creativity is not what is limiting the output as a painter, a film producer, a designer etc.

Creativity, is the ability to generate novel responses to problems and challenges, in a basic human ability. Some people are encouraged to express their creative ability more than others and may even get rewarded for doing so. Artists, in addition to expressing their creativity, also have traits like manual dexterity, good eye-hand coordination and other skills that enable them to more full-expressing their creative thoughts. Similarly, athletes, teachers, scientists and auto mechanics have special skills set that enable them to express their creative ideas.

In western societies people seem to assign certain universal human abilities, like creativity, to only a subset of all people (usually artists, musicians and architects) making it more difficult for all members of society to see themselves as creative people. This is a Western myth that designers must be aware of and work to overcome.

On the other hand eastern cultures have been assigned to a lot of creative thinking that has been an interpreted social behavior of need. "Need" on its own is dominant on creativity in design but not relatively assigned to be the whole motive action. An example for creativity is the pipe anyone would have in Islamic toilets at home. This is extremely a "need" based design which was a product of a social fact based on the cleaning behavior in the Islamic culture.

Some people have extraordinary talents in fields that have been recognized as "creative." When they combine these extraordinary talents with the determination and persistence that it takes to achieve skill mastery, they are recognized as creative artists. Inventors are generally better than average at channeling their creativity towards practical ends, whereas artists are better at expressing themselves creatively.

There are, however, many ways of being creative. Each individual can be creative if he recognizes the unique talents and develop himself to be a master in those areas. That is no guarantee that the world will recognize the individual but it does provide the soul satisfaction that comes with trying to live a creative life. Thus, it can be freely assert that creativity is found in all people and that creative talents can be increased with study. This leads us to a careful study of design processes and there intellectual importance.

In general design is the combination of processes ranging from the economical to the technical values that convert raw materials, energy, and purchased items into finished products. Design has also been viewed as a series of tasks that complement each other requiring input from precedent tasks and providing needed output to succeeding ones. Nevertheless, the design process consists of a single process made up of many related tasks such as market definition, product performance, specification,

İZMIR YUKSEK TEKNOLOJİ ENSTİTÜSÜ

product modeling, economic feasibility analysis, product testing, and production analysis.

This thesis will be a research on creativity and design with a case study of a bicycle. The case study will be with respect to this scope of freedom, and it will stand to be in the mid-point of both engineering and artistic freedom concepts. This will include the venture of design and its whole process, it will be ended with the design processes included in the thesis. Theory on its own might mean a lot but it would not be the same as in practice. The case study will be an example to understand the connection of design and creativity.   The case study will be based on careful analysis of these design processes included in early chapters. There are main components in a bicycle that will be analyzed.

The bicycle will be a good, fast and economic design with comparison to its class. In this problem creativity stages and obstacles, that may occur as the design process furthers on, will be included. There may be many other circumstances where certain blocks may occur. These will be researched and solved according to the creativity tackling processes that are included in the thesis itself. Certain models will be constructed in time to visualize the design as a three dimensional case study. There may be other modeling processes to be done by the use of computer aided programs hence forcing model construction time to the minimum.

CHAPTER 1

THE NATURE OF CREATIVE THINKING

1.1 Definition of Creativity

To give a start in the concept of creativity it would be convenient to base the phrases on definitions that would be found anywhere. Dictionaries are sources but not the only source for an interactive research.

1.1.1 Definitions of Creativity as a Word

Dictionaries give the following meanings:

Heritage Illustrated Dictionary:

Create: To cause to exist, bring into being, originate, to give rise to, bring about, produce, to be first to portray and give character to a role or part (appropriate to creating fictional characters and writing stories).

Creation: An original product of human invention or imagination.

Creative: Characterized by originality and expressiveness, imaginative.

Other words :Creativity: creativity   creativeness,   formativeness,   innovation, inventiveness,   originality,   productivity,   craftsmanship,   authorship, creatorship.

Oxford Advanced Dictionary:

Create: Make something new or original. Give rise to; produce.

Creation: Production of the human intelligence.

Creative: Having power to create; of creation: i.e. requiring intelligence and imagination, not merely mechanical skill.

Merriam-Webster, Incorporated

Create: To produce through imaginative skill <create a painting> b : design <creates-dresses> intransitive senses : to make or bring into existence something new.

Creation: The act of creating; especially : the act of bringing the world into ordered existence

Creative: 1 : marked by the ability or power to create : given to creating <the creative impulse>

2 : having the quality of something created rather than imitated : IMAGINATIVE <the creative arts>

"Being creative is seeing the same thing as everybody else but thinking of something different"

1.1.2 Definition as a concept

There are many significant meanings to creativity, but one definition would include the ability to take existing objects and combine them in different ways for new purposes. For example, Gutenberg took the wine-press and the die/punch and produced a printing press. Thus, a simple definition of creativity is the action of combining previously un-combined elements. From art, music and invention to household chores,

IZMIR YUKSEK TEKNOLOJI ENSTITÜSÜ
DEVTÄDI üÄ ü

this is part of the nature of being creative. Another way of looking at creativity is as playing with the way things are, interrelated. ***Creativity is the ability to generate useful ideas and solutions to everyday problems and challenges***.

Creativity involves the translation of unique gifts, talents and vision into an external reality that is new and useful. It must kept in mind that creativity takes place unavoidably inside the persons own personal, social, and cultural boundaries.

The more the designer defines his creativity by identifying with specific sets of values, meanings, beliefs and symbols, the more creativity will be focused and limited; the more we define our creativity by focusing on how values, meanings, beliefs and symbols are formed, the greater the chance that our creativity will become less restricted.

In creative processes there are always two different (but interrelated) dimensions or levels of dynamics with which one can create:

A- The system which may be a particular medium (e.g. oil painting or sketch on a sheet of paper), or a particular process (like a problem solving agenda, or an approach to creativity like synectics). The creative person manipulates', i.e. to a creative end.

B- The second dimension describes the conceptual "content" which the medium describes. Again, the creative person depicts', changes, manipulates, expresses somehow the idea of that content.

There is no definition of creativity that all designers can agree in. Creativity researchers, mostly from the field of psychology, usually claim that being creative means being novel and appropriate. Subsumed under the appropriateness criterion are qualities of fit, utility, and value.

There are at least four aspects of creativity that have drawn much attention (Linda Schiffer, 1996).

- The creative process, receiving the most attention, focuses on the mechanisms and phases involved as one part that takes in a creative act.
- A second aspect of creativity is the creative person. Here, personality traits of creative people are central.
- The environmental atmosphere and influence are concerns of a third aspect, the creative situation.
- Last, the criteria or characteristics of creative products have been sought. This area is of particular importance because it is the basis of any performance assessment of real world creativity and may provide a window on the other aspects of creativity.

Briefly stated, creativity is often thought to exist on at least five levels:

1. A higher level versus a lower level.
2. Grand versus modest.
3. Big "C" versus little "c".
4. Paradigm-shifting versus garden-variety.
5. Eminent versus everyday.

Some researchers claim other categories of creativity as well:

1. Expressive versus productive.
2. Expressive versus inventive.
3. Expressive versus innovative.
4. Invention versus discovery.
5. Theory versus invention versus discovery.
6. Accommodative versus assimilative.
7. Personal versus public.

There are three general ways of achieving a creative solution:

serendipity
similarity
and meditation

Creativity on its own might have a lot of definitions. Here, all definitions are not only or the design concept but are for *industrial designing*. In certain circumstances, it may defer for an alternative view. As it would be mentioned; creativity is not just taking a pencil and scribbling on a paper but it is something that lets the designer think of in parallel planes. A designer for the industry would rather mean a lot for manufacturers since all the investment would go according to the designers point of view. Production, design, consumption, marketing, etc. are all short comments on the planes that would be regarding design processes. Creative thinking would also be playing with these planes. In future sections we will be analyzing the thinking hats that a designer should be aware of while creating, e.g. the designer ought to put aside the manufacturing processes until entering into deep designing, or putting aside creativity until he finds a solution for an artistic look over the design. Further on we would see the aspects that effect a designer while he/she is creating or designing.

1.2. Sources of Creativity

In the history of explanations on creativity there has been a vast change in the meaning of the word. For example in the 1950's creativity was thought to be nothing but a gift, in the 1960's it was looked upon as if it was a skill of mental flexibility that could be taught to with time. In the 1970's attention was drawn to relevant experience as a thought of being the dominant factor on creativity, and in the 1980's it was appreciated to be a kind of motivation. In the 1990's it was seen that the effect of the climate was a great deal of effect in creativity. Below are some sources of creativity that should be taken into consideration (Henry 1995, p.8).

1.2.1. Child Creativity

Innocence is the classic creativity of a child. If the usual approach, the usual solution, the usual concepts involved are not known, then designers may come up with a fresh approach. Also, if knowing the constraints and knowing what cannot be done does not inhibit it, then the individual is freer to suggest a novel approach (de Bono 1993, p43).

When the Montgolfier brothers viewed the first hot air balloon, the world heard of this exciting event. It reached the king in Paris, who immediately saw the military potential and then called for the chief scientific officer, M. Charles, and commanded him to produce, a balloon. This considerable scientist began to think of how they flew this contraption. After a while, jumped up with the French equivalent of "Eureka". He came to a result of using the "new gas" called hydrogen, which is lighter than air. He proceeded to invent the hydrogen balloon, which is a totally different type of balloon. This is actually based on another design but rather a different one. In the south of Sweden a group of high school children were brought together by Gunnar Wessman, who was then chief executive if the Perstorp Corporation. According to Edward De Bono he gave them some training in lateral thinking. Then a number of government and industrial people who had come from Stockholm to put problems to the youngsters. The problem involved the difficulty of motivating workers to take the weekend shift in a plant that needed to be kept running over the weekend. In their innocent way the children suggested that instead of motivating existing workers it would make sense to have a fresh workforce that always worked only Saturdays and Sundays. Apparently this idea was tried out and the number of applicants for these weekend jobs was far in excess of what was needed. Adults would have assumed that no one would want to do such weekend jobs, that the unions would never permit it, and so on. Although children can be very fresh and original they can also be inflexible and they can refuse to put forward further alternatives.

The creativity comes from the fresh or innocent approach rather than the seeking for a new approach. Unfortunately, it is not easy to keep ignorant and innocent as the

11

human grows up. Nor is it possible to be innocent in one's own field. Designers ask the practical points that can come out from the creativity of innocence. On certain occasions, mature people could actually listen to children. The children are unlikely to give full-fledged solutions, but if the listeners are prepared to pick up on principles then some new approaches might emerge. Some industries, such as retailing and the motor industry, are traditionally inbred and feel they have all the answers. There is the feeling that an individual has to grow up in the business to make any contribution. There is a point in such industries looking outwards and seeking ideas from outside. Such ideas may have the freshness that cannot be obtained from insiders no matter how experienced they may be.

Some firms in Turkey are aware of the importance of fresh ideas, thus it may be a good point to say that they do succeed in finding some. A recent example may be with the company Vestel. The firm has an industrial designing department but although this could be used it still took some managerial executives to think of new ideas that could come from other industrial designing firms. Vestel bought designs from Pinninfarina and Nesne Design and consultancy just for the sake of free and fresh ideas.

According to De Bono a very important practical point concerns research. It is normal when entering a new field to read up all that there is to read about the new field. If it is not done then it cannot make use of what is known and the individual risks wasting time reinventing, the wheel. It can be seen when a person makes an attempt to challenge these and even to go in an opposite direction where it can be no longer innocent of existing ideas. There is no chance of developing a concept that is but slightly different from the traditional connects. So if competence is wanted then there must be an act of reading everything on around the world of that certain solution. But if originality is wanted then this must be avoided. One way out of the dilemma is to start off reading just enough to get the feel of the new field. Then the designer should stop and do one's own thinking. When some ideas are developed then continue to read further to get more. Then stop and review the ideas that have been created and even develop new ones. Then go back and complete the reading. In this way a person might have a chance to be original. When a person joins a new organization there is a short window of freshness that runs from about the sixth month to the eighteenth month.
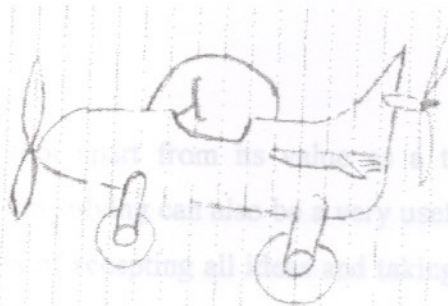
Before the sixth month the new person does not yet have enough information to get the feel of the business (unless it is a very simple business). After the eighteenth month the person is so imbued with the local culture and the way things should be done that innocent freshness is no longer possible. It should be noted that some of the most rigid businesses are soft businesses like advertising and television. In some other fields there are fixed regulations or even physical laws to guide behavior. Because these are virtually absent in the soft fields, the practitioners in such fields invent for themselves a whole lot of arbitrary rules and guidelines in order they could feel more secure. If everything is possible then the question of "how would a person know what to do?" will arise. The rigid guidelines become established by tradition and people find themselves forced to work within these totally arbitrary rules. In such fields, innocence is usually dismissed as ignorance.

Using the innocence of children in the case study was rather amusing to see how they proved themselves in creative means. The research was done on a total of 1283 students from six primary schools in İzmir[1]. The below diagram shows the results of the research that was included in the CD given with this thesis.

Age	Class	Number of Students
1 1	5	3 9 5
1 0	4	1 2 1
9	3	2 9 8
8	2	1 1 7
7	1	3 5 2
	TOTAL	1 2 8 3

The students at that certain age gave good performance. Only some of the drawings were interesting. Below are some examples from the 5th level.

---

[1] 30 Ağustos, Vali Rahmi Bey, Saadet Emir, Çakabey, Meşkure Şamlı, Umur Bey Primary Schools.

Fire

FREE

...apart from its culture... technique to ...left me... very useful approach ...The idea... collecting all the good looking ideas from ...building on others ideas, looking for what is good ...group... to listen to each other ...items in some depth in this way... me is

...Ben bisikletimin sarı, kırmızı renkte olması...
...isterdim. Jet gibi gitmesini isterdim. Uçak
gibi uçmasını isterdim. Lumina'ın gibi büyük
olmasını isterdim. Bisikletimle arkadaşlarımı
taşımak isterdim. Bütün dünyayı bisikletim
le gezmek isterdim. Bir de 3 tekerlekli
olmasını isterdim
                              Mehmet Küçükaydın

1.2.2. Attitude:

Problem solving, is a powerful tool apart from its value as a technique to generate imaginative ideas, creative problem solving can also be a very useful approach in multidisciplinary groups. The principles of accepting all ideas and taking ideas from each participant in turn, ends up with building on others ideas, looking for what is good and useful in every suggestion, hence this forces group members to listen to each other and give all parties a hearing. Examining problems in some depth in this way means many different perspectives emerge and participants see how a bad idea can act as a springboard for the final solution (Henry 1994, p12).

The effect of this can be clearly seen when participants respect others ideas and can build on them as they further on in their discovery. Listening becomes an attitude and a discipline that motivates people to use others minds and takes them as to be a part of their own mind. Participants feel the freedom when creating and generating ideas, no matter what kind of idea it is.

This technique is built on a concept first taken by (Guildford, 1967). It was the attempt that was made to measure creativity in people; a battery of tests was constructed and carefully analyzed. Out of this work came concepts of "convergent" and "divergent thinking" that were concerned with a particular result. The thinker gathers information and then proceeds, by using problem-solving rules. Please refer to section 2.2.3. The result of convergent thinking is usually a solution that has been previously arrived at by someone else. Convergent thinking is not the type of thinking people primarily use when they thin creatively.

The characteristic of *divergent thinking* is the variety of thoughts involved. When thinking creatively, people tend to think in a divergent manner, thus having many varied thoughts about a problem. Divergent thinking includes *autistic* and some *convergent thinking*. Autistic thinking is a kind of thinking that involves a highly private variety of thoughts that may use symbols with very personal meanings; dreams are an example of autistic thinking. On the other hand convergent thinking is a solution based thinking process that only deals with the solution of the problem.

1.2.3. Experience

When looked back at creative people, other than designer, whether they are chess players, musicians, businessmen or scientists, it may be seen that studies have emphasized the role of relevant experience. Studies show that creative experts, tackle problems differently from others. It seems that as they build up their experience, they organize their knowledge in ever more sophisticated ways which means they can access key-cues more quickly. According to Weiseburg (1986, p67), a person needs a ten-year time to have an exceptional creative worth. When analyzed, the lives of successful businessmen depend on the only way out, which is from timing and experience, and this is not actually based on creativity.

The creativity of experience is obviously the opposite of the creativity of in innocence. With experience things are known of how they work. From experience, the thinking of creative means changes to the one that will succeed, and that will sell. Examples of bicycles done in Bisan company in İzmir are included in Appendix B.

The first mode of operation of the creativity of experience is "bells and whistles." The idea that worked so well before is tarted-up with some modifications in order to let it appear as a new idea. This is quite often the sort of product differentiation talked about in classic competitive behavior.

The second mode of operation of the creativity of experience is "son of Lassie." If something has worked well before then it can be repeated. If the film Rocky has worked then why not have Rocky II. and then III. and even IV and V, This strategy covers copying, borrowing, and "me-too" products. A new style in advertising will immediately spawn many imitators. This type of creativity is very common in North America, where there is considerable risk aversion. If it is known that something works then it is better to repeat it again rather than try something new. This is because the personal costs of failure are so high. An executive is only as good as his or her last action. This makes for opportunism rather than true opportunity development. Turkey in "me too" production is rather a treasure. Where ever looked, the production that may go

on in firms most of the time is based on this system. Here it may be mentioned that the Turkish system of copying has been a valid fact of complex imitation. However, this is being practically avoided in some circumstance as the laws and selling departments drive manufacturers to be original. As a country develops it may be vital to see abstract development in designs. Japan in the history of transportation design started the concept of "me too" but as time passed by it is one of the biggest pioneers in transportation design.

The third mode of operation of the creativity of experience is disassembly followed by re-assembly. Things that are known to work are packaged as a product, for example, an electronic-product such as a remote-controller. When the time comes to have a new product, the original package is taken apart and the ingredients repackaged in a different way. Usually the ingredients are mixed around amongst different packages so the combinations are always changing. The creativity of experience is essentially low-risk creativity and seeks to build upon and to repeat past successes. Most product creativity is of this sort. There will be a steady and reliable output of moderately successful creativity, but nothing new. If someone were to think of something "really new" then it would be rejected because there would be insufficient evidence to guarantee of the success that is needed. Manufacturing is based on profit most of the time.

1.2.4. MOTIVATION

By contrast, Amabile (1983) argues that neither the possession of mental flexibility or relevant experiences are sufficient for creativity to flourish. Rather that creativity emerges when there is a combination of these factors along with intrinsic motivation, that is, where people are doing what they want to do. So whilst chance may favor the prepared mind, motivation seems to be an equally important factor, just as good a measure of the level of creativity. She argues that the designer needs to be intrinsically motivated to drive the persistent effort needed for a creative outcome. If really cared about something, it is doubted that the designer will be prepared to persist longer at it, and take more risks to achieve it. Both perseverance and a capacity for risk taking is seen to be necessary for creative attributes. The creativity of motivation is very

17

important because most people, who are seen as being creative, derive their creativity from this source.

Motivation means being willing to spend up to five hours a week trying to find a better way of doing something when other people perhaps spend five minutes a week. Motivation means looking for further alternatives when everyone else is satisfied with the obvious ones. Motivation means having the curiosity to look for explanations. Motivation means trying things out and tinkering about in the search for new ideas.

One very important aspect of motivation is the willingness to stop and to look at things that no one else has bothered to look at. This simple process of focusing on things that are normally taken for granted is a powerful source of creativity, even when no special creative talent is applied to the new focus. This is so important a point that shall be dealt with later under the chapter of creative techniques.

With all the above it could be concluded that *motivation means putting in time and effort and attempting to be creative*. Over time, this investment is seen to pay off in terms of new and creative ideas.

A lot of what passes for creative talent is not much more than creative motivation-and there is nothing wrong with that. If the designer can then add some creative skills to the existing motivation, the combination can become powerful.

At this point *motivation* is to be noted in two main ways. One is the extrinsic and the other is intrinsic reinforcement. Pelé in some time of his bright life noted; "I don't actually enjoy football as much as I used to. It's just a way to make a living, and I'll stop playing if they refuse to pay me what I'm asking".

Designers engage in certain behaviors for *intrinsic* reasons (for reinforcement that they can provide for themselves) or *extrinsic* reasons (for reinforcement that designers receive from others) (Smith p308). A research with both college students and children indicates that extrinsic reinforcement can indeed undermine intrinsic reinforcement (Deci 1975).

Industrial design students that are due to a high level of study and work would want some extrinsic reinforcement as they start there life of design. As the designer (student) continues on, it is vital that he would develop an intrinsic reinforcement with time.

1.2.5. TUNED JUDGEMENT

There is a difference between a photographer and a painter. The painter stands in front of the canvas with paints, brushes, inspiration and proceeds to paint a picture. The photographer wanders around with a camera until some particular scene or object catches his or her eye. By choosing the angle, the composition, the lighting, and so on, the photographer converts the "promising" scene into a photograph.

The creativity of "tuned judgement" is similar to the creativity of the photographer. The person with tuned judgement does not initiate ideas. The person with tuned judgement recognizes the potential of an idea at a very early stage. Because that person's judgement is tuned to feasibility, the market, and the idiom of the field, the person picks up the idea and makes it happen.

Although this sort of creativity seems to lack the glamour and ego satisfaction of the originator of ideas (deBono p47), in practice it may be even more important. An idea that is developed and put into action is more important than an idea that exists only as an idea. Many people who have achieved success with apparently new ideas have really borrowed the beginning of the idea from someone else but have put the creative energy into making the idea happen.

The ability to see the value of an idea is itself a creative act. If the idea is new then it is necessary to visualize the power of the idea. People who develop ideas in this way should get as much credit as those who initiate ideas.

Design management is also a great deal of effect on the creativity process. Defining management and its role on the designer or the role of the executives is

19

important. The *role* would be defined as the process undertaken by one or more individuals to co-ordinate the activities of others to achieve results not achievable by one individual acting alone. In the design process, management may also be done by the industrial designer. Here tuned judgement is seen to be the patriot of creativity. The role simply is to see the products future before even starting the designing and going into deep processes and detailed data structuring.

1.2.6. CHANCE, ACCIDENT, MISTAKE, AND MADNESS

The history of ideas is full of examples of how important new ideas came about through chance, accident, mistake, or madness.

Tradition, which is a summary of history, is going along in one direction. Then something happens, which could not have been planned, and this takes thinking out in a new direction and a new discovery is made.

Many of the advances in medicine were the result of accidents, mistakes, or chance observations. This also exists for design. The first antibiotic was discovered when Alexander Fleming noticed that a mold contamination of a Petri dish, seemed to have killed all of the bacteria; thus penicillin was born. Pasteur discovered the process of immunology when an assistant made a mistake and gave too weak a dose of cholera bacteria to some chickens. This weak dose seemed to protect them against the fuller dose that was given later.

Columbus only set of to sail westward to the Indies because he was using the wrong measurements . He was using the measurements derived from Ptolemy's erroneous measurement of the circumference of the globe. He had been using the correct measurements, which had been worked out by Eratosthenes (who lived in Alexandria before Ptolemy), Columbus would probably never have set sail because he would have known his ships could not have carried sufficient provisions.

In some ways (deBono p47), the whole of the electronics industry (about $150 billion a year in Japan alone) depended on a mistake made by Lee de Forrest. Lee de

Forrest noted that when a spark jumped between two spheres in his laboratory, the gas flame flickered. He thought this was due to the "ionization" of the air. As a result, he proceeded to invent the triode valve (also known as the vacuum tube or thermionic valve) in which the current to be amplified is applied to a grid and so controls the much larger current passing from the filament to the collector plate. This invention provided the first real means of amplification and gave rise to the electronic industry. Before the invention of the transistor all electronic devices used such vacuum tubes. It seems that the whole thing was a mistake and that the gas flame flickered because of the noise from the spark discharge. This slight fault came a major effect in the development of design.

Mistakes, anomalies, things that go wrong have often triggered new ideas and new insights. This is because such events take the designer outside the boundaries of "reasonableness" within which it is normally forced to work. These boundaries are the accepted summary of past experience and they are very jealously guarded, particularly by people who are themselves rather unlikely to have new ideas. Apparent "madness" is a source of creativity when a person comes up with an idea that does not fit current paradigms. There is heavy condemnation of the idea. Most of the ideas are mad and do go away. But sometimes the new and mad idea proves to be right and the paradigm has to be changed, but not before there is fierce opposition from the defenders of the old paradigm. So at *first* we get a point that arises the question of the practical point from the powerful source of creativity. Should or not a designer make mistakes on purpose. One practical point is to pay close attention to mistakes and anomalies when things do not turn out as had hoped.

The *second* practical point is the deliberate use of provocation. The techniques of provocation allow the creator to be mad, in a controlled way, for 30 seconds at a time. In this way he can achieve those boundary jumps that otherwise have to depend on chance, accident, mistake, and madness.

The below figure shows how the boundaries of past experience and "reasonableness" turn back thinking. These boundaries can be jumped by chance, accident, mistake, madness-or deliberate provocation.

Chance

Thinking
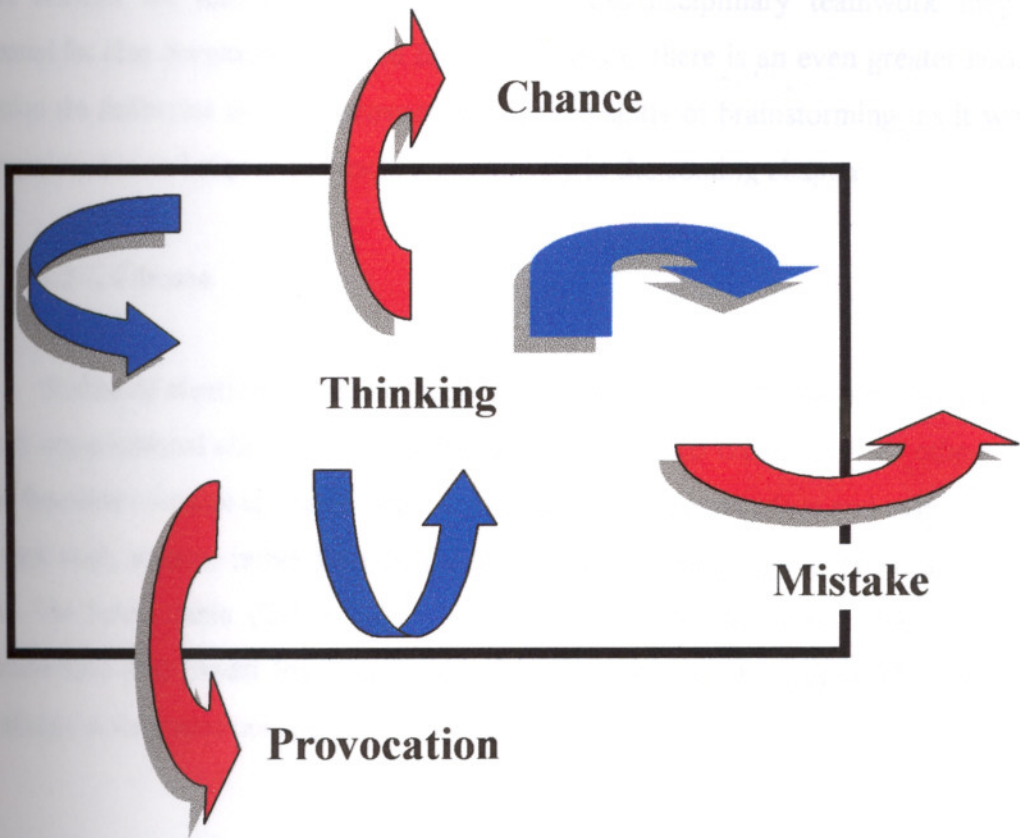
Mistake

Provocation

Figure 1.2.6. Boundary of reasonableness

There is a further practical point that arises here. Individuals working on their own can hold and develop ideas that are at first "mad" or eccentric and only later become acceptable (deBono p50). If such a person is forced to work with a group from an early stage then it might not be possible to develop such ideas. This is because of the "reasonableness" of the group that will force the new idea back within the boundaries of acceptability.

Cultures which rely heavily on group work (such as Italy and the United States) may be at a disadvantage in this regard. Countries like the U. K., with its tradition of eccentric individuals working away in corners, may have an advantage. That is why M.I.T.I. in Japan found that 51% of the most significant concept breakthrough of the twentieth century had come from the UK and only 21 percent from the United States, in spite of the much larger technical investment of the United States.

It has to be said, however, that the complexities of modern science make it much more difficult for individuals to contribute. Cross-disciplinary teamwork may be essential for idea development in the future. Therefore, there is an even greater need to develop the deliberate skills of provocation. Or the skills of brainstorming, as it would be mentioned in techniques and tools for creativity in the coming chapter

1.2.7. Climate

Studies of creativity at work (such as Ekvall, chapter 7[2]) have emphasized that certain organizational climates are much more conducive to creativity than others. The more favorable climates are more open, they give employees freedom and responsibility for their work, tolerate rather than punish mistakes and make a point of nurturing new ideas. The below table (Table 1.2.a. Studies of creativity at work) shows contrast characteristics that Ekvall found in innovative companies with creative climates with the climate in stagnated companies.

Dimension	Innovative Companies More Creative	Stagnated Companies Less creative
Challenge	Enjoyable, energetic	Alienated, indifferent
Freedom	Independent initiatives	Passive, rule bound
Liveliness	Excitedly busy	Boringly slow
Openness	Trusting, failure accepted	Suspicious, punished
Idea time	"off-task" play	Little "off-task" play
Mood	Happy, humorous	Serious, dull
Conflicts	Handled with insight	Warfare
Support	People listen	Negative and critical
Debates	Ideas voiced	Little questioning
Risk taking	Fast decision, action	Cautious, safe

Table 1.2.a. Studies of creativity at work

---

[2] J Henry and D. Walker Managing Innovation

23

IZMIR YUKSEK TEKNOLOJİ ENSTİTÜSÜ
REKTÖRLÜĞÜ
Kütüphane ve Dokümantasyon Daire Bşk.

Many companies now incorporate creative principles into company policy. For example 3M, a company with 30% of products newly developed in the last five years, has a system, which runs to find the inventors and never get in their way. They allow researchers 15% of their time to pursue their own projects, Hewlett Packard's research had 90% of post-it pads and super conductive materials emerged from projects conducted with researchers 'free time'.

Climate is important because motivation, and through this performance, are affected by environment. It is a psychological effect that people will not take risks unless they feel safe and valued. If people feel threatened they react more defensively. Initiatives like total quality management, which are trying to document and control the process of creative improvement, are facing an uphill battle, that cannot Legislate for creativity, it has to be trusted. Not that everything is in the easy way looking but in open and creative climates; Typically people find they need to allow more time to communicate with such other. Working in multidisciplinary teams with people who do not agree with you and have other concerns is bound to be uncomfortable from time to time. However, it seems that there are few alternatives in running innovative, creative companies caring organization.

The net effect of these changes in the workplace is a move to a more human form of organization. A more caring come from the principle of organization when it becomes one of commitment rather than control and the traditional mechanisms of fear or conformity (Table 1.2.b.). Punishing people, who make mistakes, are replaced by approaches designed to nature and empower people and ideas. The below table is to show a comparison. At the same time, it is seeing moves away from an unceasing emphasis on competition to a greater appreciation of the benefits of collaboration. Western organizations are beginning to see the advantage long appreciated by their Japanese cousins in developing long term partnerships with a few suppliers rather than merely accepting the lowest tender.

The organizational type, climate and organizing mechanism

Organization	Climate-adhesive	Mechanism
autocracy	fear	control coercion through punishment
bureaucracy	caution norms	comply with rules
creative	care	commitment nurture and end-power

Semler (1931)

Table 1.2.b. The organizational type, climate and organizing mechanism

1.3. LATERAL THINKING TOOLS AND TECHNIQUES OF CREATIVITY

1.3.1. THE SIX THINKING HATS

How do you get time for creative thinking?

How can you ask someone to make some creative effort?

How do you stop someone from being persistently negative?

How do you encourage people to look at the benefits of an idea?

How do you express your intuition and gut feeling in a serious meeting?

The six thinking hats method is extremely simple but it is powerful simplicity.

There was a breakfast meeting in Tokyo to launch the Japanese translation of the book Six Thinking Hats.[3]

---

[3] Little, Brown, NewYork, 1986, and also ICCT, New York. Published in London by Penguin Books.

At this meeting were the chief executives of some of the best known Japanese corporations, including Mr. Hisashi Shinto, who was chief executive of NTT (Nippon Telephone and Telegraph). He had just been chosen as Japanese businessman of the year for his feat in privatizing this giant organization. At that tame NTT had 350,000 employees and in stock market valuation was worth more than the top five US corporations put together. Mr. Shinto liked the idea of the six hats and asked his executives to read the book. I met him again six months later and he told me the method had had a powerful effect on his executives who were now more creative and more constructive. He asked me to give a talk to give his board and also to the top managers in NTT. In 1990, IBM used the six hat method as part of the core of their training for their 40,000 managers worldwide. The method is widely used by Du Pont, Prudential, and many other major corporations. It is used because it is practical and makes a difference.

It would be convenient to introduce this method for designers since most of the creativity is demanded in initial stages of creativity. This is to be used in the creative process and to give a good control on the improvement of creativity while designing. Below are the six thinking hat techniques that would be used actually in group solutions (deBono p77). The designer can also do this personally while in the creativity process.

a. White Hat

Thinking white paper, which is neutral and carries information. The white hat has to do with data aid information. What information does the designer have? What information is missing? What information would be needed in the future? How would the designer get the information?

When asked for white hat thinking at a meeting it is asking those present to put aside the proposals and arguments and discuss directly on the information. For the moment everyone at the group looks to see what information is available, what is needed, and how it might be obtained.

This stage is to convince the designer to prepare the data for-needed to design and explore. This stage is also used in engineering. Engineering problems are always due to a lot of problem solving. To actually start the process or solution process the engineer needs the right amount of data that would be used to solve the problem. For

26

instance, when an engineer is about to design an air-conditioning system for a room or building he should have the correct data to further on his engineering and problem solving. The data that is needed would be the rooms size, wall thickness, construction material, average temperature etc. Then it would be right to go on the next stage which would be problem solving.

The industrial designer, has to have the same information to go on creative processes. If a designer is trying to create a remote-controller he would want to know the approximate dimensions of the PCB, the number of batteries, the size of the batteries, the number of leads that would be used etc. (Figure 1.3.1).

input ——————▶ | **Data evaluation** | ——————▶ Continuing
problem solving
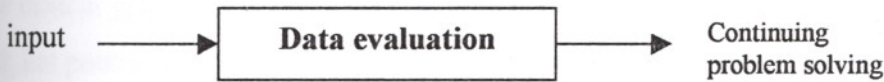
(Figure 1.3.1)

b. Red Hat

Thinking of the color red, fire and warning. The red hat has to do with feelings, intuition, hunches, and emotions. It is a serious meeting that the individuals are not supposed to put forward their emotions, but people do this by disguising their motions. The red hat gives people permission to put forward there feelings and intuitions without apology, without explanation, and without any need to justify them. The following are some examples:

... Putting on my red hat, this is what I feel about the project.
... My gut-feeling is that it will not work.
... I don't like the way this is done.
... My intuition tells me that prices will fall soon,

Because the red hat "signals" feelings as such, they can come into the discussion without pretending to be anything else. Intuition may be a composite judgment based on years of experience in the field and may be very valuable even if the reasons behind the tuition cannot be spelled out consciously. It should also be said that intuition is not always right, and it can be wrong. It is sometimes valuable to et feelings out into the open.

c. Black Hat

It is the thinking of a judge wearing black robes who comes down heavily on wrong-doers. The black hat is the "caution hat". The black hat prevents designers from making mistakes, doing silly things, and doing things which might be illegal. the black hat is for critical judgment. The black hat points out why something cannot be done. The black hat points out why something will not be profitable.

... The regulations do not permit us to do that.

... We do not have the production capacity to meet that order.

... When we tried a higher price the sales fell off.

... He has no experience in export management.

Mistakes can be disastrous. None of the designers would want to make mistakes. For this, the black hat is very valuable. It is the most used hat and possibly the most useful hat. At the same time it is very easy to overuse the black hat. Some people feel that it is enough to be cautious and negative and that if used it wold prevent all mistakes that would lead to success. Designers would have to give much of their attention to the foredooming problems that would awake in the future. It is easy to kill creative ideas with early negativity. Wine is fine but overuse of alcohol can turn a person into an alcoholic. It is the same with the black hat. The hat is very valuable but overuse of it can be a problem.

d. Yellow Hat

Here a designer should think of sunshine. The yellow hat is for optimism and the logical positive view of things. The yellow hat looks for feasibility and how something can be done. The yellow hat looks for benefits but they must be logically based.

... This might work if we moved to the customers.

... The benefit would came from repeat purchases:

... The high cost of energy would make everyone more energy efficient.

The black hat is much more natural than the yellow hat because it would need to avoid mistakes and danger for survival. Yellow hat thinking often require a deliberate effort. Benefits are not always immediately obvious and it might be necessary to search for them. Every creative idea deserves some yellow hat attention.

e. Green Hat

Vegetation and rich growth. The green hat is for creative thinking. The green hat is for new ideas. The green hat is for additional alternatives. The green hat is far putting forward possibilities and hypotheses. The green hat covers "provocation" and "movement". It requests creative effort.

... We need some new ideas here.

... Are there any additional alternatives?

... Could we do this in a different way?

... Could there be another explanation?

The green hat makes it possible to ask directly for a creative effort. The green hat makes time and space available for creative thinking. Even if no creative ideas are forthcoming, the green hat asks for the creative effort.

f. Blue Hat

Here the designer should think of the sky as an overview. The blue hat is for process-control. The blue hat thinks about the thinking being used. The blue hat sets the agenda for thinking. The blue hat can ask for other hats. The blue hat asks for summaries, conclusions, and decisions. The blue hat can comment on the thinking being used. Below are examples of statements:

... We have spent far too much time looking for someone to blame.

... Could we have a summary of your views?

... I think we should take a look at the priorities.

... I suggest we try some green hat thinking to get some new ideas.

The blue hat is usually used by the chairperson or the organizer of the meeting, but other participants can put forward suggestions. The blue hat is for organizing and controlling the thinking process so that it becomes more productive. The blue hat is for thinking about thinking. Designers, while on their own, should use this hat to control their creativity thinking and to put it in an orderly matter. This hat is also an important factor in designing creativity since it has the over viewing of the whole concept of designing creativity at once.

Instead of argument the Western tradition of argument insists that designers should try to move forward by means of position taking and argument. "A" has a point of view and "B" disagrees. The ensuing argument is supposed to give adequate exploration of the subject. Too often the protagonists get locked into their positions and become more interested in winning or loosing the argument than in exploring the subject. The six hats method allows to get right away from argument in order to get more productive discussions. Both "A" and "B" can wear the black hat at that same time to find out the dangers. Both "A" and "B" can wear the yellow hat to explore the possibilities. Instead of adversarial thinking there is cooperative exploration. That is why the method has been so eagerly taken up by those who have to run meetings. At last there is a way of breaking free from the traditional argument system.

Ego and performance in thinking are too closely bound together. There is vital information on the attitudes of people who do not like an idea that they will make and go into any effort to find points in favor of the idea or vice-versa. The hat method separates ego from performance. The thinker is challenged to use the different hat and actually experience a sense of freedom because the thinker is no longer limited to one position.

Persistent negativity is the effect that is on some people who are cautious with the natural fact and feeling that they have to put forward the possible dangers. In a normal discussion there is nothing to stop a person being persistent or negative. With the hat system there is sample opportunity to be negative at the right moment (under the black hat) but at other times negativity is out of place. In this way the natural dominance of the black hat is reduced. If a person is being negative, he would inform that he is good at black hat thinking; He would ask for some more of it. Then after a while someone would say that they have had a lot of black hat thinking and would vote for green hat thinking. The black hat wearer must now keep quiet or make a green hat effort.

Space for positive and creative thinking in the yellow and green hats make it possible to allocate time for deliberative creative effort and so a positive effort.

It is not natural to allow time for creativity. It is not natural to allow time for positive thinking unless designers happen to like the idea. But once done it would make the deliberate effort. This effort can be well rewarded. The natural flow of thinking and discussion allows insufficient time for creative effort unless an idea immediately comes to mind and insufficient time for a positive effort.

In the game the more a designer invests in the six hat method as a "game" the more powerful the method comes. People feel very foolish if they are seen not to be playing the game. If everyone is making a yellow hat effort then the person who comes out with some black hat comment feels out of place. If the participants invest in the game "using the hat colors" when it is not really needed then the method is available for

use when it is really in need. Fierce argument, crisis, conflicts, dogmatic views, and so on.

Not categories is perfectly true when some people are much better at one type of thinking than others. It is perfectly true that some people are much more comfortable with one type of thinking rather than another. But it would be right to emphasize very strongly that the hats are not categories or descriptions. It would be wrong for a designer to consider himself "the black hat thinker in the group". Or "the green hat thinker in the group". That is exactly the opposite of the purpose of the six hats. Everyone must make an effort to use all of the hats. When a group is doing green hat thinking then everyone is wearing the green hat at that time. If a person chooses to keep quiet at all times other than when his or her favorite hat is in use then that person can be asked directly for some "green hat views" or "yellow hat views."

The process is rather difficult as the individual or designer does it on his own. It might look simple for a group of designers when they are all at the same table but it would not be the same for a one person group. The difference is that the group has for instance five persons to act in the discussion and any one of the group would say anything at any time without any control and restriction. The designer should have this be done all in his mind. It is the same as drummers do while they are playing the drums. As they get the rhythm they part the mind to control the hands and feet. On the sequential beat of the song the drummer would feel like having four people playing at the same time. The designer should take this fact into consideration while applying the hat technique.

It is only too easy to see the hats as categories. They are categories of thinking behavior, but not of people. Just as every golfer needs to attempt to use all clubs, so every thinker must attempt to use all six hats.

Occasional use is the most frequent use of the hats is the "occasional" use. This means that the designer would ask for one hat at a time. This is to request on a certain type of thinking or to change it out. Before the use of the hat, there is a normal discussion and after the use of the hat there is again a normal discussion. A single hat is

used as a convenient way to switch thinking. The group member can ask another to put on or take off a particular hat. Can announce that he or she is putting a particular hat ("I am putting on my black hat, there are difficulties I foresee") He can ask a whole group to put on a particular hat "I think it is time we had some green hat thinking. We need some new ideas".

The great virtue of the six hat method is that it can switch thinking immediately and without offense. If will tell someone to stop being "so negative" that person is likely to be offended. But if it is asked if that person would try the yellow hat then there is no offense.

After a while the six hats become part of corporate culture and are used freely and automatically to ask for different types of thinking.

Systematic use are times when a group, or an individual, wants a quick exploration of a subject. This can be clone by putting together a formal sequence of the hats and then going through them, one by one, spending about four minutes on each hat. There is no one correct sequence because the sequence will vary with the subject, whether it has been considered before, and who is doing the thinking. There are formal guidelines that may help to select the sequence. For example, it is useful to use the black hat towards the end to seek out difficulties and danger and to see whether the proposed idea is viable. This should then be followed with the red hat, which allows someone to say: "In its present form this idea will not work, but I still feel the idea has potential. So let us try to find a way of making it work". This allows a feeling to prevent total dismissal of an idea that in its present form is not usable. These guidelines would only be confusing at this point because readers would be forever trying to remember the correct sequence. The guidelines are more properly given in the formal training on the use of the six thinking hats. For practical purposes it is enough to agree on a sequence that seems sensible and then to use it. This gives good results. Unless there is some obstacle, gap or hold-up thinking and action flow along smoothly the brain works to make life easy making things routine. To form patterns of thinking and behavior and then use these patterns. This makes good survival sense and the brain does an excellent job of what it is supposed to do. Creative attitudes and motivation can

be built up by exhortation, by praising the results of creativity by showing examples, and by general inspiration. Creative attitudes can also be established in a more reliable manner with such simple techniques as the "creative pause."

1.3.2. THE CREATIVE PAUSE

Unless there is some obstacle, gap, or hold-up, thinking and action flow along smoothly the brain works to make life easy by making things routine. It forms patterns of thinking and behavior and then uses these patterns. This makes good survival sense and the brain does the job of what it is supposed to do.

Creative attitudes and motivation can be built up by exhortation, by praising the wonderful results of creativity, by showing examples, and by general inspiration. Creative attitudes can also be established in a more reliable manner with such simple techniques as the "creative pause."

Creative effort at various points emphasizing the importance of asking for creative "effort" could be seen. The green hat is a formal way of asking for creative "effort" during a meeting. I have suggested that, instead of rewarding creative results, it makes more sense to reward creative effort. It cannot demand that someone have a brilliant idea. But can demand (request) that a person make a creative effort.

Once the effort is there, results will eventually follow. Once the effort is there, it can add skills to the effort by formal training in lateral thinking techniques. The creative pause is the simplest of all creative techniques, but it can also be powerful. The creative pause should become a mental habit for anyone who wants to be creative. The creative pause is the simplest way of making a creative effort.

The pause is no problem. There is no hold-up. But pause in the mind itself and thinking solely because it is wanted to be done. The pause is not in reaction to anything. The pause is the result of your intention to pause. In some places this might also be said to be the *incubation* process.

"There should be a new idea here."

"There could be a new idea here."

"I want to pause to think about this."

If a designer does not pay attention to something then he is unlikely to think about it. The creative pause is an interruption in the smooth flow of routine in order to pay deliberate attention at the point.

Why stop here?

Why not there?

Why not everywhere?

There need be no reason at all for stopping at a certain point. It is better that there should be no reason because once the designer is looking for reasons then he will only pause when there is reason to pause - that would destroy the whole purpose of creative pause. It is quite true that there are times when the thinker may sense some possible value or opportunity or may be that something is being done in a very complicated way. Those are legitimate reasons for a creative pause, but the creative sense should not depend on legitimate reasons. The creative pause is very simple, but that does not mean it is easy to do so. It requires a lot of discipline to halt the smooth flow of thought for a creative pause.

Motivation brings up the questions such as; which comes first? Does the designer stop for a creative pause in order to be motivated, to be creative? Or, does he become motivated to be creative so that he develops the deliberate habit of the creative pause? It can work both ways, but there does have to be the initial motivation; otherwise a person would never bother develop the habit.

Here it is important to emphasize that the "creative pause" is a deliberate process. It is not the result of some sudden inspiration that has been followed through. Pausing is done because the individual wants to do so. In order to make a creative effort this process is done. There is an intention to being creative.

Hope is an important part of creativity and hope is also related to excitement. There is the possibility of a new idea if the effort to pause is concerned to be a stage. The individual can walk quickly along the country road or can pause to look at the wildflowers by the roadside. If he walks quickly along the road he will not notice the wildflowers unless there is a spectacular grouping of them. But if an effort to make a pause is done and attention is paid to the flowers, he may be rewarded by their simple beauty. Why should this stage be done? Why should a person hold things up? Why should he waste time in an effort that is likely to be futile? The answer to all these questions lies in an appreciation of the "investment" nature of creativity. Certainly cannot guarantee that every creative pause is going to be productive. But as it is continued to invest in creative effort the rewards will start to flow. If no serious creative effort is done then it is rather unlikely that the individual is going to get any new ideas. If no time is spent gardening then certainly no one is to grow a garden.

Obviously the creative pause should not be allowed to interfere with the main purpose of the thinking or meeting. The pause may be personal: "I wonder if there could be a different way of doing this?" The pause may involve the group: "Let's see if there are any other alternatives." The pause may only be momentary and no one else need even notice.

The use of creative pause arises two questions of "what happens in the creative pause?" and "how long should the pause be?". There is no need to use any of the systematic tools of lateral thinking in the creative pause. The creative thinker may look quickly for simple alternatives but that is about all. The main point of the pause is to give attention to something and to place that pivot in the mind being worthy of attention. As the person becomes more skilled at creative thinking, even a short pause may suggest a better way of doing things. If a stream is temporarily blocked, the water may quickly find new channels of flow. Sometimes the mere interruption of the quick flow of thought can open up new lines of thought. The pause as such has a value. The value of the pause is not that it allows us to do anything during that pause. If it is paused when eating then savoring the taste of what is being eaten will go on. If it is paused in thinking then it will attend more closely to the point at which is paused. If it paused at a

road junction then the signposts could be read. If it is driven past the junction at high speed then the driver will have no idea where the side roads may lead.

There are some occasions when it is important to think quickly but there are also occasions when it is much better to think slowly. Creativity is one of the occasions where thinking slowly is an advantage. As with driving slowly, the driver can notice things, he can pay attention to things. Instead of being obsessed only with the ultimate destination, he can examine the way you to getting there and note the possibility of different routes. The pause should not be long. Nor should cudgel the brains in a determined effort to come up with a new idea. Just pausing to think and to wonder for a moment (perhaps twenty to thirty seconds as an individual and two minutes as a group) and then go and move on. The person always returns to the point later if he wishes. There is no pressure to get an-instant result. The creative pause is an end in itself. In fact, it is better not to suave too hard at each creative pause, because then the pauses will become burdensome and it will be less inclined to make them. The pauses should be almost casual. It is almost like saying, "That is interesting," and then moving along.

Although the creative pause involves both focus and intention, there is a clear distinction between the simple creative pause and the picking out of an important focus area followed by a determined and systematic attempt to generate new concepts. The deliberate definition of a focus and the sustained application of creative effort (whether or not the systematic tools of lateral thinking are involved) is a different order of magnitude.

Even as a person listen to someone talking he can be making creative pauses or creative "attention points" with regard to what is being said.

Proactive is so much of human thinking that may be said to be reactive: responding to requests, solving problems, overcoming difficulties. There is little time for any other thinking and less motivation to give self additional thinking tasks. The creative pause is an important proactive thinking habit. It is a brief pause in which the thinker says:

"I want to notice that."

"I want to pay attention to that."

"That needs thinking about."

"Is there another possibility here?"

"Is that the only way of doing it?"

If a person or an organization puts any value on creativity then that value justifies the proactive creative pause. The pause is a simple technique. The pause is a way of building up a creative attitude. The pause is a way of turning creative attention into a habit. The pause is a concrete way of showing creative effort, at least to one self if not to others. The creative pause is an investment in creativity and an investment in the building up of creative skills. It is important to realize that the creative pause is a simple and light procedure. It should never be turned into a heavy challenge or demanding task.

1.3.3. PROVOCATION

Einstein used to carry out what he called "thought experiments". He would say: "What would I see if I were traveling at the speed of light?"

The child who places one block upon another to see what happens is carrying out an experiment. Provocation has everything to do with experiments in the mind.

In earlier sections, it was described how many important new ideas came about through chance, accident, mistake, or madness. All these provided a sort of discontinuity, which forced us outside the usual boundaries of reasonableness that had been established by experience. With deliberate provocation, there is a systematic method that can produce the same effect. A designer does not have to wait for chance, accident, or mistake. He can be temporarily mad for just thirty seconds at a time in a controllable fashion. Switching about, can let the madness on and off as wished. That is why provocation is such a fundamental aspect of lateral thinking and of creativity in general.

Considering river pollution.[4]

Po: the factory is downstream of itself.

That is a provocation. It seems utterly impossible. How could the factory be in two places at once? Here the symbolic word **"po"** is used to indicate that this is intended as a provocation and not as a serious suggestion (the origin and nature of **"po"** will be described later).

From this provocation comes a consideration of the input and output of the factory. It would be normal to take in water upstream and put out effluent downstream. The provocation suggests that it might be legislated that if a factory is built on a river then the input must be downstream of the output. So the factory is the first to sample its own pollution and must therefore be more concerned to minimize effluent pollution. In hindsight this idea is perfectly logical. There was some discussion about how to handle a new bicycle. Someone put in a provocation.

Po, we sell it to our competitors.

That provocation led to a change in the normal way of handling such a product, and a huge reduction in development time:

Po, cars should have square wheels
Po, planes should land upside down
Po, letters should be closed after they have been posted

All the above statements seem highly illogical and improper. In fact, they are perfectly logical statements in the context of a patterning information system.

---

[4] Serious Creativity (De Bono)

The definition of a provocation is[5]:

With a provocation there may not be a reason for saying something until after it has been said.

This contrasts strongly with normal thinking habits, which must be a reason for saying something before that thing is said. With a provocation, the statement is made and the effect of that statement will provide the retro-justification making the statement. At first it might seem that provocation is simply a scatter gun approach in which anything is said, that comes to mind; The hope that something might just prove useful. To some extent, this is the way brainstorming is used by some designers. Such approach would be weak and very wasteful.

Provocation is a logical necessary in any self-organizing system. Mathematical papers have been written to this effect Such systems go into stable states. A provocation introduces instability and allows a new stable state to be reached.

The brain forms asymmetric patterns as shown in the brain in figure 1.3.3.a. Humor occurs when it is taken from the main track and deposited at the end of the side-track. From there the person can see his way back to the starting point. Creativity occurs exactly the same way. But how do people get across from the main track to the side-track is a question. This is where the systematic provocation methods of lateral thinking come in.

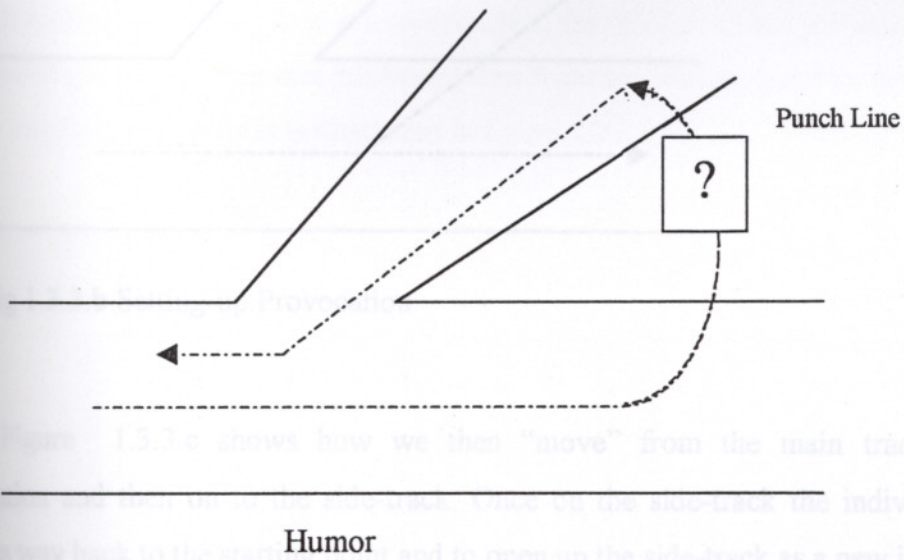[5] De Bono - Serious Creativity

40

Fig 1.3.3.a   Asymmetric Patterns

Figure 1.3.3.b shows how to set up a provocation, a concept, an idea that does not exist in experience. So this provocation lies outside the patterns of our experience.
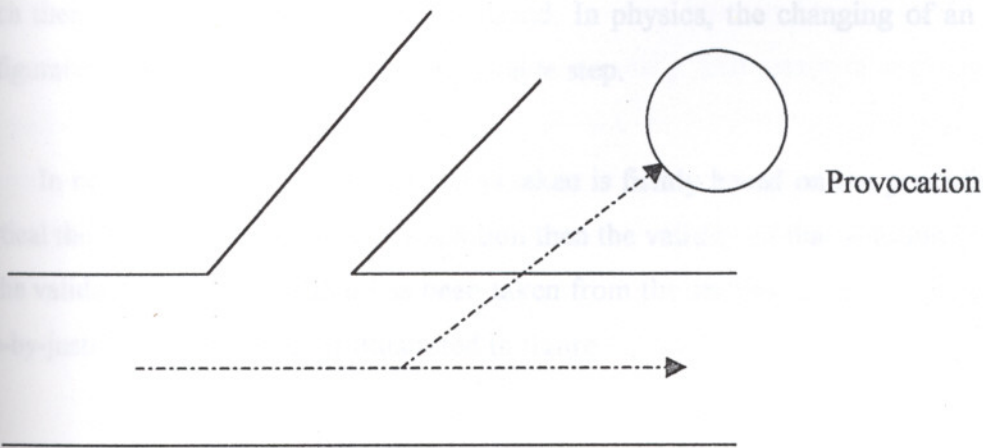
Provocation

Fig 1.3.3.b Setting-up Provocation

Figure 1.3.3.c shows how we then "move" from the main track to the provocation and then on to the side-track. Once on the side-track the individual can trace his way back to the starting point and to open up the side-track as a new idea.
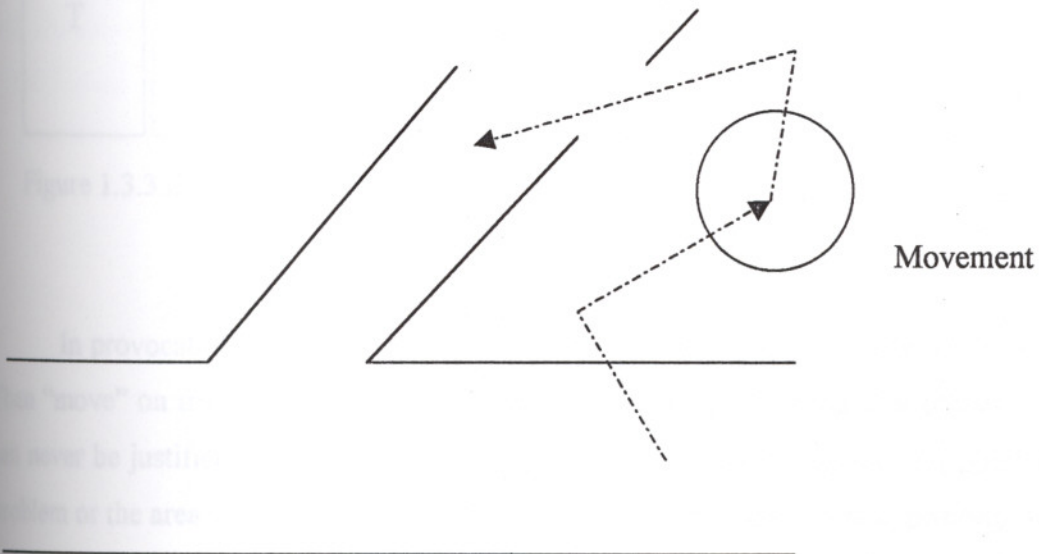
Movement

Fig 1.3.3.c Moving from the main track

here is no magic in the process. In chemistry, if a chemist wants to move from one stable compound to another he may have first to move to an unstable compound which then re-stabilizes as the new compound. In physics, the changing of an atomic configuration may go through the same unstable step.

In normal thinking, each step that is taken is firmly based on the preceding step (vertical thinking). When arrived at a solution then the validity of that solution is proved by the validity of every step that has been taken from the starting point to the end. This step-by-justified-step process is illustrated in figure 1.3.3.d
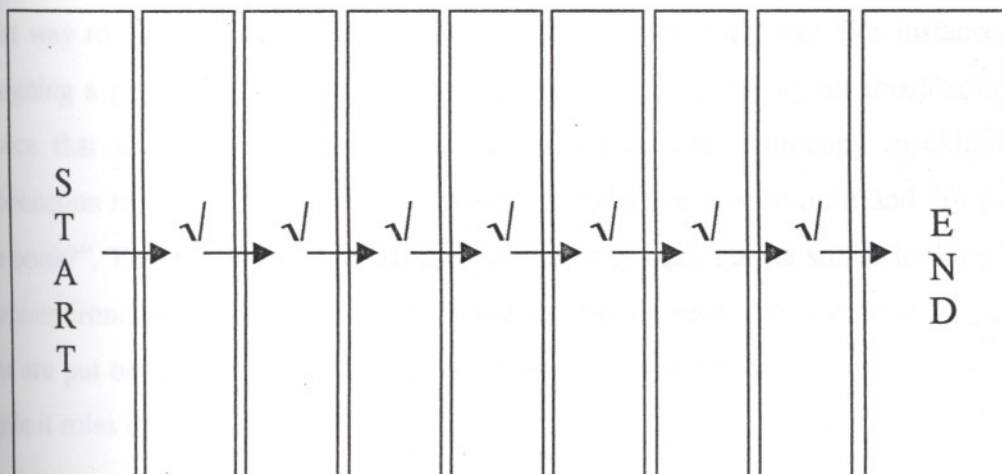
S
T   √   √   √   √   √   √   √   E
A   N
R   D
T

Figure 1.3.3.d Step By Step Solution

In provocation, the move is from the starting point to an arbitrary provocation. Then "move" on from the provocation to an idea or concept. The validity of this result can never be justified by how to go there. But if looked back to the starting point (the problem or the area of concern) it may be seen in hindsight, how the new position has a real value. If this value can be shown, logically, in hindsight then the value is just as useful as if it had been achieved through a succession of valid steps. Hindsight justification of an idea is every bit as valid to any other form of justification. But why does a designer need to use the "jump" method while creating a new design may be a question. "Is it necessary to have to justify by working backwards?" may also be a

43

phrase to be thought of. If the creator is having a good time of creation why go back one step and start from there? It might be simple to say that if a person could do this, he would be doing what they have done years ago (in the Ottoman Empire as it was said "the army use to go two steps ahead and one step back"). The reason is very simple. In any pattern-forming system the designer has to take the established pattern forward at any point. So the established or traditional line of thinking takes forward. There is no choice and he is not even aware of other possibilities. It is only by working backwards that is able to open and use these other tracks-which have been there the whole time. This process is shown in figure 1.3.3.e.

To put this process in a valid example of designing might seem as if it is not the right thing to do at that point. However, it may be rather inadequate to go on. It is the right way to go back as mentioned, before going on another step. For instance when designing a product like a "scanner" the designer is only having an imagination of a device that a book is put on and it scans just as the photocopy machines. The provocation here that should be done would be "why put a book on it and not put it in the book?". This phrase lets the designer go one step back but he still is looking on the problem from another point of view. Today, as may be seen, there are a lot of scanners that are put on the books or pictures (at great sizes) and the scanner works on its own while it roles on the picture. (Figure 1.3.3.f.)
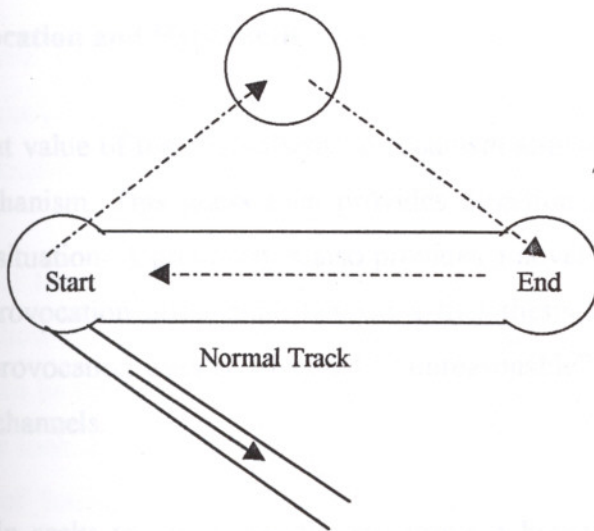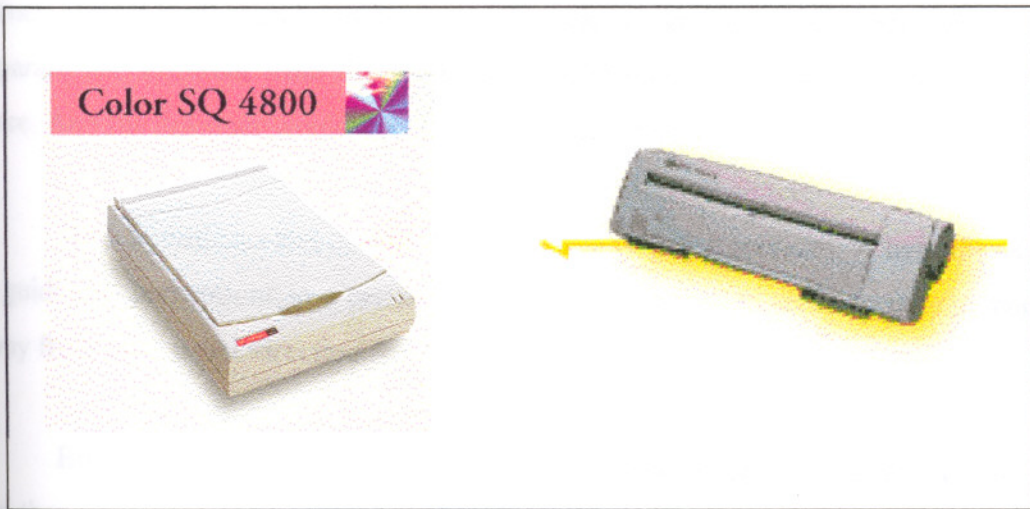

Figure 1.3.3.e Working Backward

Figure 1.3.3.f.

The purpose of the provocation is precisely to get out of the usual main-track of thinking. From the provocation it is seen that going on to find a new point which in hindsight seems to offer value. If it is the escape from the established main track that is so important. The brain has to work to establish the main tracks. That is the very essence of the excellence of the brain. At the same time it needs ways of getting out of those main tracks in order to be creative. That is why provocation plays so central a role in lateral thinking.

a. Provocation and Hypothesis

The great value of the "hypothesis" mechanism allows the designer to guess an underlying mechanism. This guess then provides direction and a framework for the thinking of the situation. A provocation also provides a novel framework for looking at things. But a provocation goes much beyond a hypothesis. A hypothesis tries to be reasonable. A provocation usually tries to be "unreasonable" in order to jerk thinking out of its usual channels.

The brain seeks to reach, justify, and prove a hypothesis, which then moves from being a guess to being a provisional truth. It never seeks to reach or justify a

45

provocation. Never seek to prove that square wheels would be useful on a car or that planes should really land upside down. It seeks to get to a useful idea that is quite separate and different from the provocation. The provocation is just a way of getting there. And the designer would use this brain to get there.

Both hypothesis and provocation seek to change perceptions. A hypothesis seeks to guide our perceptions in a certain direction. A provocation seeks to take perceptions away from their usual direction.

Both hypothesis and provocation are speculations that are constructed in minds and then used to improve thinking about a situation. Both hypothesis and provocation are part of the active process and are quite different from analysis. Analysis looks at what is there. Provocation and hypothesis both bring in something that is not there.

b. Two-Stage Process

The formal and deliberate technique of provocation is a two-stage process. The first stage involves the setting up of the provocation The second stage involves the use of the provocation to move forward to a useful new idea. Obviously, the first stage precedes the second stage when it comes to apply the technique of provocation. The sequence has to be:

1. Choosing the creative focus
2. Setting up the provocation
3. Using the provocation

In practical terms, however, it makes sense to learn how to use provocation before learning how to set them up. In this way a person knows how to use provocation's when he leans on how to set them up. There would not be much point in setting up strange looking provocation's without any sense of how to use them. This general process of learning backwards is very powerful and very logical and is described elsewhere.

46

Using provocation's involves a special mental operation called "movement". This is an active mental operation. It is also completely different from judgment. Movement is an operation d we have to learn and practice in order to build up skill s fluency.

When we have considered the operation of movement w can proceed with the methods of setting up provocation's.

1.3.4. BRAINSTORMING

There is one type of task in which the combining of the independently-produced-products is not a problem namely the simple production of ideas. A classic example would be advertising men thinking up names or slogans for a new product. Separately produced lists of ideas can simply be added together, with duplications eliminated. There have been a number of comparison of the effectiveness of people working alone versus separately to generate ideas. Most of these studies have been concerned with the technique of "brainstorming".

Brainstorming was first described by Osborn (1957), an advertising executive, who claimed that more ideas could be produced by a group than by the same number of independently-working individuals. As long as certain principles were followed:

1- Ideas are freely expressed, without regard to quality.

2- Criticism of the ideas produced is not permitted;

3- Ideas, which are variations of previously expressed ideas, are encouraged.

a. Research on Brainstorming :

Contrary to Osborn's contention, in 9 of 12 experiments comparing sets of individuals working independently (under brainstorming instructions), with actual brainstorming groups the individuals produced more idea (Lamm and Trommsdorff, 1973). In the other experiments no differences were found. The notion that groups

sacrifice quantity of ideas by producing ideas of higher quality supported by the evidence.

In their review of the brainstorming literature, Lamm and Trommsdorff (1973, p370) consider several possible explanations why people produce fewer ideas together than separately. The most common explanation is that; in groups people suffer from social inhibition, a fear of negative evaluations of the other members. Although the brainstorming instructions rule out explicit criticism, a member may still hold back ideas for fear that the others will consider them "stupid", "nonsense" or "worthless". However, postex-perimental self-reparts of subjects (Bouchard, 1969 p23; Collaros & Anderson, 1969, p161) indicate little if any inhibition due to fear of other members' evaluations. Furthermore, when subjects in groups were later asked individually to list any ideas which they had not expressed in the group, very few inhibited ideas were produced (Collaros & Anderson, 1969). Thus, can safely reject social inhibition as an explanation for the inferiority of idea-generation in groups.

Another possible reason why groups produce fewer ideas than individuals working alone is simply that in a group everyone cannot talk at the same time. Listening to others' ideas, even without attempting to evaluate them, takes up time, which could otherwise be i.e. voted exclusively to thinking up one's own ideas.

Finally, it can be can noted that two of the prime sources of group effectiveness on other types of tasks, namely the combination of skills and the division of labor, are not possible in the simple idea-generation task. Indeed, in this type of task it is likely that a group situation may interfere with the maximum use of member's different skills. (Taylor, Berry, and Block p30) suggest that brainstorming groups may develop "one-track thinking". An idea produced by one member may stimulate other members to devise other ideas of the same type, but in the process they may neglect other possible types of ideas.

b. Group Size

If two heads are generally better than one, then the question of quantity occurs. Here it could be asked if e.g. it would be better to have three individuals in a group instead of two? Would a larger group be more effective than a smaller one? Steiner (1972) concludes that for most tasks group productivity increases with group size up to a certain point, after which it levels off and then declines. A large task group has certain advantages over a small group. Large groups generally have greater member resources. On the other hand, large groups have difficulties in the areas of organization and motivation. Beyond a certain size, the disadvantages out-weigh the advantages, and group performance declines.
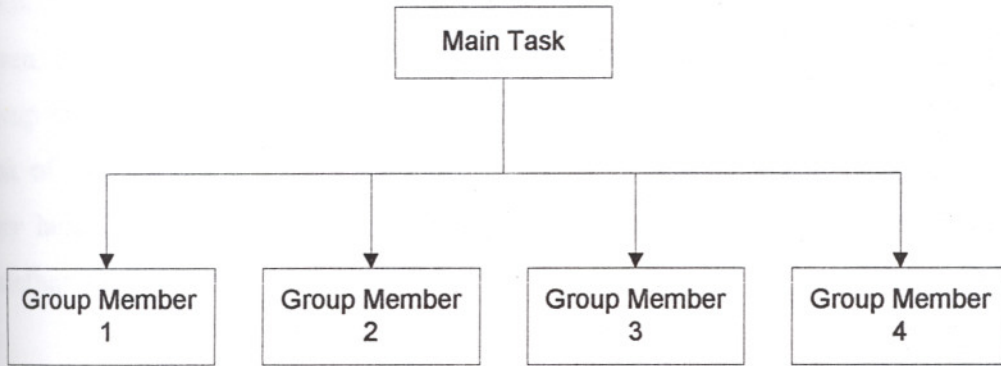
Advantages of Large Groups

The *potential* productivity of a group goes up when more members are added. The more members, the greater the total pool of group resources (information, skills, etc.). For tasks that can be divided into a number of subtasks, the more members are available, the less work any one person must perform. However, there are limits to the potential advantages of dividing a task into parts, since the more parts there are, the more difficult it will be to assemble them into a satisfactory whole. For those tasks in which a division of labor is not possible, very often the effectiveness of the group will depend on the most competent person.

Disadvantages of Large Groups

One major disadvantage of large groups is the increased problem of organization and coordination of the members. These organizational problems, moreover, increase more and more rapidly as group size increases, The larger the membership, the more time must be spent deciding who does what (assuming that a division of labor is impossible). If a task considered which can be easily broken into two subtasks, then if the group has two members, there are only two possible ways to match subtasks with members. However, with three members, there are six possible assignments of members to two subtasks, and for 4 members, 20 different

49

arrangements. Furthermore, the more complex the division of labor, the greater the chance that some members will be assigned duties for which they have little ability. Also, the larger the group the more difficult it will be to monitor how well each member is performing his job.

```
                        ┌─────────────┐
                        │  Main Task  │
                        └──────┬──────┘
          ┌────────────┬───────┴───────┬────────────┐
          ▼            ▼               ▼            ▼
   ┌────────────┐ ┌────────────┐ ┌────────────┐ ┌────────────┐
   │Group Member│ │Group Member│ │Group Member│ │Group Member│
   │     1      │ │     2      │ │     3      │ │     4      │
   └────────────┘ └────────────┘ └────────────┘ └────────────┘
```

Besides problems of organizations, the large group tends to suffer from a loss of member motivation. One source of the lack of involvement in large groups lies in the idea of diffusion of responsibility, which designers have. The less an individual feels that his performance will affect the total group product, the less incentive he will have to work hard. Furthermore, poor performance is less visible and less likely to be punished in a large group than a small group. One study (Wicker, 1969) found that the larger a church, the less active was the typical member, and the less critical he was of non-active members. In design groups as in Vestel it is seen that the individuals get more time to put on their thoughts as in crowded groups. Designers attend meetings at a maximum of 7 where it would be a good chance to put in ideas at an extreme. The meeting of a group goes on with the brainstorming technique and designers, engineers etc. put on all ideas at any extent.

Another reason for the lower involvement in large groups is that whatever rewards the group may receive for successful task performance must be distributed among more people. The larger the group, the smaller the "slice of the pie" each member receives. Finally, the larger the group, the less opportunity each member has to participate and influence the group's decisions.

Determining the optimum size of a task group is not easy. Both the nature of the task and the abilities of the members must be taken into account. Slater (1958) measured the satisfaction of members of discussion groups varying in size from two to seven. The members of *five-person* groups expressed the greatest satisfaction with their group size. Dissatisfaction with larger groups centered on organizational problems and lack of opportunity to participate. The members of smaller groups may have felt that they lacked a sufficiently wide range of viewpoints to analyze the discussion topic satisfactorily.

Figure 1.3.4. summarizes the effects of group size on productivity. Potential productivity increases steeply as new members are added to the group, but eventually levels off. Problems of organization and motivation, on the other hand, become progressively greater as the group becomes larger (Figure 1.3.4.a). Subtracting the organizational and motivational losses from the potential productivity gives the actual group productivity (Figure 1.3.4.b.). At a certain point these losses begin to offset the gains of increased potential, and the resulting actual productivity peaks and declines. Finally, if we divide the actual group productivity by the number of members, we find that the average actual productivity per member (Figure 1.3.4.b.) decreases with increased size.

c. Group Composition and Performance

How do the individual qualities of the members of a task group affect the group's performance? As before, when we considered group composition in relation to satisfaction and cohesiveness, we shall not be concerned with the average individual level of a particular characteristic, but rather with the relationships among member qualities. How do various combinations of qualities affect task performance?

Problems with Research or Group Composition

Steiner (1972) points out certain inherent difficulties in research on composition. The most common research strategy has been to construct some similar (homogeneous) groups and some
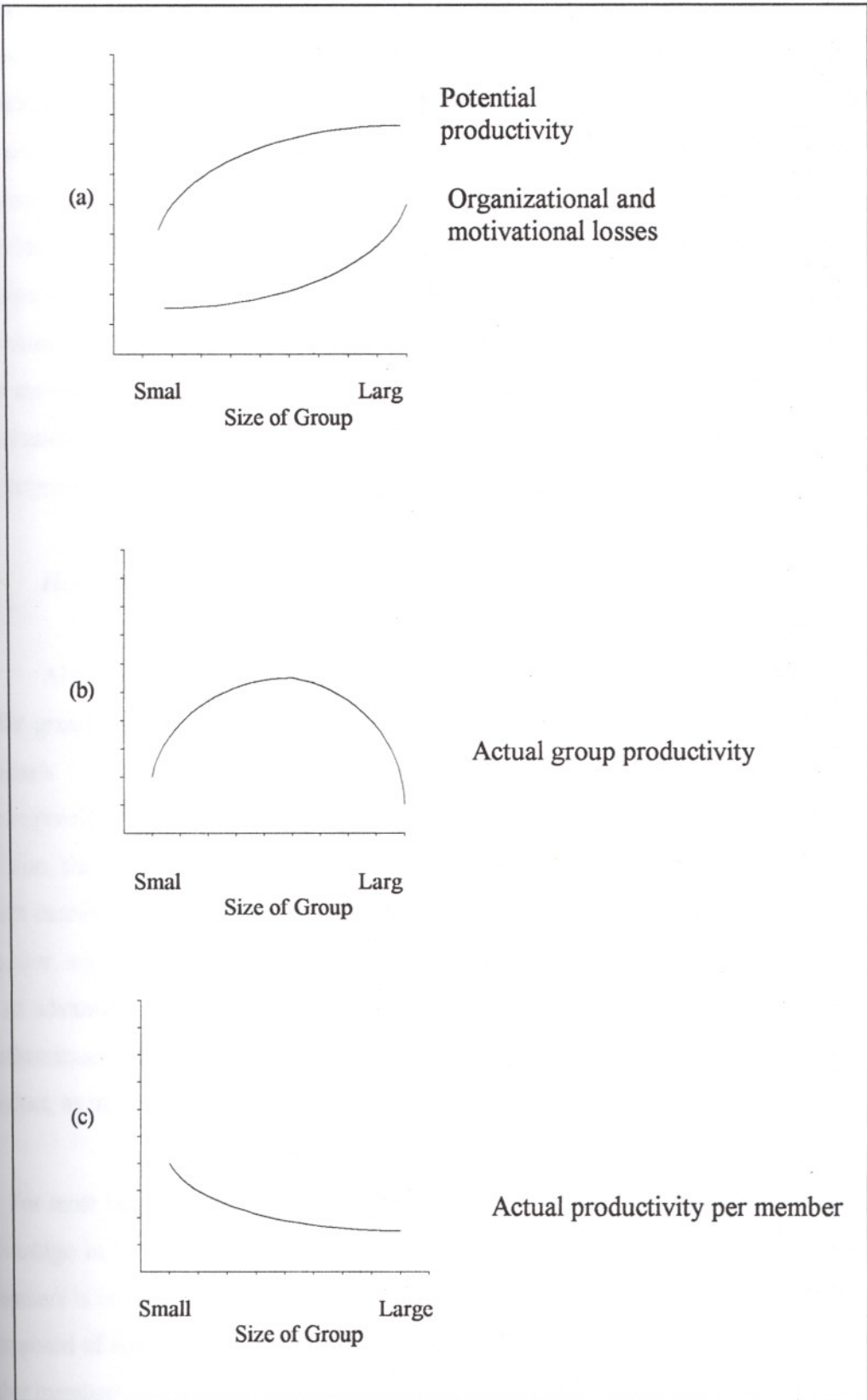
(a)

Potential productivity

Organizational and motivational losses

Smal   Larg
Size of Group

(b)

Actual group productivity

Smal   Larg
Size of Group

(c)

Actual productivity per member

Small   Large
Size of Group

Figure 1.3.4. a-b-c Effects of group size on productivity

dissimilar (heterogeneous) groups and to compare the performance of the two type However, by manipulating homogeneity c one dimension, we may at the same time t manipulating homogeneity on other dimensions. For example, groups whose member are similar on level of anxiety may also be similar on extroversion-introversion and dissimilar on intelligence. At the present time, it still has a very incomplete idea of what individual qualities tend to "go together" in people. Since designers cannot measure or manipulate variables which might be relevant, designers can seldom be sure that the variables that have been used compose heterogeneous and homogeneous groups are the true causes of any observed effect. In spite of these methodological problems, some conclusions can be drawn from the research evidence. Creators will first consider heterogeneity of ability; and then heterogeneity of personality.

Heterogeneity of Abilities

Although two groups may have the same average level of ability, they may still differ greatly in the heterogeneity of ability levels of their members. According to Steiner's (1972) theoretical analysis, the particular task determines the effect of heterogeneity of abilities on group performance. The more heterogeneous the group's abilities, the more competent will be the best member and the less competent will be the worst member. Thus, for those tasks which can be performed alone by one competent member, such as the statistical analysis for our research team, heterogeneity of abilities is an advantage. On the other hand, some tasks depend for success on an adequate performance from all the members; one low ability performer can spoil the total product, as in the performance of a musical group.

For most tasks, some type of division of labor is possible. Heterogeneity can be an advantage in these cases providing that none of the subtasks assigned to low-ability members is critical for the success of the total group effort. The ideal group would be composed of specialists, each member having certain highly developed skills which the other members lack, as on a football team. Heterogeneity has effects similar to those of increased size: Potential productivity is usually boosted, but problems of organization and motivation may develop. When all members possess equal skills, who does what is

54

relatively unimportant; however, with heterogeneous abilities, the problem of matching members with subtasks appropriate to their abilities becomes critical.

d. Groupthink

One consequence of too great a level of cohesiveness in decision-making groups is that critical thinking will be replaced by what Janis (1972) has termed "groupthink." When group think occurs, argues Janis, loyalty to the group, its norms, and its past decisions replace the realistic considerations of alternatives. Group think is likely to appear during crisis situations when members of the group are experiencing severe stress. Another factor promoting group think is the sharing of the same set of values by all the group members. In both encounter and problem-solving groups, too much homogeneity can be harmful to the group's efforts by restricting the variety of viewpoints available.

The lack of conflict resulting from group think is not due to the usual group pressures for conformity. Members are not so much afraid of punishment for expressing deviant views; rather, they seldom have deviant views in the first place. Loyalty to the group results in the immediate approval of any proposal favored by the leader or the majority of the group. The emphasis on agreement and harmony prevents the careful weighing of pros and cons.

Janis has analyzed in great detail the deliberations of government leaders in situations where groupthink led to disastrous decisions, for example, the Vietnam War, the Bay of Pigs invasion, and the Pearl Harbor attack. He has identified eight primary symptoms of group think. Members of groups suffering from groupthink share an illusion of *invulnerability,* which leads them to be overly optimistic. This feeling that "our side can't lose" causes members to disregard clear warnings of danger, as demonstrated by American officials ignoring many indications that Japan would attack Pearl Harbour. If a warning signal cannot be ignored, it can be explained away by means of various *rationalizations.* For example, the evidence that Japan would attack Hawaii was discounted by assuming that Japan's leaders would never start a war with

the U. S. which they knew they could not win. Since groupthinking members believe that their group is inherently moral, the *morality* of its decisions never come into question. The enemy, and especially its leaders, are characterized in terms of *stereotypes*. The opposing leaders are assumed to be weak, stupid, and immoral. The enemy's weakness and lack of intelligence makes his defeat inevitable, while his lack of morality means he cannot be trusted in negotiations. *Self censorship* is another characteristic of groupthink. Members tend to keep questions about the wisdom of the group's policies to themselves. Because of this reluctance to express doubts and the assumption that silence means agreement, the group suffers from an *illusion of unanimity*. Certain members may assume the role of *"mind guards"* who protect the group from exposure to adverse information.

Janis offers a number of specific recommendations for preventing groupthink. The leader of the group should explicitly encourage criticism of policies and proposals. The establishment of several different policy and planning groups, all working on the same problem, enables each to serve as a check on the others. Group members should discuss the group's deliberations with the subordinates, who often have available information which their superiors lack. Outside experts should be invited to sit in on some of the meetings and offer their comments. One member should play the role of a "devil's advocate," arguing against the group even though he really agrees with it. Decisions can be made in stages, rather than made and then never reviewed or challenged.

1.3.5. MOVEMENT

Movement is an extremely important mental operation. It is central to the whole of creativity (deBono, p51). It is almost impossible to be creative without having some skill at "movement". Yet, movement is not a normal part of our thinking behavior except, perhaps, in poetry. In poetry it is moved forward from images and metaphors to meaning and feelings.

The brain acts as a self-organizing system which allows incoming information to organize itself as patterns, tracks, channels, sequences, and so on. This is why the brain

does such a job of allowing the designer to cope with the complex world around. This patterning behavior is not in any sense a defect of the brain. On the contrary, it is the main strength of the brain as an information mechanism.

Perception is the original formation and subsequent use of the patterns. This involves "recognizing" the appropriate patterns and being sure that follow along the pattern is done. This is where judgment comes in. Judgment is an essential part of perception.

There is judgment that is exercised consciously, as with a judge in court or with a teacher marking a paper or an industrial designer choosing from amongst some textures for a product. As mentioned before this might be called "the black hat thinking". But there is also the judgment that happens automatically and unconsciously in the brain: "what have we here?". So it might be also named as "green hat thinking".

Judgment has two main roles in perception. The first role is to find, identify, match, or recognize the appropriate pattern. This happens almost automatically but may need to be helped by conscious analysis which breaks down a situation into more easily recognizable parts.

The second role of judgment is to be sure that the designer does not wander of the judgment track. It points out the mistake, the wandering, the deviation, or the mismatch and hastens back to the established track. This second aspect of judgment deals with the rejection of ideas that are wrong and contrary to experience.

If provocation's such as "cars with square wheels" or "planes landing upside down" are presented to judgment then clearly they are, and should be, rejected immediately. Judgment has its job to do and should do it properly. "Black hat" thinking should be "efficient black hat" thinking. It is at this point, and for obvious reasons, that teachers of creative thinking start talking about "suspending judgment", "deferring judgment," "delaying judgment," and so on. This is the traditional approach of brainstorming. Unfortunately, this is far too weak. Telling people not to use judgment

İZMİR YUKSEK TEKNOLOJİ ENSTİTÜSÜ
REKTÖRLÜĞÜ

does not tell them what to do. Telling people not to eat fried eggs for breakfast does not provide them with any breakfast.

"Movement" takes into mind, which is an active mental operation. This operation could be lessened, practiced, and used deliberately. Movement is not just an absence of judgment. But movement is the providing with oatmeal for breakfast instead of the, fried eggs.

The difference between judgment and movement is suggested in Figure 1.3.5. In judgment, when a designer comes to an idea to compare the idea with existing patterns of experience. If the idea does not fit, then it is rejected. That is good "black hat thinking". In movement, an individual comes to an idea and totally uninterested in whether the idea is right or wrong or whether it fits his experience. He is solely interested in where he can "move" to and from the idea. It is seen that the attitude of seeking to move forward goes on. Judgment is static and is concerned with "is" and "is not." Judgment is part of traditional rock logic. Movement is fluid and is concerned with to where it leads to. Movement is part of water logic with its flow and fluidity. Movement might also come under the green hat.

It is very important to appreciate that movement and judgment are totally different "games". Someone teaches to play; contact bridge. Then someone else teaches to play poker. When it is time to play bridge then it is time to play good bridge and not bad poker. When it is time to play poker then it would be playing good poker and not bad bridge. So when judgment is used it is ought to be good judgment. But when, it is switched to movement then good movement is used or wanted. They are two separate mental operations and there is no compromise, in-between position.
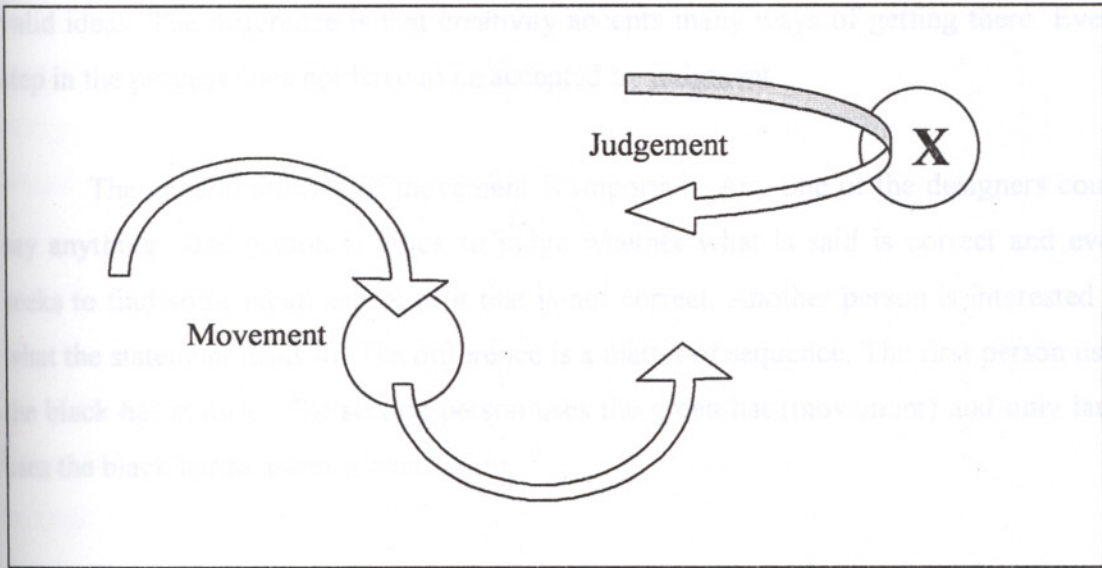
Judgement

X

Movement

Figure 1.3.5.

a. The Use of Movement

Here it is better for the designer to consider the use of movement in order to move forward from a provocation to a useful new idea or concept. Without movement there is no sense in using provocation.

It should be said, however, that the use of movement in creativity is much wider than this. The use of movement with provocations is the extreme form of movement. How does a person move forward from an "impossible" provocation to something useful is the question that should be asked to let the designer get an advantage from what he is doing. But there are other occasions when the use of movement is not extreme. Movement could be used to move forward from a weak idea to a stronger one. Movement could be used to move forward from a suggestion to a concrete idea. Movement could be used to move forward from a concept to an idea.

The general sense of "movement" means the willingness to move forward in a positive exploring way rather than stopping to judge whether something is right or wrong. In creativity, the designer is indeed interested in arriving at practical, useful, valid ideas. The difference is that creativity accepts many ways of getting there. Every step in the process does not have to be accepted by judgment.

The general attitude of movement is important. Any one of the designers could say anything. One person is quick to judge whether what is said is correct and even seeks to find some small aspect of it that is not correct. Another person is interested in what the statement leads to. The difference is a matter of sequence. The first person uses the black hat at once. The second person uses the green hat (movement) and only later uses the black hat to assess a conclusion.

There are two broad ways of using movement: general attitude and systematic techniques.

General Attitude

This is the general willingness to move forward from a statement or provocation. There are new ideas that may occur at once. A person who has practiced movement and who is aware of the systematic techniques of movement will often get useful movement just by using this general attitude. The general attitude is always worth trying first. If the general attitude does not yield any useful results then it is worth trying the systematic techniques of government. When learning lateral thinking it makes sense to use the systematic techniques in order to build up a general skill of movement.

Systematic Techniques

There are five systematic techniques for getting movement from a provocation or statement. Each of these can be learned, practiced, and applied in a deliberate fashion. There is no need to use any of them on every occasion-but they are there to be used. All is very different from just telling people to "delay judgment."

İZMIR YUKSEK TEKNOLOJİ ENSTİTÜSÜ
REKTÖRLÜĞÜ

b. Techniques of Movement

Five techniques that can be used systematically to get movement will be described here. This does not mean that there are not other techniques or that the five given cannot be subdivided into others. In some cases the different techniques can overlap. This does not matter at all since the sole purpose of movement is to move forward to a new idea or concept.

1. *Extract a Principle*

The designers look at the provocation (provided by themselves or by others) they seek to extract a principle from the provocation. What is extracted may be a "principle" or a "concept" or a "feature" at an "aspect". The choice of word is not important. It takes nothing from the provocation. The group or individual completely ignores the rest and now proceeds to work only with what has "extracted". It is seeks to build a usable idea around this principle.

An advertising agency was seeking a "new advertising medium." A provocation was suggested:

Po, bring back the town crier.

In a modern city with high-rise buildings, sealed ventilation, and a lot of traffic, a town crier would not be much good-but it is only a provocation. What principles, concepts, or features would be seen in a town crier may lead to a point:

* the town crier can go to where the people are
* the town crier can change the message according to the situation
* the town crier is a respected social figure
* the town crier is always up to date you cannot switch the town crier off.

Each one of these items could be "extracted" and used. The principle that was used was that you "could not switch the town crier off". Now the group could forget all about the town crier and look around for a medium that would be unable (or at least,

unwilling) to turn off. The telephone comes to mind. The idea would be to have public telephones that made no charge for a call because the conversation was interspersed with advertising messages. Advertisers would pay for the insertion of these taped messages and the caller would get free calls. This could be limited to local calls. This has happened and is been done in Europe since 1997.

So it is to see how it is possible to move forward from a provocation to develop an original idea which could have a real value.

2. Focus on the Difference

Here the provocation is compared with the existing idea or way of doing things. The points of difference are spelled out and pursued to see if they might lead to some interesting new idea. Even if the provocation appears to be very similar to what it already is being done, a conscious effort is made to focus on this difference. Even if the difference is only one percent, this "one" percent can be explored.

There is a "general-area-type" focus regarding a postage stamp. Someone puts forward a provocation:

Po, stamps should be long and very thin.

The designers focus on the "difference":

- you could put messages on the stamps
- the stamp would leave more space for the address
- you could use the stamp to seal the envelope
- stamps might be sold in self adhesive rolls
- the length of the stamp might be proportional to the value
- the stamp could be folded around to be on the back of the envelope, too

The suggestion that the length of the stamp might indicate the value follows directly from the "difference" of the long dimension new available. This suggests that a

unit of length might represent a unit of value. So there would be no need to put a value on the stamp, which would just be divided into "postal units." These postal units would be purchased at the prevailing price like units of electricity or gas. This concept could now be carried back to stamps of normal shape which would carry no value but would be designated "internal mail," "first class mail," and so on. Such stamps would be purchased at the going price.

So we see that an idea stimulated by the provocation can be applied back to normal stamps. There are other ideas that might be worth pursuing. Some of these might require the long thin stamp of the provocation. Occasionally the provocation itself turns out to have a direct value even though this is not the purpose of a provocation.

3. Moment to Moment

This is possibly the most powerful of the techniques of movement. Here the designer imagines of the provocation being put into effect-even if this involves fantasy. It is visualized of what would happen "moment to moment." It is not being interested in the final result, but only in the "moment-to-moment" happenings. It is like watching a videotape frame by frame to watch what is going on. From this observation, the creator seeks to develop some interesting concept or idea.

Po, bicycles have square wheels.

Here the person should imagine a bicycles with square wheels. This bicycles starting to roll. The square wheel rises up on its corner. This would lead to a very bumpy ride. But the suspension could anticipate this rise and could adjust by getting shorter. This leads to the concept of an adjusting suspension. This in turn leads to the idea of a vehicle for going over rough ground. A jockey wheel would signal back the state of the ground to the suspension which would then adjust so that the wheel was raised to follow the "profile" of the ground. In this way the bicycles would "flow" over the ground rather than bump on the ground. This was an idea first suggested about the case study. Today several companies such as Bianchi and Bisan are working on "suspensions" which behaves in a similar way.

63

Po, planes land upside down.

This seems totally absurd except that provocations are never absurd. Someone remarks that when a plane was coming in to land the pilot would get a better view of the landing area. This is typical moment-to-moment movement. From this, comes a consideration of where pilots are placed. in aircraft. When planes were very small the pilot had to sit on top. This has remained the chosen place. But a question of wondering if it is the best place may arise. Or even would it stay alike at all times? The Concorde comes in at so steep an angle that the pilot cannot see anything. So there is a mechanism to drop the nose of the plane to allow the pilot vision. Perhaps the pilot could be placed somewhere else for landing. There would also be video cameras at selected points.

Po, in petrol stations there should be no people serving customers.

This comment came from a three person group in the industrial design department of Izmir Institute of technology. The question was if whether the stations could be switched to self-services or not. The problem focused on the "do-it-yourself" concept of customers. The comment that would have been given on customers in Turkey; is to such as "Customers in Turkey want people to serve them. It is rather distinct to see people fulfilling their ego with this service. So it may not be a very good idea to put such a system in such a country. In contrast to this, it is not the same in countries of Europe, individuals there have the potential of doing the job themselves".

4. Positive Aspects

This is the simplest of the movement techniques. It is more yellow hat than green hat. The designer looks directly for any benefits or positive aspects in the provocation. What values are immediately present etc. Here the individual is interested in what is directly present rather than what the provocation might lead to. Then take this value and seek to move forward with it to a new idea.

64

Po, cars should have their engines on the roof.

There would be trouble with transmission and the high center of gravity but there are many positive aspects as well:

- Ease of access to the engine for maintenance
- Less risk of engine damage in a collision
- Equal weight distribution on both axles
- More space in the car or a shorter car
- Less impeded air flow for cooling

From this might come the idea of a shorter mid-engine car with the passengers sitting above the engine platform. When a value is turned up by the provocation then the designer or engineer tries to find ways of achieving the same value in a more practical fashion. To concern oneself with the value and try to build an idea around it.

5. Circumstances

"Under what circumstances would this provocation have a direct value?" is another question to be asked. A glass could not be put down until the drink in it had finished so perhaps bars could sell more drinks. In flooded conditions, a car with the engine on the roof would have a direct value because it would be possible to drive in a little, getting movement to look around for special circumstances that would give value to the provocation.

Po, drinking glasses should have rounded bottoms.

"Under what circumstances would rounded bottoms have a direct value?"

It could not be able to put down the glass until a person has finished his or her drink so perhaps bars would sell more drinks. The person would not put down the glass unless he placed it in a special holder so perhaps polished furniture would not get white

rings on it because all glasses would need to be placed in special holders rather than being placed anywhere.

It is obvious that there is a great deal of overlap. For example, with the round bottom glasses there is an element of "moment-to-moment" movement as it is visualized to see someone putting down an emptied glass. There is also an element of positive aspects when to examine the long thin shape of the provocative stamp.

Here, considering a final example:

Po, everyone who wants to be famous, should use a yellow bicycle.

Here a designer can take each of the movement methods and put down just one point for each.

Extract a principle: the principle that the user should be able to indicate his or her ambitions for fame in an unmistakable way

Focus on the difference: ambitious people would now make themselves visible. Is it better to try to give ambition to the talented or to try to give talent to the already ambitious? This is an interesting training question.

Moment to moment: when a cyclist gets a red bicycle and wants to go out for a ride, in the morning; A brother or sister might say, "why no yellow bicycle today" So there might be the beginning of an idea to involve families in motivating cyclists.

Positive aspects: anyone using a yellow bicycle has made a declaration to himself or herself and may try to live up to this.

Circumstances: anyone being served would prefer to go to a service using a yellow bicycle because service might be better and also because a complaint would be more meaning.

It may be noted that, certain aspects of the movement techniques are analytical and "convergent" hence **"creative"**. This is why a general "divergent" attitude of thinking is not sufficient for effective creativity. Moment to moment involves both fantasy but also an analytical attempt to see what might happen. The search for positive aspects is also analytical. Extracting a principle has an analytical aspect too.

c. Possible Results of Movement

As proceeding with "movement", a number of things may happen.

Negatives

When it is focused on the difference or when to proceed "moment to moment" there may well be some genuinely negative points that arise. Such negative points should never be put forward because it becomes so easy to fall back into simple judgment. The negative points should be observed and a conscious attempt made to move forward from them to a useful idea. For example, it might be said that a person who persistently used the yellow bicycle but never got famous might get rather fed up. This is perfectly true. But perhaps it would be better for that person to know at once that he is not going to get famous (as soon as he used the yellow bicycle) rather than to wait for years in a false hope.

Old Ideas

Sometimes movement tracks back into old ideas. When this occurs, a conscious effort needs to be made to develop other mutes. There is no virtue at all in simply connecting a provocation to
an already known idea.

Interesting Point

Movement may take the thinker to an "interesting point." This sense of "interesting" is important. The point need not have value but there is the sense that it has potential. As skill builds in creative thinking, students get better at noting interests: "I feel that there is something here" There is a sense of potential to pause and look around. It is the same feeling as the one a driver would get when driving around the countryside and coming across, an "interesting" village. There is no hurry in movement. It is of the times when it is better to think very slowly because that way it is possible to notice more.

Difference

"Difference" is itself a strong point of interest. A designer notices a concept or idea when it is different from what has gone before. It is notice that ones own thinking is taking a different line. Difference is always worth exploring to see if it leads to any significant value. An individual can explore for difference and can follow up reference. Points of difference or change in thinking are all worth noting even if they do not lead anywhere useful at the moment.

Value

This is a prize "catch." When it is time to come across a point of value or obvious benefit then it is obvious to measure it. To dwell on the value and appreciate it. Then look around to compare this new value with what existed before. Finally to make an effort it is time to see if this same value can be obtained in another, more practical way. People do this as when they see a new design.

Whenever it is to reach a final idea in lateral thinking it should always important look around to see if the "value" can be obtained in a simpler or more practical way. Value becomes the fixed point in what alternative ways of providing this value might there be.

Reach a Concept

Whatever the provocation, it is usually possible to reach interesting concepts even if they do not immediately offer. There is a need to spell out such concepts in order to be more aware of them. Fresh concepts are compared with old established ones. There is an attempt to redefine and to strengthen the concept.

It may not always be possible to go forward from a concept to a practical way of putting it into action. So concepts *should be listed and stored as part of the output of the*

provocative exercise. Concepts have a right to exist on their own. Concepts are not just steps in the process of getting an idea.

Finally, an attempt is made to move from the *concept* to *practical ideas* for putting it into effect. Sometimes these may be realistic ideas, but at other times, they may be no more than "for instance" ideas to show how the concept might be applied.

Reaching an Idea

The desired output of any creative session is a usable new idea. Occasionally, such an idea may occur directly as a result of the application of the provocative technique. More often there is a hint of an idea or the beginning of an idea that needs a lot more work done on it before it can be considered usable or fit for judgment.

Sometimes movement reaches an idea, which is obviously impractical or unusable in its present form. In such cases, there is an attempt to pull back from the idea to the concept behind the idea. This concept can be stored as such an attempt that it may also be made to seek another way of carrying through the concept. There is always some value in "for instance" ideas because they show some concept in action.

Nowhere

Sometimes movement gets nowhere. Thinking always seems to come back to established ideas. In such cases an attempt should be made to "harvest" as much as possible from the thinking session. It is also useful to acknowledge, "I have not gotten anywhere useful". There is little point in continuing to think about the matter. The designer should try again later with a different provocation or a different technique. There is nothing promising that every time it is set out, it would be creative or that it will get to be a wonderful idea. It will build up more confidence through acknowledging that it has not gotten anywhere than by trying even harder and still failing.

What is important, is to try to build up a fluency, skill, and confidence in the movement process so that whenever a designer wishes can set out to use movement. As to build up skill and confidence then results will occur more frequently.

The individual cannot be confident in the mental operation of movement, it will get a wonderful idea every time it is sought. However, it can become confident that the designer can use the process of movement with skill and fluency.

When a thinker becomes confident in the mental operation of movement, it will be obvious for him to find that it is possible to apply movement to any provocation whatsoever, no matter how illogical or nonsense it may seem.

1.3.6 WHY –WHAT –WHEN –WHERE –WHO - HOW?

Asking questions is another way of expressing the design strategy[6].

Ask "Why" a problem is occurring and then ask "Why" four more times.

For example...

1. Why has the tire of the bicycle blown?

    It was because of an overload on a weak tire.

2. Why was it a weak tire?

    There wasn't enough material used.

3. Why wasn't enough material used?

    The cost of the tire would go up too much.

4. Why would the cost go up too much?

    The material is bought from another country.

5. Why is it bought from another country.

---

[6] According to Chic Thompson from "What a Great Idea",

No manufacturer produced this material in Turkey.

"THE PRODUCTION OF TIRES BEGINS".

The Six Universal Questions

Idea Generators i.e. designers should be aware of a simple universal truth. There are only six questions that one human can ask another:

- What?
- Where?
- When?
- How?
- Why?
- Who?

To draw a mind map of the problem with these six words as nodes on the map would be a good way of knowing what is going on in the mind.
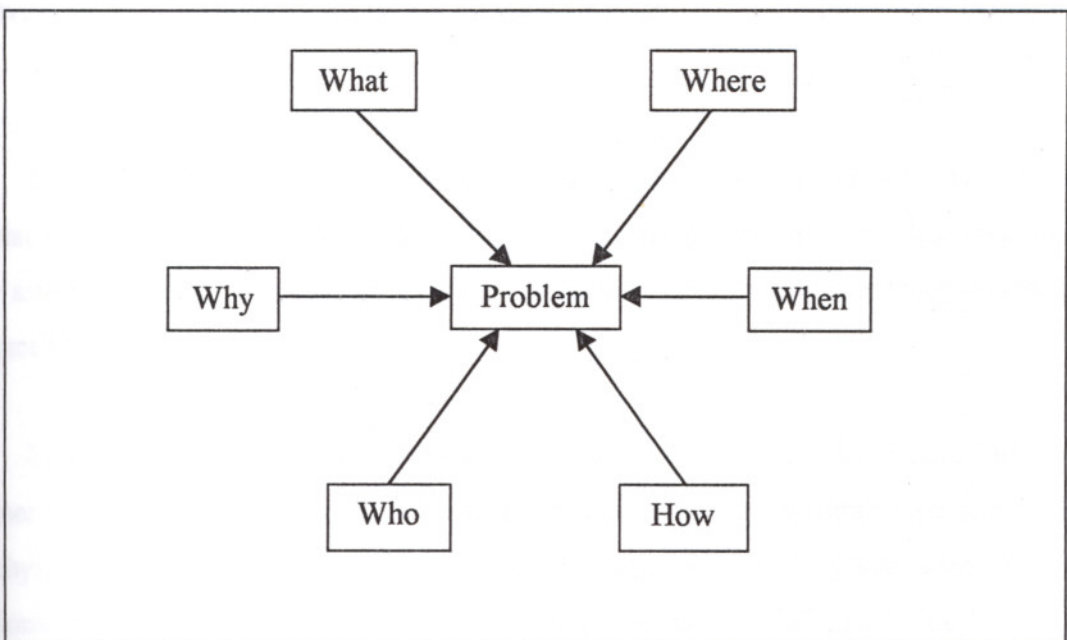
Figure 1.3.6

CHAPTER 2
CREATIVITY IN THE DESIGN PROCESS

Introduction :

This chapter is to be totally different from the previous chapters hence to show the strict techniques to be taken in the procedure of creativity. The following techniques and definitions of design etc. are to put an engineering touch to creativity that would be a restriction to industrial design creativity.

2.1 Definition of Design and the Design Process

2.1.1 Introduction to Design

In this part the concepts "designing" and "design" will be taken from dictionaries. The word "design" will be noted not only as a definition but also as a concept in creativity.

Design with various meanings, ranging from conceiving a plan in the mind, whatever this plan may be, to making a drawing or pattern of something to be made or built.

The following focuses on design in the more limited sense of "designing material products". For that purpose "design" is defined as "to conceive the idea for some artifact or system and/or to express the idea in an embeddable form (Oxford Advanced Dictionary).

Usually the function, or a set of functions of a new product, will be given to the designer at the outset. The design problem is defined as to find a suitable geometrical and physico-chemical form for the product and its parts, so that the given function, or functions, can be fulfilled. Products are "designed" to be "made" and to be "used". Making and using are the actions. Then it shall therefore continue with an analysis of

72

the structure of human action. By acting, people set the autonomous events of nature onto a new course. In doing so, people can make an ally of parts of the material reality and include these as an "instrument" in their actions. Moreover, people can invent and make instruments. Here it should be encountered that the phenomenon of "technology" is important. Technology encompasses the invention and making of instruments, as well as their operation and use. The analysis of the structure of technical action demonstrates which elements play a role in action, and how they are linked to one another. The analysis will also show how essential designing is for technical action.

It shall be concluded later, with a more formal analysis of some important patterns of reasoning. Designing is a process in which all sorts of things are done (drawing, building models, experimenting, research etc.), but above all, it is a process of goal-directed reasoning. The reasoning from function to form is a form of reductive reasoning. This means that the conclusion (the design) does not indisputably follow from the premises (the function to be fulfilled), and that, in principle, there are always many good solutions. The reasoning from function to form is a creative process, which can be encouraged methodically, but cannot be logically be guaranteed.

2.1.2 The Design Problem

A product is a material system, which is made by people for its properties. Because of these properties it can fulfil one or more functions. By fulfilling functions, a product satisfies needs, and gives people the possibilities to realize one or more values. Figure 2.1.2.a shows this state of affairs.

Figure 2.1.2.a

73
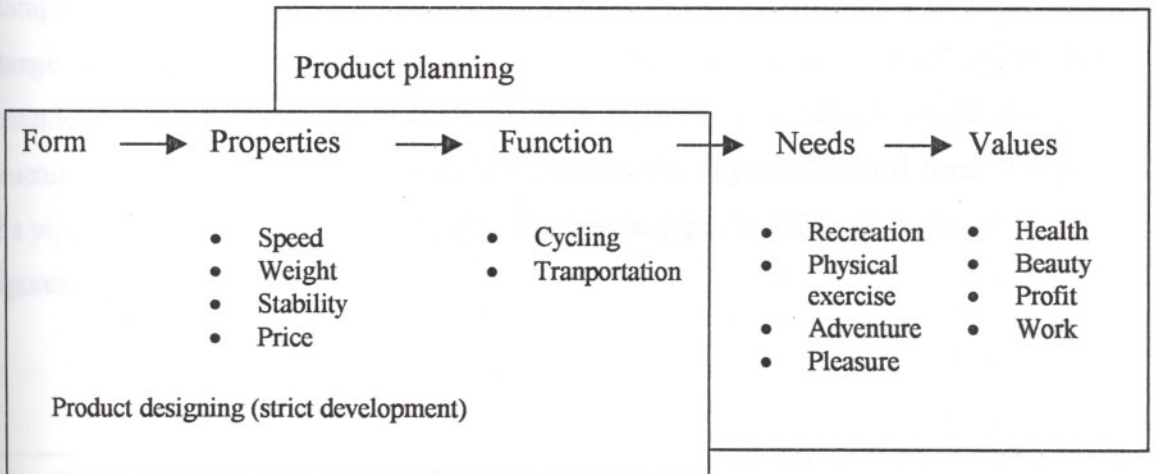
In general, the development of new products proceeds in the opposite direction. The more to the right it is started (Figure 2.1.2.a), the more open-ended the product development process will be. If several designers were to be instructed to develop a product such as a bicycle, no matter what that would contribute to the value of "enjoying nature", one of them would come up with a tandem, another with an easy HPV (human-powered vehicle as the bean) and still another with racing bike and so on.

However, usually product designers do not start entirely to the right of the diagram. The product development process can be divided in two parts, namely product planning and strict development. In the product planning phase one seeks product ideas that fit with the company and the market. Of course seeking is meant to be as creative as possible. Reasoning back from the goals (values) of the company to statements on functions that are worth fulfilling forms the nucleus of this part of process of product development. The actual designing of products takes place in the strict development phase. The nucleus of that phase is reasoning back from statements on functions to statements on the form of the product. The structures form is tried to be reasoned. To find the answer to the reasoning, the designer should first study what statements are made in the design process.

In the manufacturing processes an in-going material is transformed into an out-going material (please refer to frame building in Appendix A). In doing so, energy and information are transformed. What is usually "immediately evident is that the geometrical form of the in-going material changes in the manufacturing process, for example when machining a part. There are, however, also manufacturing processes that change the physicochemical form (the properties of the material) of an object. For example, by welding two pipes (of a bicycle) together in a factory would give the structure a different hardening[7], apart one changes the physicochemical form. Forging of a pipe end to form the fork would also change the pipe thickness as it gets to the end (figures 2.1.2.b).

---

[7] Bisan TIG welding processes done on bicycle tubes.

Ordinary pipe changed to a resulting shape of a fork.
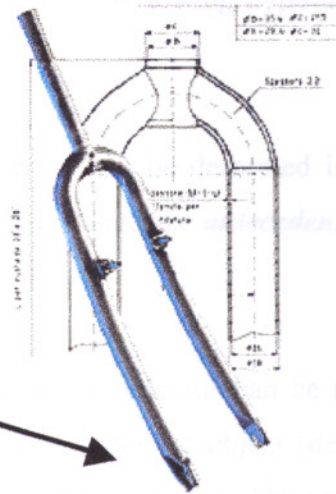
Forging is a process of forming metal parts by the use of heat and pressure. Forging develops a grain structure in the metal, which makes it stronger in the direction that it has been stretched. Forging is done in special molds called "dies", and when the dies are properly designed to take advantage of the grain structure introduced by the forging process, the resulting parts are stronger in the important directions than those manufactured by CNC machining

Figure 2.1.2.b

Yet, it is inevitable that the dimensions of the part change a little as well (not actually too much in comparison to the size of the tubes "pipes" used).

In manufacturing, changes of geometrical and physicochemical form always go together, but usually these changes are not actually wanted at the same time. The geometrical and physicochemical form that a product must have after the manufacturing process, is the design of the product. It has been thought up by a designer and laid down in a technical drawing. Thus, a technical drawing can be seen as the coding of two kinds of categorical statements which comprise a design: statements as to geometrical form (this product is so and so long) and statements as to the physicochemical form (this product is of steel).

Because of its form, a product has certain properties, such as weight, strength, hardness, color etc. Although usually describing properties categorically, it actually would be claimed that some corresponding hypothetical statement is true for the object

75

concerned. For example, if the categorically state that "the stiffness of this construction is a great value", then the bicycle designers thus claim that the following hypothetical statement on that construction is true:

"If this construction is loaded in the manner, then it will be deformed in the other manner". The first-part of the hypothetical statement is called the *antecedent,* the second part the *consequence* (Roozenberg 1991).

An object has as many properties as true hypothetical statements can be made about it. Each property tells thinkers something about the reaction the object (design) will show if brought into a certain environment and used in a certain way. The total of all properties describes the behavior to be expected under certain conditions.

Designers distinguish between intensive and extensive properties. Intensive properties depend on the physicochemical form only, such as specific gravity. Extensive properties, or thing properties, are results of intensive properties plus the geometrical form; for example, the weight of a bicycle. In designing, one is especially interested in the extensive properties, as these directly determine the functioning of the product. By choosing a certain material, the designer immediately sets many intensive properties for a product, both good and less desirable ones (steel is stiff, but it is heavy and rusts; aluminum is less heavy and does not corrode, but is more floppy). The art of designing is to give the product such a geometrical form that has the desired extensive properties, also including the intensive ones too (table 2.1.2.a.).

Table 2.1.2.a. Material properties and construction of bicycles.

STEEL		TITANIUM	
Pros:	**Cons:**	**Pros:**	**Cons:**
• Inexpensive	• Heavy	• Light	• Expensive
• Strong	• Corrosive	• Strong	• Designs limited by available tubes and lugs
• Stiff	• Designs limited by available tubes and lugs	• Resilient and "lively" feel	
• Resilient and "lively" feel		• Shock absorbing	
• Easy to work with and repair	• Assembly produces weaker, heat-affected zones	• Non-corrosive	• Not easily repaired

ALUMINUM		CARBON FIBER	
Pros:	**Cons:**	**Pros:**	**Cons:**
• Fairly inexpensive	• Fatigue risk requires overbuilding	• Lightest	• Expensive
• Adequately strong	• Lack of resilience gives "dead" feel	• Strongest	• Technology still evolving
• Shock absorbing		• Best shock absorption	• Strength and stiffness are design dependent
• Non-corrosive	• Not easily repaired	• Unlimited design applications	
	• Bonded joints can fail	• Non-corrosive	• Bonded, lugged designs can fail at joints
		• High fatigue resistance	
		• Some designs are easily repaired	• Molded styles have limited sizes

The function of a product is the intended and deliberately caused ability to bring about a transformation of a part of the environment of the product.

To realize a goal, a goal is a desired state. Something must be changed in the environment. The natural process of change that affects this environment - including mankind - should be adjusted by the product in a desired direction. Some process should run differently than it would without the product; a coffee mill changes beans to ground coffee, a chair supports (prevents one from becoming tired), and a poster provides information (decreases uncertainty).

Beans ⟶

Electric energy ⟶

Signal ⟶

coffee mill

⟶ Ground coffee

⟶ Heat

⟶ Signal
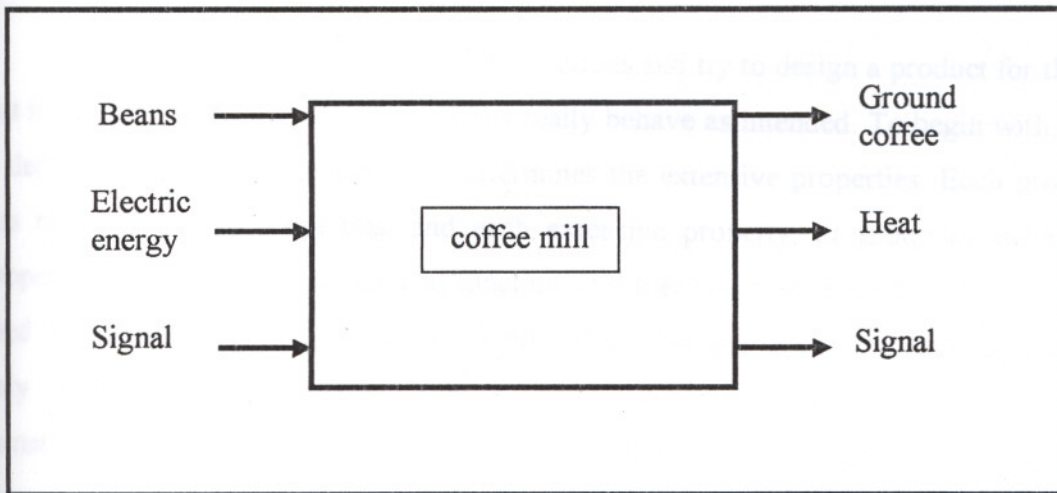
Figure 2.1.2.c. The function of a coffee mill as a black-box

Functions of products can be described in different ways, such as in normal language, in mathematical formulae, or as a "black box" (figure 2.1.2.c). Particularly the last form of representation is often used in design. Yet, whatever representation is chosen, actually statements are made on the intended behavior of the product. Those statements have a hypothetical form, just like statements on properties. For example: in grinding coffee, a final state S2 is wanted, which yields ground coffee (with a certain size of granule) and a coffee mill that is not too worn out. It is assumed that there is a beginning state S1, which is characterized by a certain amount of beans of a certain

78

kind, the availability of energy in a certain form, no extreme temperatures, etc. If this intended behavior were put into the form of statements, would result with the hypothetical form S1 ➡ S2 (read as: if S1 then S2, or S1 implies S2).

Unlike statements on properties, statements on functions are normative. A product has certain properties or does not have them, irrespective of the purpose of a user. Functions, however, are imposed on products; they have to be fulfilled, otherwise the intended goal will not be reached. "Function" is a general concept. It refers to the purpose of a product, which is usually many-sided. Designers can therefore talk about the technical, the ergonomic, the aesthetic, the semantic, the business economic, the social and other functions of a product. The detailed description of "the function" of a product in all its aspects leads to the design specification; this is the list of all properties that the product should possess to achieve its purpose.

A person can think up all sorts of functions and try to design a product for them, but it must be asked whether that product really behave as intended. To begin with, this it depends on its form, for the form determines the extensive properties. Each product has many extensive properties, and each extensive property, or group of extensive properties, represents a possibility to function. But there is more: a product must also be used in a certain manner. Of the many properties that any product possesses, usually only notice a few. Properties only become "invisible" when the designer does something with the product. Properties are hypothetical statements, and even if such a statement is true, the consequence only becomes evident when the designer actualizes the antecedent. To do so, it is actually desired to bring the object into certain conditions (iron has the property that it rusts, but only when it meets water). A product "with the required properties therefore functions in the intended manner", only if it is used in an environment and in a way that the designer has thought up and prescribed. The instructions for use are not given facts for the designer, like the function, but are thought up - together with the form of the product - and thus form an essential part of the design. Figure 2.1.2.d shows how the functioning of a product depends on its form and its use. The arrows indicate causal relations. The designer, however, should reason against the direction of the arrows. Given a desired function, the form should be thought of also including its use, and this should be done in such a way that, if the user acts in

accordance with the usage instructions, the intended function is realized. This is the kernel of the design problem. The descriptions - represented in whatever manner - of the form plus the use of the product form the design. The process of thinking, supported by all sorts of doing, which lead to these directions, is designing (Roozenberg 1991).
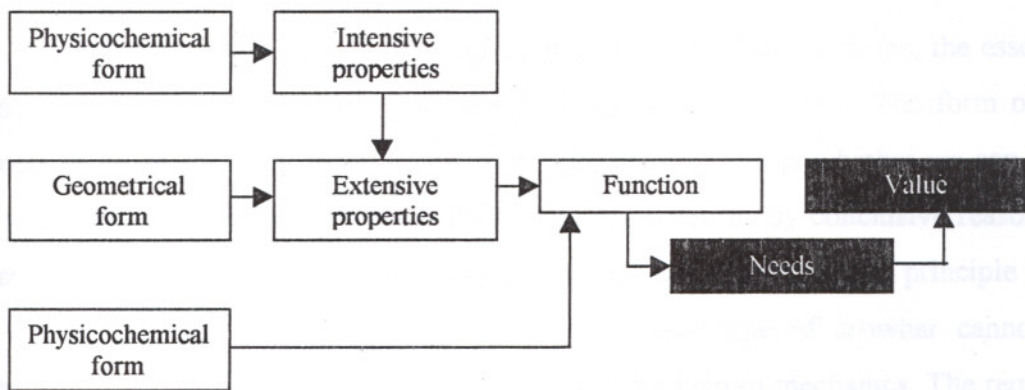

Figure 2.1.2.d: The functioning of a product

To clarify figure 2.1.2.d, below is a simple example:

The form of a crowbar is described in categorical statements: this crowbar is made of steel, has a length of 850 mm, a diameter of 30 mm, etc. The function of a crowbar is "enlarging force", that is to say: if, on a crowbar, at point P a force F1 works in direction x, there results at point Q a force F2 in direction y, This is a hypothetical statement. If the design of the crowbar is given, that is to say, if all dimensions are known, the material, and how and what for it is used, then a calculation, with the help of the formulae of mechanics will be done. How large F2 will be as a result of F1, how much it will bend, and whether it will resist the stresses involved will be found. This reasoning from form to function (or rather: to functioning) - in figure 2.1.2.d. from left to right - is based on deduction. In principle there is only one type of answer: the product has or does not have the required properties. With a certain form of crowbar and certain values of F1, x and y, one value of F2 corresponds.

Nevertheless, a crowbar can fulfill different functions. If it is used in another environment or in another manner, other laws of nature become operative and other transformations will take place. Each transformation corresponds to a function that the product can fulfill (e.g. that of a hammer). Thus the form determines the potential of functions for a product (Roozenberg 1991).

However important the reasoning from form to function might be, the essential mode of reasoning in designing is to reason from function to form. The form of the product to be designed is then the unknown. The question arises whether we can infer the geometrical and physicochemical form from the function, by conclusive reasoning, given the designer knowledge of the laws of nature. The answer is no; in principle there are always different possibilities. The form of a new type of crowbar cannot be calculated from its function - enlarging force - with the help of mechanics. The required stiffness and strength can be achieved with many different materials, with shapes and dimensions attuned thereto. Only by making an arbitrary choice for all degrees of freedom minus one can the remaining form factor be unambiguously determined.

The indefiniteness of the transition function to form goes even further, for a lever is not the only technical principle to enlarge force. This can also be accomplished with the help of pulleys and cables, gear-wheels and hydraulics, and new principles can be invented. In figure 2.1.2.d the thinking process function to form proceeds from right to left. It is based on reductive reasoning and is a creative process. This does not mean that scientific and technical knowledge does not play a part. Causal models indicate the direction in which may choices can be made (choice of material, choice of geometric shapes, choice of one or more key dimensions as in table 2.1.2.a.). Yet this never leads to an unambiguous answer. The number of solutions is in principle even innumerable.

Here lies the great challenge for designers and for design methodology, for the most important step in designing is not to predict the properties of a product already thought up, but the preceding step of conceiving of the form of that product. In a rather poignant contrast to this stands the fact that for the transition form function much scientific knowledge and methods are available, while the transition function form

depends largely on the creative abilities and insight of the designer. Nevertheless, there are many successful practical examples, which can often serve as a guideline. Design methods can also be useful aids. Yet, whatever course engineering sciences and design methodology might take for the transition of function to form, the crucial step in any design process, creativity and intuition remain the driving forces.

In the preceding analysis much has been left out in order to highlight the kernel of product designing. One important characteristic of present day production is the separation of manufacturing and using products. A product must therefore function in at least to respects. Users see the product as an object they buy to satisfy some of their needs. This is called the socio-economic function of a product. For the manufacturer, the product must fulfill a business economic function (profit), with social functions, such as providing employment, following naturally there from (figure 2.1.2.e).
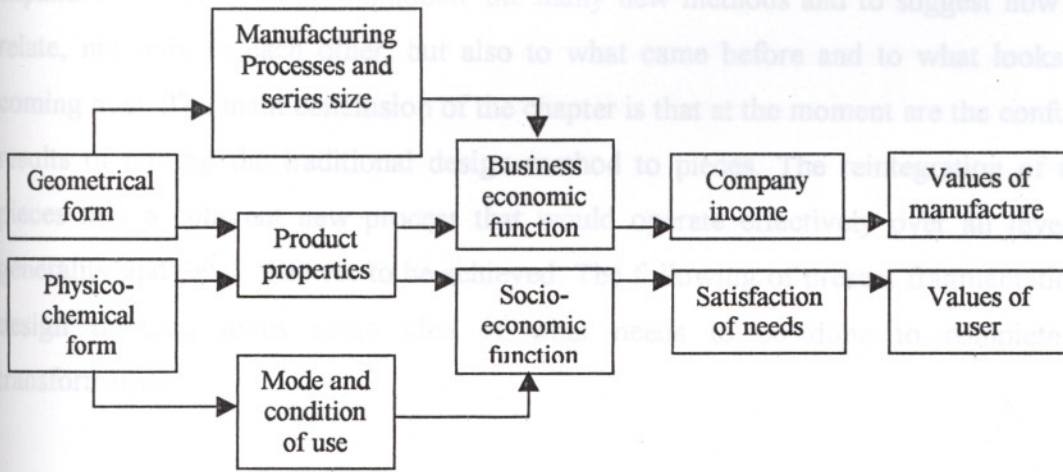
Figure 2.1.2.e. The dual functioning of a product

The business economic function is usually not aimed at with just one product, but with a series of identical products. The determination of the proper manufacturing methods for the numbers to be run off is just as important for the success of the business as the product design itself. For the product designer, the size of the run is usually a given datum, but for product development as a whole this element must also be thought up as part of the plan for the new business activity. In a broader sense, the product design problem can therefore be phrased as: to think up (the creation process) the form

of the product (geometry and material), the usage, as well as the manufacturing, given a business economic and socioeconomic function, and given a certain size of the run.

The means-ends chains of producer and user end in the value domain, and value conflicts between users and producers are more rules than exception. The environmental issue is a clear example. For designers this causes many complications. They cannot restrict themselves to "embodying" a technical principle as effectively as possible, but must, negotiate between often opposing objectives.

2.2 THE DESIGN PROCESS DISINTEGRATED

The new methods reviewed as steps towards an expanded design process that is becoming necessary to the continued development of the man-made world are reviewed. It is an attempt at sketching out a large enough, and loose enough, picture of this expanded designing to accommodate the many new methods and to suggest how they relate, not only to each other, but also to what came before and to what looks like coming next. The main conclusion of the chapter is that at the moment are the confusing results of pulling the traditional design method to pieces. The reintegration of these pieces into a coherent new process that would operate effectively over all levels of generality and detail, has yet to be achieved. The following of present fragmentation of design thinking gives some idea of what needs to be done to complete the transformation.

The obvious agreement between the inventors of new methods is their assumption that scale drawings can no longer be the main instruments of designing. This, is because innovation at the system level requires freedom to drastically alter not only the components of which a product is made but also the kinds of product that go to make up a new system and the organization of the community that the new system is to serve. A second point of agreement between design methodologists is that the thinking (creativity process) that designers are accustomed to keep to themselves has now to be externalized so that the many people (including users), whose knowledge is relevant to designing at the systems level, can put forward their ideas at an early stage and can share in the taking of critical decisions. An equally good reason for externalizing design

thinking is to make possible design automation i.e. the use of computers to speed up those parts of the design process for which the thinking is sufficiently well understood to be represented by a mathematical model or process.

The most characteristic feature of the literature on design methods is the prevalence of block diagrams, matrices and networks of man kinds that resemble to varying degrees, the diagrams and calculations that computer programmers use. It can be regarded to this mapping of interrelationships as an attempt to find something mare tangible than thinking but less detailed than a scaled drawing, with which to portray the complexity of desiring at the systems level: a means of giving the systems designer a wide enough "perceptual span".

This key idea of a network seems to be both useful and misleading. It is useful when the items and relationships of which it is composed can be related to physical entities that are capable of being measured, or made to exist. It is, however, only too easy to forget about the relationship between the network and the real world (existing or possible) and to deceive oneself into believing that whatever can be drawn as a network can also be produced. A recurrent difficulty, is that of distinguishing between realistic and unrealistic networks and of deciding what variables or categories to represent. So far at least, this seems to be a skill that can be "learnt by doing" but is difficult or impossible to teach.

One could sum up the whole business of designing at the systems level by the analogy with an explorer looking for hidden treasure. A new problem is like an unknown land, of unknown extent in which the explorer searches by making a network of journeys. This network is not something that exists before the beginning, but there is an approach to invent, either before the start or as it is proceeded.

Design methods are like the navigational tools and charts that are used to plot the course of the journey so as to maintain some control over where cues. The process continues until it is bound to come across the treasure long before it has been searched every millimeter of the ground. The main objective of a designer, in mapping the track of the search, is to make as much sense as can be made of every fragmentary clue that

he can find so that it can be arrived at the treasure without spending a lifetime on the search. Designing, like navigation, would be a straightforward matter if one did not have to depend upon inadequate information in the first place. The point at which this analogy breaks down is in the nature of the space to be searched, The designer's landscape is his creativity, unlike that of the explorer, is an unstable and imaginary one: It changes its form according to the assumptions that the individual is obliged to make and according to the willingness of others to put ones own plans into effect.

Here a question may be asked if there is any connection between intuitive (black box) methods and rational (glass box) methods on the other. A related question is whether the many methods are to be regarded as alternative ways of designing or else as elements that can be combined within a single design strategy. The answer to these two questions is that none of the design methods that have appeared so far is as complete as it looks and that some mixture of both rationality and intuition is needed in the solving of any design problem. The way in which this mixing of judgment and calculation is to be achieved is not settled, and is perhaps not capable of being settled, except for a particular problem and for a particular person. It depends upon the quantity of objective evidence available and upon the skill and experience of whoever is to do the mixing.

Having it to be the design team to construct its own strategies, using any combination of new or old methods that may seem appropriate, there remains the question of understanding what one is doing. Is there any general theory, or set of principles, to which one can refer selecting and combining design methods? The plain answer is "no". nothing like enough is yet known about the behavior of designers, or about design problems. to attempt an explanation that could be verified best observation and experiment. All that can be done at present is classify, and speculate, in the hope of making it easier to understand what it is that makes the construction of an effective design strategy, in which rational and intuitive methods are combined, so difficult for many people to do and for anyone to explain.

It should be mentioned that not everyone shares the view that designing cannot at present be explained. (Archer 1968), in his thesis on the structure of design processes, presents a unified rational picture that is explicable at all points, once the protagonists

have recorded a set of micro-judgements upon which the process is based. As will be seen in the following much looser view of designing, there is reason to doubt whether proposals for restricting intuition to the start is possible in the uncertain, that precise and accompanies innovation. There may, however, be many well-defined design problems to which Archer's rational procedure could be useful application

Designing as a three-stage process:

It is one of the simplest and most common observations about designing. And one, upon which many writers are, is that it includes the three essential stages of analysis, synthesis and evaluation. These can be described in simple words as *"breaking the problem into pieces"*, *"putting the pieces together in a new way"* and *"testing to discover the consequences of putting the new arrangement into practice"*. Most design theorists agree that it is usual to cycle many times through this science and some, (Asimow, Watts, 1966) suggest that each cycle is progressively less general and more detailed than the one before it.

The three stages that are described below do not necessarily fit together to form a universal strategy composed of ever more detailed cycles. They are more elementary than that being merely categories into which the many loose ends of design theory, as it now exists, can be discussed at the inexact, or faithful, level that designers partial knowledge and partial ignorance permit.

The three stages are here named *divergence, transformation* and *convergence*. These names are meant to refer more to the new problems of system designing than to the traditional procedures of product and of engineering design. Confusing and unhelpful as it may be to a professional designer to think of these three things, as separated, there is little doubt that their separation is prerequisite to whatever changes of methodology the necessary at each stage before they can be reintegrated to form a process that works well at the systems level.

2.2.1 DIVERGENCE

This term refers to the act of extending the boundary of a design situation so as it has a large and fruitful enough search space in which to seek a solution this is the creativity section that the human brain deals with. All the methods of exploring design situation fall into this category (Jones p65). The properties of this category are as follows;

(a) The objectives are unstable and tentative,

(b) The problem boundary is unstable and undefined.

(c) Evaluation is deferred : nothing is disregarded if it seems to be relevant the problem however may conflict with anything else.

(d) The sponsor's brief is treated as a starting point for investigation and is expected to be revised or evolved, during divergent (creative) search, and possibly at later stages as well (but not without the sponsors agreement).

(e) The aim of the designers is to deliberately increase the uncertainty, to let themselves get preconceived solutions, and to reprogram their brains with a mass of information that is thought to be relevant.

(f) One objective of research carried out at this stage is to test the sensitivity of such important elements as sponsors, users, markets, producers etc. to the consequences of shifting the objectives and problem boundaries in many direction and to varying degrees. The directions in which such sensitivities are explored may depend very much on what inconsistencies and conflicts are found to be present in the existing; situation

It may be useful to think of divergent search as being a testing for stability, or instability, in everything connected with the problem. An attempt to discover what, in the hierarchy of community values, systems, products and components (and also in the minds of those who will take critical decisions) is susceptible to chance and what are to be regarded as fixed points of reference. Stable and unstable points are just as likely to be discovered at that low level of products and components as they are at the higher levels of collective goals and personal value judgments no orderly picture can be expected to emerge at this stage. The aim of the designers is to avoid as far as it can be

87

done. Imposing a premature pattern upon what the designer discovers. Decisions should be deferred until the next stage, by which time the individual should know enough about the background of the problem to be able to envisage the probable consequences of organizing data in any selective way;.

It should be noted that the methods appropriate to this stage involve both rational and intuitive actions (Jones, p66) and that many of them require leg-work rather than armchair speculation. A common error of newcomers to design methodology is to be far too speculative at this stage and to fail to see the point of fact-finding before any critical decisions are taken and before discovering what it is that is to be looking for. The skills necessary for this pre-design activity come much more readily to people trained in such subjects as easy writing scientific research and statistical analysis than they do to those who have been trained for the design professions, i.e. engineering, architecture, industrial design, urban planning etc. Designers may have quite a lot of unlearning to do before they can maintain the detachment, flexibility and breadth of view that is appropriate before design decisions are taken and before it is wise to get involved in anything approaching a cut-and-dried solution.

The costs of this kind of pre-design work can easily be out of control. It is essential to anchor the work to realistic judgments of the magnitude of the penalties for not collecting information, which is usually done by the producer. It is equally necessary to divert a proportion of the search cost to the business of guiding the search rather than carrying it out. It is, for instance, more important to verify that the reliable and relevant sources of information are being tapped than to go on tapping in the hope that something useful will turn up, or just because the searcher happens to know that the source of information exists. The main error at this stage is to ask the wrong questions. The tasks of posing questions, of deciding, where to go for the answers and of estimating; how rough or precise the answers need to be, should be given to the most experienced and intelligent people whose help can be enlisted. In short it can be said that the aim of divergent search is to de-structure, or to destroy, the original brief while identifying these features of the design situation that will permit a valuable and feasible degree of change. To search divergently is also to provide, as cheaply and quickly as

possible, sufficient new experience and new creative ideas to counteract any false assumptions that the design team members, and the sponsors, held at the start.

2.2.2 TRANSFORMATION

This is the stage of pattern-making, fun, *high-level* creativity, flashes of insight, changes of set, inspired guesswork; everything that makes designing a delight. It is also the critical stage when big blunders can be made, when wishful thinking or narrow mindedness can prevail and when valid experience and sound judgment are necessary. This is the stage when judgments of values, as well as of technicalities, are combined in decisions that should reflect the political, economic and operational realities of the design situation. Out of all this comes the general character, or pattern, of what is being designed, a pattern that is perceived as appropriate but cannot be proved to be right. As has been pointed out by Manheim (p67) one cannot achieve an optimal solution only an optimal search. There is no way of being sure that what is done will, in the end. be "best". Beer (1966) suggest that only in retrospect can one decide that the search, rather than the goal was worthwhile.

Many methods entail small degrees of transformation here and there. The methods that are predominantly transformational and are grouped together, methods of searching for ideas, methods of exploring problem structure.

The chief characteristics of the transformation stage which can occur unexpectedly at any time but which should only be applied after sufficient divergence has occurred are listed below:

(a) The main objective is to impose upon the results of a divergent search. A pattern that is precise enough to permit convergence to the single design that must eventually be decided upon and fixed in every detail. The chosen pattern must reflect all the realities of the situation. Pattern-making, is the creative act of turning a complicated problem into a simple one by changing its form and by deciding what to emphasize and what to overlook.

89

(b) This is the stage when objectives, brief and problem boundaries are fixed, when critical variables are identified, when constraints are recognized, when opportunities are taken and when judgments are made.

(c) It is also the stage when the problem is split up into sub-problems each of which is judged to be capable of solution in series, or in parallel, and in relative isolation. The instruments at this vital stage are the specialized words and symbols that are invented to define sections of the problem. These comprise the "problem language" upon which subsequent work will be based.

(d) The most important requirements for a successful transformation are. firstly, the freedom to change sub-goals, in order to find feasible ways of avoiding major compromises, and, secondly, the speed with which the feasibility and consequences of any particular choice of sub-goals can be predicted. This second requirement is almost you ask for the impossible because the act of changing sub-goals is that of jumping to an altogether different design. Such a change could introduce a fatal delay in the feedback of experience by which the choice of sub-goals must be informed. At the traditional level of product designing, quick feedback is ensured by relying largely on the chief designer judgment and on the speed and reliability with which he can try out alternative designs "on the back of an envelope" or "on a tissue when at a dinner in a restaurant". At the system level the changing of sub-goals involves the testing of alternative products, as well as of alternative components, and feasibility can no longer be predicted by experience or by sketching. In this case the main hope is scientific testing. One well-chosen test, or "predictor action", can provide feedback on the feasibility of a wide range of alternative product designs, thus providing the designers with sufficient room for maneuver for the transformation a whole system.

(e) The personal aspect of designing is most evident at this stage. In general, the stronger a person has a mental grasp of the world, the more intolerant he will be of any transformation, but the one he perceives as being correct. This is where "design by committee" can go wrong. Any voting that is done should be between one transformation and another; rival transformations should not be mixed, there will usually be several transformations each capable of achieving an acceptable, if different, result.

2.2.3. CONVERGENCE

The last of the three stages is that which, traditionally, is nearly the whole of designing, but which, under the impact of design automation, may eventually become the bit that people do not do. It is the stage after the problem has been defined, the variables have been identified and the objectives have been agreed. The designer's aim becomes that of reducing the secondary uncertainties progressively until only one of many possible alternative designs is left as the final solution to be launched into the world.

The rational or "glass box" (Jones, p68) methods that, at least in principle, can be automated can also be shared out between assistants who need not have in their minds, a picture of the complete problem and can do without rapid access to relevant data. The main features of convergence are as follows:

(a) Persistence and rigidity of mind and method is a virtue; flexibility and vagueness are to be shunned. The main objective is to reduce uncertainty as fast as possible and anything that will help to rule out alternatives that are not worth investigating is of the greatest help, the main enemy is the rapidly rising cost of dealing with the problem in more and more detail as the point of convergence is approached. The most important decision is the order in which variety-reduced decisions are taken. As far as possibly this should be the reverse of their order of logical dependence, thus yielding a linear strategy with no recycling.

(b) The convergence concept is that unforeseen sub-problems prove to be critical i.e., to be insoluble unless an earlier design is changed, thus causing recycling. The objective of the magical transformation stage was, somehow or other, to pattern the problem in such a way that critical sub-problems are anticipated or avoided, by action at a more general level.

(c) The models used to represent the range of alternatives remaining should become less abstract and more detailed during consequence. In the case of system designing neither the scale drawing, nor the full-scale prototype, is general enough for any but the last parts of convergence. Mathematical models and

91

abstract analogues of many kinds are relevant to the earlier stages of convergence and comprise the main body of knowledge in applied science. Being so well known, and being so extensive.

(d) There is a choice of two fundamentally opposed strategies for converging. One is the conventional "out-in strategy", such as an industrial designer may employ when proceeding from the external shape a telephone to the arrangement of buttons, PCB etc. within it. The other is the "in-out strategy" that an industrial designer may also employ if begun with activities, or with buttons, and works outwards to they external shape. Usually it seems, a skilled designer will work from both ends at once. Creating problems for one at the points where out-in and in-out meet and probably fail to match.

(e) Many of the new design methods imply an exclusively in-out strategy with solution of sub-problems in isolation before any thought is given to their combination, the solution of sub-problems is independent of their mode of combination. To sum up we can say that to converge is to reduce a range of options to a single chosen design as quickly and cheaply as can be mannered and without the need for unforeseen retreats. This is the only aspect of designing that appears to lend itself to a wholly rational explanation and which can, in some cases at least, be done entirely by a computer. There remain, however, some doubts.

These can be summed up in the thought that a rational description of how one got there last time not be an adequate guide to the next journey that one undertakes. This might only be the production information that would be a guided tour in "how to get" to the solution but not on how "it had been" to the solution".

2.3. CHOOSING DESIGN STRATEGIES AND METHODS

The term "design strategy" is used to mean a list of actions taken by a designer (Jones, p75) , or by a planning team, in order to transform an initial brief into a final design. The team is to consist of various individuals such as engineering, marketing, manufacturing, advertising and other personnel that may come to mind who would be of help in the dimensioning and influencing of the design. The actions of which a design

strategy is composed can be decided at the outset or they can be changed according to the results of previous actions. Each "design action" can consist of whatever the designers chooses. Some actions will be new methods, and some will be traditional actions like sketching or scale drawing, while others may be novel procedures that the designers invent for themselves.

When a design method is, by itself, sufficient to solve a design problem, it is called a "strategy", but most of the new methods are insufficient to do this and are classified here as actions out of which complete strategies can be composed. The analogy with military strategies can be misleading so it is best to think of a design strategy simply as a list of the methods that one intents to use.

It is helpful to classify design strategies according to two criteria (Jones, p76) :

a-) The degree of pre-planning
b-) The degree of search

Pre-planned strategies are rigidly fixed in advance just like computer programs. They are more suited to familiar than to novel situations, i.e. to assembles or to modifications of existing designs rather than to the invention of new products which is actually been done at a very high rate in Turkish manufacturing firms. Although practicing designers may be unwilling to admit it, much design work follows a predictable pattern and is therefore capable of being done by a computer. Ideally a pre-planned strategy is linear, being composed of a sequence of actions. Each action is dependent upon the output of the last but must be independent of the output of later stages, (fig. 2.3.a.)

If an earlier stage has to be repeated after the output of a later stage becomes known the strategy becomes cyclic. Sometimes there will be two or more feedback loops nesting inside each other, as in figure 2.3.b.

Fig. 2.3.b. Cyclic strategy

This pattern of loops is typical of many computer programs. It resembles progress in a game of snakes and ladders in which there are no ladders but only snakes. The designer's main enemy is the endless loop or "vicious circle", out of which he cannot break unless the pattern of the problem is changed. When design actions are wholly independent of each other a Branching Strategy, Fig.. 2.3.c., is possible. This can include parallel stages, which have the great advantage of increasing the number of persons working on the problem at one time, or alternative stages which allow some adoption of strategy according to the outcome of previous stages.
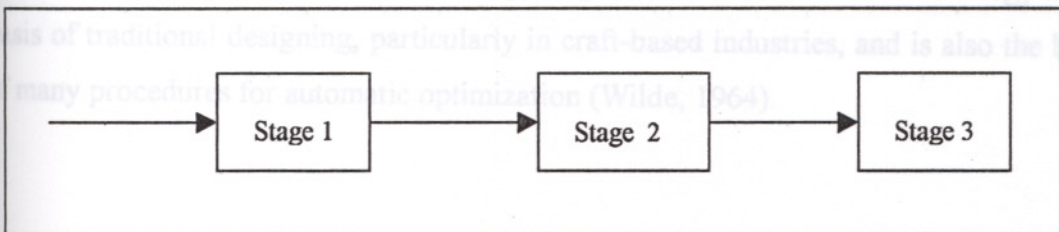
Fig. 2.3.a. Linear Strategy
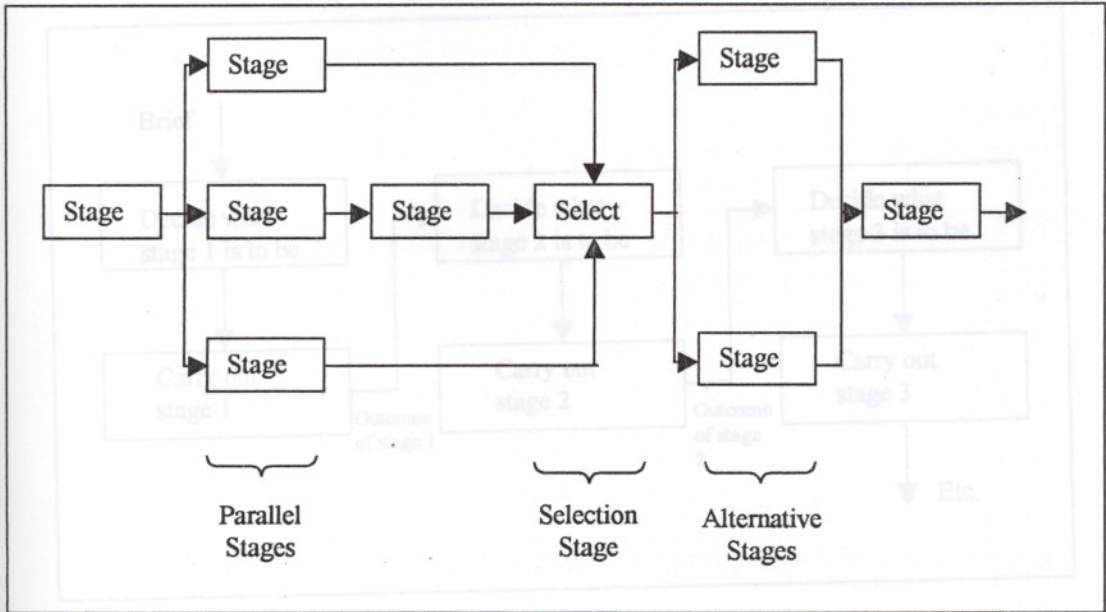
Fig. 2.3.c. Branching strategy

Adaptive Strategies, figure 2.3.d, are those in which only the first design action are decided at the start. The choice of each action thereafter is influenced by the outcome of the previous action. This is, in principle, the most intelligent strategy in that the search pattern is always being guided by the best available information. The disadvantages are that of being unable to predict or to control design cost and design time. Many people prefer to use an Adaptive Strategy because it gives full scope to the human (or animal) ability to act correctly on impulse. A reliable but modest version of adaptive search is the Incremental Strategy, Fig. 2.3.e. This conservative strategy is the basis of traditional designing, particularly in craft-based industries, and is also the basis of many procedures for automatic optimization (Wilde, 1964).

Brief

| Decide what stage 1 is to be | → | Decide what stage 2 is to be | → | Decide what stage 3 is to be |

| Carry out stage 1 | Outcome of stage 1 | Carry out stage 2 | Outcome of stage 2 | Carry out stage 3 |

Etc.
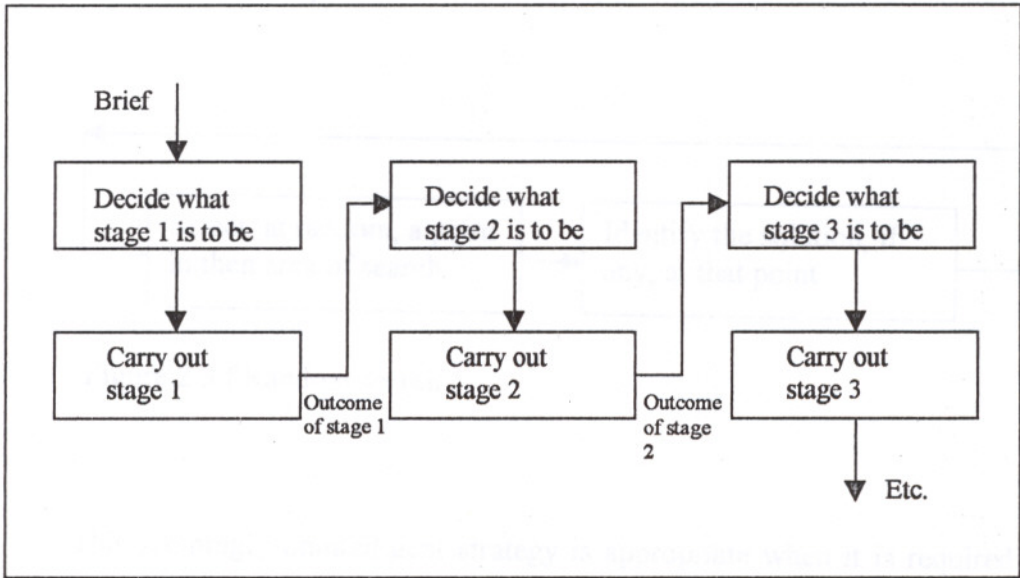
Fig. 2.3.d. Adaptive strategy

| Re-assess an existing solution | | Adjust existing solution to | outcome |

Brief →

| Explore a few minor modifications |
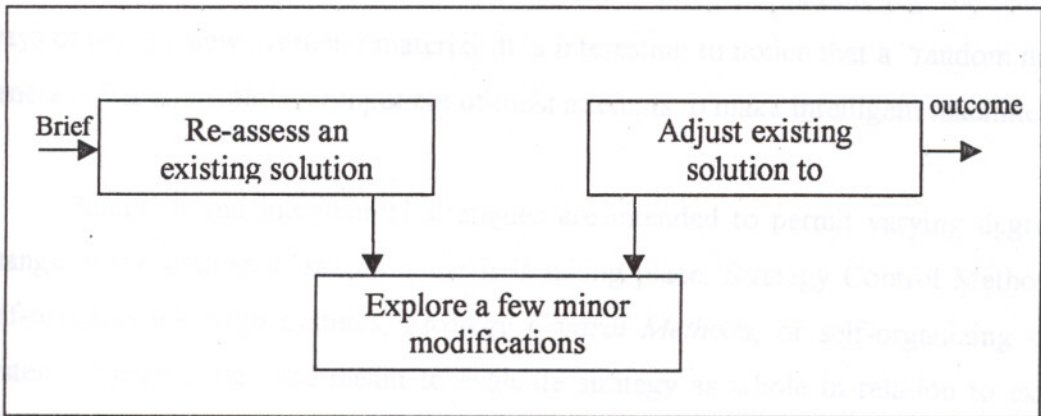
Fig. 2.3.e. Incremental strategy

96

A completely unplanned strategy, known as Random Search, figure 2.3.f., is in some cases the best policy.

```
┌──────────────────────────────────────────────────────────────┐
│◄─┐                                                             │
│  │  ┌─────────────────────────┐   ┌──────────────────────┐   │
│  └──│ Select, at random, a point│──►│ Identify the solution, if│
│     │ in then area of search   │   │ any, at that point   │
│     └─────────────────────────┘   └──────────────────────┘
```
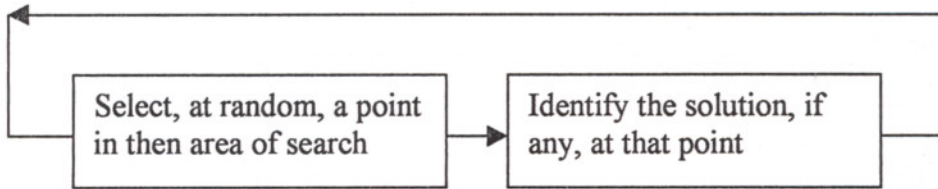
Figure 2.3.f Random search

This seemingly unintelligent strategy is appropriate when it is required to find many starting points for independent searches over a wide area of uncertainty. Each step is chosen in deliberate disregard of the outcome of the others so as to make the search as unbiased as possible. The principle of random search underlies such procedures as method 1.3.4. Brainstorming, and is applicable to novel design situations in which it is unwise to dismiss any proposed solution without further information, e.g. the search for ways of using a new synthetic material. It is interesting to notice that a "random number generator" is an essential component of most attempts to make intelligent machines.

Adaptive and incremental strategies are intended to permit varying degrees of change in the pattern of search while it is taking place. Strategy Control Methods, or self-organizing design systems, *Strategy Control Methods*, or self-organizing design systems, figure 2.3.g , are meant to evaluate strategy as whole in relation to external criteria and to the partial results of the strategy itself.
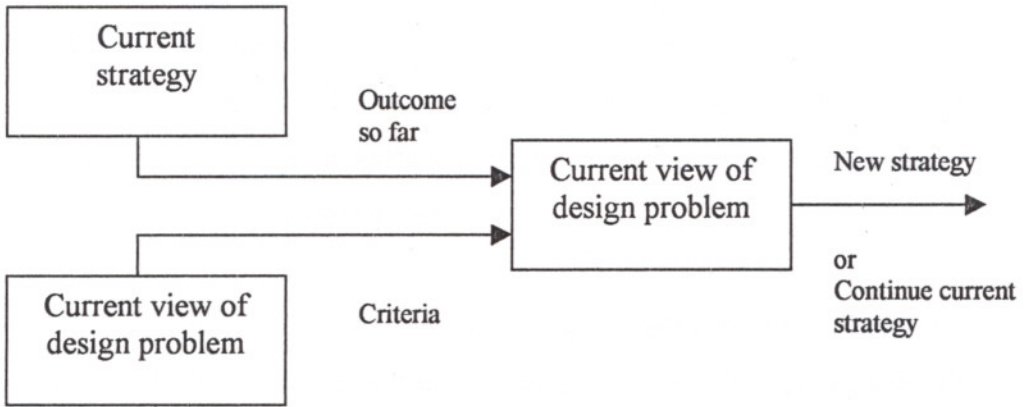
Figure 2.3.g Strategy Control

This aim is to ensure that strategies are continued, in the face of difficulties, for as long as they hold promise, but that they are altered or abandoned when they case to match the external situation.

PART 3

CASE STUDY OF A BICYCLE

3.1 Problem Statement

A great variety of bicycles are used to mobilize people. As a result of manufacturing and production processes by artisans, and small series, these vehicles are usually not so much of a comfortable design.

The Bicycle project aims at developing a new generation of mobility for the Turkish industry, which are characterized by an attractive appearance and optimal functioning. The products will be manufactured in series for an international market, but at the most to be involved in national sales. In the bicycle project, the development of mobility aids for the functions of cycling will be a dominant point in the construction of the bicycle design. The target group was mature men and women. The product is characterized by a neat-like appearance that provides the user with a comfortable ride. They will be used in and around the city for relatively short or long and bumpy distances.

Based on the information available and the choices made, a list of requirements was drawn up. The requirements have been ordered on the basis of a "process tree". In this tree the different processes in the life cycle of a product have been established on the basis of creativity, divergence transformation and convergence. The list of requirements has been formulated as operationally as possible. Besides general requirements for the series, specific requirements per product have been given in an essential way by the use of a schematic diagram in order to see the future tasks that will be done. (Figure 3.1)

Since the product aims at the global market, it must satisfy international standards and guidelines in the categories of "products for the human being". Besides general requirements already mentioned, good driving characteristics, safety and comfort are special importance for mobility aids.
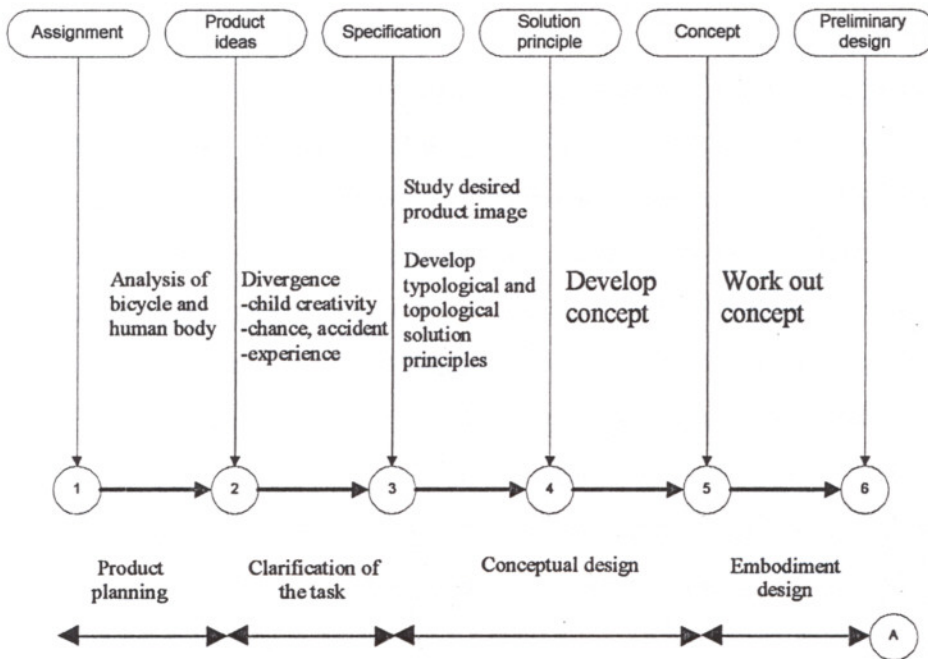
Figure 3.1 A schematic diagram of the design
process

3.2 Analysis

To determine which product series was to be developed for the function of
cycling, the needs for mobility were analyzed. Different needs arise from the
combination of mobility functions and the abilities of the human body.

3.2.1 The Human Engine

The human engine is similar to a combustion engine requiring a continuous
supply of oxygen and fuel to maintain its efficiency (Ballantine, p18). It works most
effectively when the power output and oxygen intake are balanced. Working the body
too fast causes panting; running it over-hard causes waste by- products to accumulate in
the muscles, which leads to pain and cramps.

The *arm muscles* both help to control the bike and to move the body position back and forth over the handlebars. Avoiding locking of elbows straight–bending them helps absorb any road shocks at a limit. *Back muscles, which are the back and stomach muscles,* are not directly employed in pedaling, but operate in equilibrium to keep the upper head positioned, and the chest open. Lower back muscles are not fully exercised. The thigh muscles are the largest and most powerful muscles that the cyclist utilizes. In the thigh the quads and the hams work in harmony to drive the pedals around the bike forward. As the quads are pushed down with the quads at the top of the thigh and the leg extended, the hams underneath contract to bring the leg back up to complete the circular pedaling motion. Strain can occur if unnecessary force is applied by having the saddle too high and over stretching the quads, or too low and over contracting the hams. In the lower leg, the gastrocnemius (calf muscle), is connected to the thigh bone behind the knee and the Achilles tendon above the ankle. Upper and lower leg muscles lever and pivot through the knee. Pedaling at an aerobic cadence or 80 rpm (revolutions per minute) bends and extends the knee 4,800 times an hour. Strain occurs if a knee is pulled out of its vertical plane or if the pedal twists the foot out of its natural alignment with the knee. (Figure 3.2.1)

101
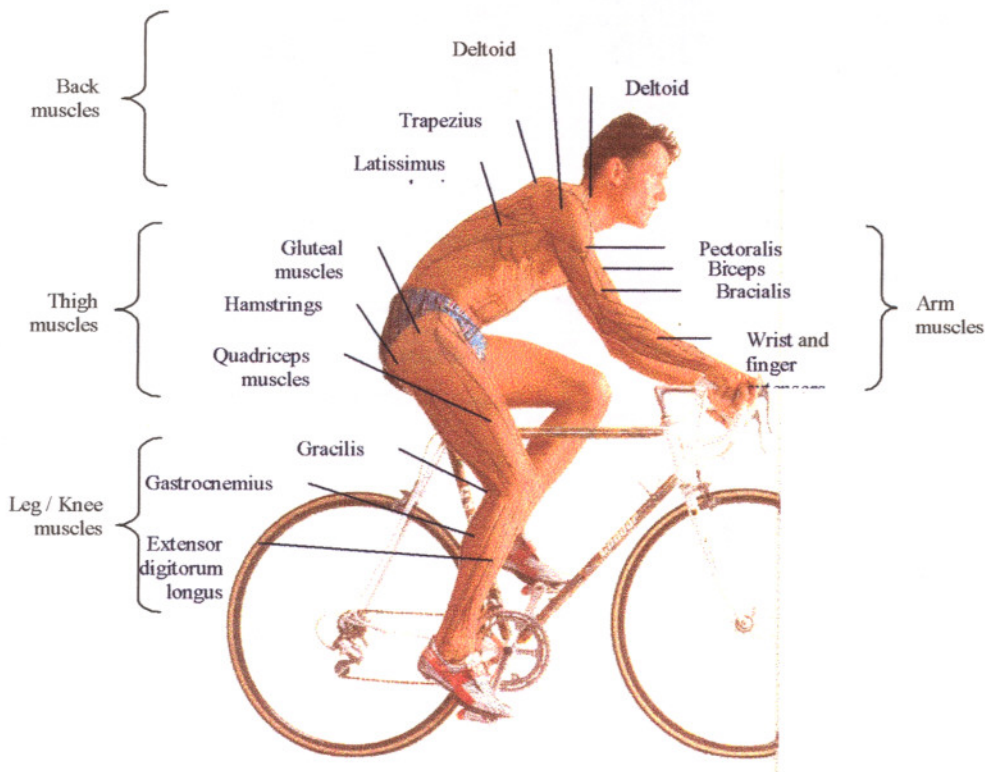
Figure 3.2.1. The human anatomy

3.2.2 Sizing

One of the most important features is how the bike fits the rider. Performance, comfort, and the risk of injury can be effected by variations, sometimes as little as 5 mm in the riding position, so it has to be meticulous about establishing the bike size and the cycling position. The method for doing this are well founded, although not infallible. Physically the human being is unique, for this adjustment should be made for oneself own physique and type of riding. (Figure 3.2.2.)

SADDLE HEIGHT: The formula for the height is;
Inseam leg length X 0.885= Distance between the top of saddle and center of bottom bracket axle.

HEAD ANGLE : This results from the frame size, seat angle, top tube length, front wheel clearance, and the quickness of steering.

SEAT POST : Exposure should be 8.9-12.7 cm for racing, 7.6-10.2 cm for touring, and 15.2-20.3 cm for mountain rides.

TOP TUBE CLEARANCE: The combined top tube and the stem length should ideally position the handlebar so that in a normal riding position the front hub axle is blocked from the view by the handlebar

CLEARANCE : Clearance between crotch and top tube of 2.5 cm on touring bikes 6 racing and 7.6 or more for mountain or hybrid bikes .

SEAT POST : These range from 68°-75° with 72°-74° most common..

Figure 3.2.2. Sizing

3.3. Design Specifications

Based on the information available and the choices made, a list of requirements was drawn up. The requirements have been ordered on the basis of a "process tree". In this tree the different processes in the life cycle of the product have been established on the basis of the main processes of production, distribution, use by riders, and disposal. The list of requirements has been formulated as operationally as possible. Besides general requirements for the series, specific requirements per product have been given.

Since the product aims at the global market it must satisfy international standards and guidelines in the categories of "products for the adult user aimed to be produced by the Turkish industry". Besides the characteristics already mentioned, good driving characteristics, safety and comfort are of special importance for mobility aids. It was decided to attune the necessary investment and manufacturing techniques to a total series of 5000 pieces.

Furthermore, the product must of course meet a number of objectives which apply to every product such as, "standardization of parts and materials" and "minimal dimensions at transportation"

3.4. Imaging

The product series must be attuned in major to the Turkish users but also including international riders since exporting the goods still gives an importance. To gain a better insight into what this actually means, literature on "bicycles" was studied and semantic features of bicycles were analyzed. For adults the phrase was to include each age-group of teen-agers. Semantic features with regard to form, color, and tactile characteristics of bicycles were related to the riders concept of looking upon the word bicycle.

3.5. Conceptual Design

In generating concepts, use has been made of a method developed. The core of this method is that a number of different abstraction levels is passed through systematically, during which on each level as many alternative design proposals as possible are generated.

To be able to work in the proper proportions of adult's body measurements, and to gain a good image of the combination of user and product, all positions are visualized with the help of standards[8].

Although the entire product series has been elaborated into concepts, only the further development of the "standard use" of a cyclist will be described[9].

First, solutions were generated in which only the place of the different "elements" varied in respect to each other. The elements are the supporting surfaces and different types of wheels also including different types of frame structures and different combinations were done. On the basis of the product image and functional aims, such as maneuverability, stability and drive, a configuration with a choice between an amorph type of bicycle or a mostly industrial type (that could be manufactured at minimal cost). The combination may also be diverged to a design with use of a shock absorber or even it would be able to play with the general structure of the sitting culture. The concept was to change the sitting position of the regular bicycle to a position of the recumbent bicycle.

This so-called "topological" solution principle then functioned as "carrier" for the development of different "types" of solutions. As many solutions as possible were generated with the help of sketches. Three solution types could be distinguished:

Henry Dreyfuss Association

Richard's Ultimate Bicycle Book

"amorph construction", "tube-like construction", and "shock-absorbing construction" (Figure 3.5).
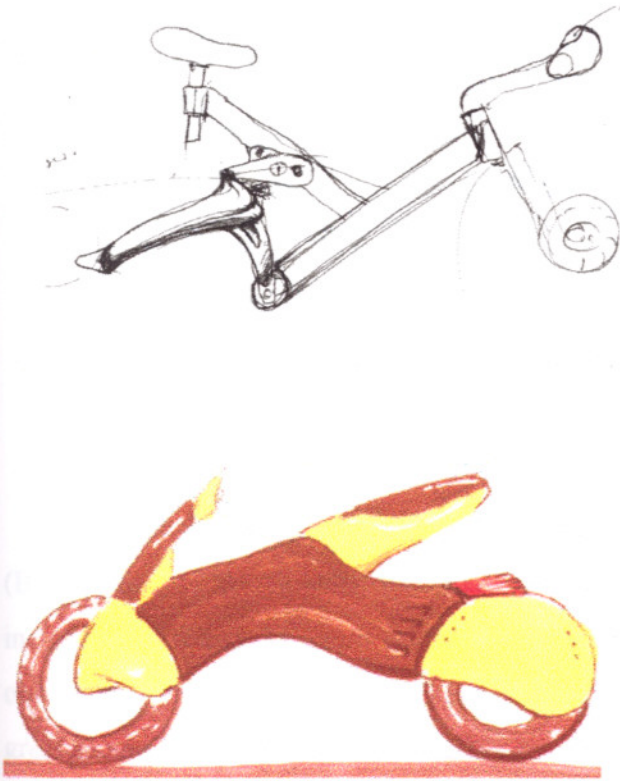
Figure 3.5 "amorph construction" &
        "shock- absorbing construction"

These solution types are not only concepts, but images of possible design directions. The visual image of the product is especially important in this phase. Solution types, however, should be realistic in a technical sense too.

İZMIR YUKSEK TEKNOLOJI ENSTITÜSÜ

The design that was approached was a "bicycle" but it was right to take the design concept not only as a two wheel convenient but much to be a design of a two wheel human-powered vehicle. Therefore at this phase (creativity block) it was thought to change (provocation) the sitting position to a position of a human sitting in an automobile (Figure 3.5.b). This position would be more comfortable than regular sitting positions. The name for this sort of bicycle is "recumbent".

Figure 3.5.b Change of regular sitting position

Human-powered vehicle (HPV) designs vary according to function and purpose (Ballantine, p128). A cyclist who averages 30 km/h on a conventional racing bike will increase to around 35 km/h in this type of design. The designs embrace a range of objectives: greater speed, better handling, more powerful braking, larger cargo space, greater comfort and safety, and weather protection. The design varies, but improving the performance by reducing aerodynamic drag is usually paramount. At 32 km/h, a conventional bicycle and rider displace some 1,000 lb. of air a minute, work which accounts for about 85 % of a rider's energy output. Most HPVs are recumbents, for their smaller frontal area reduces drag by about 25 %.

A recumbent is easier to fit with a full-length fairing that smoothes air flow and can cut drag by up to 80%. Maintaining 32 km/h on conventional bike requires a strong rider capable of steady ¼ horsepower output; on a street HPV with a body shell, half the effort, 1/8 horsepower, is needed. Recumbent also score on concerning powerful

braking because of better weight distribution and/or a lower center of gravity. The net effect inspires confidence, and results in better riding.

The concept to be used was decided with the help of the research on primary school students. One primary school student (child creativity) came out with an idea of a bicycle looking like a limousine (Figure 1.2.1)
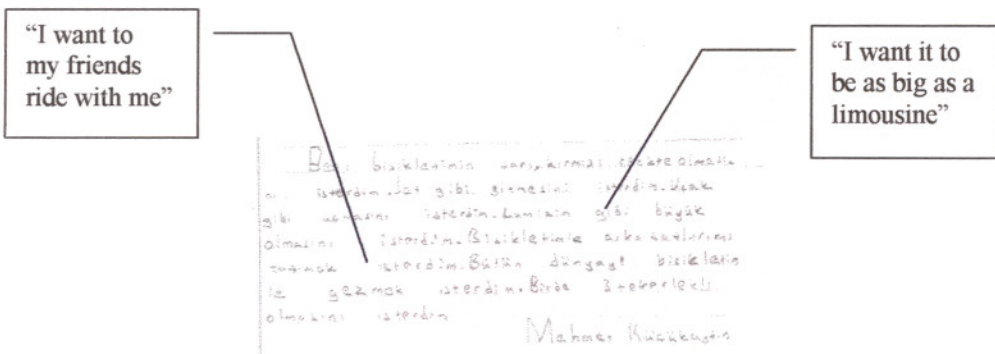
Figure 3.5.c Concept of a child

Out of a variety of models and sketches (figure 3.5.d) the project began to get its final shape and came to a solution of a design .

Figure 3.5.d Ideas of a recumbent

107
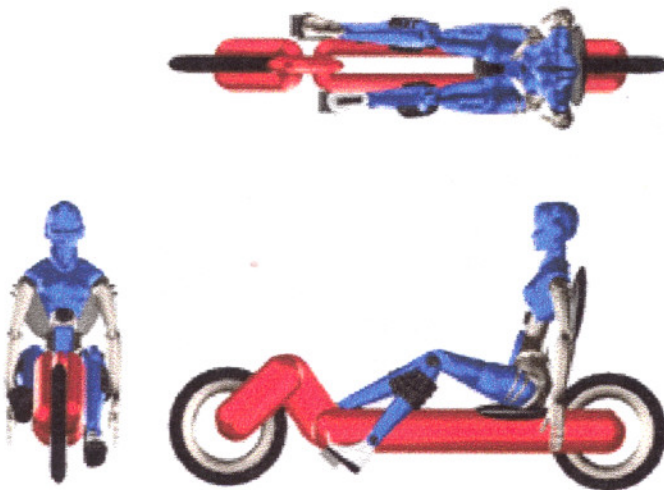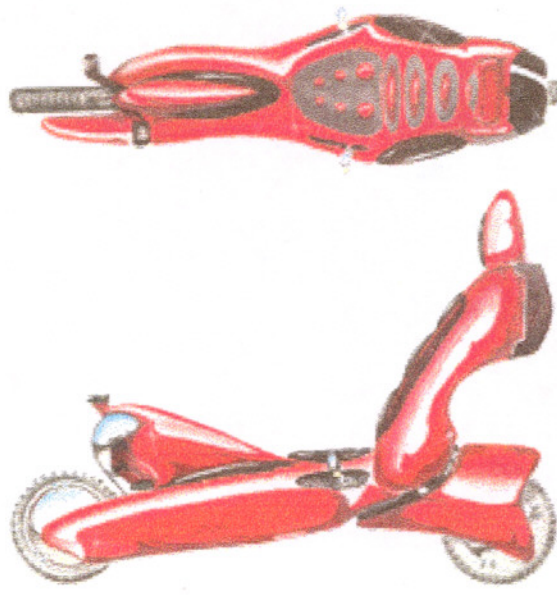
Figure 3.5.d Ideas of a recumbent

Figure 3.5.d Ideas of a rcecumbent
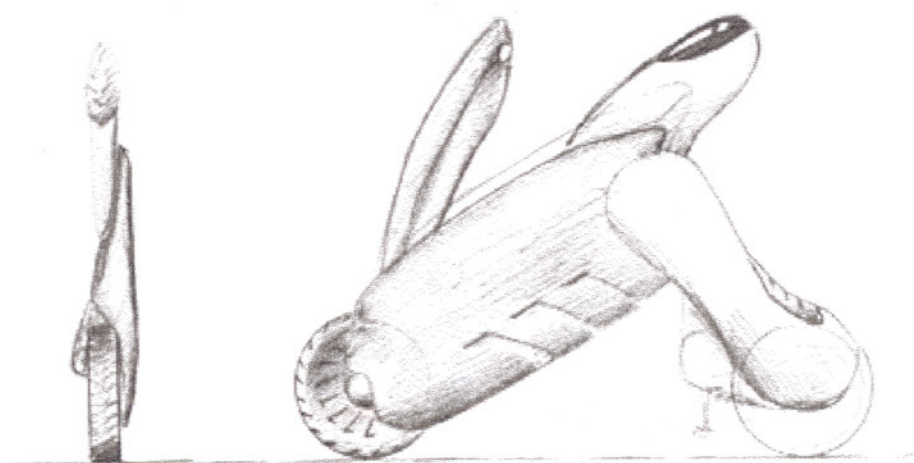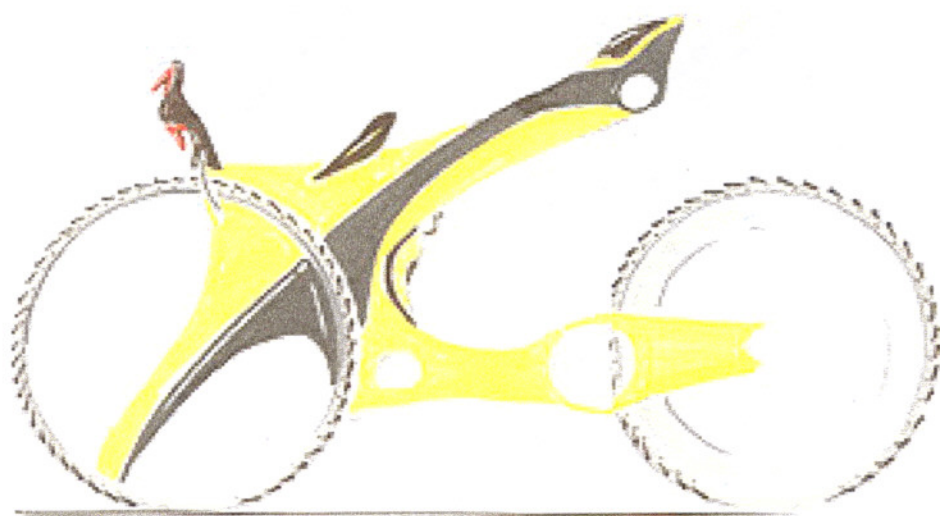
Figure 3.5.d Ideas of a alternative bicycles
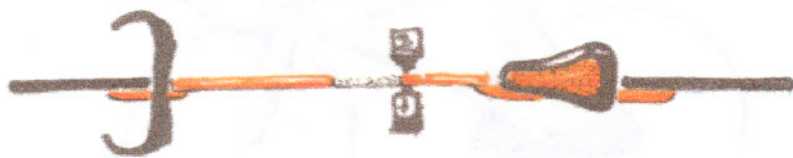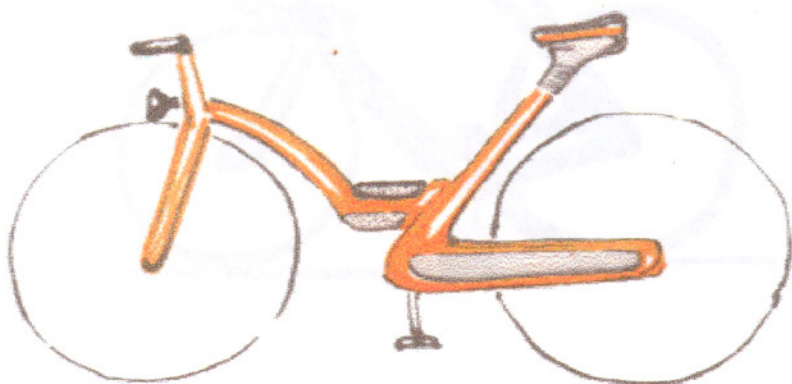
Figure 3.5.d Ideas of a alternative bicycles
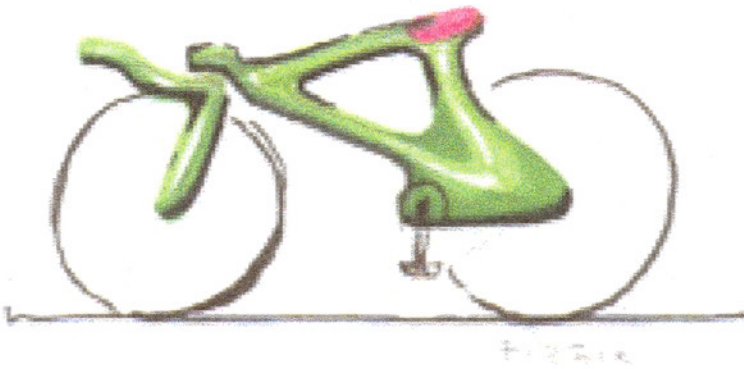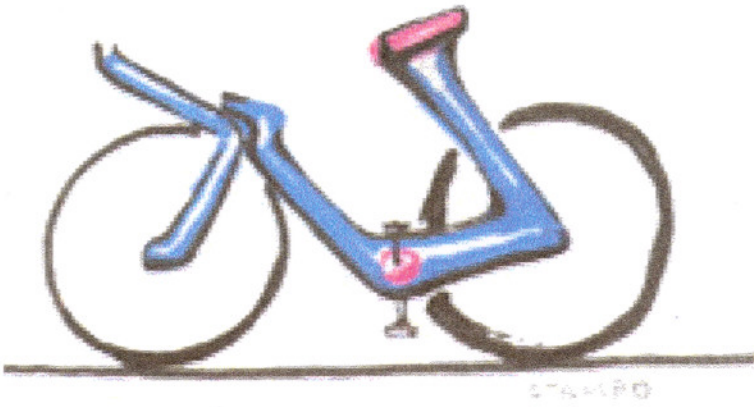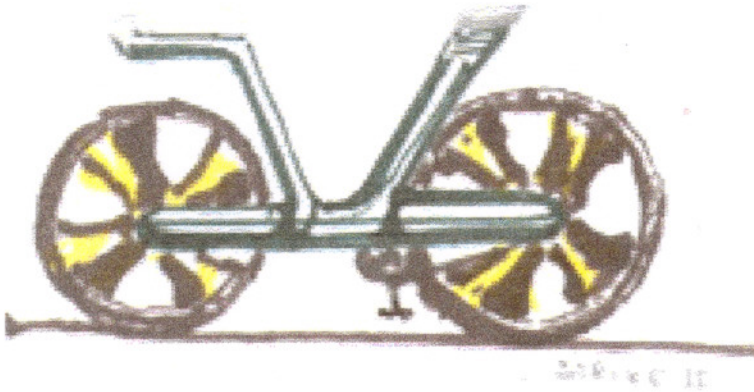
Figure 3.5.d Ideas of a alternative bicycles
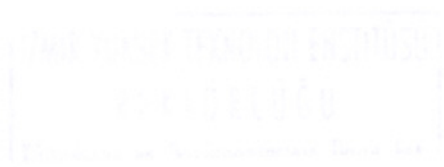
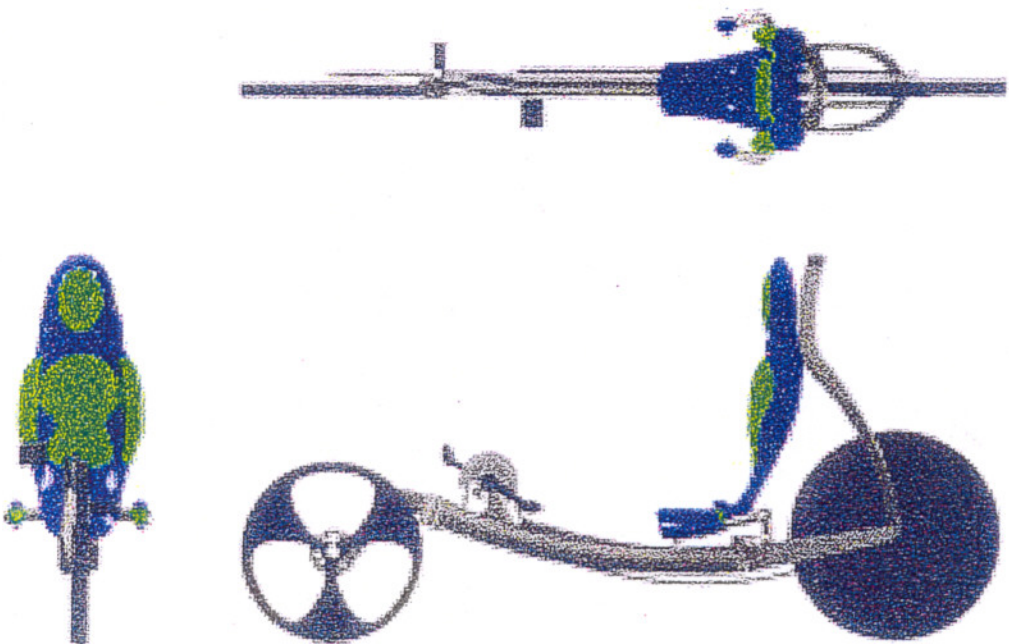Below the final structure of the bicycle is included (Figure 3.5.e).
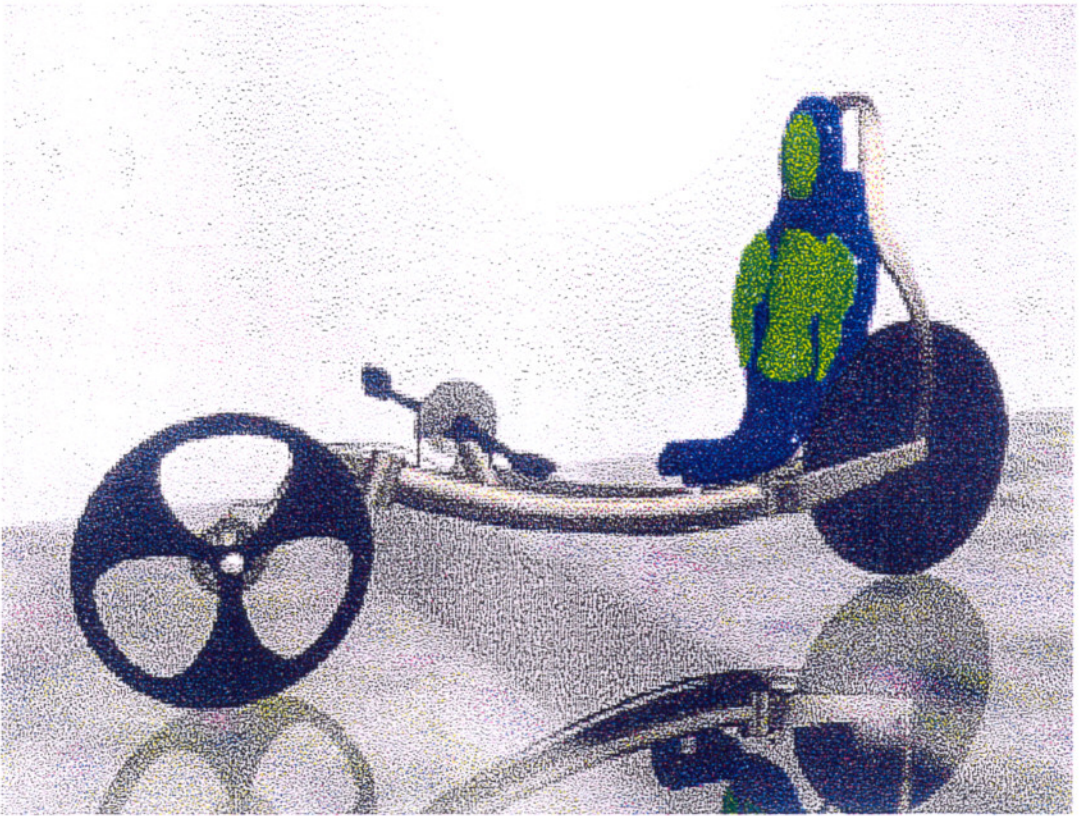
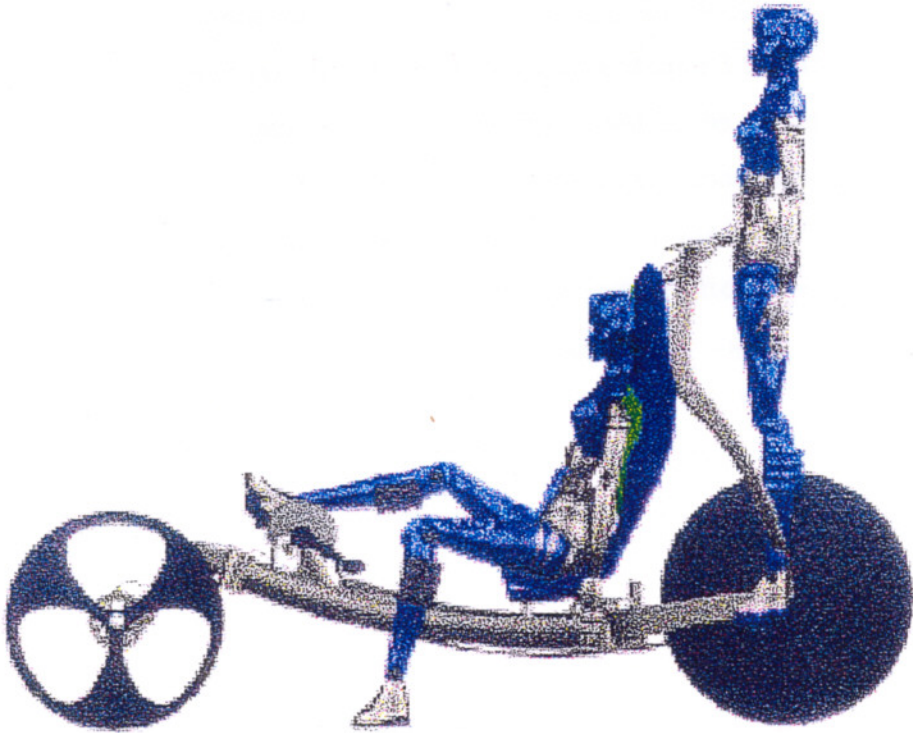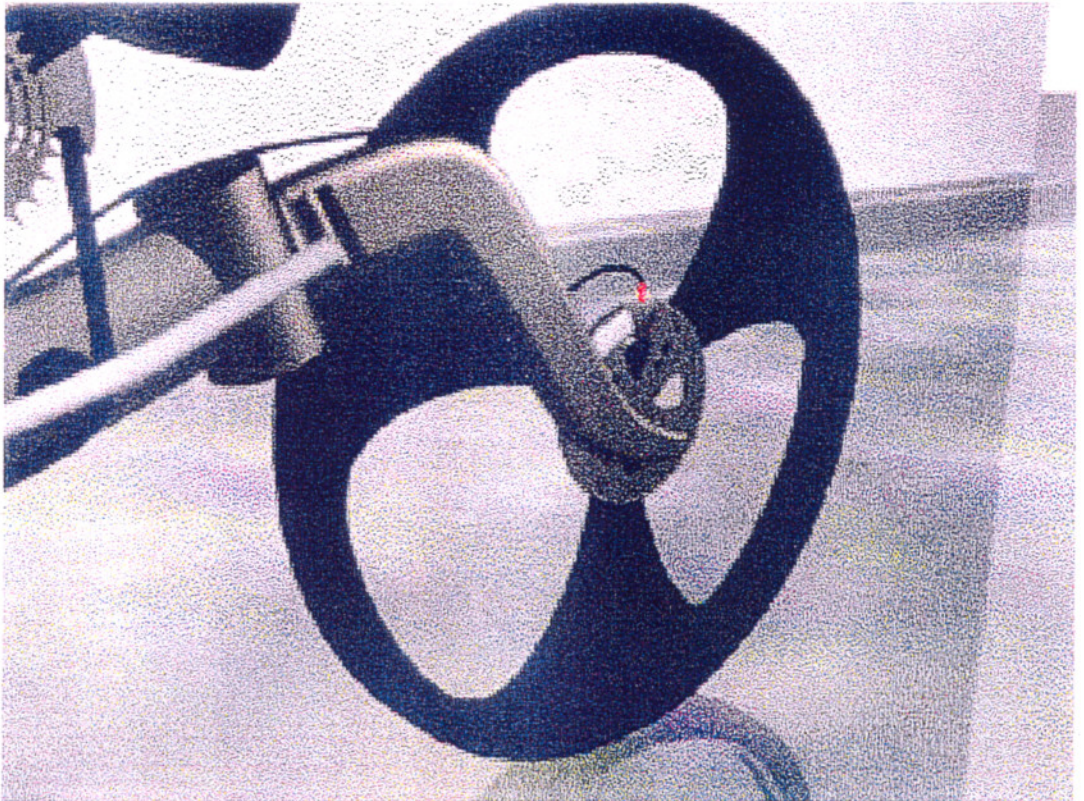Figure 3.5.e Final Structure of the Design

Figure 3.5.e Final Structure of the Design

The projects idea was to have the rider (cyclist) in such position that it would be more comfortable than the regular cyclist position. In the above (figure 3.5.d) there are certain pre-works on the bicycle. These designs have been used to be a step for the final structure. The first designs had problems like, cost, assembly, manufacturing etc. were bused to get more of the design. It was changed with the use of low cost material structure. The bar that is in the middle could be manufactured from both an aluminum or iron material. The structure is open for both materials. Mounting the components one to one is easy like and done with respect to the regular bicycle. Other elements have been included, like the baggage, and a spare component that could be used to mount on the bicycle for other friends of the owner to ride with the cyclist. So this might be an advantage for a two-rider cycling.

They are then placed in a jig which holds them at the correct angle. Then the joints are connected by TIG welding, fillet brazing, or lugs.

Because the tubes move slightly during welding, the frame isn't constructed all in one step. Here you see the front part of a frame (Top tube, Head tube, Down tube). By relieving any tension which would be formed by this movement, the frame will not crack years later.
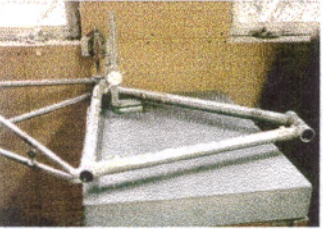
This is the main triangle of a bicycle. At this point, it is aligned to .003" to .000". A very true frame rides like no other. Truing at this point without chain stays and seat stays allows the seat tube to be moved side to side without putting stress on the seat stays. The center line of all the tubes is aligned with the drive side face of the bottom bracket. Notice the long head tube: This is so an accurate reading can be made if the bicycle is very small.

At this point the rear triangle is assembled and aligned to the main triangle. Brazons are installed and headset reinforcing collars are silver soldered on to the head tube.

The last of the many alignment checks is done before painting.

The finished frame set with carbon fork and Chris King headset. The frame is finished in the customer's choice of Dupont Imron.
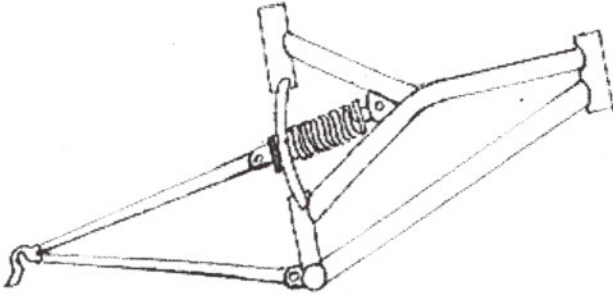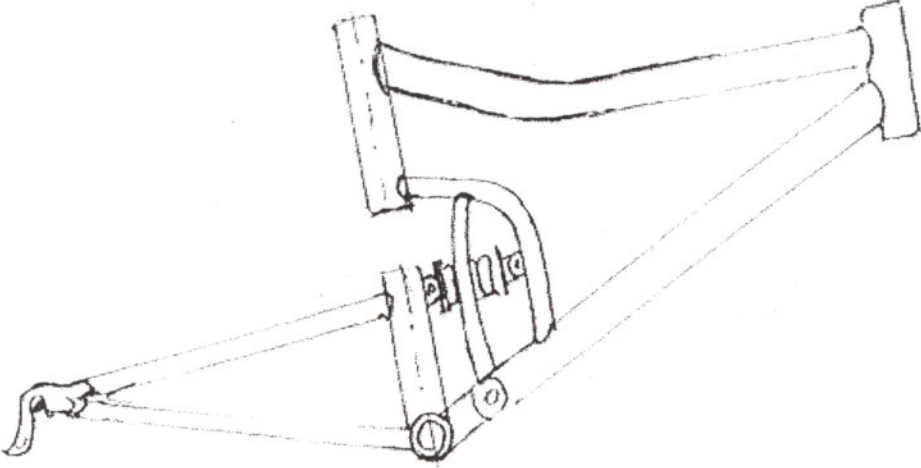

The bare frame is coated with a rust inhibitor, premiered with an epoxy paint, sanded, color coated, baked, decals attached, and clear coated three times over the decals and once over the entire frame set. Then it is baked again. The last step is an internal rust proofing.

116

The finished frame set with carbon fork and Chris King headset. The frame is finished in the customer's choice of Dupont Imron.

The bare frame is coated with a rust inhibitor, premiered with an epoxy paint, sanded, color coated, baked, decals attached, and clear coated three times over the decals and once over the entire frame set. Then it is baked again. The last step is an internal rust proofing.
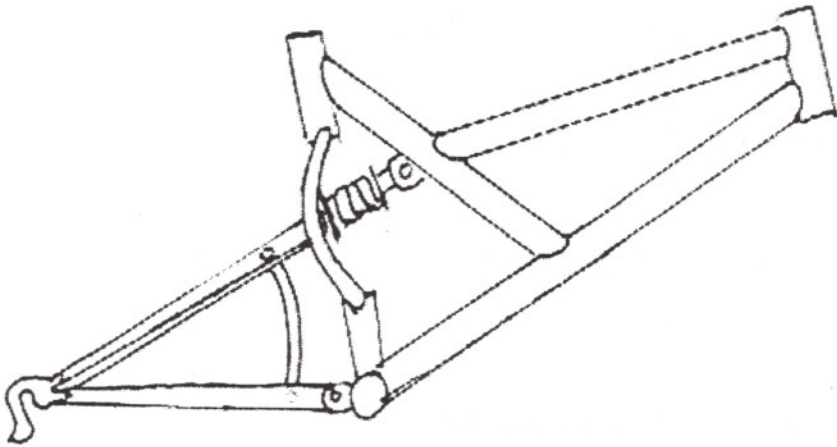
APPENDIX B

Bisikletin üretimi sırasında değişik bölgede tüm ihtiyaçlarını
tanışabileceği şekilde yardımcı düzeneklerin yerleştirilmesi gerekir. Hydrokt.
ma sistemi çok iyi olmalı ve nokarla tahrik edilebilen bir çekiş
sistemi üzerinde yer almalısın düşündüm. Kısaca Tikray bisikleti

Büyük ve küçük yaştaki iki insanın kullanabileceği (bozbe:) bir model. Uzun bir yolda dengelemeyi sağlamak için yanlarda süspansiyonlu destek tekerleği yer almalı ve yük taşıma kapasitesi arttırılacak bir düzenek ve bisikletin hareketini sağlayacak elektrik motoru (ilave) takılabilir.

REFERENCES:

Dictionaries

[1]   Merriam-Webster, Incorporated

[2]   Oxford Advanced Dictionary, Oxford Press, 1978

[3]   Heritage Illustrated Dictionary

[4]   English-Turkish Dictionary of Terms Fono, 1995

Books:

[1]   Amabile T. , The Social Psychology of Creativity, Springer Verlag, New York, 1983

[2]   Archer L. Bruce, Systematic Methods for Designers, Thesis, London (Royal College of Art), 1965

[3]   Asimov M., Introduction to Design, New York, Prentice Hall, 1962

[4]   Beer, S., 1966, Decision and Control,, London, John Wiley and Sons, 1966

[5]   Bernard Seidenberg, Alvin Snadowsky, "An Introduction to Psychology" *Social Psychology,* The Free Press, 1986

[6]   Deci E. L. Intrinsic Motivation, Plenium Publishing Corp, New York, 1975

[7]   Donnelly, Gibson, Ivanevich, *Fundamentals of management.* BPI-IRWIN, 1990, seventh edition

[8]   Edward de Bono, "using the power of lateral thinking to create new ideas," *Serious creativity,* HarperCollins, 1993, c1992

[9]   Edward Shingley J., Charles R. Mischke, *Mechanical Engineering Design*, McGrawHill, 1989, seventh edition

[10]   Ekvall G., Creative Climate for the management of ideas, New York, 1991

[11]   Janis I.L. & Katz D. The reduction of inter-group hostility, Research Problems and Hypothesis, Conflict Resolution, 1959.

[12]   John Chris Jones, "How it could be", *Design Methods*, Van Nostran Reinhold, 1992, second edition.

[13]   Linda Schiffer October 1996 http://www.ozemail.com.au/~caveman/Creative/

[14]   Lionel Bender, Dorling Kindersley, *İcatlar*, Sabah Kitapları, 1997

[15]   Manheim M., Problem Solving Processes in Planning and Design, Professional Paper (Department of Civil Engineering, MIT)

[16]   Marjorie Elliot Bevlin, "An introduction to art and design" *Design Through Discovery*, Harcourt Brace College Publishers, 1993, sixth edition.

[17]   Osborn A.F., Applied Imagination, New York, Scribner's, 1957

[18]   Richard Ballantine, Richard Grant, *Richard's Ultimate Bicycle Book*, Italy : Dorling Gatward, 1995

[19]   Roozenberg N.F.M., J. Eekels, "Fundamentals and Methods of product design", *Product Design*, Wiley Publishers, 1991

[20]   Ronald E. Smith, Irwin G. Sarason, Barbara R. Sarason *"The frontiers of behavior"*. *Psychology*, Harper & Row Publishers, 1978

[21]   Semler R. Maverick Arrow, 1993

[22]   Slater P.E. Contrasting Correlates of group siz, Sociometry, 1970

[23]   Steiner I.,Group process and productivity, New York, Macmillan 1972

[24]   Taylor D.W., Berry P.C., and Block C., Does group participation when using brainstorming facilitate or inhibit creative thinking?, Administrative Science Quarterly,1958

[25]   Victor Papanek, "Creativity v. Conformity", *Design for the Real World*, Thames and Hudson, 1972

[26]   Weisburg R., Creativity, genius and other myths, Freeman, New York 1986

[27]   Wilde D. J., Optimum Seeking Methods, Englewood Cliffs, Prentice Hall, 1964

Periodical Articles:

[1]   "Das Mountain Bike Magazin", *Bike* 9/93 september, Das Mountain Bike Magazin 8/94 august.

[2]   "The interdisciplinary journal of design and contextual studies", *Co-Design*, 10.11.12 / 1994.

[3]   "How Kids Draw; From Scribbles to Art", *Psychology Today*, August, 1986

[4]   Lamm H. and Trommsdorff G, Group Versus individual Performance on Tasks Requiring Ideational Proficiency (brainstorming): A Review, European Journal of Social Psychology, 1973

[5]   Bouchard, T. J., Personality, problem solving procedure, and performance in small groups, Journal of Applied Psychology, 1969

[6]   Collaros & Anderson, Effects of perceived expertness of creativity on members of brainstorming groups, Journal of Applied Psychology, 1969

[7]   Wicher A.W. Attitudes vs. Actions, The relationship of verbal to overt behavioural responses tp attitude objects, Journal of Social Issues, 1969