Trabajo Fin de Grado

Study about the relation between different design methodologies

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Study about the relation between different design methodologies

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Abstract

Nowadays when a person starts to develop a design project, it is necessary facing the situation of following a methodology. Then the problem arises, which one must be chosen? Current design students are bombarded with a lot of different methodologies from different authors, but they are responsible for choosing the one that they consider more proper. This could be solved by collecting some methodologies and divide them into categories so that it would be easier to check them and select one.

Thus, the aim of this thesis is to establish specific methodologies to apply when developing a design project so that the designer (or the person who is carrying out this action) saves time and has the security that every important step is done.

Through this thesis we have had to deal with several problems that we had to solve. The main one was collecting, analysing and summarising all the methodologies that we had chosen in order to create our results. This was a hard stage due to the huge amount of information that we counted with and also because of how different some of the methodologies were, being difficult to establish a connection between them.

When we proposed this thesis topic we already had an idea about some of the methodologies we wanted to analyse. Besides, our supervisor suggested us to include some that according to him would make our perspective wider. We started by reading, summarising and analysing these methodologies. Once we counted with this data it was necessary to extract the points that we needed to proceed with our results. We made this by creating a template. This template allowed us to analyse the points that we were most interested in like the main focus of the methodology, the inputs needed... After this, we made some tables comparing the methodologies, these tables helped us a lot when developing our results because they offered quick , short and specific information about everything that we had analysed.

Thanks to our experience we selected the main and most common kind of design projects depending on the inputs which are provided, either from a professional or academic source. This was the starting point of our results because we based them on the different kind of projects that we explained. Thanks to the templates and the tables we created a different methodology for each kind of design project. We translated each methodology into a diagram and an explanation to better understand it.

Once having all the methodologies we “developed” a project for each of them, taking these processes as examples to certainly prove that the methodologies were correct and made sense. These examples allowed us to make the last changes that we considered necessary to improve the final diagrams that we offer.

Acknowledgements

This thesis is for us the end of our studies at our home university in Zaragoza, Spain, of the four years bachelor “Engineering in industrial design and product development”; and also it is the end of our year spent at Mälardalen University, Sweden, as exchange students.

We have specially to thank Ragnar Tengstrand, from the Division of Product Realisation, who has enormously helped us through these four months to develop this thesis work.

Thanks also to every professor that we have had at our home university in Spain during our years of studies because thanks to them we currently count with the knowledge that we have used during this thesis.

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1 Introduction

Study and comparative between some design methodologies from different authors in order to describe the most accurate one depending on the kind of the design project to develop.

We decided to focus our thesis work on the design methodology field because during our bachelor s years we have seen a lot of design students, including ourselves, discussing about the best methodology to follow in order to carry out with their projects. Nowadays, there are several methodologies from different authors and of course those which are given out during the lectures. These methodologies differ between them so that it is very difficult to choose one which fits with the project we are dealing with. By this token, we have chosen to study this topic by analysing different methodologies in order to create some guide steps to make the choosing process easier and faster, obtaining the best results.

The first important step during a project is choosing the correct methodology according to its requirements and characteristics. Depending on the methodology we chose the results might hugely vary in relation to the aspects which are the most relevant ones. That is why it is so important to develop this study.

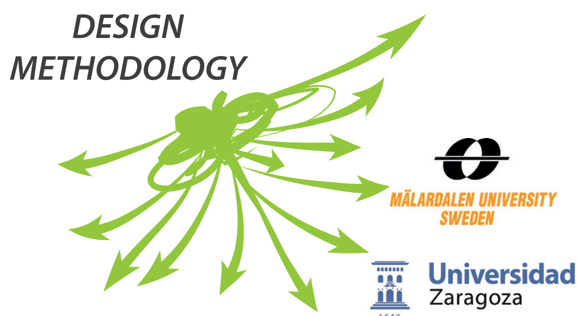
For instance, if we are asked to design a plastic toy we could take different design directions. One option could be only and exclusively focused on the material and its properties in order to obtain a toy with great physical characteristics and perfectly optimized. Other option could be studying the user and their interaction with the product; then we would obtain a toy with interesting pedagogical elements. As this example shows: one requirement (plastic toy), two possible methods (based on material and based on user) and two different results.

- Which of the previous methods would be the good one?
- How much should we use one or another?
- How should we combine the different methodologies depending on the project?

These are some of the questions that we will try to solve with this study.

1.1. Background

This thesis work has been performed at Mälardalen University at the department of Innovation, Design and Technology (IDT), Eskilstuna, Sweden. We belong to Zaragoza University, Spain, so that we have developed this work concurrently under Spanish and Swedish supervisors.
Due to the fact that we have been taking design courses in both universities, we have realised how different working ways they have and that is why we can now compare them. We have widely discussed which is the best methodology to work and carry out a project without agreement. By this token we thought it would be interesting to study more deeply this topic.



1.2. Concept of methodology

We are going to deal with different methodologies through this thesis work and we want to make it clear what it is.
A methodology is usually a guideline system for solving a problem, with specific components such as phases, tasks, methods, techniques and tools. It can be defined also as follows:
"the analysis of the principles of methods, rules, and postulates employed by a discipline"
"the systematic study of methods that are, can be, or have been applied within a discipline"
"the study or description of methods".

Methodology usually means how you are going to do something.

Design methodology refers to the development of a system or method for an unique situation by establishing a framework or steps to follow. The key to design a methodology is finding the best solution for each design situation.

2 Aim of project

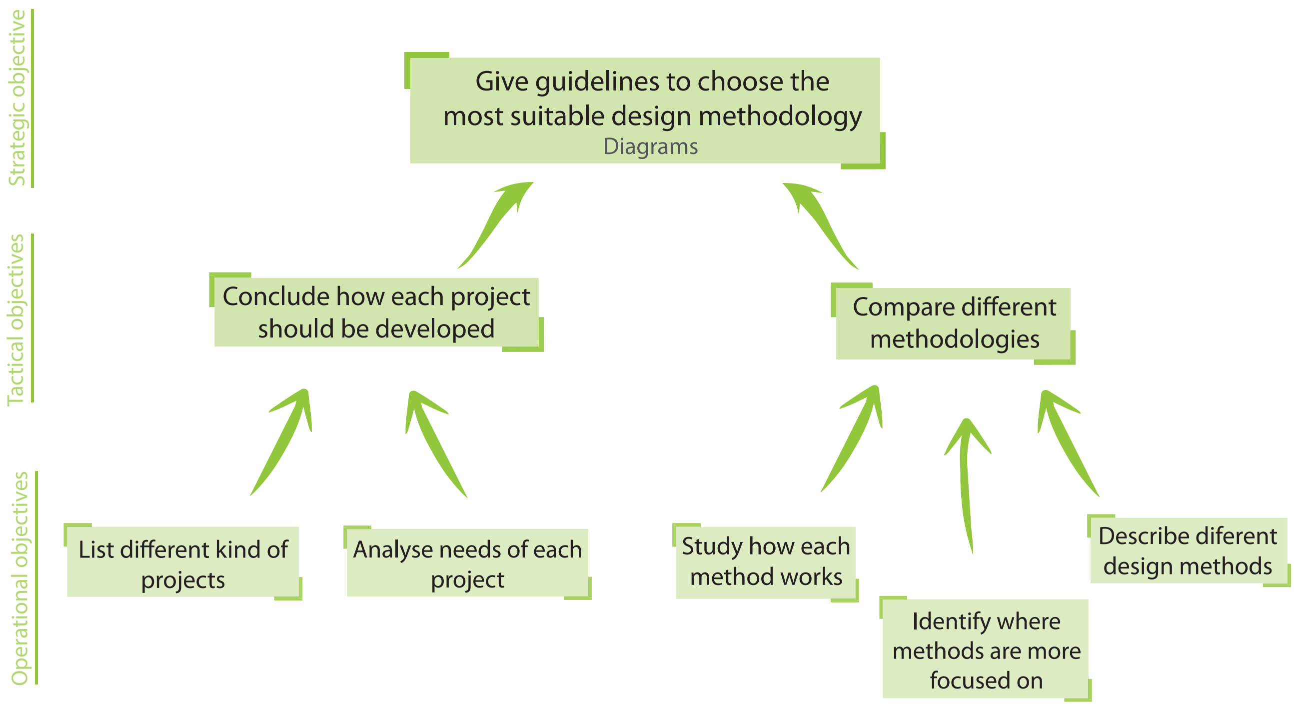
The aim of this thesis work is to give the guidelines to choose the most suitable methodology for each kind of design project, by giving a diagram which explains how to act when we face them.

In order to achieve the previous statement it is necessary to get some objectives before. We have classified them in different levels according to the importance that they have, being necessary to achieve the ones in the lowest level to reach the highest ones.

We would like to describe and classify the methods in a way that makes it easier for designers to find a method that suits a particular design situation.

As explained before, there are several kind of projects depending on the initial guidelines given to the designer. After studying these different projects we will use them to base our results on.

The results that we expect are some **diagrams**. Each diagram will explain the different guidelines that we would recommend to follow in each situation. Therefore, we will obtain one diagram for each kind of design project. The diagrams will differ between them because they will be focused in different sections depending on the project requirements. Besides, we guess that they will not be linear, they will probably have some feedback steps instead. Furthermore, we also expect to be able to create an extra **compilation** of our results so they can be used by everyone to develop a design project.



3 Project directives

The next directives are the main stages we are going to follow through this thesis work and all of them have been supervised and approved by the commissioner at MDH.

- Establish a planning
- Choose the lectures.
- Reading: analysis, conclusions and product examples.
- Add a global view.
- List and explain different types of projects.
- Provide the guidelines.
- Write up a personal view.
- Presentation of the project at Mälardalen University.

The thesis project covers 30 ECTS from the course which is called "Master thesis" code KPP305. This means 25 working hours per credit, 750 hours in total since this project is initiated (6th week) till it is finished (24th week).

The project will result in a report which will deeply and carefully describe the whole research process as well as some examples to make it easier to understand. There will also be all the necessary appendices as well as a list of the main information resources.

4 Problem statement

There are several methodologies which differ between them so that it is very complicated to choose one which fits the project a designer is dealing with.

As explained previously, this project is initiated due to the need of creating some guidelines in order to choose the most suitable methodology for each kind of design project. As far as we are concerned, there are several methodologies and authors recommendations related to design methodologies but what we miss are some standard and general guidelines to follow in order to obtain the best result depending on the kind of project we are developing.

In order to achieve that we will review some methodologies and we will analyse them. In the end, we will be able to answer the questions below:

1. How can a methodology affect to the result of a design project?
2. How should a methodology be chosen?
3. Which are the main differences between design methodologies?
4. How do the different kind of design projects differ between them?
5. Which methodology is the most suitable for each kind of project and why?

5 Project limitations

From our point of view this is a kind of thesis that we could extend as much as we wanted. There are a lot of design methodologies from different authors that we could study. However, we are constrained by time so we will follow an accurate methodology settled thanks to an initial planning.

Firstly, we will read, study and analyse different methodologies written by different authors. After that we will study different kind of projects in order to base on them our results. Finally, we will make a relation between the conclusions obtained in our study and the projects. Thus, we will create some diagrams where we will recommend some guidelines to act in each kind of situation.

We will reinforce our results by adding some examples in each situation in order to confirm that our conclusions have been the right ones through the study. The examples will consist in a design product process and they will be given once we have the final diagrams in order to prove them.

6 Theoretical background

The methodology and the procedure that we have followed through this thesis work is explained below.

The procedure that we have followed can be seen in the list below:
1st: **Book selection**
2nd: **Study and analyse**
3rd: **Project selection**
4th: **Templates**
5th: **Conclusions**
6th: **Results**

1st: **Book selection**

First the more interesting books and authors are selected. The selection is based according to the field that they covered, trying to cover as much as possible. We chose them taking into account some recommendations through our studies and also from our thesis supervisor. The main fields in which they can be classified are:
· Concurrent methodology
· Stage gate system methodology
· Particular methodologies

2nd: **Study and analyse**

The selected books are read and analysed to obtain some conclusions later on.

3rd: **Project selection**

The different kinds of projects that we want to base our work on are identified. This is an important step because this decision is going to directly affect the results. This identification is made according to a inputs criteria and also to our own previous experience when facing a product design project.

4th: **Templates**

We create a template in order to have a general viewpoint about what has been studied. By using this templates (shown later) it is possible to compare every single methodology. The templates check the main points of the methodologies and the most useful ones in order to obtain the results. Anyway, their structure is explained in the Templates point. These templates are created because it is considered that they are the best method in order to analyse the methodologies and obtain the desired information.

5th: **Conclusions**

Thanks to the templates some conclusions are obtained. This conclusions are deeply explained in Empirical findings point. These conclusions are the first step in order to start developing the final results.

6th: **Results**

We obtain twelve different diagrams with their corresponding explanation and examples in the thesis. Furthermore, these results are all gathered into a guide which plans to be used as help for the student/designer when starting a product design project. The complete results are completely explained in the results point later on.

We will base our results in some methodologies by some authors, so these methodologies constitute the theoretical background of our thesis.

In this section we will explain the main points of the methodologies author by author.

6.1. Zaragoza University (EINA)

In this point we will resume all the methodologies which have been showed to us during our bachelor's lectures and seminars. They belong to different well known authors and also to our professors at university. Most of them go with a diagram which helps us to understand better the methodology.

Cartesian method 1637

"I think therefore I am"

René Descartes, the originator of Cartesian doubt, put all beliefs, ideas, thoughts, and matter in doubt. He showed that his grounds, or reasoning, for any knowledge could just as well be false. Sensory experience, the primary mode of knowledge, is often erroneous and therefore must be doubted. For instance, what one is seeing may very well be a hallucination. There is nothing that proves it cannot be. In short, if there is any way a belief can be disproved, then its grounds are insufficient. From this, Descartes proposed two arguments, the dream and the demon

It is based on complexity reduction:

- Not accept anything which has not been proved previously, avoiding prejudges.
- Divide the problem in as much parts as possible.
- Order our thoughts, trying to solve what we best know at first, and the most complicated problems after that.
- List everything often to avoid forgetting anything.

To apply at: any kind of project, problem or situation to solve. It is used as a basic model to solve creativity problems.

Morriz Asimow 1962

1. Analysis
2. Synthesis
3. Evaluation
4. Decision
5. Optimization
6. Review
7. Implementation

To apply at: projects based on collecting information and on using this information to make decisions.

Archer's model 1963 (Leonard Bruce Archer)

Analytical stage

1. Planning: establish how we are going to act through the project.
2. Search of information: collect, clarify and store all the necessary data to start with the project.
3. Analysis: identify problems and priorities thanks to the collected information. Define the design requirements.

Creative stage

4. Synthesis: develop conceptual proposals which solve the problems which have been found.
5. Development: develop the design deeply and with detail. Check it and validate it.

Action stage

6. Communication: prepare all the documents needed to complete the manufacturing process.
7. Solution.

Hans Gugelot

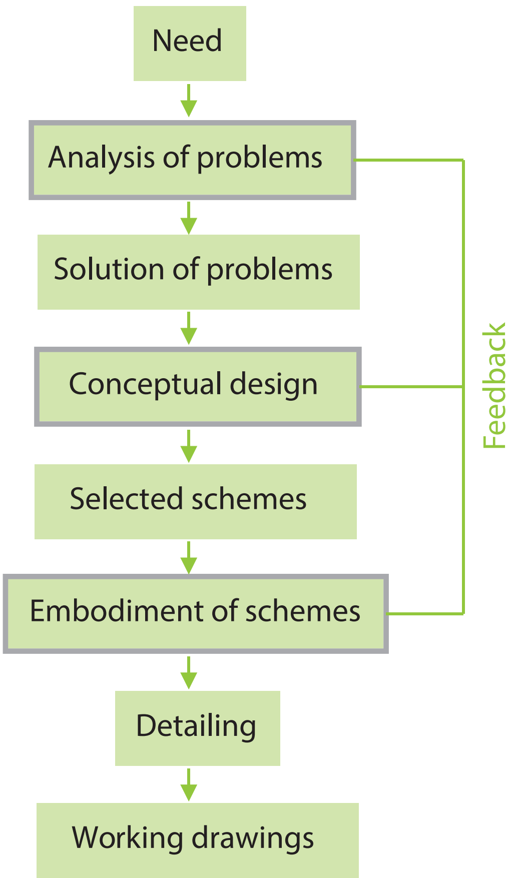
According to this author the first step is collecting information related to the kind of project we are developing. After that and thanks to this information it is time to identify the user needs and the functional requirements. Having all this factors perfectly clear we can now explore the different formal options. Then it is necessary to clarify the costs calculations as well as benefits. Finally, it is time to take into account the most technical characteristics, for instance, regulations, materials and manufacturing issues. Then the final step is to get the prototype.

Apply at: projects with a probing view, indeterminate ones where decisions are made based on a rational process.

Michael Joseph French 1985

According to French, the conceptual design stage puts greatest demands on the designer and in this stage the most important decisions are made. The result of this process is a candidate for the design solution and a clearly formulated set of desired measurable properties of the future product, which introduces the quality measure into the design process. This cross-domain design takes into account the overall system requirements and goals. The conceptual design as well as other design stages are implemented in many cycles.

Apply to: projects where the conceptual stage might be repeated. By using the feedback it might have a review of the initial stage.



French's picture of design starts with a need and proceeds sequentially through formal stages with feedback. It is relatively simple. For example, if you were building a house you would start with a need (somewhere to live), you would prepare and analyse a specification (the price, number of rooms, location, etc.), and you would state the problem to the architect who would come up with some conceptual designs. You would select those you liked best. Embodiment of schemes means an integration of the best features of several schemes and certainly the production of drawings. These drawings would eventually have to have all the details specified for the builders, and they would be recorded as working drawings. The drawings are also used to communicate the design from designer to fabricator.

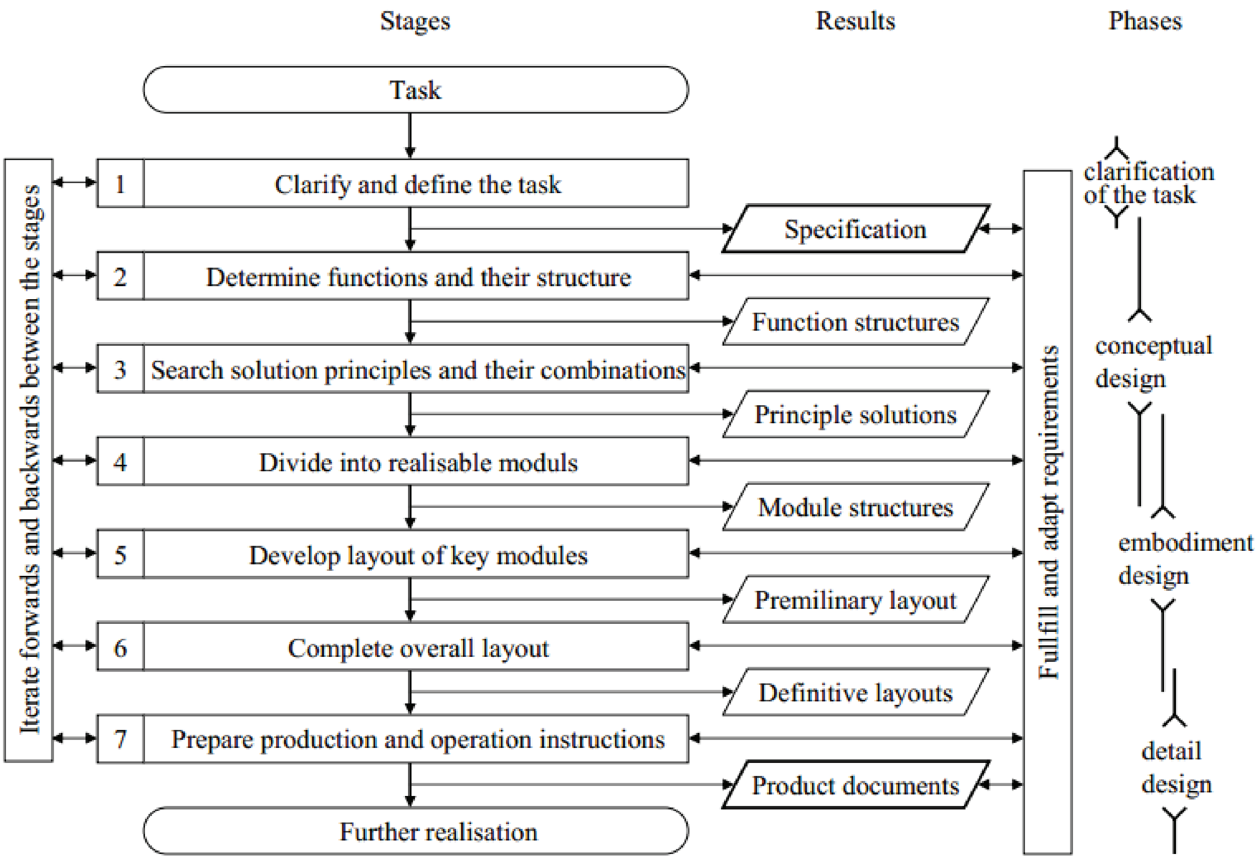
An important feature in French's model is the possibility of 'going round the design cycle'. At almost every stage, the designer must expect to revisit earlier stages to make changes so that the design 'works' lower down. French's model captures a very important part of the design process, that it is iterative in the way it cycles round until a satisfactory solution/scheme is found.

VDI 2221

Verein Deutscher Ingenieure (VDI) (Association of German Engineers)

VDI regulations propose 7 basic stages according to the fundamentals principles of Technic Systems theory. This regulation is specially suitable for mechanical engineering. It also contains a classification of the most extended design methods, pointing which stage fits better each situation.

Apply at: well structured project (in different stages), where the functional definition is really important. Projects where the conceptual stage and product requirements are the guides of the design process.



Conclusion: Basic methodology and common points

Every methodology analysed previously, they share some common stages. The first common stage, named with different designations, would be the "Exploration", it means collecting information from different sources in order to feel more familiar and acquire knowledge of the project we are dealing with. The next step would be the "Creative stage", where we come up with new ideas and new solutions for the problems which have appeared in the previous stage. After that, it comes de "Checking stage" where we check our proposals and we test if we have reached the objectives. After this stage, the feedback is possible, if we are not satisfied with the results or we find problems in our proposals it s possible to go back and create something else. Finally, once happy with our ideas/proposals, it is necessary a good "Communication" stage in order to show our ideas and proposals properly.

All the methodologies have a common base, choosing one or another method is the key of the success.

Through our four years of bachelor we have taken many courses where we have been dealing with methodology theory and process design guidelines. We have always been told about the difference between dealing with an academic project and a professional one. Following I will make a short comparison between the stages when developing an academic project and a professional one.

A. Initial stage

B. Informacion stage

C. Development stage

D. Application stage

A. Initial stage

The origin is the existence of a need, then the project starts.
When beginning a new project it is completely necessary to write up some conditions. This implies a basic analysis of the idea of product we are going to work with and it forces us to consider the following questions:

· How can the company get benefited with the developing of this project?
· Who can be interested in the final product?
· Which kind of expectations might users have?
· What is our position regarding the competence?
· Will this position improve after the project?
· What position will the product reach among the company's product offer?
· What factor can influence the product development?
· What productive factors mark the nowadays and the future of the company?

B. Information stage

In this stage we have to make a deep search about all the information that we might need for the project. It has to be information related to the product, the market it is involved, the company, the users... Then a thorough analysis will be needed attending to different fields: ergonomic, functional, formal...

C. Development stage

· Conceptual generation
· Ideas analysis
· Work document
· Applied creativity: Sketches generation
· Analysis
· Presentation
· Alternatives development
· Analysis.
· Presentation
· Final development

D. Application stage

Management of how the project is being developed.
Check the finished work

Design brief

Before a project starts it is necessary to have a **design brief.** A design brief is a written document for a design project developed in concert by a person representing the business need for design and the designer. The document is focused on the desired results of design – not aesthetics. Design briefs are commonly used in consulting engagements, when an independent designer or a design agency executes a design on behalf of a client. They are less common when the designer is in-house. it is commonly used in EGD, in schools across the world.
Design briefs are part of the design functions of companies and corporations, especially architecture, graphic design, product design and engineering firms.
In some of our lectures we are given examples about different examples of design brief, two of them appear on the pictures below:

By Javier Zarrabeitia

A. Antecedents
B. Project definition
C. Market information
D. Commercial information
E. Technical and legal information
F. Economic information
G. Project specifications
H. Planning

By DZ
(Sociedad pública de la Diputación Foral de Vizcaya)

1. Project definition
2. Project objectives
3. Information
4. Market and user
5. Design specifications.
   Available production processes
6. Production process
7. Costs
8. Opportunities and limitations
9. Comments

By Ignacio López Forníes

1. Project definition
2. Project objectives
3. Antecedents. Information (market included)
4. Design specifications (user and environment)
5. Project stages
6. Budget and deadlines
7. Aditional clauses
8. Signatures

CADI (Industrial Design Aragón Centre)

A. Project definition
B. Project objectives
C. Product and project information
D. Market information
E. Production process information
F. Prices references
G. Technical information

In the previous section we have defined and mentioned some brief structures that we have been taught during our lectures. It is completely essential to define clearly all these steps to reach the next ones. First, we will list them and after we will get deeper into them.

As we have mentioned before, the design methodology is divided into four stages:
1. **Initial stage:** brief *
2. **Information stage:** collecting information, analysis and conceptual stage.
3. **Development stage:** alternatives development and final development.
4. **Application stage:** Checking time.

Stage 1_ Initial

Design brief
- Antecedents
- Project definition
- Market information
- Comertial information
- Technical and legal information
- Economic information
- Project especifications
- Planning

Stage 2_ Information

Product analysis
- Market
- Structural
- Functional
- Formal
- Use, user and environment
- Ergonomical

Conclusions
Ideas: creativity work
Concept proposals

Stage 3_ Development

Concept choice
Analysis- Problems
Alternatives development
Analysis
Final development

Stage 4_ Application

Project management

The **Stage 1** has been defined in the previous point, listing different options perfectly valid. In the next pages the rest of the Stages will be deeply explained.

Stage 2_ Information

Market analysis

Product analysis
Structural
Functional
Formal
Use, user and environment
Ergonomical

Conclusions
Ideas
Concept proposals

Market analysis

Why?

- To know how the product and its competitors work.
- Come up with conclusions in order to improve and development of the product to design.

How?

We have to define the market our product belongs to as well as its place, activity that develops and the main users.
It is also important know if it is present in many countries. Knowing the present situation of the trade will help us to know if it is possible an augment of the market and to determine if it is possible to insert the product in other market field.

Tools

Segmentation

It is not possible to know about the whole market so what we do is to gather the users according to some common characteristics.
A **segment** is constituted by an identifiable group of users with desires, needs, acquisitive power, buy habits which are similar to those that the product could cover.
There are two kinds of segmentation:

1. Macro-segmentation: Attending to the product areas.
– Functions or needs
–Technologies
–Buyers groups

2. Segmentation: Attending directly to the product.
– Population behaviour
– Demography
– Age
– Acquisitive power
– Population behaviour
– Psychology
– Life styles

The product is defined by the **American Marketing Association** as:
"A bundle of attributes (features, functions, benefits, and uses) capable of exchange or use; usually a mix of tangible and intangible forms. Thus a product may be an idea, a physical entity (a good), or a service, or any combination of the three. It exists for the purpose of exchange in the satisfaction of individual and organizational objectives."
That is why we can affirm that we do not buy products but the things they can do for us.

In order to know more about the product and its competitors it is important to make clear what **positioning** is: The way consumers, users, buyers, and others view competitive brands or types of products.

In order to make positioning methodology is necessary to:
- Identify the best attribute of our product.
- Know the competitors' position according to the identified attributes.
- Decide our positioning according to our competitive advantages.
- Communicate our positioning to the market. Advertising.

AttributeO	ur product	Competitor 1	Competitor 2
Brand	5	7	6
Packaging	6	6	7
Quality	5	8	8
Design	7	6	5
Power	9	5	8
Materials	87		9
Total	∑	∑	∑

It is also important to know about the product line/range and to identify concepts then. To do this we can help ourselves with some tables. We will be have to:

- Identify needs.
- Needs which have not been satisfied (segment)
- Detect a deficiency.
- Identify concepts (new ideas)

To achieve this we might use positioning maps and fashion analysis tools. We will have to analyse the product under some common characteristics. The image shows an example of **positioning map.**

It is really important to know the product's competitors, to do that we will analyse:
- Product's typology
- Portfolio offerings

Structural analysis

Why?

- To understand the product from a syntactic view point, in other words, thanks to its structure and components; and thanks to the need of each of them.
- It gives to us an idea about how the analysed product work due to the fact that not every product develops the same handling to achieve a function or objective.

How?

The structural analysis is based on the principle "From general to particular" and it is related to other design techniques based on decomposition as well as simplification in order to rebuild it later.
It is applied in the first stages of a design project and it is well recommended in order to know the own product as well as the competitors' one.
There is not any classification for this kind of analysis, nor a specific equation or procedure. The structural analysis might be divided according to the product complexity and its development is orientated according to the desired objectives and results.

One possible procedure could be:

1. Determine complexity of the product.
2. Determine objectives of the analysis.
3. Sample selection to analyse.
4. Analysis development.
5. Conclusions.

Tools

Technical monograph

It is a document where the product's structure and components are analysed, as well as how the assembly is done, how it is activated, how it works and its interaction with users.

Depending of its complexity, it is sometimes necessary to make a decomposition according to its functional groups. It is also necessary to define how the interaction is between these groups when using the product. The objective is to understand the importance of each component of the product.

The technical monograph define the structure and it gives us information about the dimensions and materials. It is a basic and useful document when carrying out a new design.

It is quite common to make a monograph about several products which share characteristics.

Functional analysis

Why?

- To identify and define clearly the main function of the product.
- To generate new solutions which accomplishes the same function.

Because it allows us to know other functions of the product in order that we can create more valid concepts, removing unnecessary functions, adding more innovative ones.

How?

It is related to the "value analysis", due to the fact that the products must cover the needs defined by the market with a specific cost.

It has four basic principles:

1. From the general to the particular
2. It is transferable: it isolates the functions so they can be changed of area or field.
3. Semantic structure: the function must be defined as clear as possible.
4. It is based on functions: how they are accomplished, who aim them, how they interact.

The functional analysis has four stages:

1st stage: define the global function in a sentence.

2nd stage: sub-functions division. We must analyse which are the main functions.

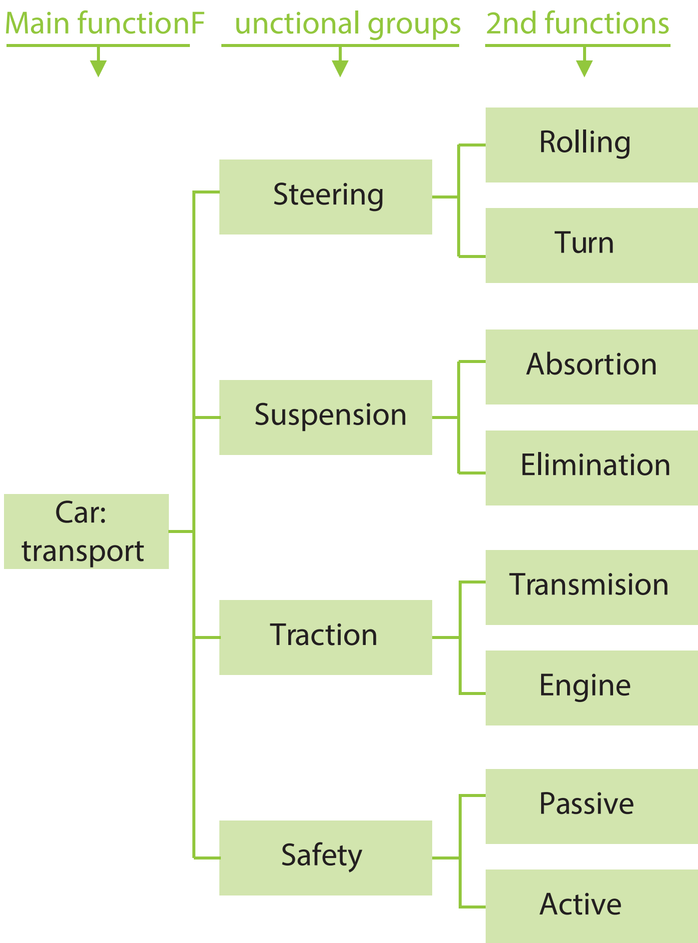
3rd stage: Here we can act either with a functions tree or a functions diagram.

Tools

Function tree and function diagram

The function tree has several advantages such as an easy representation , the possibility of reaching static functions and abstract ones. Some disadvantage are that the logic and temporal relation between the functions are hidden.

1. List the functions.
2. Organise them into different fields.
3. Describe them
4. Evaluate them.
5. Functions' tree or functions' diagram.



Formal analysis

Why?

- Because it is necessary to know the relation between the perception and its mechanisms.
- To study the relation between shape and function.
- It allows us to find differences between the products and value them. By doing this we can better understand why they succeed (or not) in the market.

How?

There is any standard formal analysis because there are different ways to analyse products.

The aim is to analyse the product regarding its shape, composition, structure, function relation and understood like a communication element.

The product will be analysed attending to a few characteristics, like:

- Composition: volume of the product.
- Surface: colour, texture...
- Visual quality: manufacturing process, technological level...
- Perception: psychological aspects like simplicity, symmetry...

Tools

Comparison table

A possible procedure could be a comparison table, facing different products against some characteristics explained previously and defining them.

	Characteristic 1	Characteristic 2	Characteristic n
Product 1			
Product 2			
Product 3			
Product n			

It is also necessary to settle the **relation between shape and function.** The shapes comes from the function, in other words, the function defines the shape. Therefore, the shape of a product is not the result of the technique nor the result of the formal fantasy. The shape must be clear, showing the meaning of the product and the benefit which adds.

Use, user and environment analysis

Why?

- Because it is really important to show the importance of orienting the product to its use and user.

Use analysis

It can be defined as the evaluation of the product in its environment with the objective of getting the meaning of the product and make it different from its competitors.
It studies the product into de environment and with the user, not in an isolated way.

How?

It is possible to do it in two stages:

1. General use analysis

a. Use modalities:
We should define and list the different uses of the product. We could list different product and list their uses in order to get new ideas to improve the product.

b. Use situation:
We should know all kind of users and their relation with the product, how the environment is and how is the situation when using the product.

2. Formulate the use requirements

a. General recommendations.
b. Demands and benefits.

Tools

User test

The objective is to detect the different needs and desires of our target.
It is a way to obtain quick information of users.
The information must be contrasted with other kind of analysis in order that it shows us real situations and not only the ideal ones.

The most common way to proceed is to create a list of questions taking into account different characteristics like the gender of the user, the age, the social group, the status...
We must also include:

- How is the contact with the product: how, when, where, why... defining the particular use situation.
- Personal satisfaction with the product.
- Deficiencies, problems, dissatisfactions.
- Possible improvements.
- Test analysis.
- Conclusions.

Ergonomic analysis

Why?

- To show the importance of adding the ergonomic requirements to the general design requirements.
- To show the relation between ergonomics, shape and function.

Ergonomics

The applied science of equipment design, as for the workplace, intended to maximize productivity by reducing operator fatigue and discomfort.

Design factors, as for the workplace, intended to maximize productivity by minimizing operator fatigue and discomfort.

The ergonomics is constituted by some factors:

- Body dimensions.
- Physical ability.
- Muscular strength.
- Position loads.
- Information treatment.
- Perception mechanisms.
- Surroundings characteristics (heat, noise, vibrations…)
- Psychological surroundings characteristics (colour, social ambient…)

Anthropometry

The applied science that aims to accurately measure the body dimensions, its individual change as well as its evolution through the time.

Bio-mechanics

It is the study of the structure and function of biological systems such as humans, animals, plants, organs, and cells by means of the methods of mechanics.

How?

We pretend to stablish a satisfactory relation between the product and the user by analysing carefully the situation as well as all the aspects which have influence.

We should take into account:

- The most common users.
- The problems that appear when using the product correctly.
- Maintenance problems.
- Safety problems.
- The problems that appear when using the product incorrectly.
- Link environment/product/user.
- Physical user's limits.
- Psychological, social, cultural and emotional limits.

Tools

In order to analyse different body positions to achieve the best one when using the product that we intend to design, we can use these two methods:

- RULA (Rapid Upper Limb Assessment)
- REBA (Rapid Entire Body Assessment)

- RULA (Rapid Upper Limb Assesment)

Rapid Upper Limb Assessment (RULA) is a survey method developed for use in ergonomic investigations of workplaces where work related upper limb disorders are reported. RULA is a screening tool that assesses bio mechanical and postural loading on the whole body with particular attention to the neck, trunk and upper limbs. RULA is intended to be used as part of a broader ergonomic study.

Step 1 Observing and selecting the posture(s) to assess

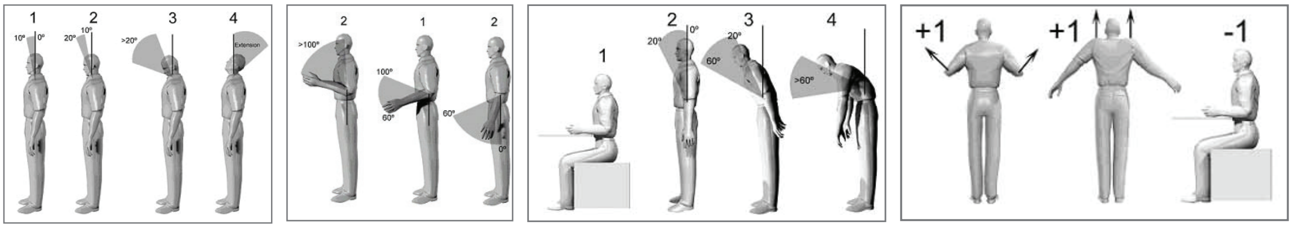
A RULA assessment represent a moment in the work cycle and it is important to observe the postures being adopted whilst undertaking the tasks prior to selecting the posture(s) for assessment. Depending upon the type of study, selection may be made of the longest held posture or what appears to be the worst posture(s) adopted.

Step 2 Scoring and recording the posture

Decide whether the left, right or both upper arms are to be assessed. Score the posture of each body part using the software. Review the scoring and make any adjustments if required. Select calculation button.

Step 3 Action Level

The grand score can be compared to the Action Level List.

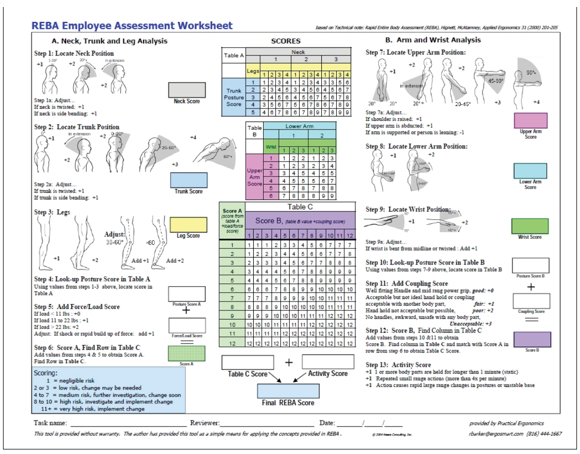


- REBA (Rapid Entire Body Assessment)

REBA is a postural targeting method for estimating the risks of work-related entire body disorders. A REBA assessment gives a quick and systematic assessment of the complete body postural risks to a worker. The analysis can be conducted before and after an intervention to demonstrate that the intervention has worked to lower the risk of injury.

The REBA worksheet is divided into two body segment sections on the labelled A (Trunk, Neck and Legs) and B (Upper Arms, Lower Arms, and Wrists)

It consists in giving different punctuations depending on how the different parts of the body move when carrying out an action. These punctuations are measured by some tables which will finally give a final score.



Conclusions

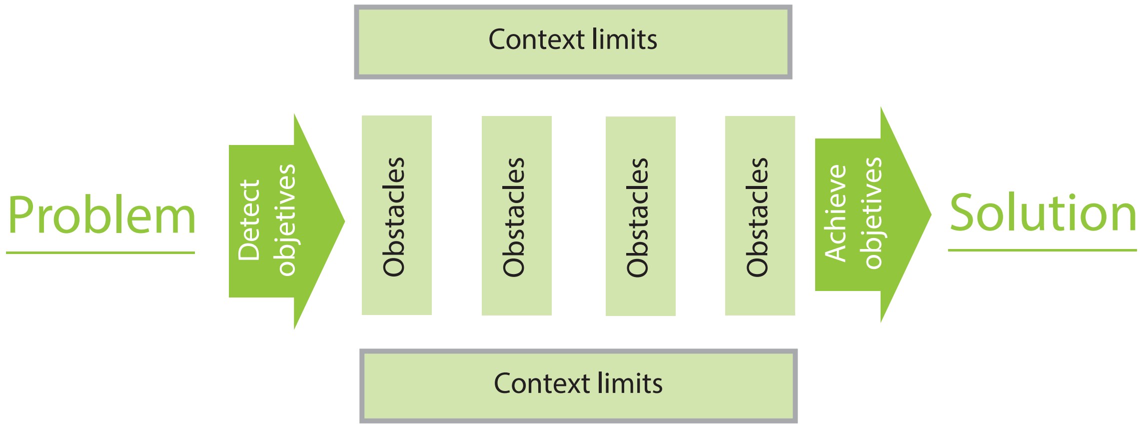
To conclude the analysis stage it is recommended to make some final conclusions which help us to come up with ideas for the product. Thanks to the information that we have been collecting as well as the methods that we have followed we will obtain some important points to take into account in our final design.

Ideas

To obtain new and good ideas we have to take into account all the conclusions from the previous analysis and also the creativity is important. **Creativity** is the ability to create, it is to generate ideas to solve problems.

To incorporate creativity to our design process we have to follow an scheme:

1. Set out a problem in order to know the present situation
2. Redefinition: divide the problem. > **Problems re-definition techniques***
3. Ideas generation: search of solutions. > **Creativity techniques***
4. Implement solutions. Select idea. > **Ideas selection techniques***



Problems re-definition techniques

The techniques which follow are used for the analysis and detection of the problems we usually find when designing something. So that we redefine them or we re-write them giving them a positive approach. Sometimes it is necessary to use these techniques in order to reveal invisible problems or situations.

Limits exam

Its aim is to re-organize a problem's assumptions, in order to make it easier a new viewpoint, discussing its limits at the same time that the study goes on, specially in wrong formulated problems.

1. Write the initial problem formulation.
2. Highlight key words and key sentences.
3. Examine them to look for possible assumptions.
4. Write all the new definitions suggested by these implications.

Objectives orientation

Think about a problem in order to clarify its objectives and aims, considering obstacles, obstacles and limitations.

1. Write a complete and general problem description.
2. Wonder:
   - What do we want to achieve? (needs)
   - What is stopping me to achieve it? (obstacles)
   - What do we have to accept to face the problem? (limitations)
3. By using these guide questions, we will have to write possible re-definitions of the problem.

Creativity techniques

The catalogue

Individual technique which contrasts couples of random words, objects, ideas and it examines the result in order to solve the formulated problem

1. Formulate the problem.
2. Look up some catalogues, magazines, newspapers to pick up a couple of random words.
3. Consider and contrast both words simultaneously and evaluate the result taking into account if we can apply it to the problem.
4. Keep trying with new random choices till obtaining ideas that we like.

Clean eyes

Individual technique which introduces a new non-conditioned mind into the problem, breaking the limitations caused by the close contact with the problem.

Brainstorming

It is a group or individual creativity technique by which efforts are made to find a conclusion for a specific problem by gathering a list of ideas spontaneously contributed by its member(s).

Method 6-3-5

Technique which uses a structured procedure, writing the ideas and exchanging them among the participant.

6 = number of participants of the group.
3 = number of ideas generated every 5 minutes.
5 = number of minutes spent in each intervention.

Ideas selection techniques

Analysing systems

Synthesize group decisions from individual decisions, two role options:

a. Those who feel more able to evaluate people, they share out their votes among the participants.
b. Those who feel more able to evaluate options, they share out their votes among the options.

The idea defender

The defender is a person who act as the particular defender of the idea he/she considers more useful. Therefore, both good and bad points are considered.

Concepts proposals

After the ideas stage, we will be able to choose the one that seems to be the best one. It is time now to propose the concepts. They are usually begun by some basic sketches to have a general idea about the main characteristics and then they can be developed as much as we want.

It is good to have several concept proposals to be able to make a comparison later. It is not totally compulsory to choose one of them, maybe we can integrate them, creating an unique solution. To make this decision it will be necessary estimate if the concept accomplishes with the initial objectives and if it has potential to be developed; also it will be necessary to make a first approach to the mechanical solutions.

Stage 3_ Development

Concept choice
Creativity work
Analysis- Problems
Alternatives development
Analysis
Final development

Concept choice

After the ideas stage, we will be able to choose the one that seems to be the best one. It is time now to propose the concepts. They are usually begun by some basic sketches to have a general idea about the main characteristics and then they can be developed as much as we want.

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Here, the most important point is to discern the advantages and disadvantages of a proposal.

To make the correct choice we can use the methods which have been explained in the **ideas choice point*** or in the appendix n*

Analysis problems

Once we have a concept chosen we have to work on it. Logically the first step would be to check if it accomplishes the objectives as they appear in the design brief. Also we will have to discern some problems. In order to analyse them we can re-define them by using the methods explained in the point before and try to solve them.
Most of the problems will be mechanical because when we have an idea and we come up with a concept we tend to neglect the mechanical aspects.

Alternative problems

Related to the problems we will come up, hopefully, with different solutions. In other words, we will have different ways to solve a problem. Each of these possibilities will be a different alternative. Alternatives usually differ in their shape and exterior appearance. We will have now to decide which alternative we want to choose in order to start the development stage. Now we have to think carefully which of our alternatives fits better with our initial requirements and which of them answers better the problems that we found.

Final development

Once we have an alternative we have to develop it. We could be constantly changing the alternative or proposing different solutions but a really important part of a project is the timing. In other words, we have deadlines to reach.

Final development means that we have to develop our project as much as we can, related to different aspects such as appearance, mechanical solutions, materials, dimensions, prototype...

A good beginning could be dimensioning the product. In order to do that we have to take into account the ergonomic analysis made in the first stage. Likewise, we will have to take some anthropometric tables to the dimensions according to our product's target (potential user). One good advise in this point is developing **"simple volumes".** They allow us to visualize and to check the first dimensions of the product as well as to verify some dimensions affected by ergonomics. The materials which are commonly used are soft foams, clay, plaster... In short, materials that we can work easily with and can be easily shape changed.
This kind of technique allows us to make quickly some volumes and to compare them so that we can make decisions.

When having the shape and dimensions perfectly clear we can start with the essential 3D model. In order to do that we can use a lot of different computer 3D programs depending on the product complexity, shape and characteristics. Some examples of these programs are: SolidWorks, Autodesk Inventor, Rhinoceros, Autodesk 3D Studio Max...

Once we have the 3D model we can play with materials because most of the programs offer the possibility of checking what the maximum tension that a material bears is. Also we can now try with different colours and different graphics to make it more suitable with the brand or the company's corporate image.
We are now able to take some renders which can reinforce our product presentation.

We can now prepare the blueprints, essential point to develop a product.

Rhinoceros
NURBS modeling for Windows
CATIA
Autodesk 3ds Max 2010
Autodesk

6.2. DELF University

PRODUCT DESIGN IN DELFT

DELFT design school defines 'design' as 'to conceive the idea for some artifact or system and to express that idea in an embodiable form'.

Products are designed and made because of their functions. To design a product is to conceive of the use of the product and to find a suitable geometrical and physico-chemical form for the product and its parts, so that the intended function, or functions, can be fulfilled.

In order to understand the nature of product design one must understand the nature of that reasoning process, wich means the relationships between the function, the properties, the form and the use of products.W

FORM

By the form of a part it is meant the geometrical form (geometry or shape including size) as well as the physico-chemical form (the material).

Eg. computer mouse: An assembly of different parts

PROPERTIES

Intensive properties: Depend on the physico-chemical form only.

Eg. The density of the body

Extensive properties: A result of the intensive properties plus the geometrical form

Eg. The weight of the body of the body depends on the density and its volume.

Designers are particularly focused on the extensive properties, as they most directly determine the functioning of a product. The art of designing is to give the product such a geometrical form that it has the desired extensive properties, given the intensive ones.

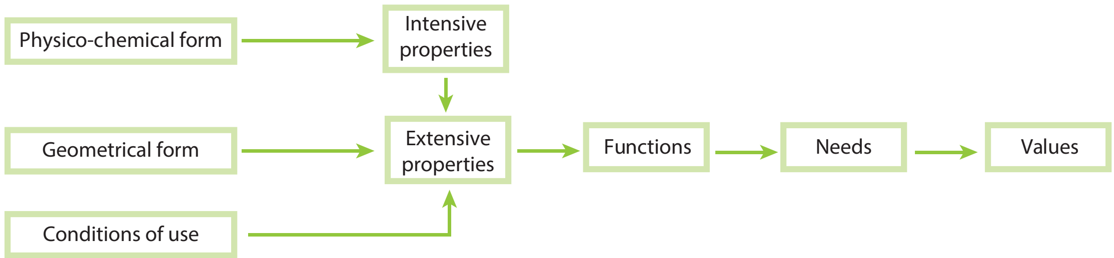
FUNCTION

A function is the intended ability of a product to change something in the environment (including ourselves) of that product.

Functions express what a product is for, its purpose, and this depends on intentions, preference, objectives, goals and the like, of human beings. So different persons might see different things as the function of a product.

NEEDS & VALUES

By fulfilling functions products may satisfy needs and realise values. For instance 'writing' may provide for a need to express oneself and thereby realise aesthetical or economical values.



_Model of reasoning by designers. (Roozenburg and Eekels, 1995)

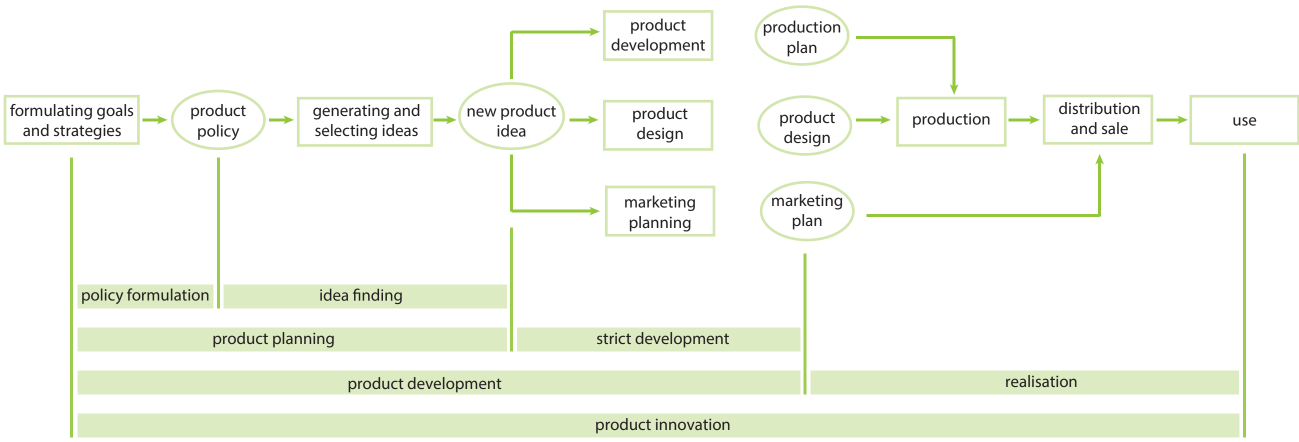
Product Innovation Process

What is it?

Product design is embedded in a large process, which is called 'product development'. Product development includes the development of a new product as well as the plans for its production, distribution and sales. This process is also called 'new business development'. Product development in turn is part of the product innovation process. Product innovation encompasses all activities that precede the adoption of a new product in a market.

Product Innovation according to Roozenburg and Eekels

A company that wants to innovate must know very well what it wants to achieve. It must produce fruitful ideas for innovation, work them out skilfully into comprehensive plans for action and then realise them.



_The phases of the product innovation process (Roozenburg and Eekels, 1995)

They divide the innovation process in three parts:

PRODUCT PLANNING

In this phase it is decided what product(s) will be developed and when. Product planning has two parts:
Policy formulation: What a company wants to achieve is shown by its policy. Proclamation of goals and the strategies for fulfilling the goals are the basis to formulate the *product-market strategy* wich lays down the kinds of products the company is going to apply, now and in the future, and the markets it is going to attend. A proper crystallised policy is the basis for the next part.

Idea finding: Companies must to keep informed about markets and consumer needs and investigate the strengths and weaknesses of the company. After this research the next step is getting inspired by those studies and generating new product ideas, selecting the most promising and formulating them into an assignment for further development.

STRICT DEVELOPMENT

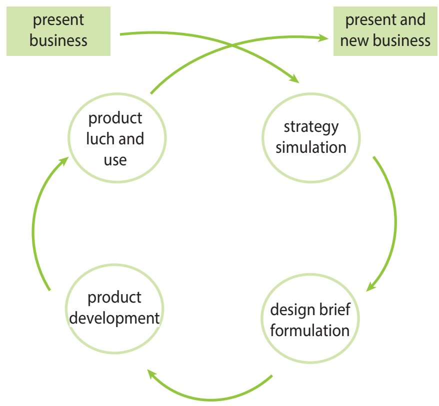
Ideas for new products must be worked out into detailed plans for the product, the production and the sale. The plans are developed with the new business idea, as point of departure and it is very important that the plans are properly attuned to one another. To that end the product development process must be arranged 'concentrically'. Concentric development means that at first all plans are worked out in outline, to be able to estimate the technical and commercial feasibility of the new business activity as a whole. Whenever a product idea survives the first round, the plans are further worked out in a second round, etc., until they are completed and fit one to another. (See Concurrent Methodologies)

REALISATION

In this phase the detailed plans out of the strict development phase are transformed into reality. This phase includes production, distribution, sales and the actual use of the product. The development of a new product will be successful in so far as the previous activities, product planning and strict development, are properly attuned.

Product Innovation Process according to Buijs

J. Buijs introduced a four-stage innovation model based on the assumption that the product innovation process is similar to an experiential learning process. Coming up with new products and services is the response of a company to its changing competitive environment. The four-stage product innovation model consists of:



1_Strategy formulation (i.e. policy and strategy formulation).
2_Design brief formulation (i.e. idea finding).
3_Product development (i.e. strict development).
4_Product launch and use (i.e. realisation).

Buijs puts more emphasis on the first phase of the product innovation process and divide it into six activities:

1_analysis of the present situation, which leads to the strategic situation of the company
2_internal analysis
3_external analysis
4_search area generation
5_search area evaluation
6_search area selection

Based on an analysis, the strategic situation of the company is formulated. The strategic need for innovation is made explicit by estimating the future corporate situation when no strategic changes are made. During the internal analysis, the strategic strengths, the core competences are defined. In the external analysis, the competitive environment is analysed and the opportunities and threats are made explicit. Search areas are strategic ideas for innovation and potential new business opportunities. A search area is a combination of a strategic strength and an external opportunity. During search area evaluation, the strategic innovation ideas are checked with the outside world by interviewing experts, looking at patents, observing potential clients/users, etc. In search area selection, a definite choice is made. The selected search areas form the starting point for the next phase: design brief formulation.

Basic design cycle (Roozenburg and Eekels)

What is it?

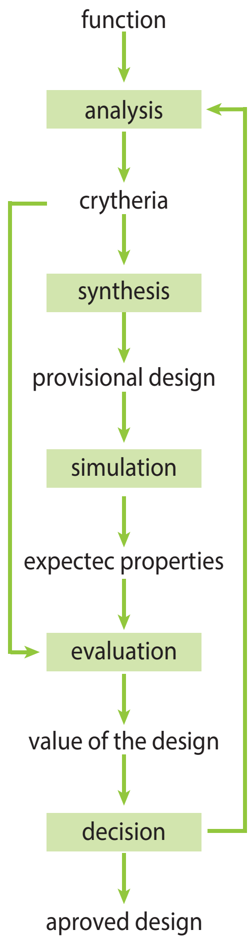
The kernel of designing is reasoning from functions to form and use of a new product, but it is not possible to deduce the form and the use of a product from its function(s) and many different can exist for a particular function. Therefore we use a trial-and-error process that consists of a sequence of empirical cycles. In each cycle by experience, intuition and creativity provisional solutions are generated, which have to be tested by theoretical simulations and practical experiments.
Roozenburg and Eekels have called their model of this cycle 'the basic design cycle'. They say that the basic design cycle is the most fundamental model of designing, because this cycle can be found in all phases of the design process and is applicable to all design problems, whatever their nature.

Analysis
Point of departure in product design is the function of the new product. We do not only include the technical function, but also the psychological, social, economic and cultural functions that a product should fulfil.
In the analysis phase the designer forms an idea of the problems around such a new product idea (the problem statement) and formulates the criteria that the solution should meet. The list of criteria is called the 'program of requirements'.

Shyntesis
The second step in the basic design cycle is the generation of a provisional design proposal. The synthesis step is the moment of externalisation and description of an idea, in whatever form (verbally, sketch, drawing, model, etc.) The result of the synthesis phase is called a provisional design; it is not yet more than a possibility.

Simulation
Forming an image of the behaviour and properties of the designed product by reasoning and/or testing models, preceding the actual manufacturing and use of the product. The whole array of technological and behavioural scientific theories and formulas are availables, yet in practice, many simulations are based on generalisations from experience.

Evaluation
It is establishing the 'value' or 'quality' of the provisional design by comparing the expected properties with the desired properties in the design specification. As there will always be differences between the two, it will have to be judged whether those differences are acceptable or not.



_The basic design cycle

Decision
continue (elaborate the design proposal) or try again (generate a better design proposal).
Usually the first provisional design will not be the right one and the designer will have to return to the synthesis step, to do better in a second, third or tenth iteration. But you can also go back to the formulation of the problem and the list of requirements. You might therefore want to adjust, expand, or perhaps sharpen up the initial formulation of the problem.

Engineering models of product design

What is it?

The engineering models are fundamentally derived from the way in which engineering design problems are conventionally perceived and modelled. The engineering design problem is to find and define the geometry and materials of the system in such a way that the required prescribed physical behaviour is realised in the most effective and efficient way.
Engineering models are based on the idea that a design-in-the-making can exist in three different ways:

-As a function structure: The product and its components and parts are represented by their functions. It is an abstract representation that does not refer to concrete shape and material of the physical parts of the system.

-As a solution principle: Defines the working principle, or mode of action, of a product or a part thereof. It specifies (in generic terms) the function carriers or 'organs' of which a product should be built up, to fulfil its internal and external functions

-As an embodied design: It is a description, usually as a drawing, of the geometrical and physic-chemical form of a product and its parts. It is about establishing increasingly accurate, and more numerous characteristics of the new product, in particular: the structure of the entire product (the arrangement of the parts) and the shape; the dimensions, the materials, the surface quality and texture, the tolerances and the manufacturing method of all the parts.

The model of Pahl & Beitz

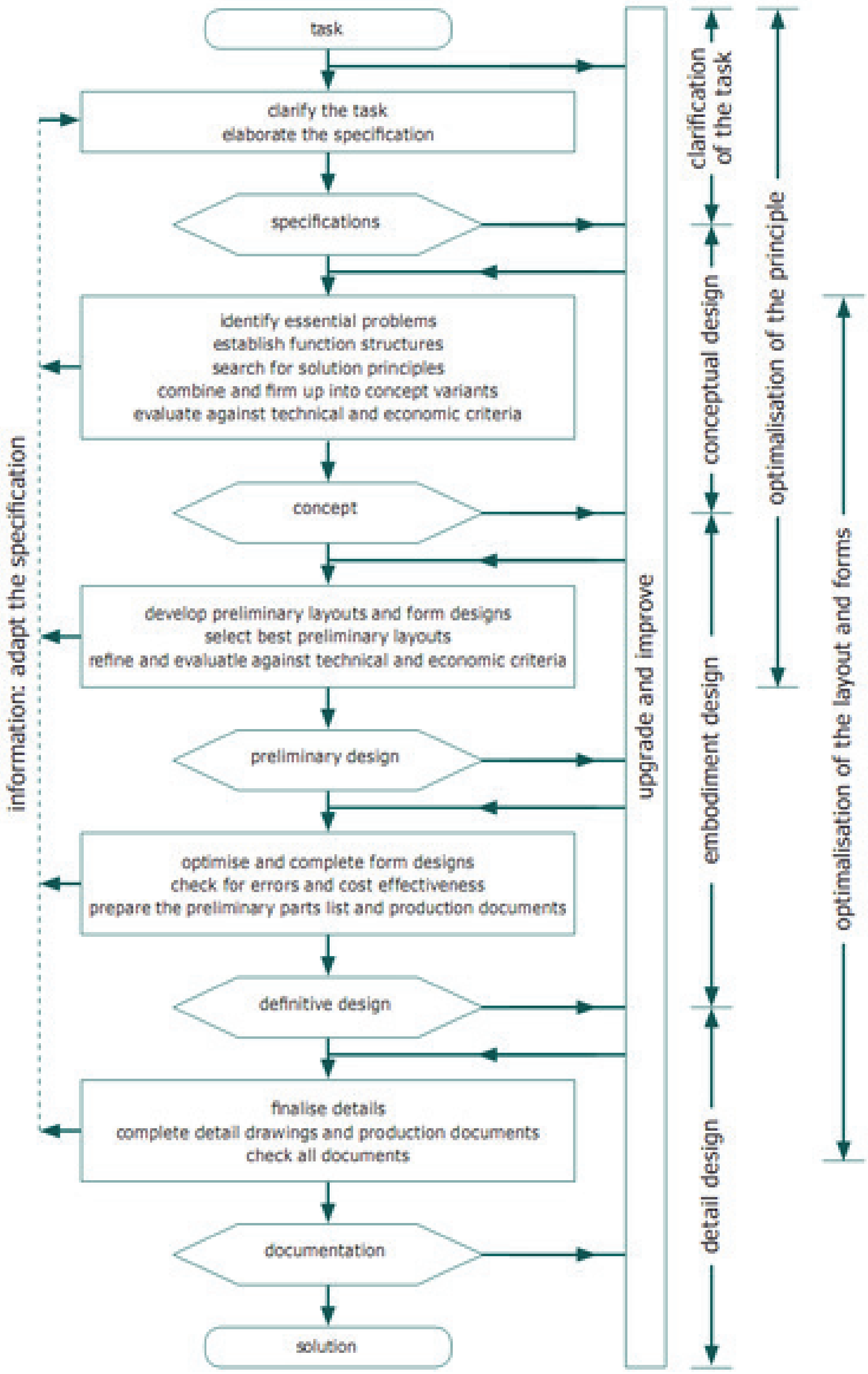
A typical example of this 'consensus model' is the model of Pahl & Beitz:
The model has four phases:

-Clarification of the task: The problem is analysed, and information is collected. Based upon that information a design specification is drawn up. The specification defines the functions and properties that are required for the new product, the constraints of the solution and the design process itself. Therefore modification and refinement of the initial specification should be undertaken regularly.

-Conceptual design: Broad solutions are generated from the specification. Such broad solutions are called concepts or schemes and they are documented as diagrams or sketches. It starts with determining the overall function and important sub functions to be fulfilled and establishing their interrelationships. They are integrated into overall solutions. A principal solution defines those physical-technical characteristics of a product, that are essential for its functioning. A scheme should be relatively explicit about special features or components, but need not go into much detail over established practice.

-Embodiment design: The chosen concept is elaborated into a definitive design. It defines the layout of assemblies, components and parts, as well as their geometrical shape, dimensions and materials. The definitive design need not be completely worked out into full detail. The configuration of the product and the form of the parts are to be developed up to the point where the design of the product can be tested against all major requirements of the specification, preferably as a working model or prototype.

-Detail design: The geometrical shape, dimensions, tolerances, surface properties and materials of the product and all is individual parts are fully specified and laid down in assembly drawings, detail drawings and parts lists. Also instructions for production, assembly, testing, transport and operation, use, maintenance and the like, have to be worked out now. All these documents fall under the heading of the 'product documents'.



Fish trap model (Muller)

What is it?

"The Fish Trap model is a method for generating and developing a form concept for a product up to sketch plan. As such, the approach is intended to cover the form-creation phase. The method is prescriptive, meaning that it indicates how a concept should be developed" (Muller, 2001, pp 196).
Fish-Trap Model is an intermediate stage between the function structure and the solutions principle and ends with the stage of the material concept.

THE MODEL PROCESS IN SHORT

Development of Criteria

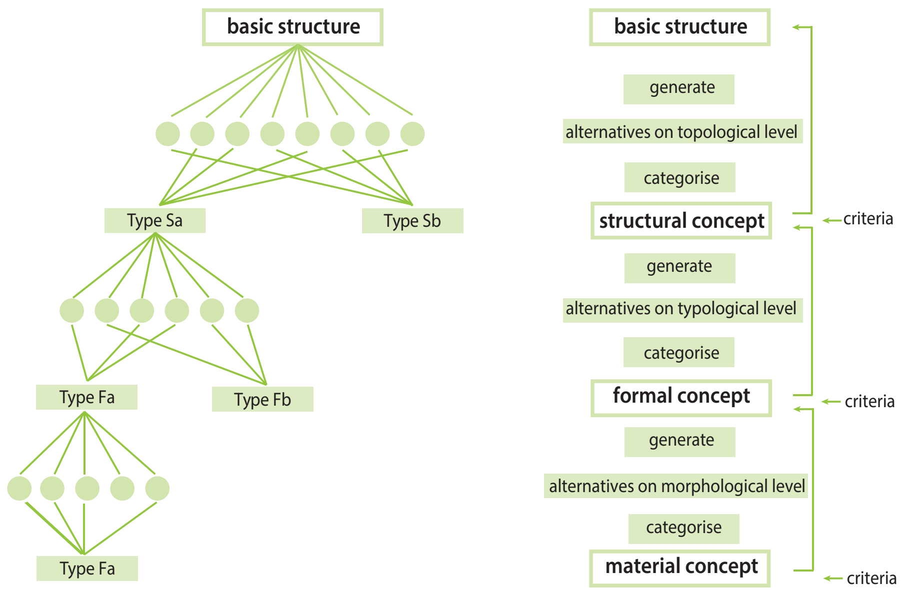
Muller emphasises the role of visio-spatial thinking, imaging and exploration by sketching that is essential to develop the criteria. It is developed simultaneously with the development of the concepts and it form an important starting point for the exploration of possible concepts.

Converging, diverging and categorisation

The generation of variants is a diverging process and should be done with an open attitude and the curiosity about new possibilities. After creating many possible variants the diverging stage can start; the variants are categorised according to their solution type. Then, one or more representations of a category will be developed into a concept. Those concepts, representing a specific solution type, will be evaluated against the criteria. One or more concepts need to be selected for the next diverging stage on a new, more concrete, level.

A Systematic Process: Levels

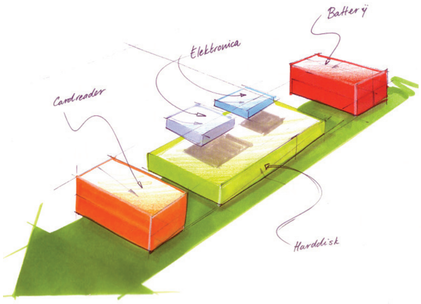
The Fish-Trap model is a systematic process because it forces the designer to explore alternatives on three subsequent levels of increasing detail and meaning: (1) topological level, (2) typological level and (3) morphological level. Exploring alternatives on each of these levels gives three types of concepts: (1) a structural concept, (2) a formal concept and a (2) material concept. On each of these levels, large variations of design alternatives are generated, put in groups and evaluated. After a selection of the most promising concepts a new generation phase starts on a more detailed level.



_The basic design cycle

Topological Level: The Structural Concept

Define the basic functional components. These components, or ordering elements, can exist of the technical parts (such as batteries and printed circuit board) or the parts that represent the functions (such as visual feedback and one-hand control). With the components you can compose many possible variants that differ compared to their topology; the spatial ordering of the components. This can for instance result in an 'open', a 'compact' or a 'horizontal structural' variant. Selection of one or more structural concepts will be done by evaluation with the criteria.



_Structural concept (from DELFT university)

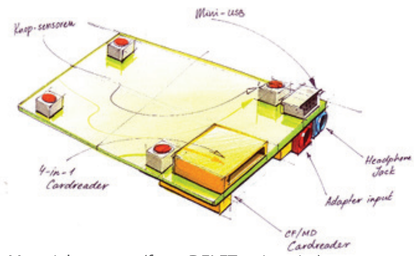
Typological Level: The Formal Concept

We focus on the global form of the concept starting with one or more selected structural concepts exploring forms and shapes. Exploration takes place by sketching.These sketches need to be evaluated and categorised in groups with the same form type. Promising solutions should be further developed into formal concepts, which clearly show the formal features and the typical intended interaction with the intended users


_Typological concept (from DELFT university)

Morphological Level: The Material Concept

It includes the further materialisation of one or more formal concepts. Manufacturing, assembly, specification of materials, finishing, texture and colours should be explored and defined.



_Material concept (from DELFT university)

Multi-sensory design

WHAT IS IT?

The main challenge in Multi Sensory Design (MSD) projects is to come up with an integrated design, in which all sensory impressions support the expression of the product. Designers who intentionally try to create specific experiences for people, such as delight, trust or the feeling of being cared for, are more likely to succeed if they are aware of the messages conveyed by the different sensory channels and of their contribution to the overall experience

THE MODEL PROCESS IN SHORT

1_Selecting the target expression

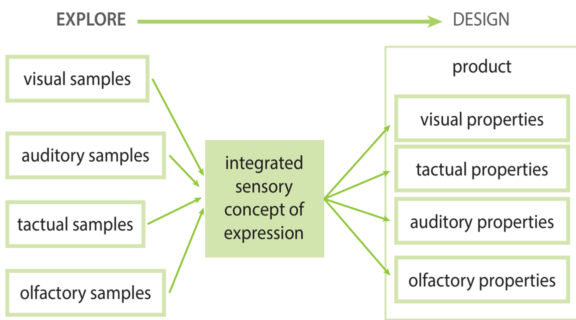
MSD takes the expression of the object (e.g., eagerness, cheerfulness, innocence) as the design starting point. It can be provided by the marketing department or the designer can start out from the effect you want to achieve among future users.

2_Conceptual exploration

Developing an understanding of the selected expression by for instance writing down the associations that come to mind when thinking about this expression

3_ Sensory exploration

Collecting samples that seem to evoke the target expression for different sensory modalities.
(e.g., pictures, materials, fragrances)



4_ Sensory samples

Describe and understand the relationships between the perceived sensory properties and the product expression. Try to find out why certain samples seem related to a specific expression and try to determine the physical properties that evoke the target expression.

5_ Mind Map

Organises the information that was acquired in the previous stages. In the end, the mind map should indicate how a particular concept may be translated into a perceivable product aspect that makes the concept physically tangible.

6_ User-interaction scenario

The scenario describes the actions users perform, the feedback they receive from the product, the instructions users receive, and so on. In the MSD approach, scenarios are used to identify all the sensory touch points during the encounter

7_ Model making

Staying in touch with the physical counterparts of a specific product expression is a safeguard that enables to develop an integrated user-product interaction that makes sense to prospective users and engages them. Actually sensing a specific property often differs from one's expectations when trying to imagine it.

8_ Multisensory presentation

The final design needs to be presented in a multisensory way;

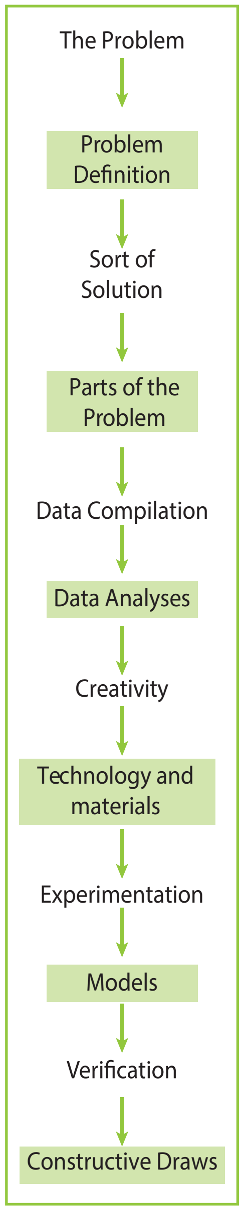
6.3. ¿Cómo nacen los objetos? Apuntes para una metodología proyectual
Bruno Munari

The Problem

The problem of *design* arises from a need. This means that latterly people fell the need of for example, a more economic means of locomotion, a different way to organizing space, etc.
These are the needs that may arise a design problem. The solution to these problems improves the life quality.
These problems can be detected by the designer and proposed to the industry, or industry can be the proposer of a problem solution.
A problem is not solved by itself, but it contains all the need elements for its solution. We need to know and use them in the solution project.

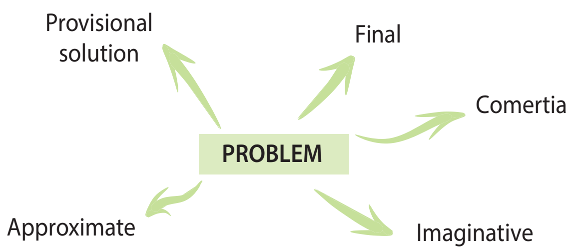
Problem Definition

It starts by defining the problem as a whole. Many designers think that the problem has been defined enough by their clients (the industry) , but it is not really enough.
Therefore it is necessary to start by the problem definition which will be also used to define the limits where the designer should work.
For instance if the problem to solve involves the design of a lamp. It should be defined if it is a chandelier a reading lamp, a work lamp, for a living room or a bedroom. If it should be an halogen, fluorescent or incandescent light. Where it is going to be deliver, if it should have a top price or if it should be detachable, and what have you.

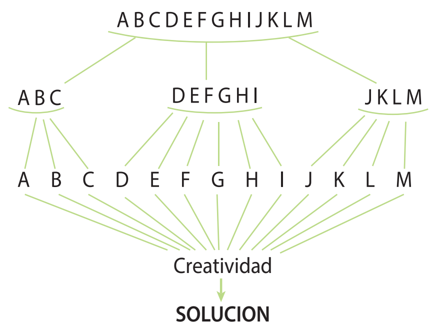


Sort of Solution

You need to define the kind of solution that you want to give to the problem: A temporary solution or a permanent one, a technically sophisticated solution or a simple and economic one, a commercial solution or one which remain in time, etc.



Parts of the problem



Any problem can be split in his elements. This operation makes easier the design because it tends to find small problems that hide behind particular subproblems. Once that the small problems are solved singly, they are pieced back together in a consistent way from all the functional characteristics of each of the functional parts, since material, psychological, ergonomical, structural, economical and formal characteristics.

Data Compilation

Before considering any potential solution it is important to get information about related products and solutions. How our problem has been solved before and which products are already in the market, how they work and what we can learn of them.
It should be researched information about all the parts of the problem that we have defined before.

Data Analyses

All the data compilation have to be analysed in order to identify how problems have been solved in every case. Also the possible defects that current designs still have, are identified and analysed, looking for a better solution.
The analysis of all collected data can provide tips on what we have or we don't have to do in a design. It can guide us to different solutions, materials, technologies or costs.

Creativity

Thanks to all the study made in the previous steps, the creativity will replace the intuitive idea. The idea is linked to the fantasy, it can suggest unfeasible solutions by technics or economics reasons. Whereas the creativity stay into the problem limitations, that have been provide by the data and the problem analyses. The creativity, before settling on a solution considers all necessary operations arising from the data analysis.

Technology and Materials

Collecting data about the materials and the technology that at the moment the designer has at his disposal to fulfil his project.
The company that request the designer to make a project will have a determinate technology to manufacture certain materials and not others. So it becomes useless to think in solutions on the fringes of the manufacturer company information.

Experimentation

The designer will try with the materials and technics which are available to make his project. It allows the designer to discover new uses of a material or an instrument.
The experimentation of materials and technics allows collecting information on new uses of a product.

Models

Now the designer starts to establish relationships between the collected data and the subproblems, making some sketch in order to build partial models. This sketches cans show us partial solutions of one or more subproblems. In this way a model of the eventual solution problem will be obtained.

Verification

Now it is time to make a verification of the model or models. The model is showed to a determinate number of potential users and they are asked to submit a sincere opinion of the product.
Whit this data a control of the model is make in order to identify changes or improvements.
It is necessary also to carry out a economic control of the product to check if th eproduction cost allows a correct sale price.

Constructive Draws

All the exact measurements and necessary instructions for the manufacturing of the prototype.
These draws will be made in a clear and legible way, enough to understand all the details, and if there are not enough, will be model a natural model to clarify all the details.
The arrival of the 3D modeling and CAD systems have simplified this step because all the details can be checked in the 3D

6.4. "Design methods" by John Christopher Jones

Christopher Jones' book is divided into two parts. The first part is a review of ancient and modern design methods which have been developed to assist designers and planners in recent years. The second part is an outline with examples of 35 new methods. Its advantages and limitations are analysed in each case. Due to that we are focused in different kind of methodologies we will stress the second part of the book.

1st Part: The developing design process

Christopher Jones explains the need of new methods. He says that it is because nowadays the traditional method of design-by-drawing is too simple for the growing complexity of the man-made world. In the book, he analyses new methods to, presumably, obtain better results. However, as he explains, there is no proof that these methods work. According to him, the problem is losing control when acquiring a systematic procedure.

1. How do traditional designers cope with complexity?

The main principle in dealing with complicated problems is to transform them into simple ones. The traditional way of dealing with complexity is to operate only upon a single conception of the whole.

2. In what ways are modern design problems more complicated than traditional ones?

Present external complexities:

- · Technology transfer
- · The prediction of the side effects of a new product.
- · Agreement between standards from different countries to assure compatibility.
- · The sensitivity to human overlap.
- · The impossibility of removing major incompatibilities between products.

Present internal complexities

- · High money investment is needed.
- · Difficulty of applying information from outside sources to an existing design situation.
- · Difficulty of discovering rational decision sequences.

3. What are the interpersonal obstacles to solve the modern design problems?

There are some problems when trying to involve all the people who are designing. These are the main groups when designing by Committee:

- · Sponsors.
- · Design team.
- · Suppliers.
- · Producers.
- · Distributors.
- · Purchasers.
- · Users.
- · System operators.
- · Society.

4.Why are the new kinds of complexity outside the scope of the traditional design process?

The search space in which we have to look for feasible new systems, composed of radically new products and components, is too big for rational search and too unfamiliar to be penetrated and simplified by the judgments of those whose education and experience has been limited to the existing design and planning professions. Multi professional designers are needed; as well as planners whose intuitive leaps are informed by knowledge and experience of change at all levels from community action to component design. Likewise, we need new methods that provide sufficient perceptual span at each of these levels.

The new methods reviewed

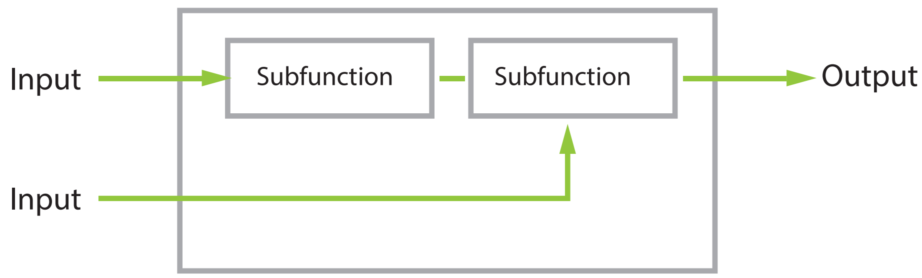
1. Designers as black boxes

The principle that these kind of designers follow is that the most valuable part of the design process is that which goes on inside the designer's head and partly out if his conscious control. These designers are capable of producing outputs in which he has confidence, and which often succeed, without his being able to say how these outputs were obtained. Two the most characteristic techniques of black box design are ***Brainstorming**** and ***Synectics*.***

2. Designers as glass boxes

The majority of design methods are based on this kind of thinking. They are concerned with externalized thinking and are therefore based on rational rather than on mystical assumptions. The design process is entirely explicable. All these methods share several characteristics:

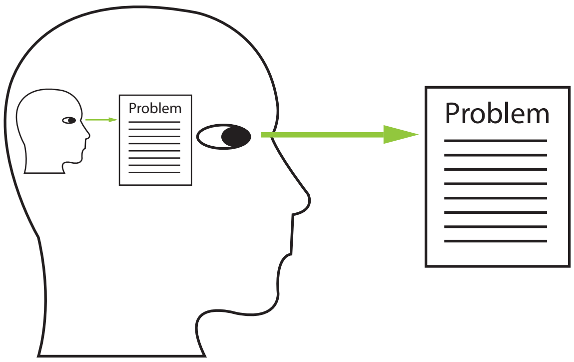
· Objectives, variables and criteria are fixed in advance.
· Analysis is completed, or at least attempetd, before solutions are sought.
· Evaluation is linguistic and logical.
· Strategies, commonly sequential, are fixed also in advance. The may include parallel and conditional operations as well as recycling.



3. Designers as self-organizing systems

Self-organization is a process where some form of global order or coordination arises out of the local interactions between the components of an initially disordered system. This process is spontaneous: it is not directed or controlled by any agent or subsystem inside or outside of the system; however, the laws followed by the process and its initial conditions may have been chosen or caused by an agent. It is often triggered by random fluctuations that are amplified by positive feedback. The resulting organization is wholly decentralized or distributed over all the components of the system. As such it is typically very robust and able to survive and self-repair substantial damage or perturbations. We can divide the available design effort into two parts:
· That which carries out the search for a suitable design.
· That which controls and evaluates the pattern of search (strategy control)

If this is done it is possible to replace blind searching of alternatives by an intelligent search that uses both external criteria and the results of partial search to find short cuts across the unknown territory. Two things have to be clear: the strategy itself and the external situation that the design is intended to fit.
The objective of this model is to enable the members of the design team to validate according to the decisions that they make if there is a balance between the new design, the situations influenced by the design and the cost of designing.



2ND PART: DESIGN METHODS IN ACTION

This is a collection of thirty-five techniques which have been chosen according these principles:
· Effectiveness
· Relevance
· Convenience
· Familiarity
· Criticism
These methods have been classified related to the three-stage process which is explained below.

The design process disintegrated

One of the simplest and most common observations about designing is that the process must include three essential stages: analysis, synthesis and evaluation. Thanks to them we will be able to break 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.

The three stages named below do not have to fit always together to form an universal strategy. They are called divergence, transformation and convergence.

1. Divergence

It is related to extend the boundary of a design situation in order to look for a solution. It is a kind of search which is mainly characterised by the following facts:
· The objectives are unstable and tentative.
· The problem boundary is unstable and undefined.
· Evaluation is deferred: nothing is disregarded.
· The design brief is treated as a starting point for investigation.
· The designers' aim is to rid themselves of preconceived solutions.

Divergent search could be understood as 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 is susceptible to change and what are to be regarded as fixed points of reference.

To sum up, divergent search is to de-structure the original brief while identifying there features of the design situation that will permit a valuable and feasible degree of change. This kind of research allows the designer to avoid any false assumptions.

2. Transformation

This is the stage of everything that makes designing a delight. It is the critical stage when big mistakes can be made.

· The main objective is to impose a pattern that is precise enough to permit convergence to the single design that must eventually be decided. Pattern-making, in this context, is the creative act of turning a complicated problem into a simple one by changing its form and by deciding what emphasize and what to overlook.

· Objectives, brief and problem limits are settled down here.

· The problem is split up into sub-problems.

· The goals can be changed to avoid major compromises. It is also important the speed which with we can predict future changes.

· The personal aspect of designing is most evident at this stage.

3. Convergence

This is the stage is nearly the whole of designing. This stage is carried out when the problems have been defined, the variables have been identified and the objectives are perfectly agreed.

· The main goal 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 most important decision is the order in which variety-reducing decisions are taken.

· The snag is that unforeseen sub-problems prove to be critical to be insoluble unless an earlier decision is changed, thus causing recycling.

In short 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 managed and without the need for unforeseen retreats. A rational description of how one got there last time may not be an adequate guide to the next journey that one undertakes.

The scheme which follows, it shows different methods from the three stages that we have just explained. Likewise, they are classified into different groups according to the purpose of each one.

Divergence	Transformation	Convergence
Stating objectives	Interaction matrix	Systematic search
Literatura searching	Interaction net	Value analysis
Searching for visual inconsistences	AIDA	System engineering
Interviewing users	System transformation	Man-machine system designing
Questionnaires	Innovation by boundary shifting	Boundary searching
Investigating user behaviour	Functional innovation	Page's cumulative strategy
Systemic testing	Classification of design information	CASA
Selecting scales of measurement		Checklists
Data logging and data reduction		Selection criteria
Brainstorming		Ranking and weighting
Synectics		Specification writing
Removing mental blocks		Quirk's reliability index
Morphological charts		

- Prefabricated strategies
- Methods of exploring design situations
- Methods of searching for ideas
- Methods of exploring problem structure
- Methods of evaluation

The main effect of the new design methods has been to make public the thinking that a designer traditionally keeps to himself and to separate it into three stages:
1. Intuitive = Black box thinking.
2. Rational = Glass box thinking.
3. Procedural = Thoughts-about-thoughts.

Choosing design methods

One option could be to use the input/output chart; comparing a method's inputs with what the designers already know and its outputs with what they want to find out.

· Inputs: They are shown in the left column. They are the sort of information that must be available in order that a method can be used.
· Outputs: they appear in the upper row. They are the sort of information that the methods produce.

How to act:

1st: Find in the input scale the categories of information that have so far become available. The rows next to these categories contain methods that are relevant to the problem.

2nd: Select from the output scale the information that is required. The methods in order to get this kind of information appear below.

3rd: Where the row and column cross, there are some methods from where we will be able to select the one that we prefer.

Outputs → / Inputs ↓	Design situation explored	Problem structure perceived or transformed	Boundaries located, sub solutions described and conflicts identified	Sub solutions combined into alternative designs	Alternative designs evaluated and final design selected
Brief issued	· Stating objectives · Literature searching · Visual inconsistency · Interviewing users · Brainstorming	· Literature searching · Visual inconsistency search · Interviewing users · Brainstorming · Synectics	· Visual inconsistency search · Brainstorming · Morphological charts	· Visual inconsistency search · Brainstorming · Synectics	· Strategy switching · Matchett's FDM
Design situation explored		· Stating objectives · Data reduction · Interaction matrix · Interaction net · Classification · Specification writing		· System transformation · Functional innovation · Alexander's method	
Problem structure perceived or transformed	· Literature searching · Questionaires · Investigating user behaviour · System testing · Selecting measurement scales · Data logging		· Boundary searching · Systemic testing · Brainstorming · Morphological charts · Selecting criteria · Ranking and weighting · Specification writing	· Brainstorming · Synectics · System transformation · Boundary shifting	· Systematic search · Value analysis · Systems engineering · Man-machine system designing · Boundary searching · Page's strategy · CASA
Boundaries located, sub solutions described and conflicts identified		· Synectics · Removing mental blocks · AIDA · System transformation · Boundary shifting · Functional innovation · Alexander's method		· Brainstorming · Synectics · Removing mental blocks · AIDA	· AIDA
Sub solutions combined into alternative designs					· Value analysis · Questionnaires · Investigating user behaviour · Systemic testing · Selecting measurement scales · Data logging and reduction · Check list · Selecting criteria · Ranking and weighting · Specification writing · Quirk's re
Alternative designs evaluated and final design selected					

6.5. "Product development and concurrent engineering" by Christoph Loch

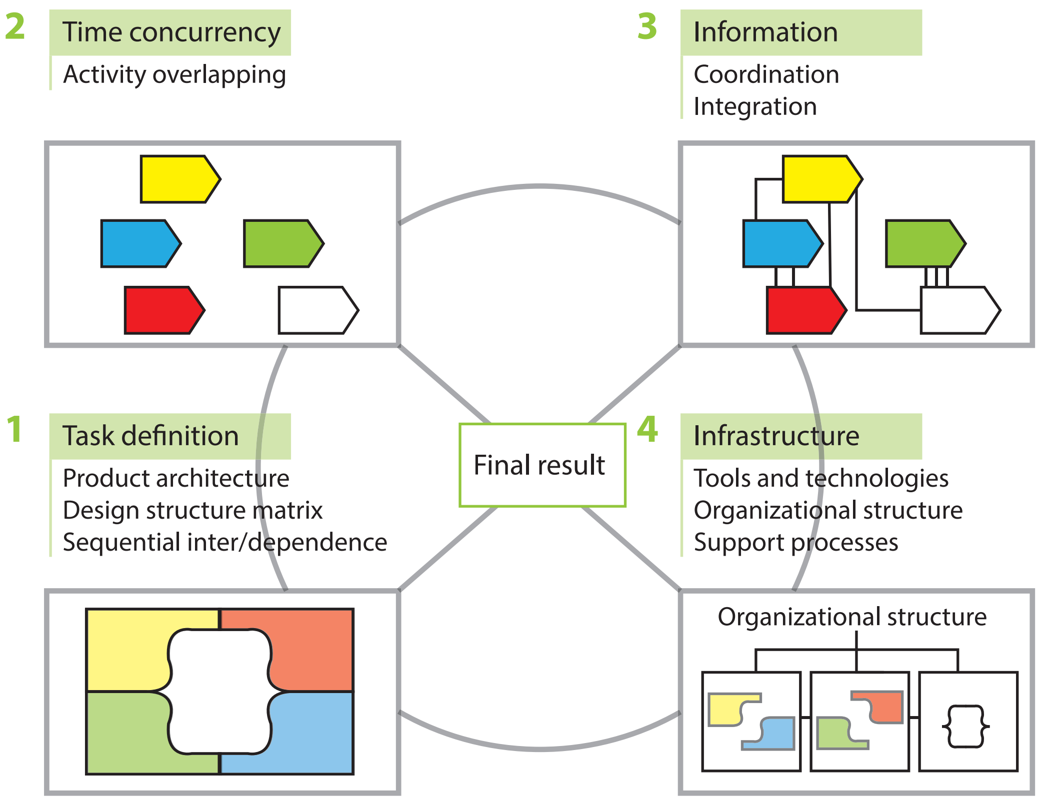
In Christoph Loch's article the general concurrent engineering system is analysed, drawing special attention to Clark and Fujimoto opinion.

Concurrent engineering can be defined as integrating a new product development process to allow participants making upstream decisions to consider downstream and external requirements. A concurrent development process is characterised by activities which overlap, information transferred in small groups and the use of cross-functional teams.

Clark and Fujimoto provide in their work an empirical analysis of product development processes, their impact on development performance and their differing use across regions. They give examples about companies with short-time-market which combine activities overlap with intensive information transfer.

The process of a concurrent development process could be divided into four stages:

1. Division and task definition.
2. Time concurrence and activity overlapping.
3. Information concurrence: coordination and integration.
4. Supporting infrastructures and implementation.



1. Division and task definition

It is common to divide the design tasks into smaller ones to make the work easier. This division will depend on how complex is the architecture of the product we are developing. This architecture identifies the functions of the product.
In this stage the main objective is to minimize the interactions among activities, or define them really explicitly so that the information can be perfectly identified.

There are two kinds of couplings:
- Sequential dependence coupling: one task is the information supplier and other one the receiver.
- Task interdependence: several tasks requiring information input from one another.

One of the tools to carry this out is the **design structure matrix (DSM):** it groups activities in order to reduce the interactions among the tasks. This matrix faces the tasks in rows and columns so that it can be marked (x) which one needs the other's input information.

	A	B	C	D
Task A	A			
Task B	x	B	x	
Task C			C	
Task D		x		D

2. Time concurrency

Once all the task are perfectly clear it is necessary to stablish how much time they will take. There are two ways to carry out the tasks, either carrying them out in parallel or make them partially. The concurrent engineering tends to overlap some tasks which are dependent.
Overlapping activities may create uncertainty for the downstream activity, which would not exist in a sequential process. Concurrence benefits decrease with increasing project uncertainty.
Different models have been given in different studies in order to time the tasks:

- Ha and Porteus

Situation: two tasks have to be developed in parallel to avoid quality problems.
They studied "how often meet", they studied how often the exchange of information is needed. Parallel activities save rework and time. The main question is how to coordinate.

- Krishan et Al

Situation: sequentially dependent activities.
The authors model preliminary information passed from an upstream to a downstream activity in the form of an interval. According to him, two concepts define this process: "Evolution" and "Downstream sensitivity". The problem is showed as a mathematical programme and they show when overlapping should be used; and when upstream information should be frozen early. If upstream information is frozen before the interval has been reduced to a point value, a design quality occurs.

- Loch and Terwiesch

"The more uncertain the upstream activity , the more Engineering Changes (ECs) are likely to arise". The ECs become more difficult to overcome the later they occur. Sensitivity analysis shows that overlapping activities produce more advantages if ECs can be avoided, if dependence between activites can be reduced and the level of uncertainty can be reduce in the early stages of the process.

The models showed previously indicate different ways to act. In general, authors agree that overlapping activities reduce time-to-market for stable and mature segments of the market. However, this does not happen when we are dealing with rapidly changing markets.

3. Information concurrence: coordination and integration.

Information exchange is needed when the subtasks of the process have been executed in order to keep the tasks coordinated. This exchange usually happens before the downstream activity. It helps to identify and solve problems before the manufacturing process. According to Clark and Fujimoto successful tasks overlapping is supported by intensive information exchange.

Coordination frequency

The point here is to know how intensively coupled activities should be coordinated.

- Ha and Porteus

"The more significant the coupling, the more quality problems exist and the more severe rework impact per quality problem, the more frequently the task teams should communicate".

- Loch and Terwiesch

They say that in sequentially dependent activities; the more significant the number of changes from upstream and the dependency of the downstream task, the more intensive communication is required.

Analytical results have been studied and proved by Morelli and Thomson, saying that the most intensive communication takes place among activities which are heavily interdependent.

Coordination format

It is referred to the format of the information which is being exchanged between concurrent activities.
The choice between set-based and iterative concurrence depends on the nature of the product component developed, and often a combination is used. The trades-off and the choice involved, also depend on technological and process capabilities of the organization.

4. Supporting infrastructures and implementation.

The three first stages must be seen within the context of a supporting infrastructure. Below there are analysed three different infrastructure components.

Technology and tools

This technologies, like CAD, simulation tools or rapid prototyping can change the trades-off involved in time and information concurrence.

According to Thomke we can divide these technologies into flexible and inflexible:
-Flexible: they allow the quick and cheap incorporation of design changes. The projects which use this kind of technologies are more efficient.
- Inflexible: they do not allow these rapid and cheap changes.

Concurrent engineering practices can be influenced by communication technologies. Email, porable phones and shared databases have the aim of making the exchange of information faster

Project organization

The structure of the project often shows the project organization architecture.
There are four different types of project organization:

- **Functional structure:** people grouped by fields, projects carried out thanks to initial specifications and occasional meetings. Its weakest point is when running tight time-to-market projects.
- **Lightweight structure:** a project coordinator leads a coordinating committee where each function has a representation.
- **Heavy weight structure:** the coordinator becomes a real project manager.
- **Autonomous structure:** the project is developed out of the regular organizational structure, the project manager controls all resources. Its main advantages are focus and speed; although it usually has integration problems .

Regardless the organization type it is being used, it implies the willingness to cooperate and to exchange information

Support processes

Concurrent engineering require support processes, the next ones are explained below: integration with suppliers, engineering change orders, and interfaces among multiple development projects.

- **Integration with suppliers:** the investments and open information which is required to involve suppliers in the concurrent engineering process only work in long term relationships with mutual commitment; describing who is responsible in each delivery by using different tools like CAD or order management. It is also necessary to settle which kind of information must be exchange and the objectives that must be accomplished.

- **Engineering change orders:** When tasks start based on preliminary information leading to mistakes, they are an unavoidable consequence. The next principles may help to make the process effective:

1. Give clear responsibilities in order to avoid hands off during the project.
2. Manage capacity to reduce congestion.
3. Avoid set-ups. To get this engineers usually divide their work into batches which can produce delays. Reducing set-ups can help to reduce batches by better IT systems or by assigning one person responsibility for one EC all the way through.
4. A complex product with a highly integrated architecture makes EC management more difficult . It is then important to educate all personnel involved about the key interactions among components and to give strong incentives for fast problem communication and resolution.

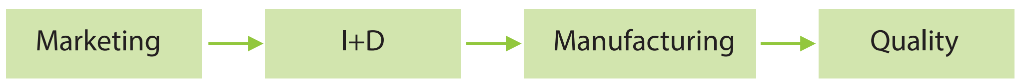
- **Interface among multiple development projects:** In many cases much of the engineering work is performed in functional organizations of specialists who work in several projects simultaneously. By this token it is necessary to settle the priorities prior to start a project in order to avoid misunderstandings later.

6.6. “Metodología del diseño industrial: un enfoque desde la ingeniería concurrente” (Industrial design methodology: approach from concurrent engineering) by Francisco Aguayo González and Víctor M. Soltero Sánchez.

This book offers a view of the design methodology under a concurrent and simultaneous engineering standpoint. The concurrent engineering can be defined as a work methodology based on the parallelization of tasks (i.e. performing tasks concurrently). It refers to an approach used in product development in which functions of design engineering, manufacturing engineering and other functions are integrated to reduce the elapsed time required to bring a new product to the market.

Depending on how the activities are being developed we can distinguish two design models:

1. PDDP (Design Process and Products Development) model by sequential engineering.
The marketing department count with some desires from the market analysis. They inform to the I+D engineering department about this desires who give their blueprints to the manufacturing department. They start to elaborate the process and to select the manufacturing methods in order to, finally, give the project to the quality department which is the responsible for test and inspection procedures .



This method implies a lot of rework in each department. As a consequence, some of the designs may not be able to be manufactured because all the conditioning aspects from each department were not taken into account. When the process is too advanced some changes cannot be done so that the result is not correct.

2. PDDP (Design Process and Products Development) model by concurrent engineering.
This model appears due to the need of decreasing the time which is spent to develop a project as well as its costs. It is based on the team work (taking into account all the departments' skills and requests); even including the components suppliers and means of production.
Thus, suppliers and means of production usually work together with the production department during a product development process. Likewise, the production department work with the design office, being able to define the means of production previously. The results, related to time and costs, are lower.

Concurrent engineering process and product/process specification

In the next point a possible design process is explained, including the different stages as well as the necessary activities to develop it.

1. Market analysis and needs identification.

Depending on the kind of project, its complexity or amount of them, these activities are carried out:
· Product object definition by using:
  - Briefing: sentence or description concerning the need or the product.
  - Objectives
  - Final market of the product
  - Boundaries and limitations assumed during the project development.

· Identification of the user/consumer and collecting information.
  - Reference market and users selection.
  - List the consumer's needs.
  - Study the user-product interaction.

· Interpretation of the information collected.
· Needs organization and hierarchy attending to their importance.

2. Product specification

· Analyse the users' needs by a functional analysis.
· Carry out a functional analysis of the competence's products.
· List different functions.
· Validation of the functional model of the product.
· Functions hierarchy (tree diagram)
· Write up the product design specifications.
· Estimate an economical approach.
· Elaborate a quality plan.
· Identify project and product interfaces.

3. Concept generation or conceptual design

· Classify and formulate the design problem.
  - Divide the problem into sub-problems.
  - Determine: input/output/design variables, boundaries, design parameters, stablish interfaces, fix tolerances.
· Solutions search: external (users, experts, patents, benchmarking...) and internal (individual, group)
· Explore the different possible solutions by using creative techniques and selecting the ones which satisfy the specifications. Among these techniques we can highlight creative techniques both individual or in group. Some of the results that we may obtain are:
  - Concepts tree which satisfy the functional tree.
  - Matrix which combines the concepts.

· Select the concept and validate it. The point is selecting the best solution, the one which better satisfies the functional requirements. Some of the techniques that can be used are:
- Giving different scores.
- Dominance matrix.
  - Multi-criteria methods.
  - Cost-benefit decision tree.

· Validate or test the solution in the market where is supposed to be, then it is possible to redefine and to improve it.

4. Preliminary design and basic engineering

In this stage the characteristics related to technology, materials and processes are specified. The design will be specified taking into consideration technological aspects, mechanical, electrical, electronic, aesthetic, shape, ergonomic, environmental...

It is important to define the modularity aspects, interfaces and giving tolerances.

In short, it is necessary to generate different alternatives concerning the technological design as well as the manufacturing process. The steps to achieve it are:

· Check the conceptual model.
· Analyse leader products by inverse engineering.
· Generate different alternatives of preliminary design and choose the most adequate.
· Validate this alternative into the market.
· Develop the product: 3D model, conceptual prototypes, define provisional materials and processes and develop an economic model to validate it economically.

5. Final design and detail engineering

In this stage it will be necessary to specify all the characteristics based on the information from the 4th stage.

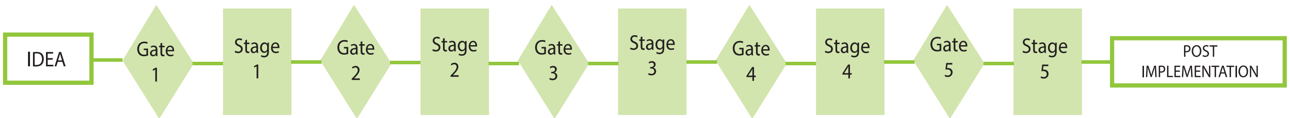
· Definitive materials and processes.
· Mechanical analysis to fix the geometrical dimensions.
· Design for X: viability, feasibility, use analysis and fail effect.
· Tolerances and parameters specification.
· Functional simulation.
· Tree assembly product development.
· Blueprints.
· CAD prototypes.
· Pieces development for manufacturing tests.
· Prototypes exposition as well as technique specifications.
· Economical final test.
· Integral modelling and product simulation.
· Use simulation.
· Related to manufacturing process: Generate the product in different programs, pre-series and tools manufacturing, Taguchi online design.

Due to the characteristics of engineering concurrent, these stages are not carried out sequentially, on the contrary they are mostly developed at the same time, simultaneously, so that they are started with incomplete initial information. This lack of initial information is supported by a system which manages this information on real time, such as PDM (Product Data Management) systems, video-conferences and other collaborative engineering systems.

The complexity of the project often lies in the fact that most of these stages are developed at the same time and the concurrent engineering teams might be (as a limit) formed by only one person. In this situation, all the concurrent process becomes one only stage for simple products. By this token, all the methods of the concurrent engineering can be developed autonomously.

6.7. Stage Gate System _ Robert G. Cooper

The stage gate system is a project management technique in which an initiative or project (e.g., new product development, process improvement, business change) is divided into stages or phases, separated by gates. At each gate, the continuation of the process is decided by the project responsible. The decision is based on the information available at the time, including the business case, risk analysis, and availability of necessary resources (e.g., money, people with correct competencies).



This schema serves as a sample or skeleton from which to develop a stage gate model.. The various stages and gates are described below

Idea

The new product process is initiated by a new product idea, which is submitted to Gate 1, Initial Screen.

Gate 1: Initial Screen

Initial screening is the first decision to commit resources to the project: the project is born at this point. If the decision is Go, the project moves into the Preliminary Assessment stage. Thus Gate 1 signals a preliminary but tentative commitment to the project: a flickering green light. Gate 1 is a "gentle" screen, and amounts to subjecting the project to a handful of key "must meet" and "should meet" criteria. These criteria deal with strategic alignment, project feasibility, magnitude of the opportunity, differential advantage, synergy with the firm's core business and resources, and market attractiveness. Financial criteria are not part of this first screen. A checklist for the "must meet" criteria and a scoring model (weighted rating scales) for the "should meet" criteria are used to help focus the discussion and rank projects in this early screen.

Stage 1: Preliminary assessment

This first and inexpensive stage has the objective of determining the project's technical and marketplace merits. A preliminary market assessment is one facet of Stage 1 and involves a variety of relatively inexpensive activities: a library search, contacts with key users, focus groups, and even a quick concept test with a handful of potential users. The purpose is to determine market size, market potential, and likely market acceptance. Concurrently, a preliminary technical assessment is carried out, involving a quick and preliminary in-house appraisal of the proposed product. The purpose is to assess development and manufacturing feasibility, and possible costs and times to execute. Stage 1 thus provides for the gathering of both market and technical information--at low cost and in a short time, so the project can be reevaluated more thoroughly at Gate 2

Gate 2: Second Screen

This gate is essentially a repeat of Gate 1: The project is reevaluated, but in the light of the new information obtained in Stage 1. If the decision is Go at this point, the project moves into a heavier spending stage. At Gate 2, the project is again subjected to the original set of "must meet" and "should meet" criteria used at Gate 1. Here, additional "should meet" criteria are considered, dealing with sales force and customer reaction to the proposed product, the result of new data from Stage 1. Again, a checklist and a scoring model facilitate this gate decision. The financial return is assessed at Gate 2, but only by a quick and simple financial calculation (for example, the payback period).

Stage 2: Definition

This is the final stage prior to product development. It is the stage that must verify the attractiveness of the project prior to heavy spending. And it is the stage where the project must be clearly defined. Here, market research studies are undertaken to determine the customer's needs, wants and preferences, that is, to help define the "winning" new product. Competitive analysis is also a part of this stage. Another market activity is concept testing, where the likely customer acceptance of the new product is determined.

At Stage 2, a detailed technical appraisal must focus on the "do-ability" of the project. That is, customer needs and "wish lists" must be translated into technically and economically feasible solutions. Finally, a detailed financial analysis is conducted as an input to Gate 3.

Gate 3: Decission on business case

This is the final gate prior to the Development Stage, the last point at which the project can be killed before entering heavy spending. Once past Gate 3, financial commitments are substantial. The project is once again subjected to the set of "must meet" and "should meet" criteria used at Gate 2. Next, the qualitative side of this evaluation involves a review of each of the activities in Stage 2, checking that the activities were under- taken, the quality of execution was sound, and the results were positive. Finally, because a heavy spending commitment is the result of a Go decision at Gate 3, the results of the financial analysis are an important part of this screen.

A second part of Gate 3 concerns definition of the project. At Gate 3, agreement must be reached on a number of key items before the project proceeds into the Development Stage. These items include target market definition; definition of the product concept, specification of a product positioning strategy, and delineation of the product benefits to be delivered; and agreement on essential and desired product features, attributes, and specifications. The development plan and the preliminary operations and marketing plans are reviewed and approved at this gate.

Stage 3: Development

Stage 3 involves the development of the product and (concurrently) of detailed test, marketing, and operations plans. An updated financial analysis is prepared, and legal/patent/copyright issues are resolved.

Gate 4: Post-Development Review

The Post-Development Review is a check on the progress and the continued attractiveness of the product and project. Development work is re- viewed and checked, ensuring that the work has
been completed in a quality fashion. This gate revisits the economic question via a revised financial analysis based on new and more accurate data. The test or validation plans for the next stage are approved for immediate implementation, and the detailed marketing and operations plans are reviewed for probable future execution.

Stage 4: Development

This stage tests the entire viability of the project:
the product itself; the production process; customer acceptance; and the economics of the project. A number of activities are undertaken at Stage 4:
• In-house product tests: to check on product quality and product performance;
• User or field trials of the product: to verify that the product functions under actual use con-
ditions, and also to gauge potential customers reaction to the product;
• Trial or pilot production: to test and debug the production process, and to determine more precise production costs and rates;
• Pretest market, test market, or trial sell: to gauge customer reaction, measure the effective-
ness of the launch plan, and determine expected market share and revenues;

Gate 5: Pre-Commercialization Decision

This final gate opens the door to full commercialization. It is the final point at which the project can still be killed. This gate focuses on the quality of the activities at the Validation Stage and their results. Financial projections play a key role in the decision to move ahead. Finally, the operations and marketing plans are reviewed and approved for implementation in Stage 5.

Stage 5: Commercialization

This final stage involves implementation of both the marketing launch plan and the operations plan.

Stage 5: Commercialization

At some point following commercialization, the new product project must be terminated. The team is disbanded, and the product becomes a "regular product" in the firm's line. This is also the point where the project and product's performance is reviewed. The latest data on revenues, costs, expenditures, profits, and timing are compared to projections to gauge performance.
Finally a critical assessment of the project's strengths and weaknesses, what we can learn from this project, and how we can do the next one better--is carried out. This review marks the end of the project.

The basic benefits of the stage-gate process are evident. The model puts discipline into a process that, in too many firms, is ad hoc and seriously deficient. The process is visible and relatively simple: what is required at
each stage and gate is understood by all. The process provides a road map to facilitate the project, and it better defines the project leader's objectives and tasks. Also, the process builds in evaluation stages to better rank projects and focus resources.

6.8. “The future of design methodology” by Herbert Birkhofer

The Future of Design Methodology gives a holistic overview of perspectives for design methodology, addresses trends for developing a powerful methodical support for design practice and provides a starting point for future design research.
It provides a comprehensive collection of perspectives and visions. The editor highlights the substantial deficiencies and problems of the current design methodology and summarizes the authors' findings to draw future-oriented conclusions.

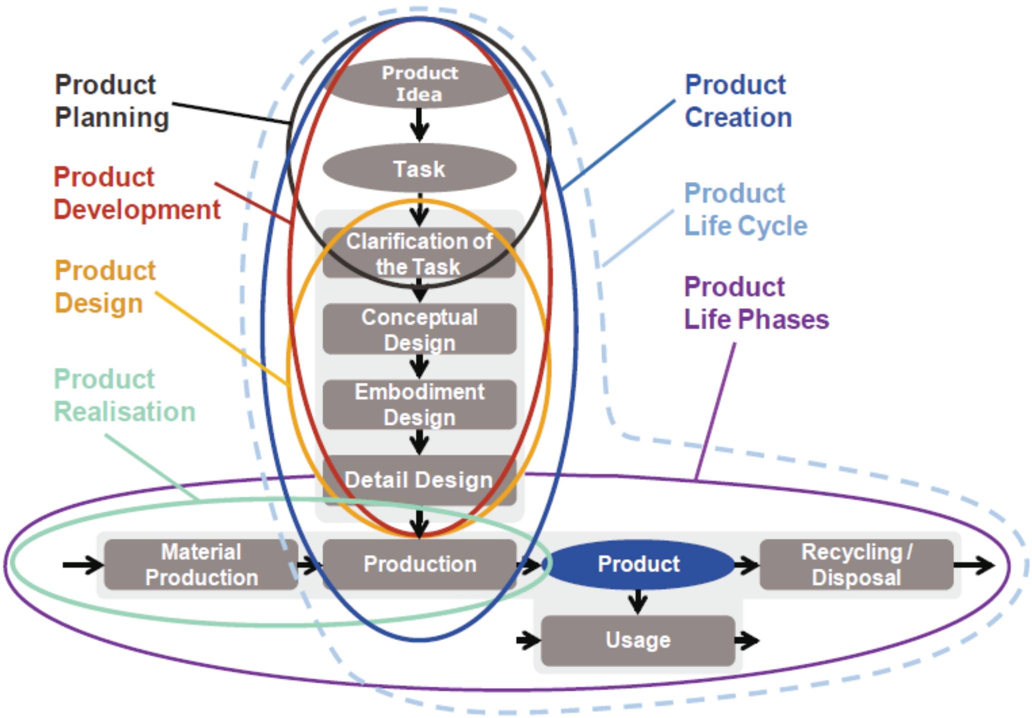
PART 1: SPECIFIC WAYS TO FURTHER DEVELOP DESIGN METHODOLOGY

Chapter 1: Introduction

Design methodology

“Design Methodology is understood as a concrete course of action for the design of technical systems that derives its knowledge from design science and cognitive psychology, and from practical experience in different domains. It includes plans of action that link working steps and design phases according to content and organisation. These plans must be adapted in a flexible manner to the specific task at hand. It also includes strategies, rules and principles to achieve general and specific goals as well as methods to solve individual design problems or partial tasks.”

The aims why the concept of design methodology arose are:
· To eliminate the conception of design as art.
· It enables to follow an appropriate, verifiable and controlled procedure to obtain reliable solutions.
· To create a framework or models enabled to be used in other disciplines.

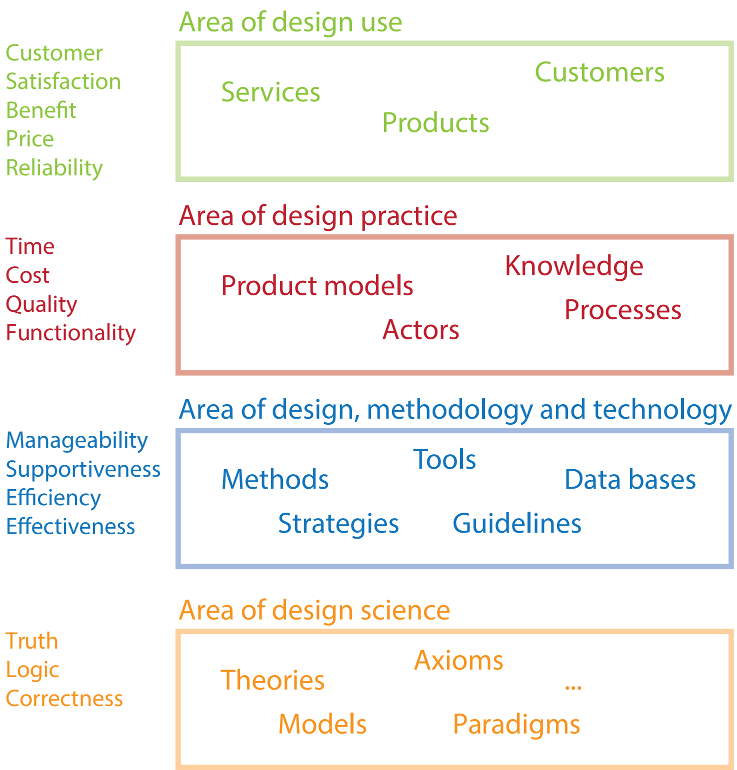


The diagram above shows different tasks of the design process, dividing them into different stages and showing their limitations and boundaries.

The demand of methodical work is being demanded by industry more and more. Products are getting more and more complex; as well the technologies which are needed to develop them. Cycles of product innovation are constantly reducing in time.
The time spent coordinating and organising tasks has highly increased. Designers become project managers with product responsibility from the product idea all the way to the release for series production. During a product development tasks are divided into many people. Diversification of the job description is attended by a rather dramatic change in the need for support, which Design Methodology only partially meets. Nowadays, a lot of time is saved thanks to computers programmes.

Design research

We can understand the design methodology as a group of models or methods which are the guidelines to obtain better results during a design process. In the explanations below we will explain how we can accomplish the proposals which show these solutions, in other words, which kind of research is necessary to be triggered by design methodology.
Design methodology and design practice are related one to each other.



There are different types of design research; such as design research methodology, research on generalization , research on product use...

In short, not everything which is called as a design methodological research can reduce the tasks when developing a project.
The information below will show similarities and differences between existent design methodologies in order to understand the future design methodology development.
Opinions from different renamed authors will be showed as well as the main points about their thoughts concerning the design methodology and research.

Chapter 2: Is engineering design disappearing from design research?

Design depends on engineering but when speaking about design research this focused is declined. The design engineering aims to materialise products and systems.
Design is the central activity that defines engineering– or at the very least, distinguishes it from the "pure" sciences – because the role of engineering is the creation of artefacts.
The three main steps of the design methodology which is proposed are:

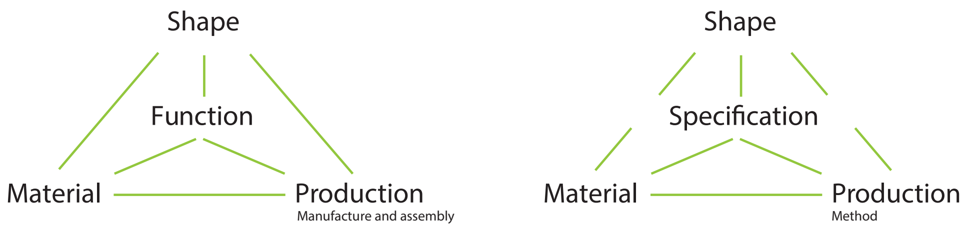
1. **Conceptual design.**
2. **Embodiment stage.**
3. **Detail design.**

From now, the main discussed point will be the second one, the **embodiment stage.**
To start with the embodiment process of a product we will need an inhomogeneous definition of the design, proposing new concepts and embodied sub systems. By this token the embodiment stage has to be started giving a general definition of the embodiment, specifying its scheme, in order to be filled when the design activity starts.
Embodiment is composed by determination of preliminary layout and definite layout. Layout design is creating general arrangement and spatial compatibility, preliminary form design of components fitted to a production procedure and provides solutions for any auxiliary function. The definitive layout shall allow a validation of function, durability, production, assembly, operation and cost. Embodiment contains these main aspects:

· Function reasoning: It involves identifying the product's aim by using natural language. These questions will have to be answered: what do we want to do with the product? What do we want the product to do?
· Structuring: in the conceptual stage it is decided what the product will do. However, lower level organs may appear in the embodiment stage and need to be composed. The dominating task in the embodiment stage is determining the part structure. In structuring the activity the designer may reuse substantial percentage of a past design, along with components, supply parts and standard parts; thus make-buy considerations are of great importance.
· Property reasoning: Designing is traditionally seen to be governed by goal formulation. Beside a formulation of a team's task and the ideal business result, the goal formulation contains a list of requirements related to the ideal product solution, setting requirements for a product's properties. When a synthesised solution appears, articulated by its characteristics, the designer should be able to reason about this solution's properties and mutually compare alternative solutions to find the best solution.
Embodiment as we see here is characterised by a difficult pattern of finalising the function reasoning and operating in the complex property reasoning pattern. Two challenges for the designer are added here.

- 'Trade off': when two or more properties are in conflict for a design and a decision must be made as to which to prioritise.
- The management of changes which is a time, cost and risk loaded topic in industry. Changes propagate through the part structure and need delicate adjustment.

· Part design: in this point we try to identify function surfaces, interface surfaces, material fields, etc. from the characteristics of previous points. Two possibilities of carrying out the part design are:



The use of information technology has become very useful for designing. However, not all the problems can be solved thanks to it. They observe that embodiment and detailing is surprisingly a theory and language empty area where reasoning about function, structural and property aspects is unsupported and the design process is actually not well understood.

Chapter 3: Methodical support for the development of modular product families.

For developing modular product families it is possible combine two market strategies:
· Offering competitive prices by developing standard mass-market products-
· To get a profit, a high number of individualized products can be a successful way to meet individual customer requirements.
The aim of developing a modular product structure for a product family is to maintain the external variety required by the market and reduce internal variety within the company to control, reduce or avoid the associated complexity of corporate processes in product development. A major advantage of this strategy is the larger quantity of standard modules derived that contribute to cost reduction.

The three main steps to develop modular product families are:
1. Decomposition of the product up to the level of the components.
2. Analysis and documentation of the components and their couplings.
3. Analysis of the possibility of reintegrating the components.

To carry out a process-based evaluation of alternatives for modular product structures for a product family, an important methodological unit is the integration and coordination between the product development processes with respect to commonality, the postponement strategy and the product architecture

External variety

External variety

Range of products
Increasing because customized products are required

Process level

Reducying the internal variety of products by
- Adjusting the range of products
- Design for variety
- Modularization

Internal variety

Last step

Internal product complexity

Design for variety

Design for variety brings the product families under consideration closer to an ideal, allowing a description to be made. This ideal is defined by four characteristics:
1. Differentiation between standard and variant components.
2. Reduction of the variant components to the carrier of a differentiating attribute.
3. One-to-one mapping between differentiating attributes and variant components.
4. Complete decoupling of variant components.

Life phases modularization

The aim of the life phases modularization is the development of modular product structures using the results of the product design for variety for each individual relevant product life phase, as well as checking their consistency and adjustment to a continual module structure. Product structure requirements can be better met by considering different product structures for individual phases. The procedure is divided into the following steps:

1. Development of a technical-functional modularization
2. Development of modularizations for all relevant product life phases
3. Combination of modularizations
4. Derivation of the modular product structure

Chapter 4: Risk - driven design processes: balancing efficiency with resilience in product design.

Product development organizations are hindered by the many uncertainties that are inherent in the process.

The development of complex products and systems continues to pose significant challenges for companies. Generally, the interest resides in increasing the efficiency of the design process, in other words, minimizing the quality of the input while increasing the quality of the output (time, cost and quality).

Uncertainty and uncertainty reduction are at the heart of every product development and design project. Designers generate information, transform imprecise into precise information, and gradually reduce uncertainty. Some of this risks are:

Risks are functions of the uncertainty of input factors and their effect on the project's objectives. The risks can arise both along the input factors, such as the technology risks, the process' risks, customer requirements risks....); and along the objectives that they impact, such as the cost risk, the schedule risk or the performance risk.

When the design process is driven by the intention to manage risk, uncertainties and their effect on the objectives are identified and quantified. Decision making then focuses on risks,usually the most critical first. This is done by reducing the level of uncertainty as much as reasonable and then creating a resilient PD system that can absorb the residual uncertainty to achieve the objectives within the target range.

Principle 1 Creating transparency regarding design risks	- Explore and identify knowable uncertainties. - Quantify resulting risks.
Principle 2 Making risk driven decisions	- Resource allocation to retire biggest risks first. - Objective setting related to risks assessment - Enterpreneurial decisions based on risks analysis
Principle 3 Minimizing uncertainty in design	- Reduction of external uncertainty. - Reduction of internal uncertainty.
Principle 4 Creating reisilience in the design system	- Create agile design system. - Create critical buffers in the design system.

Chapter 5: Methodology and computer aided tools: A powerful interaction for product development

The fundamental bases of modern product development are elements and systems, design methods and computer-aided tools. The interaction between methodology and computer support, mastered by competent engineers, can help to meet the challenges of future product development.

The basic areas of product development are:
· Machine Elements and Systems
· Design Methods
· Computer-Supported Tools

Engineers benefit from the large number of mature design methods. While there is no universal method, there is a variety of different methods available for the main stages of the product development process: planning, conceptual design, embodiment design, and detailed design. Some of the methods in each of a project stage are:

Planning

- Requirement list
- Product inquest
- Product strategies
- Project management
- House of quality (QFD)

Conceptual design

- Invention methods
  Brainstorming, TRIZ...
- Evaluation methods
- Sensitivity analysis
- DFX guidelines
- Design review

Embodiment design

- Requirement list
- Product inquest
- Product strategies
- Technology management
- Project management

Detailed design

- Check list for design review
- Evaluation methods
- Optimization strategies

Good interaction between design methods and CAx tools is very helpful in various problems and tasks. This is only the beginning; the potential for the future is great. Design methodology and CAx tools were not developed at the same time but could partner well in the future.

The development of complex and sophisticated products needs an integrated use of design metods and computer tools. Methods and tools must be customized to each other.

In a continuous interaction between synthesis and analysis, engineers will get the information necessary for making their decisions and it will be possible for designers to visualize the consequences of these decisions. All this, of course, needs well-educated engineers with detailed knowledge of both fields, based on sound knowledge of the fundamentals.

Chapter 6: Methodology and computer aided tools: A powerful interaction for product development

The final decision in a design project is generally made by a human, since they are better at interpreting the structure of the data than a computer, provided that the data is processed and presented in a clear and comprehensible way.

A computer will be used to prepare the specifications of the requirements so that the engineer can make the best possible choice. When a computer processes the requirements, it is important to present the results graphically to the decision-making person.

To develop a procedure, the approach is divided into three phases:

1. **Formulation phase**

The informal requirements are transformed into elementary requirements. Better to use linguistic methods than mathematical ones.

2. **Preparation phase**

The elementary requirements of the specifications are processed by computer-based methods in such a way that an automatic comparison of specifications is possible. The number of requirements in a variant design is not consistent. The number of requirements may vary in the specifications. Therefore, the method used for selection needs to be adequate to process such variation in the specifications.

3. **Decision phase**

The product variant with the highest potential has to be selected. As a result of the processing, a similarity value quantifying the resemblance of the specifications and a visualization of the comparison is needed.

In short, it is necessary to find an appropriate task allocation between humans and computers when making the decisions of a project. There are some tools, like SOM, which can be used to visualize the relationship of the collected data that the humans can use to make a decisions, helping themselves with their own experience.

Chapter 7: Increasing effectiveness and efficiency of product development- A challenge for design methodologies and knowledge management.

Knowledge is generated and required to design the product development process effectively and efficiently, including making the right decisions. Therefore, supporting the product development process is a major task of design methodologies, knowledge management and tools.
The main success factors for products – quality, cost and time – have become more and more important and are the same success factors in product development. Effectiveness and efficiency of product development highly influence the success of enterprises.

Engineering design methodologies are an approach for solving a task or a problem.
They refer to appropriate methods and tools. From a designer's point of view, methodologies are prescriptive. Thus, a methodology may be considered as a directive pointing towards the possible best-fit methods or tools within a science or art for coping with a task or problem.

The aspects of a design methodology description are:

Aspect	Group description	Grouped requirements
Normativity	Revisability by accepted and appropiriate means. Scientific soundness by backing up the hipotheses of a methodology.	Validation Verification Objectivity Reliability Validity
Didactics	Comprehensibility	Comprehensibility Repeatability Learnability Applicability
Uncertainty	Providing a structure for complex tasks and problems and compatibility with different environ-ments. Providing flexibility for the designer using degrees of freedom when applying a methodology	Handling complexity Problem solving cycle Structuring Compatibility Flexibility
Competitiveness	Practical relevance and competitiveness by satis-fying a need for a methodology. Usefulness	Innovativeness Competitiveness Effectiveness Efficiency
Match & Limit	Problem specificity allowing links between an assignment and a matching methodology, and defining the application limits of a methodology.	Problem specificity

Effective and efficient product development, in combination with employee knowledge, is increasingly becoming a decisive factor in the tough global market.
Thus, it is a major challenge for engineering design research to develop new and improve existing methods and tools to support companies. The scope of research should not focus overly on design methodologies, but should also consider aspects of knowledge management in product development. The research projects of the IKTD show the potential methods to bridge the gap between these domains. This contribution could mean that design methodologies will be applied more often and more successfully in future.

Chapter 8: Design theory and methodology- Contributions to the computer support of product development/design processes.

Birkhofer ends with a list of computer support requirements:

Developing a coherent prescription and description

... of products	...of development/design processes
· Product properties and their relations · Cope with multitude of properties · Multi-domain approach · Formalisation · Modular product models · Development and application of new methods/tools for product modelling ·Acceptance of methods and tools · Relation to business goals · Integration into existing environments	·General process framework · Specific/"situated" processes · Assigning methods/tools to processes · Formalisation · Modular process models (workbenches) · Development and application of new methods/tools for process support · Acceptance of methods and tools · Work distribution, collaboration · Integration into existing environments

Product design/development process has the next steps:

1. Synthesis
2. Analysis
3. Determining individual deviations
4. Overall evaluation

What Is It?

Product Service Systems, put simply, are when a firm offers a mix of both products and services, in comparison to the traditional focus on products. A marketable set of products and services capable of jointly fulfilling a user's needs". PSS can be realized by smart products.
The initial move to PSS was largely motivated by the need on the part of traditionally oriented manufacturing firms to cope with changing market forces and the recognition that services in combination with products could provide higher profits than products alone. Faced with shrinking markets and increased commodification of their products, these firms saw service provision as a new path towards profits and growth.

Change of Model

As a concept, changes the model of disposability by using and reusing. If companies get profit from the process, they become managers of reuse products.
Fewer products are needed if we share them. The user would only pay for the intended use, generating an economic flow.

The research has focussed on a PSS as system comprising tangibles (the products) and intangibles (the services) in combination for fulfilling specific customer needs. The research has shown that manufacturing firms are more amenable to producing "results", rather than solely products as specific artefacts, and that consumers are more amenable to consuming such results. This research has identified three classes of PSS:

- **Product Oriented PSS:** This is a PSS where ownership of the tangible product is transferred to the consumer, but additional services, such as maintenance contracts, are provided.

- **Use Oriented PSS:** This is a PSS where ownership of the tangible product is retained by the service provider, who sells the functions of the product, via modified distribution and payment systems, such as sharing, pooling, and leasing.

- **Result Oriented PSS:** This is a PSS where products are replaced by services, such as, for example, voicemail replacing answering machines.

Boundary conditions

The boundary conditions described in the following were identified through a series of theoretical and empirical studies, where the aim was to understand characteristics and strategies for the design and development of PSS. They were observed to be particularly characteristic to the design of a PSS offering, compared with integrated product development as the baseline for "traditional" product development activity.

- **Competencies and disciplines:** The underlying strategic principle of PSS is to shift from business based on the value of exchange of product ownership and responsibility, to business based on the value of utility of the product and services. Thus the object of value for the providing company transforms from merely the physical artefact, to any chosen and targeted transaction between the customer and the providing company. Compared to traditional product development, a new set of competencies must be present in the PSS design activity, to enable the design, development and maintenance of a satisfactory relationship with the customer.

- **Nature of offering:** It is important to observe that the traditional pattern of a manufacturing company's share of the product life cycle, followed by the owner's share of the product life, and finally the undefined ownership period, followed by disposal, shall now be viewed in a new way. The company's business intent, the user's intent in the product's materialization and their joint interest together with the artefact throughout the entire life cycle, ought to give new opportunities for innovative thinking and co-development.

- **Production forms:** There are a number of approaches towards implementing and integrating new production forms into the organisation, that are highly relevant to successful PSS design. By broadening the perspective from product life cycle to customer activity cycle , we expand the design object for PSS. And by placing the customer in focus and understanding their needs for functional, efficiency based and/or social fulfilment, it is possible to develop a competence and network-based approach to supporting the customer's whole activity and not merely providing a physical good. We can therefore describe the definition of new production forms as a shift in focus from 'design' to 'doing'.

- **Elements of choice:** a PSS will only be attractive if it:
1_ Adds more value than normal product ownership (measured by level of prestige, ease of ownership, price, total cost of ownership, etc.)
2_ Gives greater degrees of freedom than a traditional product (ease of upgrading, guaranteed takeback of goods, possibility to focus on core business, etc.)
3_ Includes greater elements of choice to the user.

Traditional mass-produced products come with in-built and implicitly regulated properties, that the user must reconcile him/herself with, or find out how to work around, if the properties limit the intended use. A large opportunity of PSS, on the other hand, is that the user is present in the specification of use and usability, leading to the creation of choice, as opposed to living with in-built regulation.

- **Executional interventions:** The conceptual development of a PSS should include the consideration of which executional interventions to build into the final solution, and what nature they should have. Examples of high-level executional interventions include: responsibility during use; management of life-cycle activities; and type of availability of the offering. These high-level interventions can be further broken down into sub-classifications of interventions, throughout the scope of the PSS. We feel it important to think in terms of executional interventions, as this gives useful insight into the key activity dimensions of a PSS. This viewpoint ought to give the PSS designer the insight into how active or passive the user is in each element of the PSS concept and in which situations to choose whether to delegate or to keep responsibility for the good, the information, the service, and so on.

- **Perceptions of value:** The very nature of PSS design – where the relationship with the customer is designed to be longer and more intense; where focus is given to functional provision and not merely sales of artefacts; and where the product life view is matched with a customer activity view – gives many opportunities for the development task to come much closer to an understanding of value perception than in a traditional product development situation.

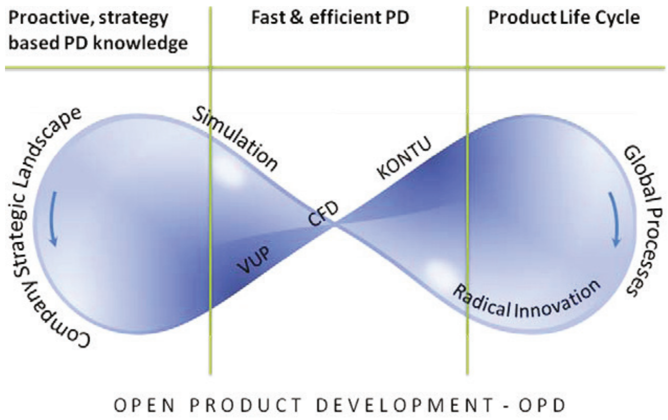
Open product development

In OPD there are three main areas:

1. Proactive, strategy-based construction of product development knowledge

2. Fast, efficient product development utilising the right resources

3. Guarantee of product life-cycle knowledge.



VUP : Verification/Validation Upstream Process
CFD : Configuration of Product Family Design
Kontu : Combined Variation of Product, Processes and Networks

VUP, CFD and Kontu are developed working models which are applied in the different OPD areas:

CSL- Company Strategic Landscape

It defines the elements related to product development operations and company production.
The key idea in the CSL framework model is the relationship between the internal structure of the product and the delivery process. In principle, the product structure and the delivery process can be selected separately. They are usually examined one at a time while using the other as background data. When optimizing operations, these two are no longer seen as separate but must be synchronized.

DFC- Product Configuration

Configuration, like design, has two meanings, one of which refers to the activity and the other, the object, the result of an activity. Here, activity is defined as a configuring or configuration task. The object is defined as a product configuration, i.e. Representation of an individual product. A product configuration consists of a group of components and their relationships. It is a special arrangement taken from a set of possible arrangements, which compose a configurable product family. The specific characteristics of a specific configuration enable the properties required by a specific purpose.

Kontu: Combined Variation of Product, Manufacturing Processes and Networks

It is important to recognize the variety within an existing product family and the effects that that variety has on the production systems and processes. The aim is to recognize the products that are of customer interest and to find similarities and differences within product families. This product-based view is supported by the process-based view, where products are approached from the production angle. In this context, the foundation of the product family changes and the composition of the family will vary greatly.
The similarities between product families can be utilized in product design engineering, production and supply in many different ways. The product family is composed of a different set of objects in each of these. The results of development should be found in the generic structures and architectures of product families, and harvested in standardised processes, which will lead to productivity increase overall.

Managing Virtual Product Creation

A virtual product creation process is an iterative decision process using information and communication technology to engineer the appropriate product solution.
Virtual product creation is strongly influenced by design methodology that promotes a continuous decision process, developing a product from requirements definition to a completely described product solution prepared for production. This decision process produces intermediate product solutions from an abstract function-based product description, passing through phases to a fully described product solution. During this iterative decision process, results of the phases are developed and stored.
Information and communication technology contribute to virtual product creation through three major technologies:

Application software systems support:

-Product modelling using parametric and feature-based CAD systems

-Analysis, simulation and optimization using FEA (Finite Element Analysis), MBS (Multi Body Simulation), and CFD (Computational Fluid Dynamics)

- Virtual validation and verification using DMU systems (Digital Mock-Up systems)

- Rapid prototyping through virtual (e.g. Virtual Reality systems) and physical prototyping (RPT, Rapid Prototyping and Tooling systems)

- Consistent use of product data in subsequent process chains (CAX process chains)

- The mapping of organizational and workflow structures into product data management systems (PDM) to allow controlled and authorized access to product development and design results via mouse click.

Digital representation of development results

- Harmonized and standardized data representation

- Consistent product data definition through administrative and organisational identification

- Seamless flow of digital data between application software systems

- Integrated representation platform for deriving downstream data generation, e.g. for product presentation in technical product documentation.

Information and communication technologies are developing rapidly, as demonstrated in Web 2.0 functionalities. The influence of information and communication technologies is perceptible in virtual product creation. Stronger integrated application software systems are covering more and more phases of the product creation process.

Lifecycle Approaches and Workflow Management

A lifecycle concept is a way of providing a holistic view of a complex time flow, dedicated to an object of interest and to categorising and structuring the necessary actions. Lifecycle concepts are typically characterised by three criteria:

- The holistic approach
The holistic approach provides an overall understanding of the complex time flow of the object of interest. When the product is the object of interest, the holistic approach supports a top down analysis of the product's time flow from cradle to grave, from requirements definition to its recycling or demolition.

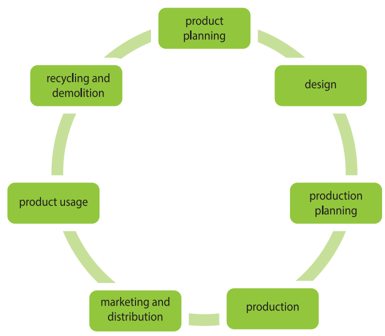
- The categorisation approach
Lifecycle approaches are typically categorised into phases that are embedded in a lifecycle phase structure, that is, a sequence. Each phase is characterised by workflows, including sets of activities. Activities are basic constructs that transform input into output and are used as major constructs to define workflows.

- The cycle approach.
The cycle approach indicates the desire to feed end-of-life results back into a start-of-life phase of the successive lifecycle.

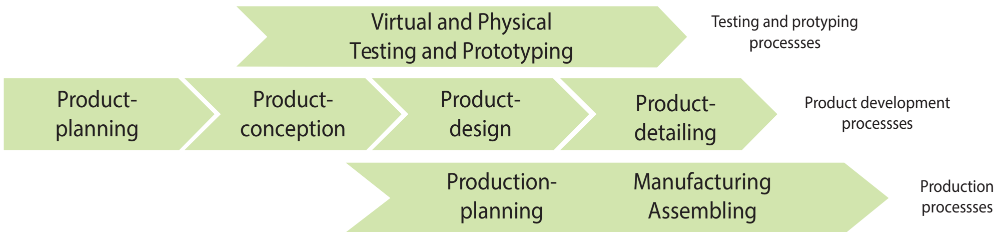
Lifecycle concepts are a major way to structure processes, particularly processes related to products.

Information Technology-driven Product Lifecycle

The product lifecycle approach driven by information technology structures the product lifecycle into 7 phases that include product planning, design, production planning, production, product marketing and distribution, product usage, and product recycling and demolition. The first three phases are classed as product development, and the first four, product creation.

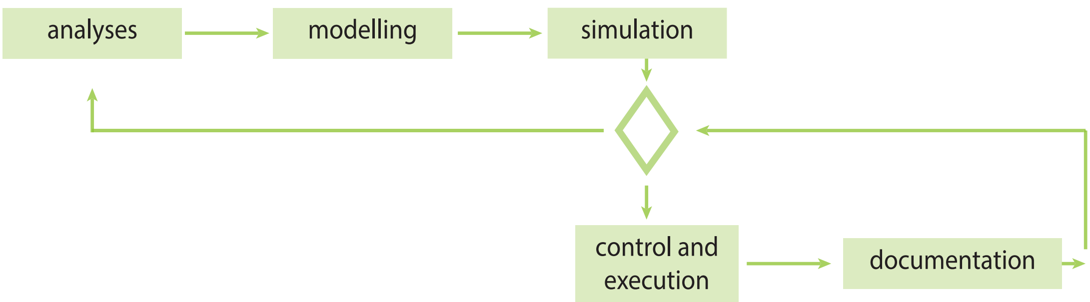


Within the product creation phase, workflows are identified to enable integrated sequences of activities that interact with each other. The two major workflows are product development and production planning, which are typically supported by simultaneous engineering methods. Besides these, a number of complementary workflows need to be established. Such workflows comprise the integration of product modelling with analysis, simulation and optimization, as well as product verification and validation.



Workflow Management

Methods for workflow planning and control are required when using workflows in virtual product creation. These methods are typically implemented in PDM systems. This diagram shows workflow planning activities, workflow analysis, workflow modelling and workflow simulation, as well as the workflow activities control, execution and documentation.



Workflow planning creates methods for workflow analysis, workflow modelling and workflow simulation. Workflow analysis methods are typically used for analysing existing workflows and defining new workflows. Workflow modelling methods aim to implement the appropriate activities and their structural composition to define the required workflow. Workflow simulation methods are dedicated to verifying and validating defined workflows through systematic walkthrough simulation.

After verification and validation, workflow control is initiated that allows the monitoring and supervision of workflow instances. During product creation, some workflows can be defined precisely, such as release management and change management. Many other workflows, however, might only be defined on an abstract level in order not to hinder creativity, flexibility and inspiration.

7 Empirical findings

In this point we plan to show the different kinds of design projects because this information will help us to better analyse all the studied methodologies previously. Once we have defined the projects we will be able to relate them to the methodologies and to explain which one is more suitable for each kind of project. Likewise, the methodologies will be analysed taking into consideration similar aspects and being compared between them.

7.1. Types of projects.

We will differ the kinds of projects according to the initial requirements given to the designer, both by the company and during an academic project. We consider this differentiation completely necessary since the work procedure wholly changes depending on the project. Each designer in each project has to work differently. We can assure then that a project work procedure is always different.

We will list the different kinds of projects and we will determine a name for each of them to make easier references in the present paper.

The list below shows different possible designs a designer can work with:
Product: consumer products, business products, depending on time-tangibility products.
Packaging: primary, secondary, tertiary.
Interface: hardware, software, hardware-software.
Services: Providing added value to the product life cycle, providing final results for customers, providing enable platforms for customers.
Graphic: web, corporate image, layout, package graphics...
Fashion: clothes, shoes, jewellery...
Spaces: work space, shops, window dressing, indoors, outdoors...

In our particular case we will focus on **product design.** In that field we distinguish different projects according to the initial requirements:

1. **Providing directly the product**
2. **Providing the function**
3. **Providing a problem or a need**
4. **Providing the brand**
5. **Providing the company which manufactures its own products**
6. **Providing the material**
7. **Redesign**
8. **Combinations**
    8.1. **Brand + product**
    8.2. **Brand + product + user**
    8.3. **Problem + user**
    8.4. **Brand + user**
    8.5. **Material + manufacturing process**

Next, the different kind of projects will be explained so that we will be able to easily identify them and also because it will help us to approach our analysis to the diagrams creation.

1. Providing directly the product

It means when the designer is told directly which product he/she has to develop.

This projects may arise in an academic environment when the students are given the design brief with all the specifications that a project has to accomplish. When a student has to develop this kind of projects he/she does not count with any company or brand so he/she is free to give the product the characteristics which are more interesting for him/her. Thus, he/she has no boundaries so he/she does not have to meet the needs from a company, brand, manufacturing process, etc.

For instance, one statement for this kind of projects could be:

"Design a new kind of tent."

2. Providing the function

This kind of projects take place when the designer is told the function that a product has to accomplish. It might be only the main function of the product or the main function and a secondary one.

This projects may take place both in a professional environment and in an academic one.
In both environments the designer is required to design a product whose characteristics satisfied a function which has been detailed previously.

For instance, one statement for this kind of projects could be:

"Design a product whose function is: allow the user to sleep outside protecting him from the weather "

3. Providing a problem or need

The designer or the company identify a need or a problem which needs to be solved. This problem establishes the beginning of the project giving the designer the keys to create a new product. The result should be a product so that the problem does not exist anymore.

This project may be ordered by a company or it may be the designer who notices the need and who decides to start this project himself.

"If I sleep outdoors and it rains, I get wet "

4. Providing the brand

It is when the designer only counts with a brand to start to develop a project. Therefore he will have to take into account all the company information and characteristics.

A company asks a designer to create a product for its brand, whatever the category of the product is. In other words, it could be said as an extension of the catalogue or a product's line. Many of the design product contests do not have any boundary but the brand the contestants have to design for.

For instance, one statement for this kind of projects could be that North Face said:

"We want to extend our products catalogue"

5. Providing the company which manufactures its own products

The designer is requested to design a product for a manufacturer company which develops its own products.
He will have to take into account the brand philosophy but also the manufacturing process that the company has available and the materials that it is used to work with. If it is a wood company we could not design a plastic component by injection molding.

A company asks a designer to create a product for its brand, as an extension of the catalogue which can be manufactured by itself.

For instance, one plastic fibre manufacturer could say:

"We want a new product in our catalogue"

6. Providing the material

The designer is requested to design a product made of a specific material.

This is a classic project in an academic context, where the student learns how to focus on a material experimenting manufacturing processes, material states and searching all the possibilities that it provides. In a professional context, it could be that a manufacturer company has the need to extend its catalogue or it wants something in a specific material.

For instance, a bioplastics company demands:

"A new product which shows the strength of our bioplastics"

7. Redesign

The designer is requested to redesign a product in order to solve any problem or need.
A company could need to solve a technical problem, to improve the usability, to change the product appearance, to make it cheaper, to improve the manufacturing process, to change the material, and all changes it considers necessary.

For instance, a company asks to:

"It takes so long to set up a tent, try to improve the way it is done"

8. Combinations

8.1. Brand + product

This situation occurs when a company asks a designer to create a particular product. By this token the designer will have to consider all the company's information and corporate identity.

The fact that a user is not specified might happen due to two reasons: maybe the brand wants a product that every customer can use, establishing a general target; or maybe the brand just leaves on the designer the decision of choosing a potential user that according to him/her is the one which can provide more benefits to the company, because a market niche has been found.

This is the typical project in a professional environment when a company feels the need of launching a new product to the market.

An example of this situation could be:

"Design a tent for North Face"

8.2. Brand + product + user

This situation comes from the previous one; it adds more boundaries when designing since it also has to be focused on a particular user.

This may occur when the company has already made a research whose results come with information about the user that a project must be focused on.

An example of this situation could be:

"Design a tent for North Face focused on children"

8.3. Problem + user

Here the designer is lacking in a brand specification. This order can come from a particular designer who finds a need in a user and decides to solve it by creating a new product or concept. This is the main example of a freelance project.

A thought that could inspire this kind of project could be:

"I have known that handicapped people have difficulties when setting a tent"

8.4. Brand+ user

This kind of project might come from a company which is highly focused on a particular user. Thus, we have all the information that the brand offers and also an specific user where we can apply this data. An example could be that the company needs an extension of its catalogue. Likewise, a brand could be interested in creating new products for new users in order to increase its market area.

For instance, a toy company like "Toys R us" could say:

"Design a new product for our multi-adventure line"

8.5. Brand + user/environment + material

There are many companies which manufacture their products in one specific material because they count with that sources. In this case, it is the company itself which asks the designer to create a new product based on a material and specifying an user and an environment.

Then the designer will have to take into consideration all the characteristics of the company as well as the necessary information to accomplish the user's expectations.

An example of this situation could be that a company which makes their products of plastic says:

"Design a plastic product four outdoors festivals"

7.2. Analysis and conclusions.

In the next point we will explain the different aspects that we will analyse from each methodology from the lectures that we did. From each methodology we will extract:

First of all we will try to identify the same stages in every methodology to help us to analyse them.

The next page will show a template that we have applied to all the methodologies' analysis so that they may be compared easily.

N. Template

1. Diagram

Here we will sum up the author's methodology in a graphic way so it can be easily understood.

2. Inputs needed

To carry out a methodology there is some needed data. Here we will specify the information that we need to begin a methodology.

3. Main focus

The most important point of the methodology, where it invests more time.

4. Deficiencies

The least important point of the methodology, where it invests less time.

5. Kind of researches

Kind of investigation that each methodology carries out.

6. Spontaneous changes capacity

Stage 1 — It can incorporate without troubles.
Stage 2 — It can partially incorporate it.
Stage 3 — It cannot admit any alteration.

How open is the methodology in order to implement new steps or stages while it is been developing. How changes are welcome.

7. Methods

Stage 1	Stage 2	Stage 3

There are many authors who particularly recommend some methods to develop some of the steps of their methodology. We have decided to list them according to the stages that a project is divided into: information stage, concept generation stage and concept development stage.

8. Applied to

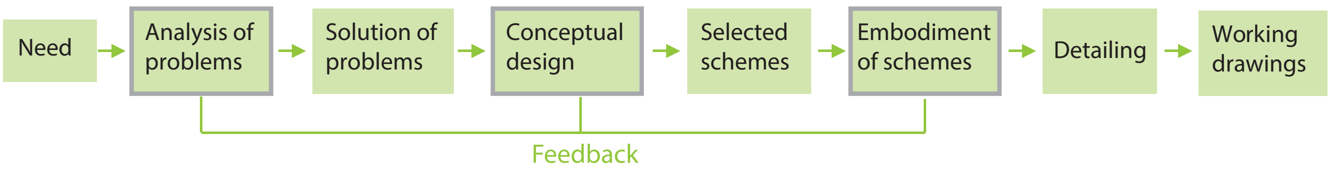
Depending on its characteristics, a methodology better suits a kind of project or another. Here we will define the characteristics of these projects.

9. Timing proportion

The bar below shows the time proportion between the three stages of a project; information, concept generation and concept development. It helps us to check visually where the methodology is more focused on.

1. Michael Joseph French

1. Diagram



2. Inputs needed

A need

3. Main focus

Conceptual design
Feedback

4. Deficiencies

Devoid of more information analysis.
It quickly goes to the conceptual stage.

5. Kind of researches

Needs research
Problems research

6. Spontaneous changes capacity

Information
Concept generation
Concept development

7. Methods

Information	**Concept generation**	**Concept development**
Not recommended	Not recommended	Not recommended

8. Applied to:

Projects where the conceptual stage might be repeated.

9. Timing proportion

2. Zaragoza university

1. Diagram

Initial Stage → **Information** → **Development** → **Application**

Initial Stage	Information	Development	Application
Design Brief	Product analyses	Concept choice	Project management
	Conclusions	Analyses problems	
	Creativity work	Development	
	Concept proposals		

2. Inputs needed

Design brief (antecedents, project definition, market/technical/commercial/legal/economic info, specifications, planning).

3. Main focus

Information stage (product analysis, problem definition and conclusions).

4. Deficiencies

Creative stage.

5. Kind of researches

Product research (competence studies, materials...)

6. Spontaneous changes capacity

Information

Concept generation

Concept development

7. Methods

Information	Concept generation	Concept development
Structural: technical monograph. *Functional*: tree diagram. *Ergonomic*: REBA, RULA.	Limits exam, objectives orientation, catalogue, clean eyes, brainstorming, 635 method, analysis system, idea's defender.	Not recommended

8. Applied to:

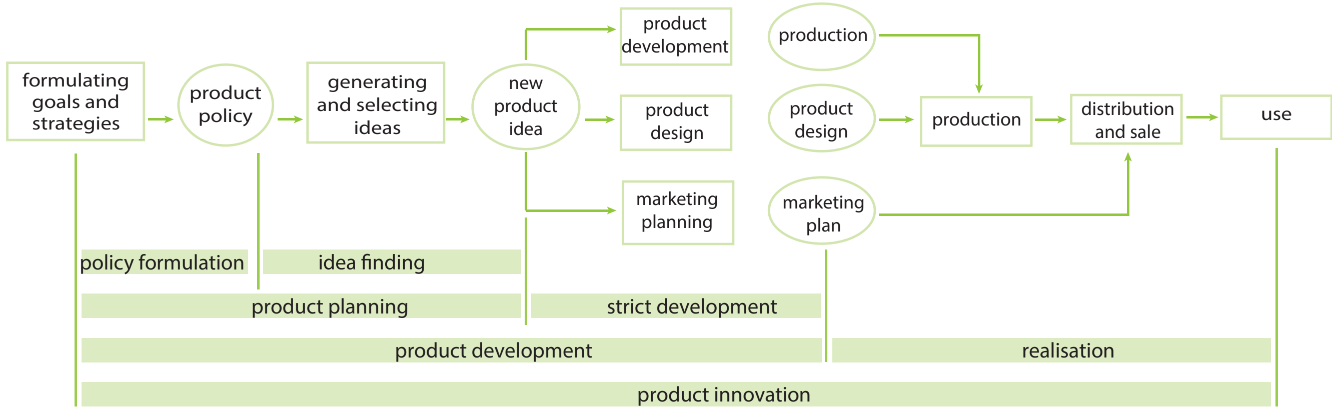
Product project: those with clear initial specifications.

9. Timing proportion

Information	Concept generation	Concept development

3. Product innovation process by Roozenburg & Eekels

1. Diagram



2. Inputs needed

Company’s policy > goals
Market and costumers needs
Strengths and weaknesses of the company.

3. Main focus

Idea finding.
Needs research.
Parallel work: production, design & marketing.

4. Deficiencies

Devoid of more information analysis.

5. Kind of researches

Market and costumer needs
Strengths and weaknesses of the company.

6. Spontaneous changes capacity

Information
Concept generation
Concept development

7. Methods

Information

Not recommended

Concept generation

Not recommended

Concept development

Not recommended

8. Applied to:

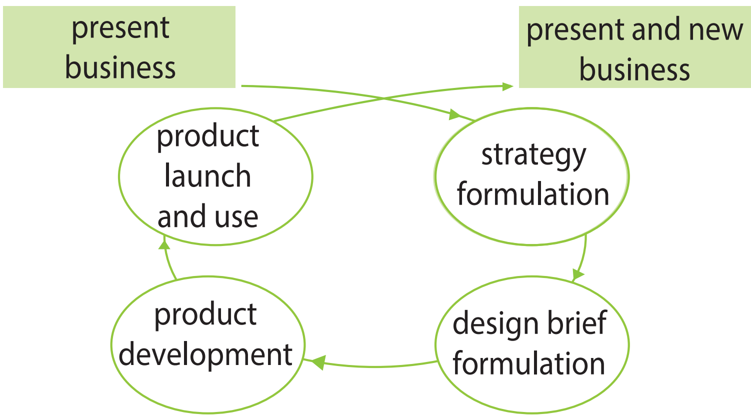
Consume products.

9. Timing proportion

Information | Concept generation | Concept development

4. Product innovation process by Buijs

1. Diagram



2. Inputs needed

Present situation
External and internal analysis
Market area research

3. Main focus

Policy and strategy formulation.
Company's situation
Market research

4. Deficiencies

Lack of parallel work in the different stages

5. Kind of researches

On the company itself.
External opportunities.

6. Spontaneous changes capacity

Information (green)
Concept generation (orange)
Concept development (green)

7. Methods

Information	Concept generation	Concept development
Not recommended	Not recommended	Not recommended

8. Applied to:

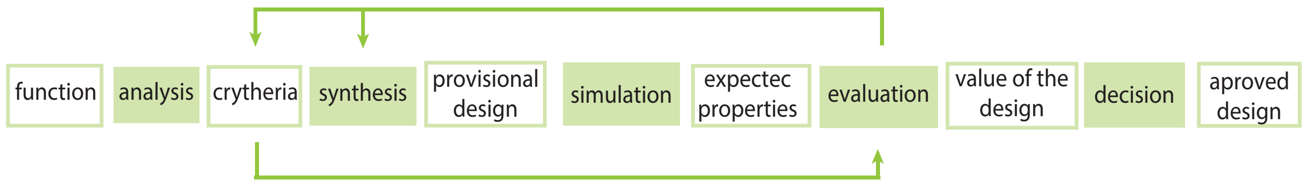
Consume products.

9. Timing proportion

Information	Concept generation	Concept development

5. Basic design cycle by Roozenburg & Eekels

1. Diagram



2. Inputs needed

Function of a new product

3. Main focus

Provisional designs and evaluation.

4. Deficiencies

It does not take into consideration the technical development of the product.

5. Kind of researches

Problems research giving a function.

6. Spontaneous changes capacity

Information
Concept generation
Concept development

7. Methods

Information	Concept generation	Concept development
Not recommended	Not recommended	Not recommended

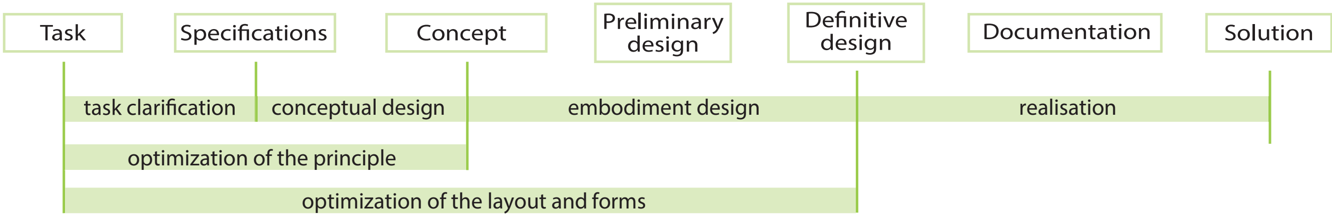
8. Applied to:

Projects where a function is provided or where it is necessary to solve a problem.

9. Timing proportion

6. Engineering models of product design

1. Diagram



2. Inputs needed

A problem.

3. Main focus

Identifying functions from the problem which arises and stabilising interrelations.

4. Deficiencies

Creative stage.

5. Kind of researches

Information oriented to solve the initial problem.

6. Spontaneous changes capacity

Information (green)
Concept generation (orange)
Concept development (green)

7. Methods

Information	Concept generation	Concept development
Not recommended	· Abstraction and problem formulation. · Function structure · Logical considerations	Repeated deliberation and verification.

8. Applied to:

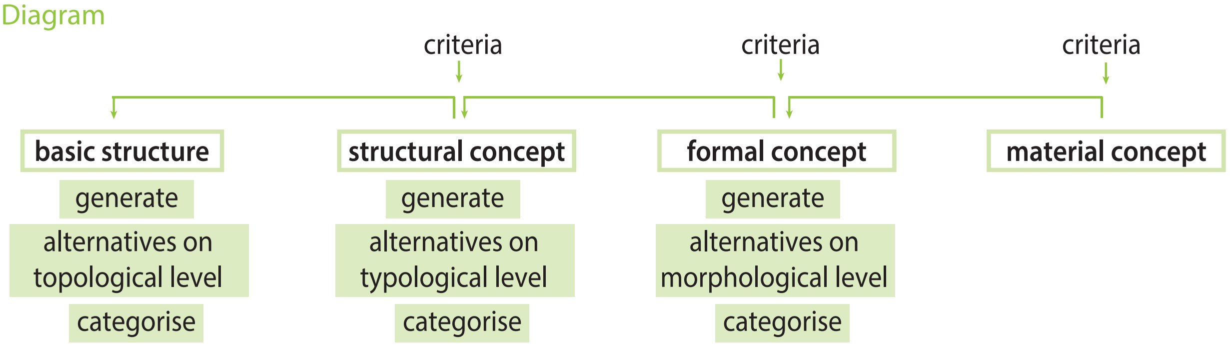
Projects where initial specifications are clearly defined.

9. Timing proportion

Information	Concept generation	Concept development

7. Fish trap model by Muller

1. Diagram



2. Inputs needed

A concept or idea.

3. Main focus

Creativity stage: sketches, schemes...

4. Deficiencies

Initial specifications.

5. Kind of researches

Oriented to develop the concept.

6. Spontaneous changes capacity

Information
Concept generation
Concept development

7. Methods

Information	Concept generation	Concept development
Not recommended	Not recommended	Systematic levels process

8. Applied to:

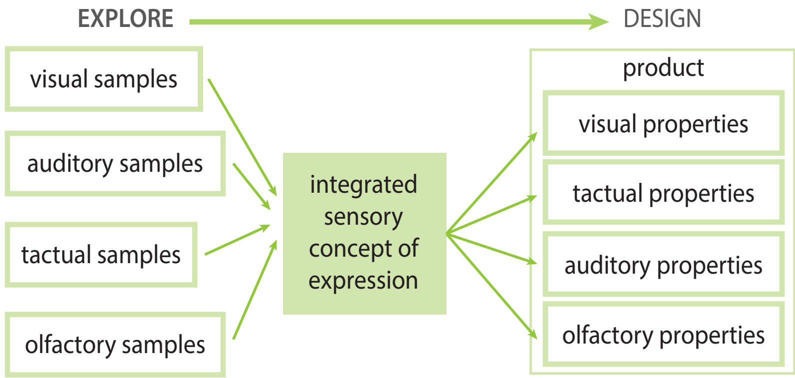
When we already have a concept or idea to develop.

9. Timing proportion

Info. | Concept generation | Concept development

8. Multi sensory design

1. Diagram



2. Inputs needed

The expression of the object, provided by the marketing department or by the designer him/herself.

3. Main focus

Feelings and effect that a product produces.
Psychological aspects derived from objects.

4. Deficiencies

It does not cover a complete design process since it is only focussed on the communication level.

5. Kind of researches

Psychological information.

6. Spontaneous changes capacity

Information
Concept generation
Concept development

7. Methods

Information	Concept generation	Concept development
Mind map	User - interaction scenario	Model making

8. Applied to:

Projects where communication between user and product is essential.

9. Timing proportion

Information	Concept generation	Concept development

9. Bruno Munari methodology

1. Diagram

The Problem → Problem Definition → Sort of Solution → Parts of the Problem → Data Compilation → Data Analyses → Creativity →

→ Technology Matherials → Experimentation → Models → Verification → Constructive Draws

2. Inputs needed

A need.

3. Main focus

Problem analysis and decomposition.

4. Deficiencies

The creativity stage is not as developed as the rest of the stages.

5. Kind of researches

Oriented to problem solution.
Product investigation.
Company technology and materials.

6. Spontaneous changes capacity

Information
Concept generation
Concept development

7. Methods

Information	Concept generation	Concept development
Not recommended	Not recommended	Experimentation methods by checking materials properties.

8. Applied to:

General projects: formal products, oriented to user... Those which do not imply a high technical complexity.

9. Timing proportion

Information | Concept generation | Concept development

10. Crhistopher Jones

1. Diagram

Divergence	Transformation	Convergence
· Research · Study brief · De-structure brief · Identify possible changes	· Creative work · Objectives · Boundaries · Problem definition.	· Alternative choice · Decision making

2. Inputs needed

Boundary of a design situation

3. Main focus

Splitting problems into sub problems and categorising them.

4. Deficiencies

Lack of design process development explanation.

5. Kind of researches

Oriented to clarify the present design situation that the designer is facing.

6. Spontaneous changes capacity

Information
Concept generation
Concept development

7. Methods

Information
- Stating objectives
- Literature searching
- Interviewing users
- Data logging

Concept generation
- Methods of exploring problems structure (interaction matrix, ADA...)
- Brainstorming
- Synectics
- Morphological charts

Concept development
- Checklist
- Selection criteria
- Ranking and weighting
- Specification writing

8. Applied to:

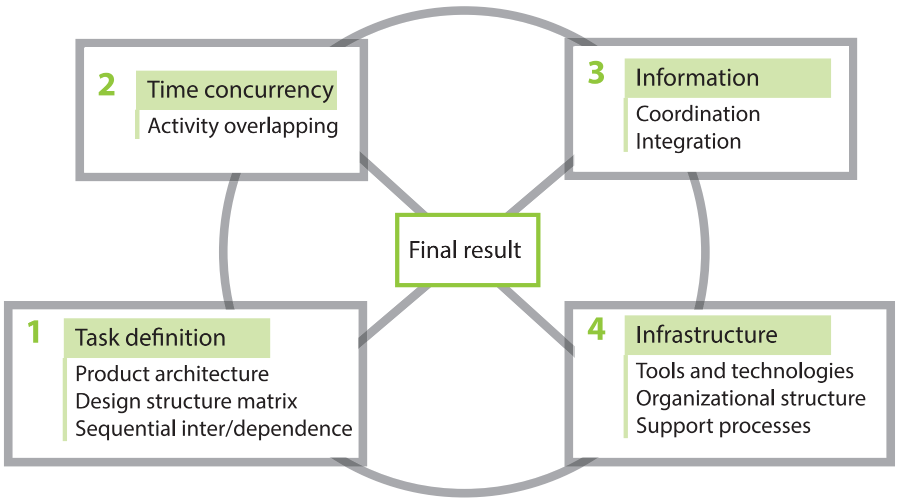
Projects where specifications are perfectly clear.
Defined initial objectives.

9. Timing proportion

Information	Concept generation	Concept develop.

11. Concurrent engineering by Cristhoph Loch

1. Diagram



2. Inputs needed

Project definition.

3. Main focus

Information exchange between all the departments which take part in the design process.

4. Deficiencies

Lacking in a creative stage.

5. Kind of researches

Those related with the tasks that must be carried out.

6. Spontaneous changes capacity

Information
Concept generation
Concept development

7. Methods

Information	Concept generation	Concept development
· Design structure matrix (DSM)	Not recommended	Not recommended

8. Applied to:

Any kind of design/development product process by any kind of company/designer.

9. Timing proportion

Information	Concept development

12. CONCURRENT ENGINEERING by Francisco Aguayo

1. Diagram

Market analysis → Product specification → Concept generation → Basic engineering → Final design

Market analysis	Product specification	Concept generation	Basic engineering	Final design
· Product object definition. · User info. · Info. organisation · Identify needs. · Need's hierarchy	· Functional analysis · List of functions · Functions organisation · Product design specifications. · Economical approach · Quality plan · Interfaces	· Identify design problem · Sub-divide problem · Solutions research · Possible solutions · Selection · Validation	· Check conceptual model · Inverse engineering · Alternatives design · 3D development	· Materials and processes · Design for X · Functional simulation · Prototypes · Economical final test

2. Inputs needed

Project definition

3. Main focus

Function and problems analysis and decomposition.

4. Deficiencies

Lacking in a creative stage.

5. Kind of researches

Based on competitors' products.

6. Spontaneous changes capacity

Information (green)
Concept generation (green)
Concept development (orange)

7. Methods

Information

. Tree diagram

Concept generation

. Concepts tree
· Matrix combining concepts
· Multi-criteria methods
· Dominance matrix

Concept development

Not recommended

8. Applied to:

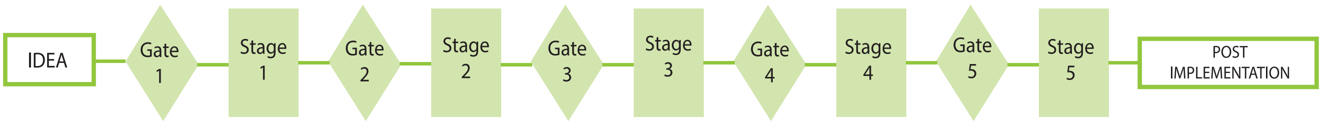
Any kind of design/development product process by any kind of company/designer.

9. Timing proportion

Information	Concept generation	Concept development

13. Stage Gate System by Robert G. Cooper

1. Diagram



2. Inputs needed

New product idea > New product development, process improvement, business change, etc.

3. Main focus

Evaluation stages to better rank projects and focus resources.
Control and discipline

4. Deficiencies

Too much control in the gates might kill good ideas
Creativity depends on financial aspects

5. Kind of researches

market size
market potential
market acceptance.

6. Spontaneous changes capacity

Information
Concept generation
Concept development

7. Methods

Information	Concept generation	Concept development
Not recomended	Not recomended	Not recomended

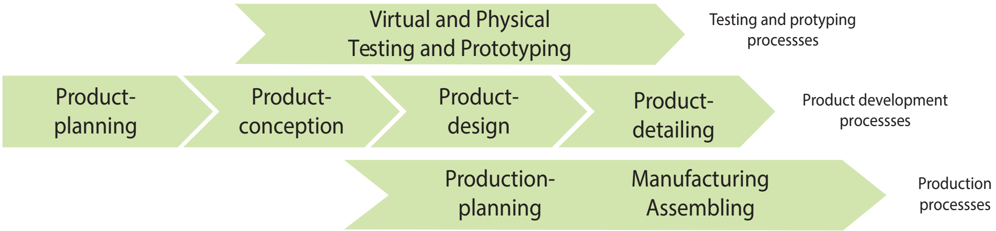
8. Applied to:

New projects.
New product development, process improvement, business change

9. Timing proportion

14. Virtual Product Creation

1. Diagram



2. Inputs needed

Function-based product description.

3. Main focus

Production and testing phases

4. Deficiencies

Creativity conditional to technology ability

5. Kind of researches

Functions
Materials
Development process

6. Spontaneous changes capacity

Information (green)
Concept generation (orange)
Concept development (orange)

7. Methods

Information	Concept generation	Concept development
Not recomended	Not recomended	Not recomended

8. Applied to:

Engineering projects
Redesign
New product development

9. Timing proportion

Information	Concept generation	Concept development

As we have explained previously the results of our thesis will be some diagrams which will explain how to act for each kind of design project. Before doing this, we will write a global view which will help us to improve our final results.

7.3. Global view

In this point we will make a global view where we will analyse the results that we obtained from our methodologies research. We will explain the differences and similarities between the methodologies as well as how they have been developed and how they can be combined. By doing this we will have an open standpoint about all the work that we have done so that we can use it for the creation of our diagrams.

INPUTS

	PROBLEM/NEED	COMPANY INFO	PROYECT DESCRIPTION	IDEA
	Michael Joseph French (1)	Product Innovation (3) Roozenburg& Eekels	Zaragoza University (2)	Fish Trap Model (7)
	Product Innovation (3) Roozenburg& Eekels	Product Innovation (4) Buijs	Concurrent Engineering (11) Cristoph Loch	Stage Gate System (13) R. G. Cooper
	Engineering models (6)		Concurrent Engineering (12) Francisco Aguayo	
	Bruno Munari (9)			
	Chrictopher Jones (10)			
FUNCTION	Basic Design Cycle (5) Roozenburg& Eekels			
FUNCTION	Virtual Product Creation (14)			

Related to the **inputs**, each methodology needs different information to be started. These methodologies can be divided into four groups. *French's (1), Product innovation process by Roozenburg & Enkels', (3) Engineering models of product design's (6), Munari's (9)* and *Jones' (10)* share the same input: a need or a problem. This means that before the design process is begun the designer is provided with a need or a problem that he/she must solve during the next process' stages. The problem might also come from a boundary in a design situation. We have gathered all these methodologies together following the criteria that every problem can be re-formulated as a problem and vice versa. Eg. if the problem is that it is too heavy the need is that it must be lighter. Likewise, a function is required to carry out Basic design cycle by *Roozenburg & Enkels' (5)* and *Virtual product creation (14)*. We have included these methodologies in this group because a function solves a problem, it is the immediate answer to a problem or a need. Eg. the problem is that when I sleep outdoors I get cold, a tent's function is protecting people from the weather during outdoors activities.

*Product innovation process by Roozenburg & Enkels' (3) and Product innovation process by Buijs' (4)*have their inputs in common too, they need information from the company who orders the design, both external and internal. It means that before getting started a deep study must be done in order to apply this information in further stages during the process.

Zaragoza University's (2), CE by Loch's (11) and *CE by Francisco Aguayo's (12)* need a complete description of the project to get started. This description must contain the objectives that must be accomplished as well as detailed information about all the stages of the project, including user's information, company, competence...

Finally, Muller's (7) and *Cooper's (13)* need an idea or a concept to get started. These methodologies are used when we already know what we have to design and they are not focused on solving problems.

A project description is the most complete input that we could count with when developing a design project. This description usually includes information of the company which orders the project and the problem or the need which trigger the project, both the description and the problem are other methodologies' inputs. However, the fourth input that we have distinguished is the idea, this one stays apart from the others because it is related to specific kind of projects; the methodologies which start with an idea do not start from the beginning as the others, they directly jump to the creative stage when the designer comes up with an idea and starts to develop it.

Concerning the **main points** where the methodologies are focused, we have split them according to the three general stages in which a project is divided: Information stage, concept generation stage and concept development stage. We have concluded from out survey that most of them are focused on the first stage, the information stage; the second biggest group belong to the concept generation stage and then a couple of methodologies which are focused in the third stage, the development of the product. As far as we are concerned, we see that most of the methodologies spend more time in the first steps of a project because it is necessary to make everything clear in the beginning so that this information can be used in later stages making them faster. Among the ones which are focused in the information stage there are some which are focused in analysing problems and classifying them and other which are focused in market research and company's information analysis.
Those which belong to the second group are more focused on ideas, concepts and developing them. Finally, those which are focused on the development stage usually work with parallel work and production phases.
Below, we show a graphic which shows this division.

MAIN FOCUS

INFORMATION	CONCEPT GENERATION	CONCEPT DEVELOPMENT
Zaragoza University (2)	Michael Joseph French (1)	Product Innovation (3) Roozenburg& Eekels
Product Innovation (3) Roozenburg& Eekels	Product Innovation (3) Roozenburg& Eekels	Stage Gate System (13) R. G. Cooper
Product Innovation (4) Buijs	Basic Design Cycle (5) Roozenburg& Eekels	Virtual Product Creation (14)
Engineering models (6)	Fish Trap Model (7)	
Multi Sensory Design (8)	Stage Gate System (13) R. G. Cooper	
Bruno Munari (9)		
Chrictopher Jones (10)		
Concurrent Engineering (11) Cristoph Loch		
Concurrent Engineering (12) Francisco Aguayo		
Stage Gate System (13) R. G. Cooper		

Note: the *Stage gate system by Cooper (13)* appears in the three columns because it is focused on evaluating each stage. Likewise the *Product innovation process by Roozenburg and Enkels (3)* also appears in the three because it develops the parallel work between departments and stages.

The deficiencies of each methodology are related to their main focus points. As most of the methodologies were focused on the information stage, in this point they have their main lack in the creativity stage. As we see it and thanks to our experience we consider that the amount of information you count with when developing a project is related to the creativity freedom that you have. Thus, a designer's creativity decreases when the information collected is bigger. The more information you have the more limited you feel in the creativity stage. This occurs because getting more and more data you get familiar with the product and also with the boundaries related to technological possibilities and economical aspects. For example, if you already know that a product's shape has to be inherited to its manufacturing process and you are already familiar with them, your creativity will be limited and you will not come up with extravagant shapes because you know that they could not be manufactured, there the creativity is being stopped.

There are also some methodologies which have devoid of a longer information stage or initial specifications. as we clarify in the scheme below.

DEFICIENCIES

INFORMATION ANALYSES	CREATIVE STAGE	TECHNICAL DEVELOPMENT
Michael Joseph French (1)	Zaragoza University (2)	Basic Design Cycle (5) Roozenburg& Eekels
Product Innovation (3) Roozenburg& Eekels	Product Innovation (4) Buijs	Chrictopher Jones (10)
Fish Trap Model (7)	Engineering models (6)	Multi Sensory Design (8)
	Bruno Munari (9)	
	Concurrent Engineering (11) Cristoph Loch	
	Concurrent Engineering (12) Francisco Aguayo	
	Stage Gate System (13) R. G. Cooper	
	Virtual Product Creation (14)	

The kind of researches which are carried out are related to the main focus of the design project. A research does not necessarily need to be done during the information stage. The designer can make researches during any stage if it is going to help him/her to continue with it. The kind of researches also depend on the inputs needed. Depending on the input we will need some or another kind of information.

The spontaneous changes capacity shows how open the methodologies are to add new data to their different stages while the project is being developed. It is generally related to the main focus points and the deficiencies of the methodologies. Stages catalogued as deficiencies hardly accept new information and they are more closed than the ones catalogued as main focus. Besides, the more feedback possibility a methodology has, the more open its stages are.

The kind of projects where the different methodologies are applied , they are usually related to the main points. That is why for instance methodologies which are focused on psychological aspects, they develop projects where the user is the main parameter.

8 Results

8.1. Methodology for each kind of project

In this point is where we will present our final results. As we mentioned before they are diagrams. Each diagram is related to each kind of project that we have considered interesting to develop.

Why three stages?

All the diagrams share their main structure. They have been divided in three stages:

1st Stage: Information stage

2nd Stage: Concept generation

3rd Stage: Development stage

We took that decision because as far as we are concerned, following some guidelines during a design project is easier when the steps are collected in different groups. Furthermore, all the methodologies that we previously studied made reference to these stages, although they were sometimes called differently.

How did we create the diagrams?

We took the conclusions of our analysis as references. Depending on the input that we had we checked one or other template to look for common characteristics and make up our own guidelines. There were sometimes that we could use part of the diagrams for more than one kind of project so we did.

How did we write the explanations?

We wrote down each explanation by following each diagram, step by step, in order to not forget anything and leave everything clear to the designer.

How did we write the examples?

We tried to be the least influenced by our previous knowledge about each case. We generally chose well known companies and products in order to make the examples easily understandable. What we wanted to demonstrate was that by following the guidelines that we suggest we can develop a project, being completely essential the inputs that we count with.

Which order did we follow?

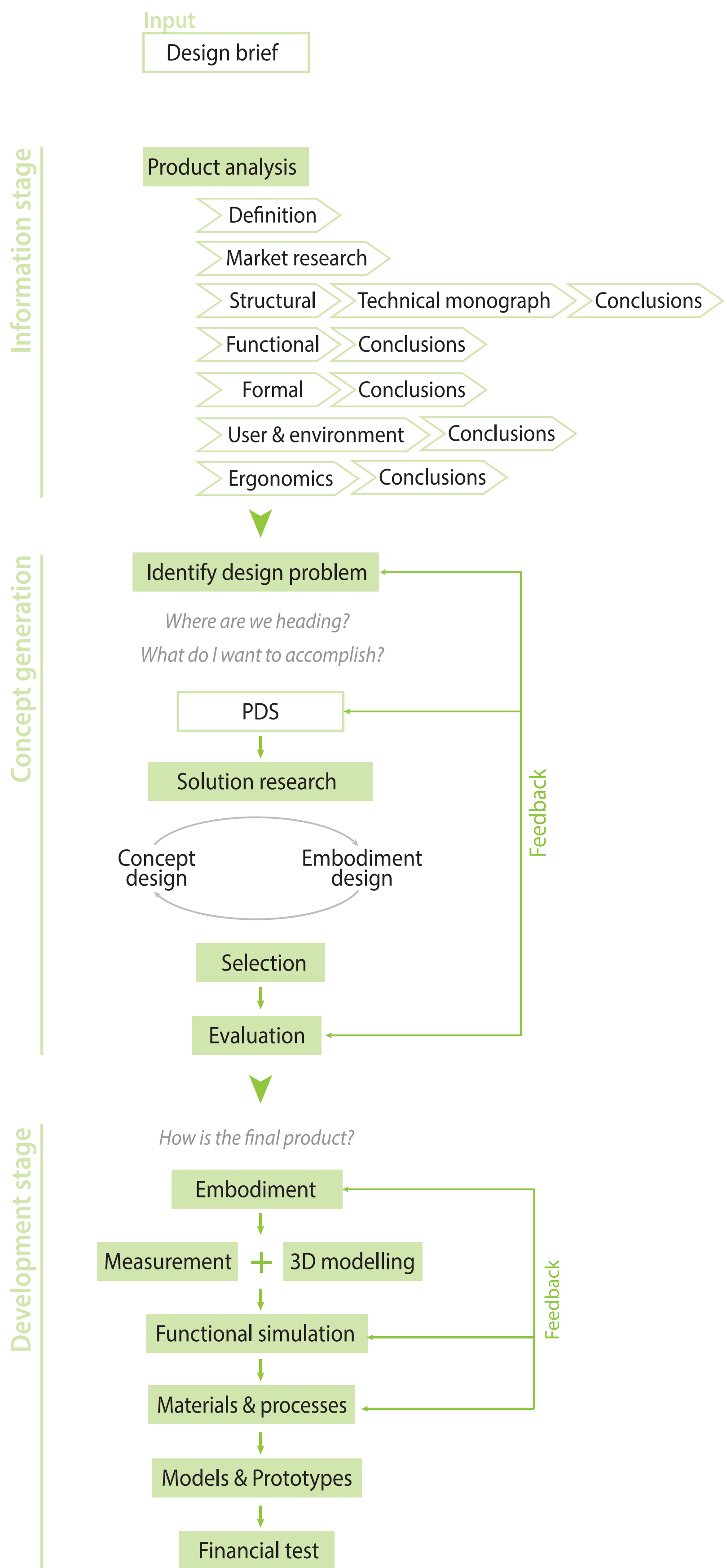
Firstly, we made all the diagrams, all the schemes hand written, what we show is the final result after having been analysing, checking and changing every single guideline.

Secondly, we proceed with their explanation. We considered that a theoretical explanation was needed in order to explain the why call step by a particular name and the work that the designer should carry out in each point.

Finally, we wrote the examples. As we saw it, it was better to write the examples once we had the diagrams and their explanations. If we had written down the examples immediately after each diagram and explanation they would not have been clear enough because we spent much time in each diagram so our mind could have been conditioned.

To conclude, the starting point when developing a design project is to know the inputs that we count with in order to classify the project, to put it into one of the categories that we suggest so we can later follow the diagram that we have specifically created for it.

1. Providing directly the product



Explanation

We need a design brief to start to develop this kind project with all the specifications that it is necessary to accomplish.
It is divided in the three stages that we are used to: information stage, concept generation and development stage.
Concerning the information stage, we must be focused on the product analysis in order to start a deep research which will help us to know where we are heading with our design. This analysis consists of different studies:
- **Product definition**: in order to know what the product is, what are its main characteristics and a first layout of how it works.
- **Market research:** to know how the product and its competitors work and to get knowledge about the product market to determine if it is possible to insert it into other market field.
- **Structural**: thanks to this analysis we are able to know the pieces a product has, as well as their functions, materials and other characteristics. The aim is to understand the product from a syntactic view. We suggest here using a technical monograph, where all the components of a product are analysed in depth allowing the designer to come up with conclusions which may help to improve the future design. In this study the designer will analyse materials, assemblies, measures...
- **Functional**: in this study the designer must define clearly the main function of the product as well as its sub-functions establishing a hierarchy if needed. By doing this the designer will be able to implement new solutions which accomplishes the same functions.
- **Formal**: studying the connection between shape and function to understand how the physical appearance of a product influence on the buyer attitude and to apply the conclusions to our future design.
- **User and environment**: it studies the product into d environment and with the user, not as an isolated issue. It also studies the way that the product is used.
- **Ergonomics**: it analyses how to maximize productivity by reducing user's fatigue and discomfort.

This analysis allows us to get some conclusions which will be used to develop the project. It is necessary to carry out this studies carefully because they are the first step where all our project will be based on, so the step of getting conclusions is essential.

The second stage is the concept generation, where we first **identify a problem** thanks to the conclusions that we obtained previously. This conclusions will show different problems or needs. The designer will choose which one he wants to solve according to his criteria. He must choose where its product will be focused on in order that it becomes as profitable as possible. For instance, the designer could choose reducing a product price, placing the product into a new environment or changing it to make it more attractive for a new potential user.

Once the problem is identified and defined it will be necessary to answer these questions: Where are we heading? What do I want to accomplish? These answers will constitute the design product specifications (**PDS**). They will settle the requirements and the objectives of our product. The next logical step is the **solution research**, there the designer will start to formulate solutions. A parallel work must be carried out here with the proposed concept and the embodiment design. This parallel work allows the designer to check if his concepts proposals also fit the structural part and making its development easier in further steps. The designer must compare the different concepts and **select** the one which best fits the PDS. The chosen one will be **evaluated** to check its feasibility before developing it.

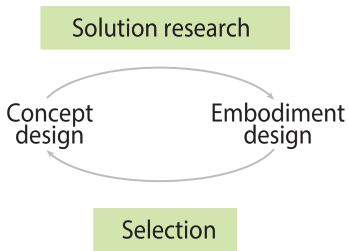
The third and last stage is the **development stage** which answers the question of how the final product is. The first step is to create a more detailed **embodiment design.** After having it the designer must add **measures** taking into account different needs (user, structural information, environment...). At the same time, the 3D model will be developed so that it can incorporate spontaneous changes. Once the **3D model** is ready a **functional simulation** must be carried out. By doing this we can check if the design is progressing as we expected. If not, there is a **feedback** possibility which takes us to the embodiment step to check our work.

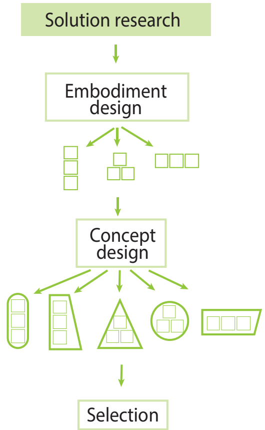
When the project is finished the designer is able to choose the **material and the manufacturing processes** of the product, being still possible to come back to the embodiment stage (due to a material or process requirement) and change whatever the designer may consider necessary.

Once everything is set, it is time to start with the **models and prototypes** which will show the appearance of the final product. And finally, a **financial test** must be carried out in order to check if the product fits the initial budget (in the case it was specified).

Comments

The first quandary that we had it was during the **concept generation stage.** We had studied different methodologies where **parallel work** was used but also some **linear** ones. We did not know which of that work ways better fit our project. The graphics below show the two options that we checked:





The first option shows a parallel work flow where we first come up with a concept and then we go to the embodiment design for that particular concept, if we see that it is impossible to establish a connection we come back to the concept proposal to make it fit, and so on. By doing this, you can easily check if your concept fits the most technical requirements before going ahead.

Opposite, the second one shows a linear work flow. First we go to the embodiment design, let's say that we have three examples with three possible designs. After that we create concepts taking into account those designs. The possibilities here could be really numerous, making the selection process more difficult.

Other quandary appeared during the **development stage**, with the **measurement** and the **3D modelling** steps. We first placed them linearly but after that we realised that it is necessary to work simultaneously with them due to the fact that the designer needs to check constantly the measures in the 3D model.

Example

Input

Design brief | "Design a tent"

Information stage

Product analysis

Definition

A tent is a shelter consisting of sheets of fabric or other material draped over, attached to a frame of poles or attached to a supporting rope.

Market research




Structural | **Technical monograph**

	Weight	Dimensions	Material	Essential: yes/no	Manufacturing process
Flysheet					
Inner tent					
Vestibule					
Groundsheet					
Poles					
Stakes					
Air vents					

Functional

Main function: protect the user of external climatological inclemencies.

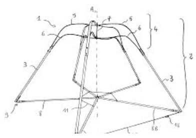
Secondary functions: to be impermeable, to allow the tent be nailed into the ground...

Other functions: to allow the user to cook inside, etc.

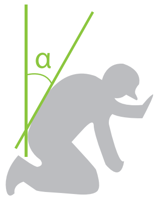
Formal



User & environment


Ergonomics

Example

Concept generation

Identify design problem

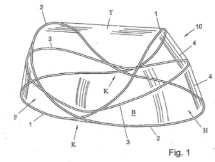
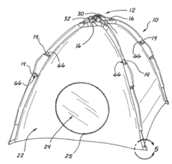
· With the current tents the user spends to much time in the setting.
· The setting requires a high effort and adopting uncomfortable positions.
· Any other company has solved these problems.

PDS

· Impermeable.
· Easy and comfortable setting.
· Able to house at least 2 people.
· Minimum number of pieces.
· Setting without tools.
...

Solution research

Concept design ⇄ Embodiment design

Concept	Embodiment design
Concept 1 	
Concept 2 	

Selection

PDS	Concept 1	Concept 2
· Impermeable.	✓	✗
· Easy and comfortable setting.	✓	✓
· Able to house at least 2 people.	✓	✗
· Minimum number of pieces.	✗	✗
· Setting without tools.	✓	✓

Concept 1 is selected because it better achieves the PDS explained before.

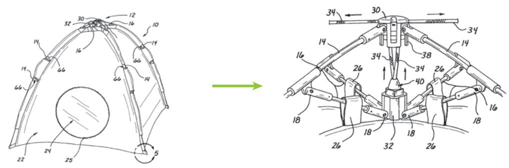
Evaluation

The concept is evaluated. If it is feasible we continue to the next stage, if it is not there is the feedback possibility until the PDS and the problem identification.

Example

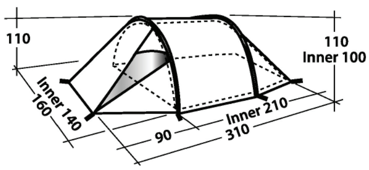
Development stage

Embodiment



Having an initial embodiment it is possible now to develop it to a more detailed embodiment design so that all the structural features can be checked.

Measurement + 3D modelling



Functional simulation

The functional simulation of the tent must allow the designer, with the help of the 3D model, to know that the design works properly and that it finally achieves all the initial objectives. This functional simulation has also to recreate the use sequence.

Materials & processes

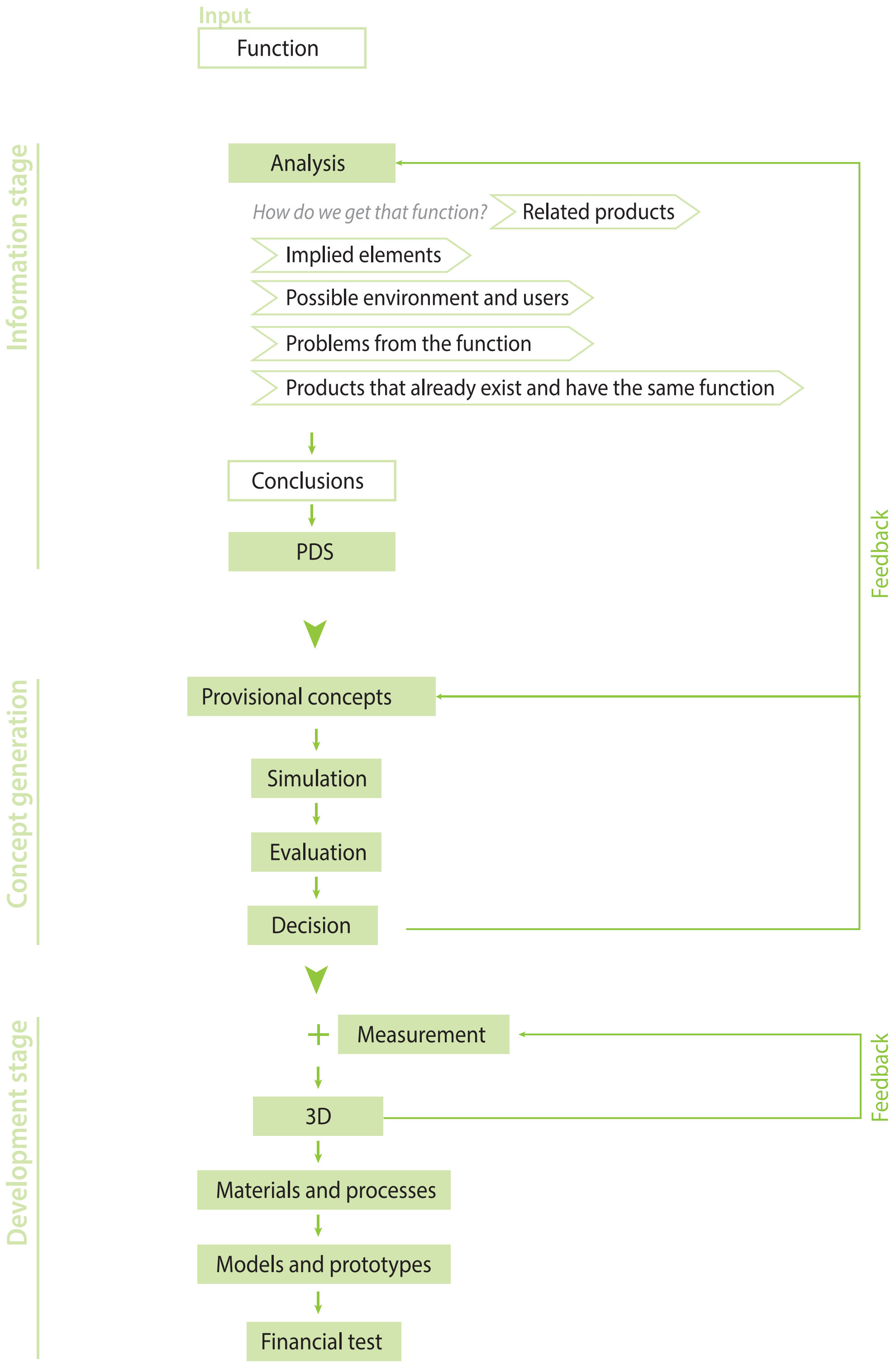
Pieces	Material	Process
· Flysheet	· Polyester with PU	· Spinning
· Groundsheet	· Polyethylene	· Spinning
· Poles	· Fibreglass	· Pultrusion

Models & Prototypes

Financial test

The production costs are analysed as well as the profits that the design may imply to the company. According to the results from the financial tests some changes might be added to the manufacturing process.

2. Providing the function



Explanation

A function is provided as input in this kind of project.
We start the **information stage** by carrying out a detailed **function analysis.** This means that we have to know how this function is achieved and how it could be achieved. To do that it is necessary to study existent products which accomplish this function an analyse them. It is also helpful to study the elements which are implied in the process of getting that function, if there is something that is essential to get it. Besides, the environment of users must be studied as well, by doing this we can come up with new ways to accomplish a function. Doing an action usually implies an effort, and an effort might imply some problems; due to this, it is also necessary to study the problems that a function implies and split them up if necessary, since solving sub-problems is easier in order to solve a whole.
After this deep function analysis the designer obtains some **conclusions**. These conclusions will be used to write down the **PDS** which will define the final design. In the PDS the designer must specify what he/she wants to accomplish and how he wants to accomplish so the first decision step is done here.

During the **conceptual stage**, the designer comes up with **provisional designs or concepts**, different possibilities which solve the problems defined previously and of course which accomplish the function that we are dealing with. To make sure that it certainly accomplishes the function we go through a **simulation** stage. This simulation does not need to be physical, real; we can just take information from our own experience to prove it. After simulating all the possibilities (concepts proposals) it is necessary to **evaluate** them, according to a criteria (eg. how they follow the PDS). After evaluating them a **decision** is made so that we can continue with the 3rd stage. The decision is revocable, in other words, it is possible to come back to the provisional concepts stage or even to the analysis step if needed. This **feedback** assures that the results will have gone through some filters to make sure that they are proper enough.

The **development stage** starts with the concept **embodiment design.** This step constitutes the bridge between the conceptual stage and the detail design stage. In the embodiment stage of the design process a more detailed analysis of the selected concepts is undertaken. It usually includes a definitive layout, preliminary component shapes and materials, design for manufacture and assembly and industrial design. To develop the embodiment design we must count with the concept we have selected and the PDS (Product Design Specifications). The output is a definitive scheme drawing accompanied by documentation (calculations, required dimensions and tolerances, suggested materials and manufacturing processes...)
Embodiment design is not solely the achieving of technical solutions but also creating useful products, which satisfy and appeal to the users. The major working principle of the embodiment design is simplicity. For each functional element, there should be a clear relationship between cause and effect. Moreover, it has to simplicity of function and shape for analysis and manufacture in the embodiment design. It also considers how to minimise the parts and integration of components. The embodiment design must be worked simultaneously with the **measurement** stage. Likewise, the **3D** model is made by checking constantly the embodiment design and measures.
Once having the 3D it is possible to specify the **materials and the manufacturing processes** as well as starting the **models and prototypes stage.** The last step during a design process is a **financial test** where the designer must analyse how profitable the product will be for the company as well as showing costs of the whole process.

Comments

We were discussing about the need of carrying out a **real simulation** or not. Finally we decided that it depends on the kind of project, because maybe most of the times we can get that information from our own experience.

Besides, one of the main problems here was making the decision about where we should include the embodiment design. We had three options:

a. Before the concepts creation
b. At the same time that the concepts creation
c. After the concepts creation

Since we are dealing with a function as input, it is a more abstract project compared with the one where is given directly the product for example. That is why it is not possible to make an embodiment design before having an idea about how the product will be. Likewise, we were thinking in a parallel work between concept creation and embodiment design (as we have suggested for other projects) but again this project's particular abstraction impedes it. We concluded that it was necessary to have an idea about what we want to develop to start with the embodiment design, and that is why we placed it **after the concepts creation.**

Example

Input

Function

" Design something whose function is hanging clothes"

Information stage

Analysis

How do we get that function? Related products

Study of different products which achieves the function the designer has been asked to: chair, clothes horse, wall-hanger, hanger, suit hanger.

Implied elements

The implied elements during this function are directly the clothes. Depending on the kind of clothes that we want to hang, the hanger will have some particular characteristics.

Possible environment and users

· **Actual environments:** home, car, school...

· **Potential environments:** street, public places, cafés...

· **Actual users:** women, men, children...

· **Potential users:** people who go shopping and have to carry their bags, handicapped people...

Problems from the function

· If the thing that we want to hold is too heavy.
· The user might not be tall enough to reach the hanger.

· The user might do too much effort.
· The thing to be held needs to be clean
...

Conclusions

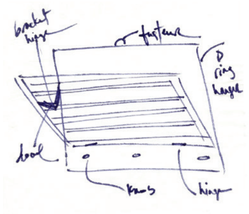
Ex1. There are a poor offer regarding bags hangers.
Ex2. When people with bags go to public places, they do not know where to place them (not in the floor because they could get dirty)

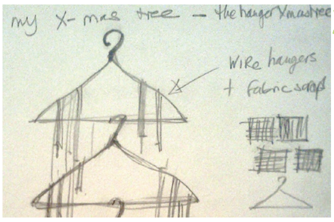
PDS

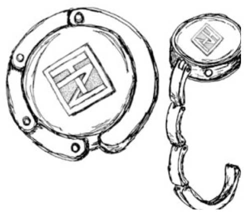
· It has to support a weight of X kg (bag's calculated weight)
· It has to be made of only one material
· It has to be portable, able to change its placement
...

Concept generation

Provisional concepts

1 

2 

3 

Simulation

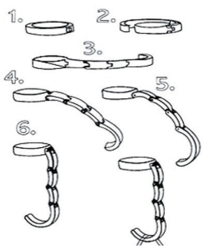
Evaluation

PDS	Concept 1	Concept 2	Concept 3
· Support X Kilograms	✗	✗	✓
· Only one material	✓	✓	✓
· Portability	✗	✓	✓

Decision → **Concept 3**

Development stage

Embodiment design + Measurement



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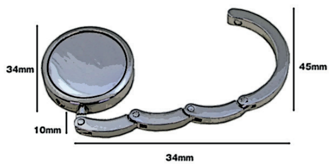


3D

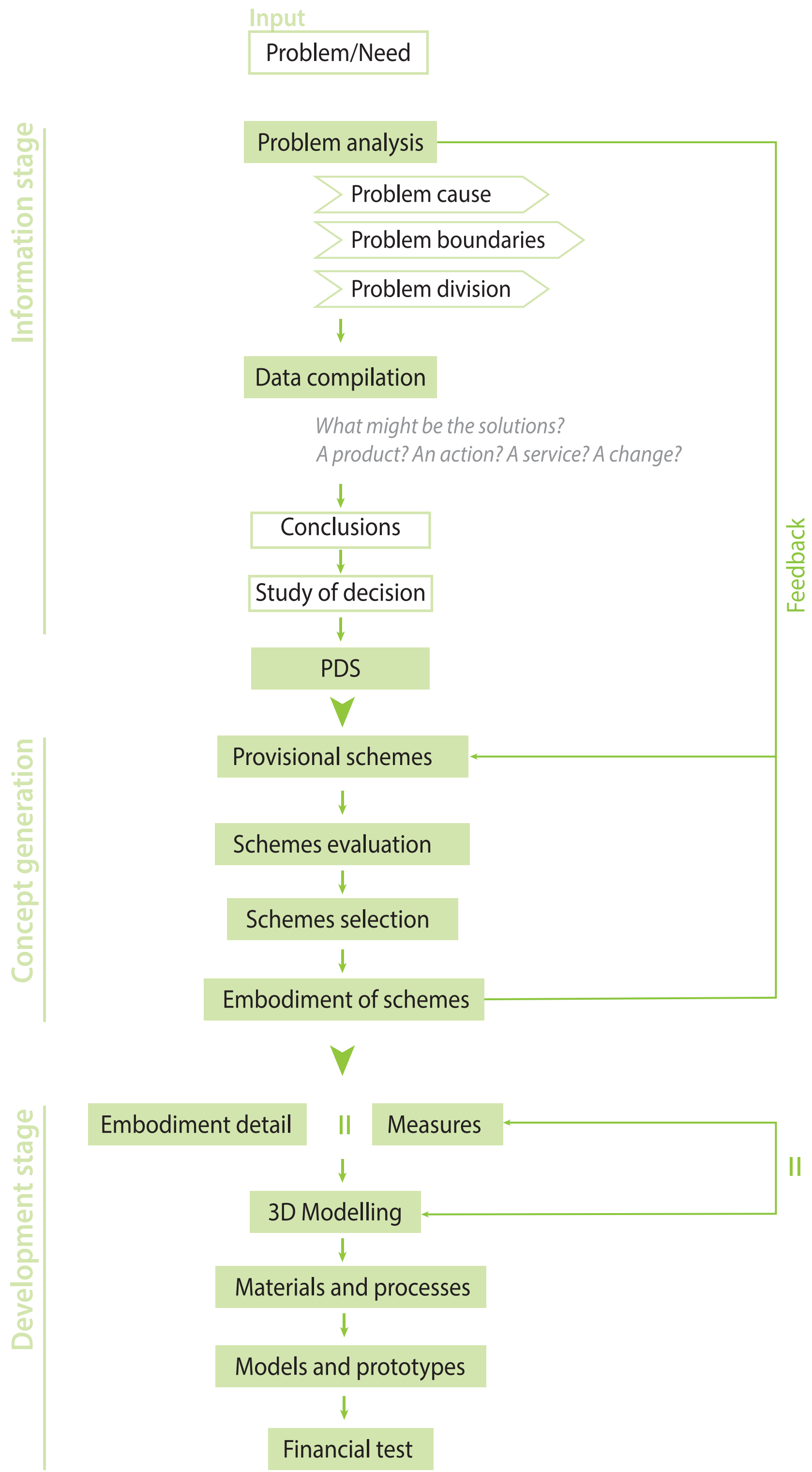
Materials and processes

Pieces	Material	Process
· Main body	· Aluminium	· Casting

Models and prototypes

Financial test

3. PROVIDING A PROBLEM OR A NEED



Explanation

The input for this kind of project is a problem or a need that is provided or the designer him/herself notices and wants to solve.
The information stage will be based on this **problem analysis** then. The designer must study the cause of the problem because knowing where it comes from it will be easier to understand it and therefore, to solve it. It is necessary to define the boundaries of the problem, defining how far we can get into. Eg. maybe the problem is that a product is too heavy and the solution is to replace the material for one lighter; but if we are working for a steel manufacturing company this change is not possible. Likewise, a small problem is easier to solve than a complicate one, that is why the problem must be divided into sub-problems and solve them. After this problem analysis the designer must **collect all the information** and start to think about solutions. This is the point where the designer must consider what kind the solution would be possible and accepted. In other words, if the problem would be solved with a product, a service, by changing the way of using an existent product... Having this knowledge, **conclusions** must be written down. If the conclusion opens a new path, it means that an extra-information stage should be done, looking for information to complete that conclusion. Once having all the necessary information, the **PDS** based on them will be written.

The conceptual stage starts by creating some **provisional schemes** which collect all the conclusions obtained in the previous stage. Having several of those, the designer must **evaluate** them and according to some criteria he must make a decision of which one he wants to develop deeper. Now, a first approach to the **embodiment design** comes, It has not to be a detailed embodiment, just a first approach about how pieces should go, first suggested materials and manufacturing processes...
Of course that after making this decision is possible to come back to the creation of schemes in the case the designer considers he should change his election.

In the third stage we start with the development of the scheme or concept that we have selected before. Now a more **detailed embodiment design** is carried out; it means that, as the previous case, the designer will have to indicate clearly the placement of the pieces as well as their function, calculations if needed, suggested materials and processes... Likewise, the **dimensions** of the product must be settle down here, working simultaneously with the embodiment design since it is necessary to check it constantly. Having the embodiment and the measures the designer is able now to start with the **3D**, being always possible a feedback to modify measures if needed. After the modelling, we have eventually to choose the **materials and manufacturing processes** based on all the information we already count with. Similarly, the **models and prototypes** stage is the next logical step since we will have everything settled to start with them. In the end, as in other sort of projects, a **financial test** will be done in order to check the profitability of the project as well as a calculation of the costs.

Comments

Something that we had to add once all the diagram was already finished, it was the **"Study of the decision"** square. It means that once we have done the data compilation and we have several possibilities and we select one of them to develop (because the designer considers that it is the one which best solves the problem), it might be necessary to make an extra-information research concerning the aspects of that choice. It means that, for instance, we consider that the solution to the problem is to change the material, we will have to look for information about that material after the 1st information step.

Example

Information stage

Input

Problem/Need

" Students spend too much time going to the school"

Problem analysis

Problem cause

· There is no school bus in the town and they go walking or by public transport.

Problem boundaries

They are younger than the age limit to drive a car or a motorbike.
The maximum distance they have is 5km.
The town can't afford a hight expense of money.

Problem division

There are students who live far from the school .
They also have to go to other places to play sports.
They carry with a backpack full of books.
There are traffic on the roads.
Sometimes the weather makes the way harder.
...

Data compilation

We start to think about solutions:
We could design a bus service with the interested students.
We could design a kind of traction vehicle for the students like bicycles, skateboards, longboards, tricycles...

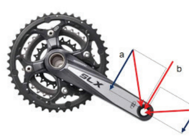
Conclusions

The best options is to provide the school with some bikes specifically designed for the needs of the students which will be deliver to them at the beginning of the year.
It will help the students to arrive faster at the school, in a healthy way, and they will have also the chance to use them in other issues.

Study of decision

In here we search everything about bikes, we make a market research and we study how they work, and how we can apply this to the students needs.



PDS

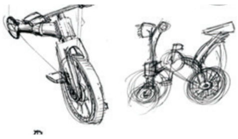
1. It doesn't have to cost more than ___$
2. It has to carry a child between 6 and 12 years old.
3. It must have something to carry the backpack.
4. It has to be as much resistant as possible.
5. ...

Concept generation

Provisional schemes

1

2



3

4

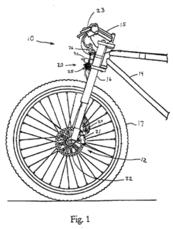
Schemes evaluation

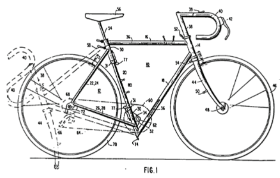
PDS	Concept 1	Concept 2	Concept 3	Concept 4
· PDS 1	✓	✗	✓	✓
. PDS 2	✗	✓	✓	✓
· PDS 3	✓	✗	✗	✗
· PDS 4	✗	✓	✗	✓
· PDS 5	✓	✓	✓	✓

Schemes selection

Concept 4 is selected because it better achieves the PDS explained before. We will make the needed changes to try to achieve all the PDS

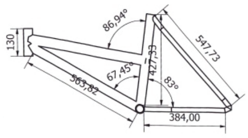
Embodiment of schemes

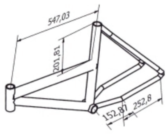




Development stage

Embodiment detail || Measures





3D Modelling

Development stage

Materials and processes

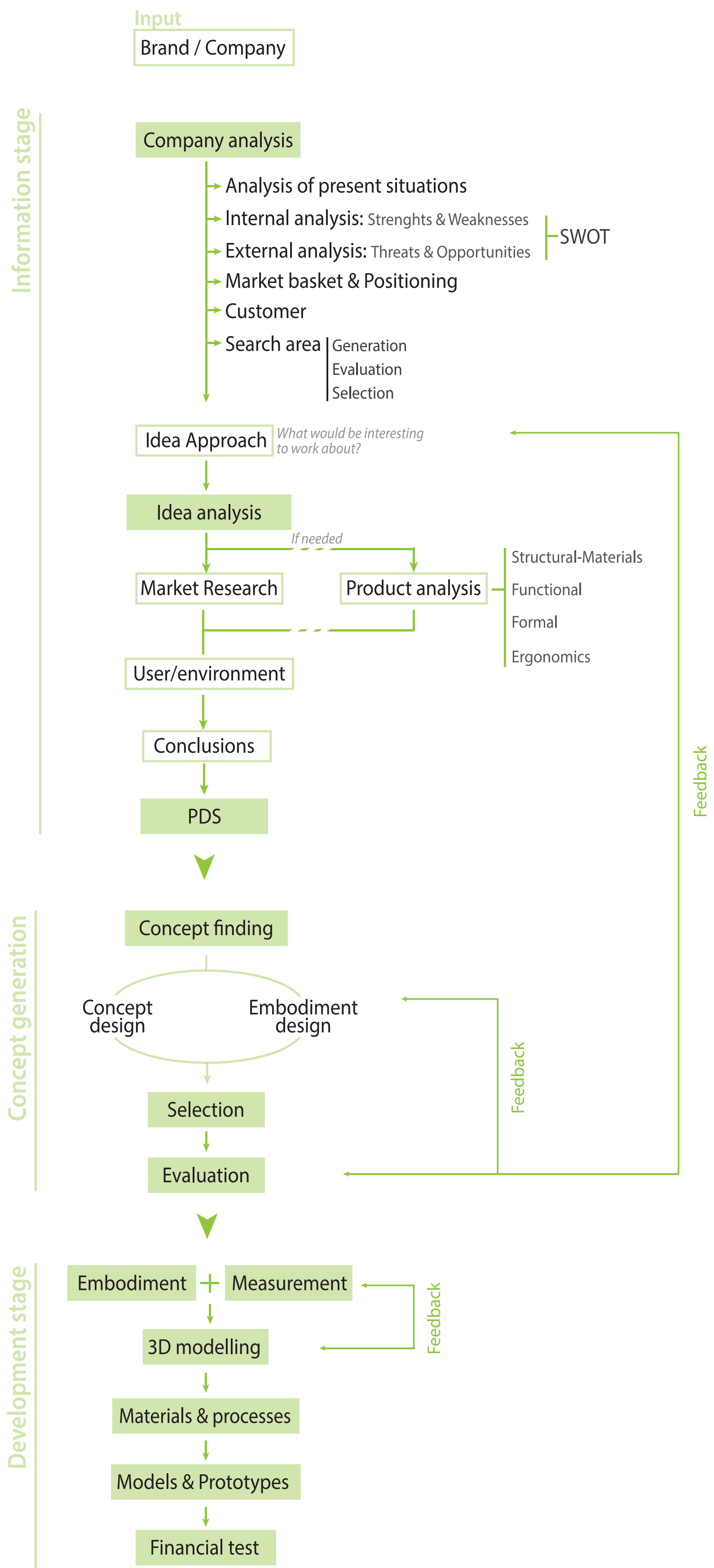
Pieces	Material	Process
· Frame · Pedal ·Seat	· Steel · Polyethylene · Foam	· Extrusion · Inyection · Molding

Models and prototypes

Financial test

The production costs are analysed as well as the profits that the design may imply to the company. According to the results from the financial tests some changes might be added to the manufacturing process.

4. Providing the brand



Explanation

The main important step in this kind of project is the information stage because the initial point is so wide that it is necessary to focus on something and to do that it is needed to carry out different studies. There we have to take into account both the company's and the product's information. Firstly, the **company** is studied , as it can be inferred from our scheme we analyse the present situation of the company as well as an internal and external analysis. In that step, a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) is defined.

- **Internal analysis:** Strengths and Weaknesses. The designer will use the strengths to know which products are the most profitable ones and which aspects (available departments, resources, technologies...) of the company we could use for our product. The weaknesses will be seen as the limitations of the companies, points that the designer will try to improve or solve with his/her ideas.
- **External analysis:** Opportunities and Threats. Opportunities are seen in the company's surroundings, the elements that the project could exploit to its advantage. One of the tools that has to be used is the market consumer needs. The threats are the elements in the environment that could cause trouble for the design project.

Thanks to the conclusions from the SWOT analysis, the designer will start with the **"search area"** points. The search area generation combines a strategic strength and an external opportunity to come up with an idea that could be the base of a future product. After this, an evaluation of these ideas has to be done according to different aspects like experts' interviews, patents research, potential users study... By comparing the evaluated ideas the designer must make a selection. The selected search areas form the starting point for the next step: **the idea approach formulation**. The **idea approach** step constitutes the initial idea of the design project. There the main idea about what the designer wants to develop is defined. It is also specified the user and environment as well as the main aspects to take into consideration. The idea might be abstract or specific, defined as a product or some features.
It is also helpful to study the company's **customers** in order to know and get more familiar who we are working with.

Once we have obtained conclusions from the company's study, we start with the idea development. Having a basic idea of what we want to develop we will carry out a **market research**, even if it is accurate (directly a product) or more abstract (some features that we want to achieve). Here, the user and the environment must be also studied. After it, a product analysis should be developed if needed, similar to those that have been developed for other kind of projects, including structural, functional, formal and ergonomics analysis. As usual, some **conclusions** result from these analysis and these conclusions will help the designer to write down the **PDS.**

Then the designer starts with the concept generation stage. Firstly with the concept finding, working in parallel with the concept and embodiment design, allowing the designer to check if his concepts also fit in a structural view of the product making the future development easier. The different concepts are compared and the one which best fits the requirements is **selected**. We check the selected concept and **evaluate** it according to the requirements or by using some recommended methods. There is a feedback possibility in the case that we find that the concept is not good enough.

The development stage is similar to the previous one. It is begun by a **detailed embodiment design** working in parallel with the product's **measures.** Likewise, the **3D** modelling is carried out more or less while these stages to allow the designer to make changes. Once the 3D is finished, **materials and manufacturing processes** are selected and **models and prototypes** are made afterwards. Finally, a **financial test** is done to check the product feasibility.

Comments

We have found the main problem in the **information stage.** This stage was the most characteristic for this kind of project so we had to make sure that it was accurate enough. As we have explained before the design brief content is inferred by the "search area" conclusions. At first we thought that these conclusions could include the product to develop. Nevertheless, we realized that obtaining directly the product that it is necessary to develop was hard to achieve. On the contrary, some desired product's features were obtained from the "search area" points so those characteristics were what it was necessary to specified in the design brief as a basic idea of what the designer wanted to accomplish, starting later with the idea analysis. Besides, depending on the idea's nature (abstract or specific) it is needed to carry out a product analysis or not.

Example

Input

Brand / Company " Increase the market basket of Braun"

Information stage

Company analysis

→ Analysis of present situations

· Nowadays Braun focuses on its core categories
- Shaving and grooming,
- Beauty and
- Hair care

· New projects related to Household Small Appliances, Health and wellness category as well as clocks and watches are run by other companies under licence (De'Longhi, Zeon, Kaz).

→ Internal analysis: Strenghts & Weaknesses
→ External analysis: Threats & Opportunities

SWOT

Braun GmbH, SWOT Analysis

Strengths	Weaknesses
Diversified Product Portfolio	Product Recalls
Innovation Capabilities	

Opportunities	Threats
Growing Demand in Emerging Markets	Intense Competition
Rising Demand for Men's Grooming Products	Counterfeit Goods Market

→ Market basket & Positioning

Female grooming

Male grooming

Hair care

Kitchen and househhold

→ Customer

→ Search area | Generation | Evaluation | Selection

Strength + Opportuniy =
Innovation capabilities + Rising demand of Men's grooming products

· Create a grooming need in men habits
· Increase the shavers collection
· Integrate various male grooming products
...

· **Increase the shavers collection**

Idea Approach *What would be interesting to work about?*

Information stage

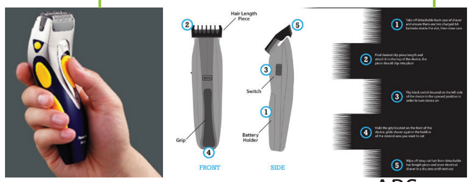
Idea analysis

If needed

Market Research

Product analysis

- Structural-Materials
- Functional
- Formal
- Ergonomics



ABS

User/environment

Conclusions

· The user considers the ergonomics in this kind of product really important.
· It is made of several pieces and different materials.
· The user prefers spending more money in a quality product than saving money with one average shaver.
...

PDS

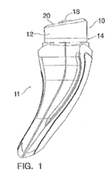
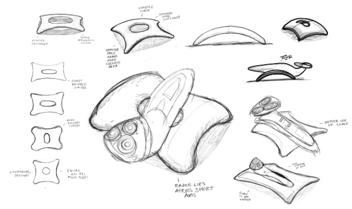
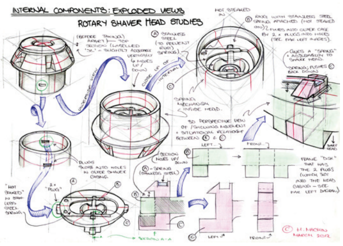
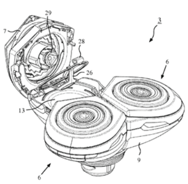
· Reduce the number of pieces.
· Make the shaver able to fit in most of the users hands.
· Unify materials if possible.
...

Concept generation

Concept finding

Concept design

Embodiment design

Concept	Embodiment design
Concept 1 	
Concept 2 	
Concept 3 	

Concept generation

Selection

PDS	Concept 1	Concept 2	Concept 3
· Reduce the number of pieces.	✓	✓	✓
· Make the shaver able to fit in most of the users hands.	✓	✓	✗
· Unify materials if possible.	✓	✗	✗

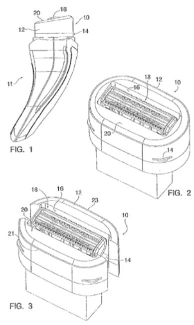
Concept 1

Evaluation

The concept is evaluated. If it is feasible we continue to the next stage, if it is not there is the feedback possibility until the PDS and the problem identification.

Development stage

Embodiment + Measurement



+

3D modelling

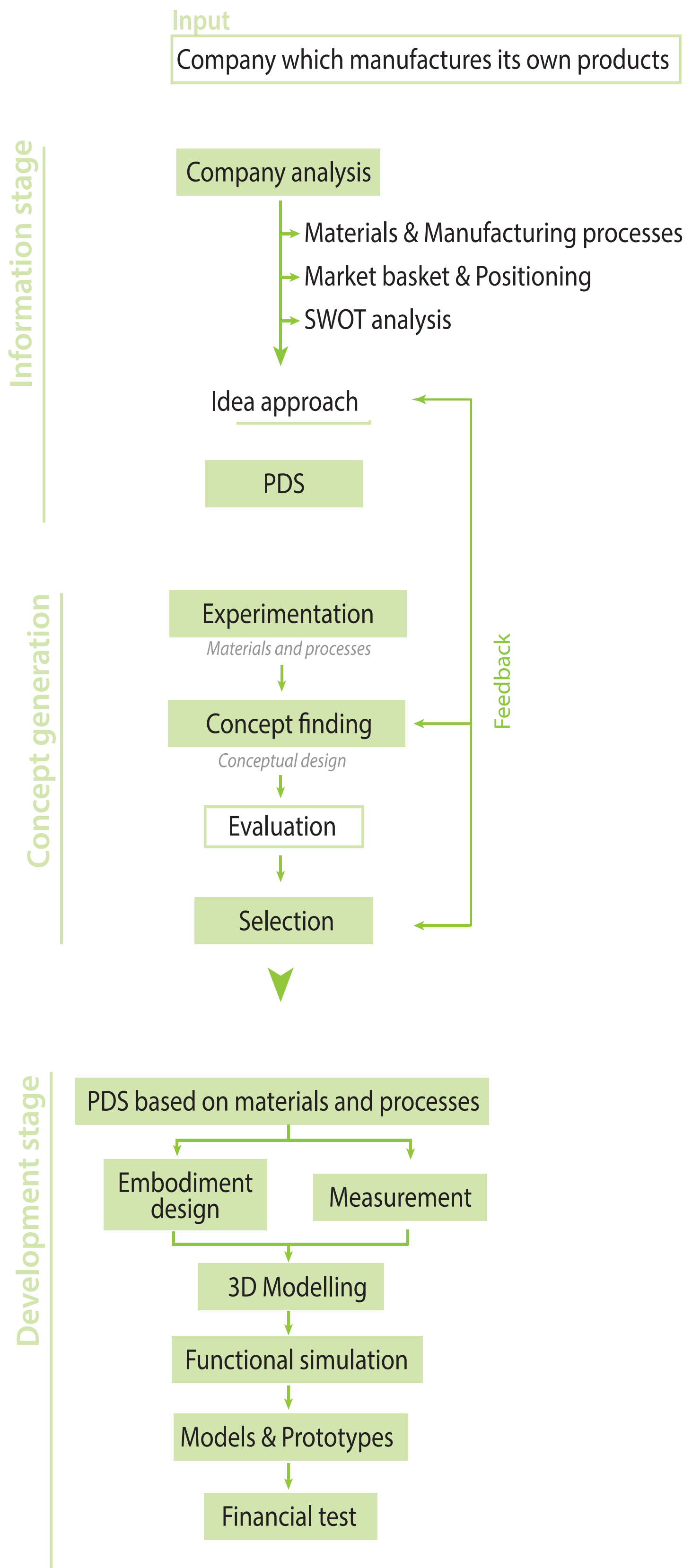
Materials & processes

Pieces	Material	Process
· Case · Head ...	· ABS · Stainless steel ...	· Injection · Casting ...

Models & Prototypes

Financial test

5. Providing the company which manufactures its own products



Explanation

The **information stage** is based on analysing the company's information. Since the designer is told to design something for a manufacturing company it is essential to study the technology that this company is upgraded with; the **materials and manufacturing processes** as well. By doing this, the designer will acquire a deeper knowledge about the company's activity and he will be able to better carry out a **SWOT** analysis. Before writing down the SWOT, the designer must study the company's **market basket** so that he can study the kind of products the company is able to manufacture and the users these products are oriented to. As in the previous case, the SWOT (Strengths, Weaknesses, Opportunities, Threats) which will help the designer to identify possible points where applying his ideas.
Thanks to all this information the designer will be able to create the **idea approach** where all the Design Product Specifications (PDS) will be explained. With this, the designer will have some basics aspects to apply on the future design, making sure that these characteristics will cover the company's needs.
Opposite to other kind of projects, here the design brief has more boundaries since we are limited by the product's material and the manufacturing process.

Concerning the **concepts generation stage**, the most different and important step is the experimentation. Before coming up with new concepts it is useful to experiment with the materials and processes that the company count with in order to better understand their properties and potential possibilities. The experimentation of materials and techniques allows to collect information on new uses of a product. After this, the concept finding is the next logical step, followed by an evaluation and a selection of the one which best suits our requirements. As usual, there is the feedback possibility in the case that the designer considers the selected concept is good enough. It would be possible then to go back until the design brief writing if needed.

The **development stage** is probably the one which most differs from other projects. First, the designer should create the **PDS list based on the materials and manufacturing processes** conclusions in order to make clear and specify the possibilities of creating the product. Taking into consideration these PDS and the selected concept the designer can start with the embodiment design. As usual, this **embodiment design** works simultaneously with the **measurement** step and followed by the **3D modelling stage**. From there, it is possible to come back to the measurement so that the product' characteristics can be constantly checked. Since we are dealing with materials and manufacturing processes the designer should carry out a **functional simulation** to check the material properties on his product. After this there is only left the creation of the **models and prototypes** and the **financial test.**

Comments

In other projects we have generally placed the **Material&Processes** after the 3D modelling step because by having the complete and finished product we can choose the material and manufacturing process which best suit it. Nevertheless, in this case we have placed it in the beginning of the **development stage** because we need to take the company's materials and processes possibilities into account in order to make a proper detailed embodiment design.

Example

Input

Company which manufactures its own products

"GlassPack. Catalogue extension"

Information stage

Company analysis

→ Materials & Manufacturing processes

Glass study
- Composition
- Properties: physical, chemical, optical...
- Applications
- Existing products

...

Glass production in GlassPack
- Blow and blow method
- Press and blow method
- Cold end: coatings

→ Market basket & Positioning

Food

Jars

Juices

Bottles

Liquors

Refreshments- Beers

Wines - Champagnes

Closure systems

Metal lid Twist off

Cork stopper

Screw aluminium lid

→ SWOT analysis

Strengths
- Lack of competitive pressure in the field.
- Abundance of raw material
- Innovation

Weaknesses
- High manufacturing process costs
- Limited economy

Opportunities
- Recycling promotion
- Glass packaging is recommended over plastic packaging: quality.

Threats
- Possible troubles with ecologists groups

Idea approach

Since it is highly appreciated the quality of a glass container it would be interesting to extend GlassPack catalogue with a container for something that reflects quality itself; like olive oil.

PDS

- Olive oil container of X millilitres of capacity
- Be able to be easily refilled

...

Concept generation

Experimentation

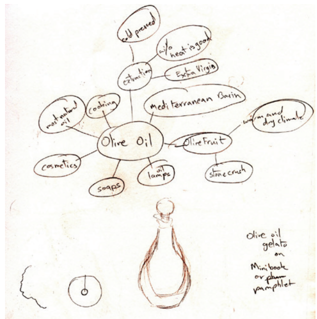
Materials and processes

In this step we start to experiment with GlassPack manufacturing processes and the glass material. We have to be aware of all the possibilities that the processes offer as well as the properties of the material, in order to optimize the process.

Concept finding

Conceptual design

Concept

Concept 1	Concept 2	Concept 3
		

Evaluation

PDS	Concept 1	Concept 2	Concept 3
· X ml capacity	✓	✓	✓
· Easy refilling	✓	✓	✗
· Quality feeling	✓	✗	✗
...			

Concept 1

Selection

The concept selected is evaluated. If it is feasible we continue to the next stage, if it is not there is the feedback possibility until the concept finding, where the designer would have to start again with the concept generation; or until the idea approach, because maybe it is more profitable to carry out other idea.

Development stage

PDS based on materials and processes

· Blow and blow method as manufacturing process
· Limit the amount of material to X kg.
· Adjust the dimensions to the machine characteristics which are: x
·...

Embodiment design

Measurement

Development stage

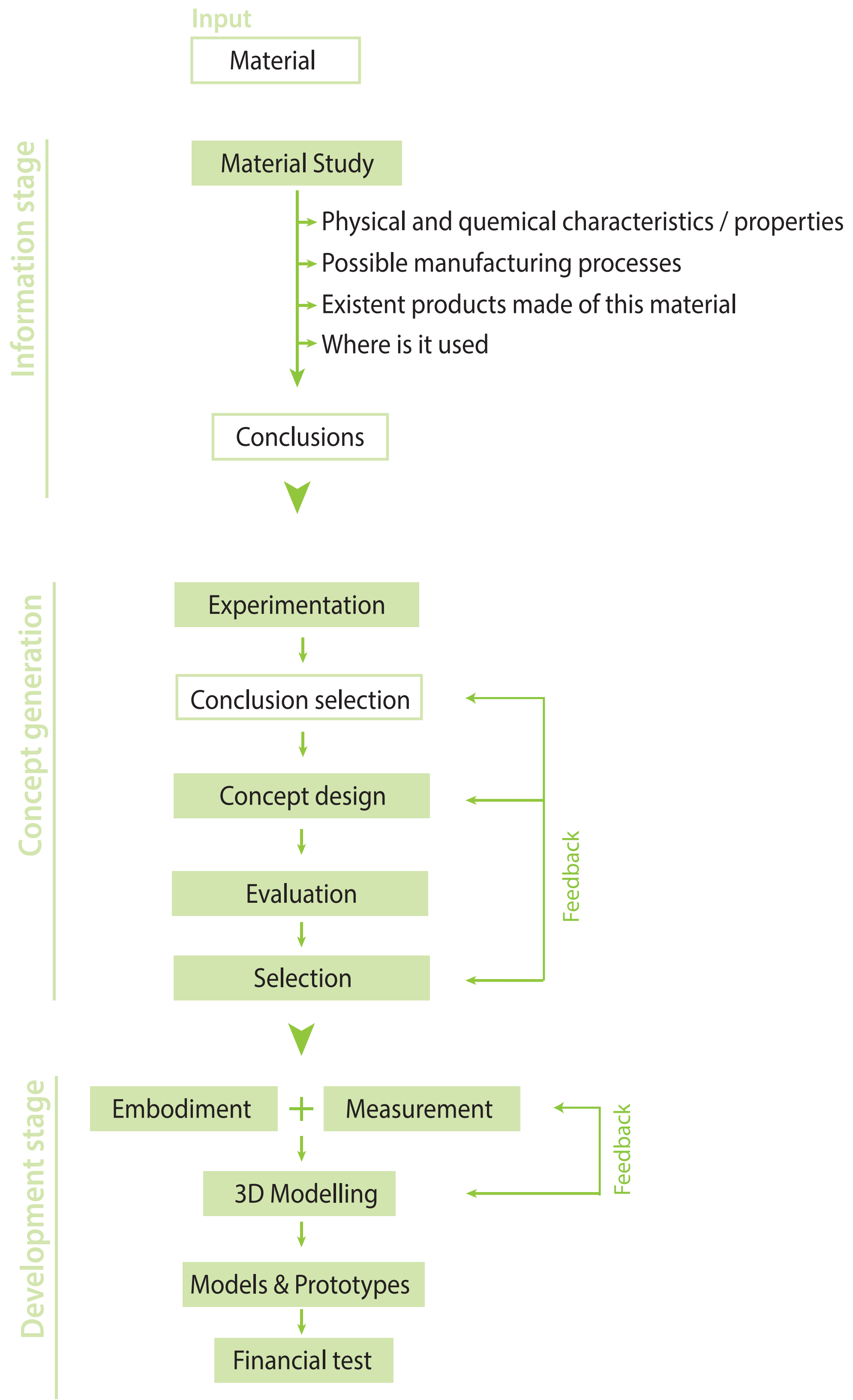
3D Modelling

Functional simulation

Models & Prototypes

Financial test

6. Providing the material



Explanation

The information stage begins by doing a **material study.** We have to study different aspects of the material we are dealing with, physical and chemical characteristics and properties to later see where the designer might be focused on. Also it is important to make a research about the possible manufacturing processes, studying how each of them works and seeing if we can optimize it. To have a wider perspective it is also necessary to study all the products that already exist made of this material. It is also useful making a classification of this products attending, for instance, to a properties criteria. It would be helpful as well studying the environment where these products are delivered and the elements they have contact with. After all this analysis the designer must come up with **conclusions** which will influence the future design. The conclusions can come up as one good property of the material that has the potential to be exploded in a new product.

The concept generation stage begins with an **experimentation** stage. This literally means experimenting with the material: see all its possibilities when its state is changed, when I apply weight on it, how flexible it is... Thanks to this experimentation the designer will be able to check all the information that he wants to obtain about the material by first-hand. This information might be used to improve the design.
Having the conclusions from the information stage and those from the experimentation, the designer must now **select one characteristic** to be focused on. By being focused in one characteristic the **concept generation** is more accurate and the results will be better. Anyway, thanks to a **feedback** it is possible to change this choice (characteristic that the designer wants to be focused on) if the designer feels that the obtained result is not good enough or it does not fit the project requirements.

Regarding the development stage, the work flow is similar to the previous projects. We will start the stage by making the **embodiment design** at the same time that applying the **measures**. After this, it is necessary to develop the **3D** of the product and checking constantly if the measures fit. After this, the **models and prototypes** should be made, followed by a **financial test.**

Comments

The main doubt resides in the concept generation stage. We had two options here: doing first the **conclusion selection** and then the **experimentation** or doing first the experimentation and selecting a material's characteristic later. If we had firstly selected a material's characteristic, then the experimentation step would have been really limited by this characteristics, limiting also the potential concepts that we could come up with. However, by doing the experimentation first, the designer can check all the material's properties being limited by nothing and having a deeper knowledge of the material when choosing a characteristic to be focused on.

Information stage

Example

Input

Material

Ceramic

Material Study

Classification :

-Red ceramic
-White ceramic
-Fireproof
-Abrasive
-Cement
-Glass
-Advanced ceramic

Physical and chemical properties to study:

Thermal
Mechanical
Chemical
Electrical and magnetics
Impermeability
Ice resistance
Acoustical
Optical
Porosity

Manufacturing processes:

1_Set the material
2_Comapacting
- -Uni-axial compacting
- -Barbonite molding
- -Extrusion
- -Injection

3_ Drying
4_ Sintered

Existent products:






Where is it used:



Conclusions

Its properties allow us to:

-Being a thermal, electrical and acoustic isolator
-Suffering at high temperatures
-Suffering at compression
-Being no toxics
-Being watertight

Its properties does not allow us to:

-Impact resistance
-Being elastics
-Suffering at traction

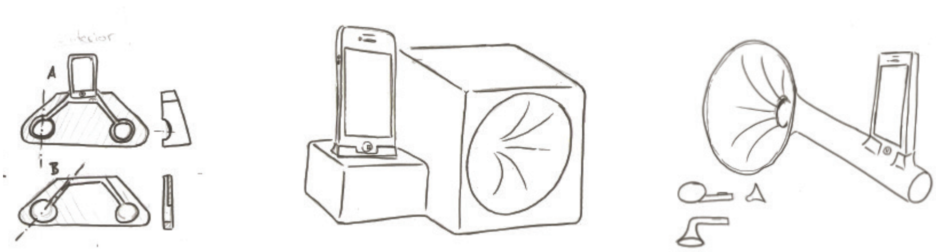
Experimentation

We experiment with the material in order to check what is the behaviour of the most interesting properties in different situations.
We have made some sound-proofs to check how much the ceramic increase the intensity and if it would be useful in some product with the help of ceramic products as mugs, vases or bowls.

Conclusion selection

We see that the reverberation amplify the sound high enough to allow the user to listen music in a quite environment so we decided to design an iPhone Desk whose amplify the speakers of it. The user could use it as speaker to listen music as well as to have phone-calls and video-conferences.

Concept design



Evaluation

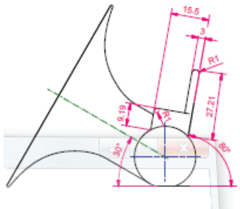
Desirable features	Concept 1	Concept 2	Concept 3
· A	✓	✗	✓
· B	✓	✓	✓
· C	✓	✗	✓
· D	✗	✗	✓
· E	✓	✓	✓

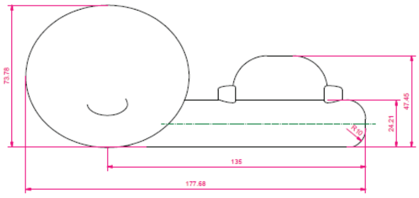
Selection

Concept 3 is selected because it better achieves the PDS explained before.

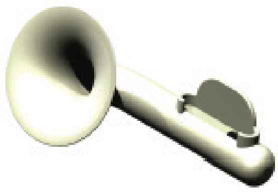
Development stage

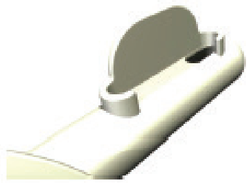
Embodiment + Measurement





3D Modelling



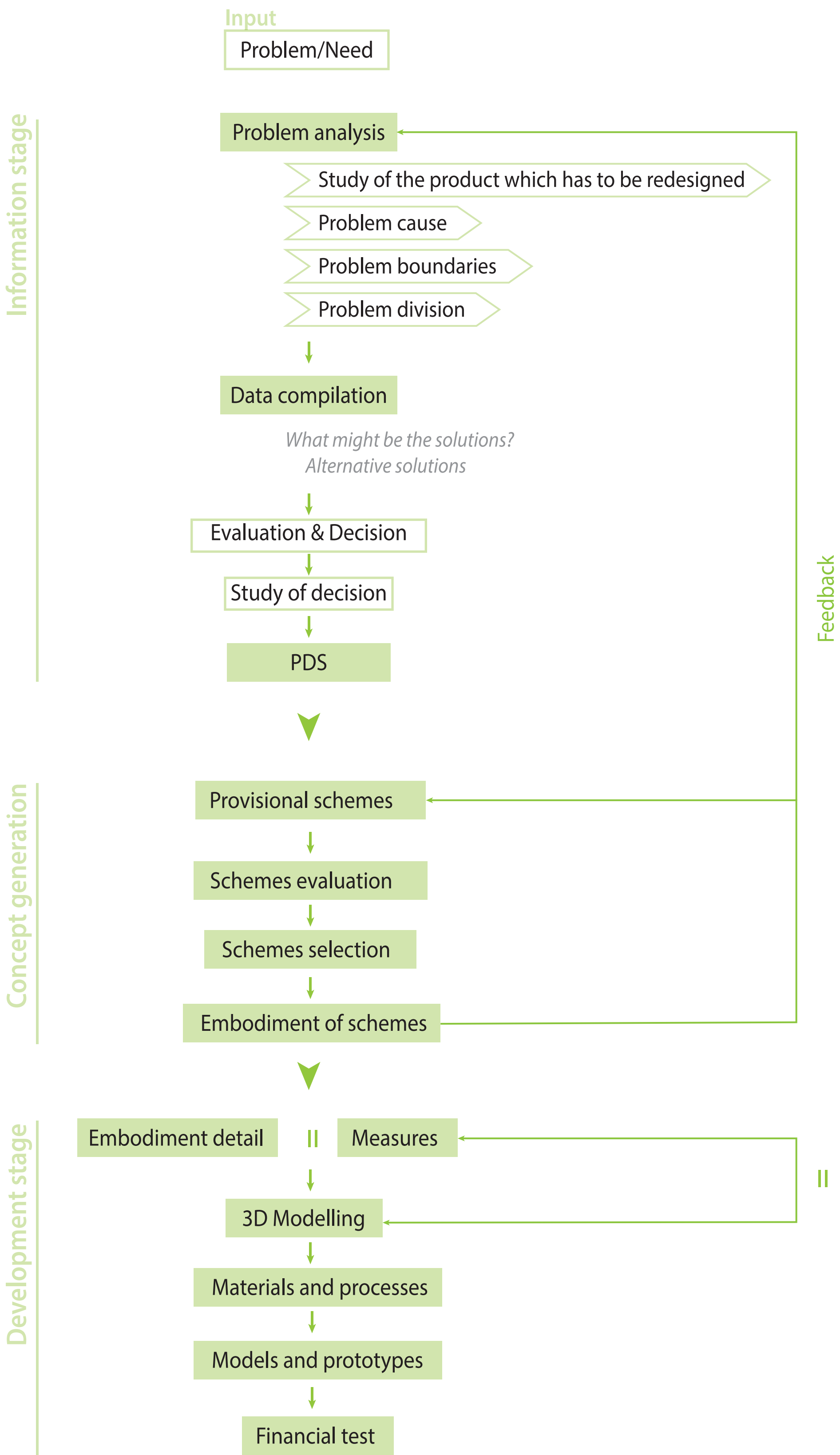


Models & Prototypes

Financial test

The production costs are analysed as well as the profits that the design may imply to the company. According to the results from the financial tests some changes might be added to the manufacturing process.

7. Redesign


Input
Problem/Need
Information stage
Problem analysis
Study of the product which has to be redesigned
Problem cause
Problem boundaries
Problem division
Data compilation
What might be the solutions?
Alternative solutions
Evaluation & Decision
Study of decision
PDS
Feedback
Concept generation
Provisional schemes
Schemes evaluation
Schemes selection
Embodiment of schemes
Development stage
Embodiment detail
Measures
3D Modelling
Materials and processes
Models and prototypes
Financial test

Explanation

As mentioned before, a redesign is taking a product which already exists and make the convenient changes to solve a problem which has been noticed. By this token, the input of this kind of project is a need or a problem since it is necessary to notice a problem to ask for a redesign. Besides, there might be different kind of redesign projects, such as:

· A structural problem which could be solved by removing some pieces, decreasing the product's weight, changing some component...
· A financial problem which could be solved by changing materials, optimizing the manufacturing process...
· An interaction problem which could be solved by improving the ergonomics of a product or the way to use it.

We have dealt with this kind of project before so the scheme will follow similar steps, varying the content of the problem analysis though.

The **information stage** starts with the **problem analysis** . First, it is necessary to carry out a detailed **study** into the product that we have to redesign. We do this because we need to understand how it actually works and how it tries to solve the problem we are dealing with. It is also necessary to find out the cause of this problem as well as to define its limits. We have to be aware of the problem's boundaries, how far we can get into it. As an useful tool to solve problems we can split the problem into sub-problems so the complexity is reduced. By solving these sub-problems the designer will be able to solve the main one.
After the problem analysis there is the **data compilation** step. Here the designer has to come up with possible solutions to the problem, possible solutions could be: changing a feature of the product, the material, a measure...
Having different proposals to solve the problem, the designer must now compare them and **evaluate** them so that he can make a **decision** based on which one better solves the problem. Once we have a potential solution it is necessary to **study** it carefully so that we can obtain the convenient information to start with the redesign. This could be for example, if we decide that the solution to a design problem would be reducing the thickness of a casing, we will have to make a study to know how much the minimum thick has to be to comply with the product requirements. With this specific data the designer will be able to write down the final **conclusions**. Likewise, with these conclusions the PDS will be written.

Both the **concept generation stage** and the **development stage** are similarly developed to the "Providing a problem or a need" project.

Example

Information stage

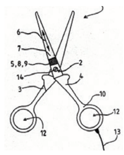
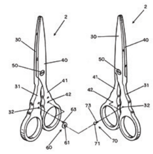
Input

Problem/Need: Redesign scissors to make them harmless for children

Problem analysis

Study of the product which has to be redesigned



We will study the market in order to know which scissors already exists and if they also have the same problem than us and how they solve it. We also study their structure, to know how they work and how they can be modified.

Problem cause

Children can not manage the scissor properly

Problem boundaries

They must cost less than __$
They are going to be used by children between 4 and 10 years old.
They will be used in the school as well as at home.
The production will be around 10000 pieces.
...

Problem division

The blades are very sharp.
They are too much heavy for a child.
They have a sharp point.
They are difficult to control with accuracy for a child because they are too big and hard.
They are heavy because they are made of steel.
...

Data compilation

We start to think about solutions:
The product will be used to cut paper and cardboard so we could change the material of the blades, they could be in plastic.
It should be interesting to make them lighter than the actual one by changing the material.
We should check the measures of children hands in order to design a proper handle.
There is no need of the sharp point in the scissor, it can be rounded.
...

Information stage

Evaluation & Decision

The best options is to change the material of the handle, making it lighter. Also the measueres have to be modified in order to adapt the product to children hands. Concernig the blades, we will study if it is possible to change the steel for a safer material, anyway the point will be rounded and covered with some protection.

Study of decision

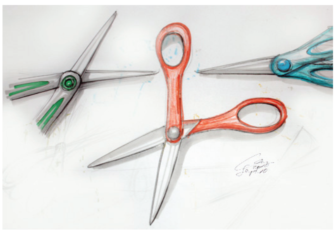
In here we study different thermoplastics and rubbers to try to find out the perfect ones.
We realise than some rubbers going with some reinforcement have the strength enough to be the handle of the scissor, they will make the handle softer and safer.
We figure out that thermoplastics can be sharp enough to cut paper and cardboard but we assume that it will not last too much time.
We also study the anthropometrical aspects of children hands in order to provide the scissor with the corrects measures

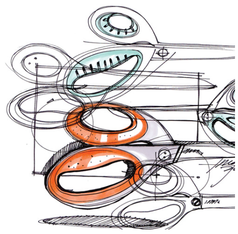
PDS

1. It must be comfortable for children from 4 to 10 years old.
2. It has to be completely safe for children
3. It must be as light as possible
4. It can not have any toxic component
5. It should look attractive for children
6. ...

Concept generation

Provisional schemes





Schemes evaluation

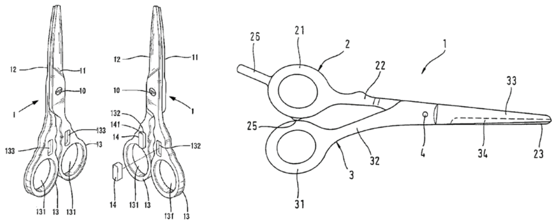
Desirable features	Concept 1	Concept 2	Concept 3
· A	✓	✓	✗
· B	✓	✓	✓
· C	✓	✓	✗
· D	✗	✓	✗
· E	✓	✓	✓

Schemes selection

Concept 2 is selected because it better achieves the PDS explained before.

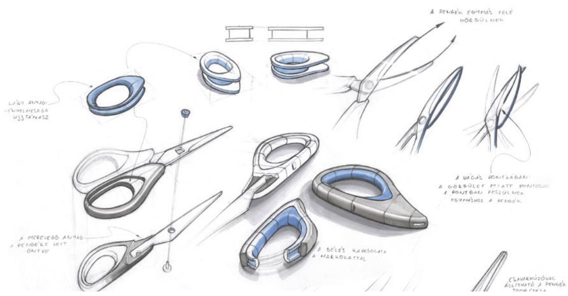
Concept generation

Embodiment of schemes

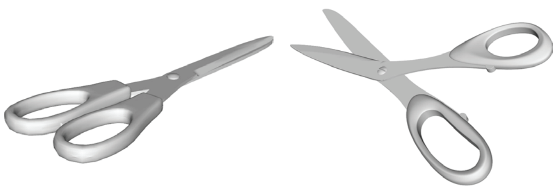


Development stage

Embodiment detail || Measures



3D Modelling



Materials and processes

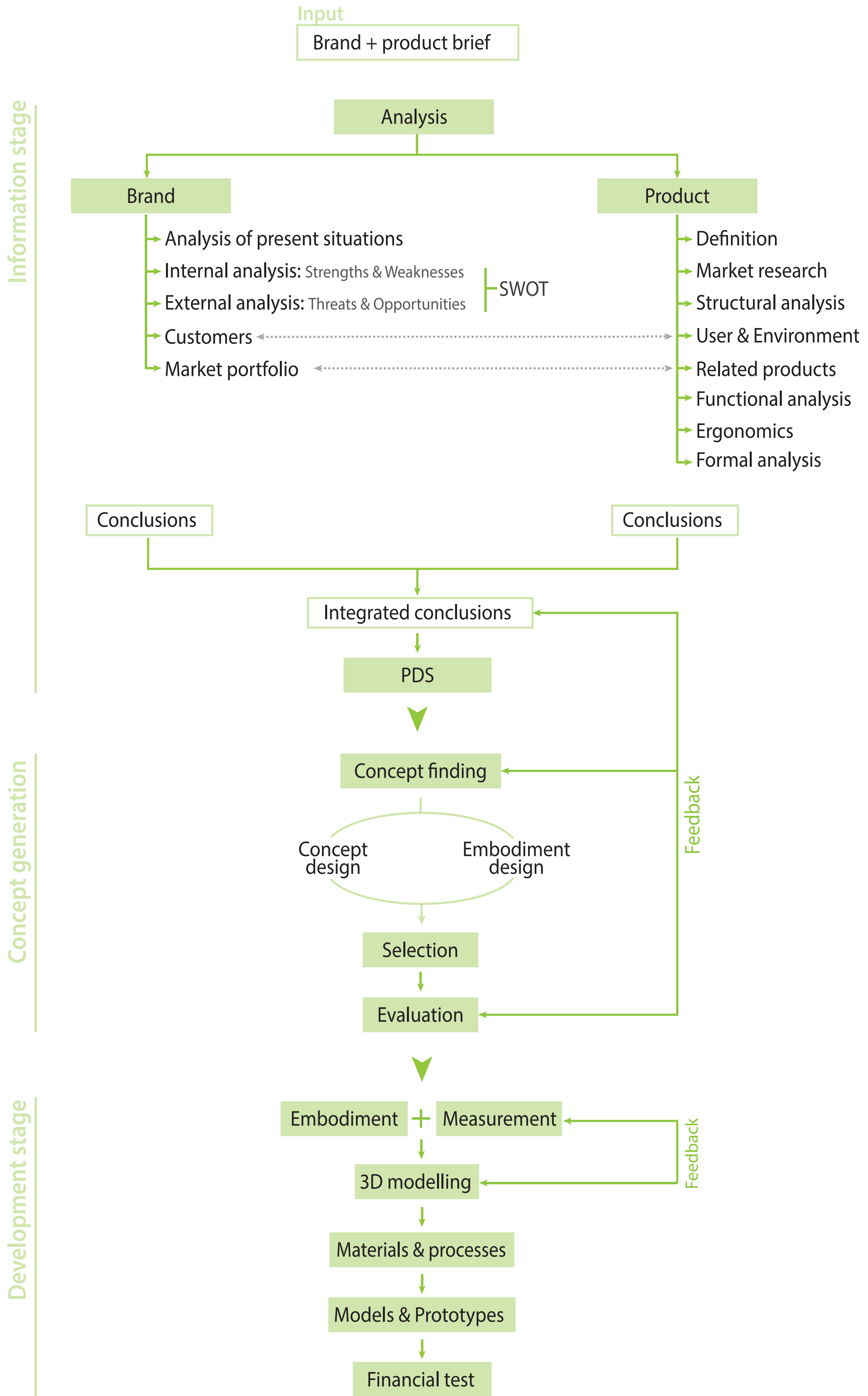
Pieces	Material	Process
· Handle · Blades ...	· Rubber · PE · ...	· Moulding · Injection · ...

Models and prototypes

Financial test

The production costs are analysed as well as the profits that the design may imply to the company. According to the results from the financial tests some changes might be added to the manufacturing process.

8.1. Providing brand + product



Explanation

The inputs of this sort of project are the brand and the product itself.
In the information stage it is necessary to study both inputs deeply. Thus, we will be making a parallel analysis.
On one hand, the brand is analysed: its present situation, how the company is working now; its external and internal situation; SWOT analysis to come up with the ideas for the next stage; its market portfolio, to know all the products the company offers as well as their features; and its current customers, to know them and be able to identify future potential users.
On the other hand, the product is also studied. As in the project when a designer is only told the product itself, it is necessary to analyse all the aspects related to it: product definition, market research, structural analysis, functional, formal, user and environment, related products and ergonomics.
After these analysis some conclusions will be extracted. It is necessary now to integrate both conclusions, from the brand side and the product side. By doing this integration the designer will be able to connect some important points which may help to the future design. Thus, the integrated conclusions will be likely oriented in one direction so it will be possible to draw the PDS from them.

Then the designer starts with the concept generation stage. Firstly with the concept finding, working in parallel with the concept and embodiment design, allowing the designer to check if his concepts also fit in a structural view of the product making the future development easier. The different concepts are compared and the one which best fits the requirements is **selected**. We check the selected concept and **evaluate** it according to the requirements. There is a feedback possibility in the case that we find that the concept is not good enough.

The development stage is begun by a **detailed embodiment design** working in parallel with the product's **measures.** Likewise, the **3D** modelling is carried out more or less while these stages to allow the designer to make changes. Once the 3D is finished, **materials and manufacturing processes** are selected and **models and prototypes** are made afterwards. Finally, a **financial test** is done to check the product feasibility.

Comments

The main doubt here is found during the brand analysis. The need of analysing the users here was discussed since it was also going to be dealt during the product analysis. Finally, we agreed that it was necessary to carry this study out in both sides because thanks to the current users of the brand, the designer will be able to identify other potential users. Then, we also noticed that some brand's customers might not be a product's users.

Furthermore, in the integrated conclusions we were discussing if we should include this step in the 1st or 2nd stage because we somehow saw some creativity action. Eventually, we included it in the information stage because it is related to analysis and synthesis.

Example

Input

Brand + product brief

"Design a computer mouse for Logitech"

Logitech

Information stage

Analysis

Brand

Analysis of present situations

· Logitech markets and sells computer hardware/ peripherals. The company has faced recent challenges due to lower demand in Europe, Middle East, and Africa.

· In July 2011, Logitech acquired the mobile visual communications provider, Mirial.

Internal analysis: Strengths & Weaknesses
External analysis: Threats & Opportunities
SWOT

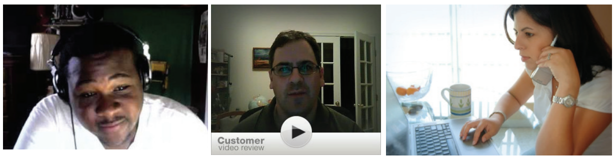
Strengths
- Well known around the world.
- It has a worldwide market.
- Diversified patent portfolio.
- Known as a leader of innovation and design.

Opportunities
- Review the packaging style guides across all categories.
- Focus the product offerings.
- Provide more focused information to help customers.

Weaknesses
- It is mostly well known thanks to mice and trackballs.
- Overall design sometimes inconsistent.

Threats
- Manufacturers may offer better interfaces.
- Customers may feel that the device does not fit their other devices' appearance.

Customer



Product

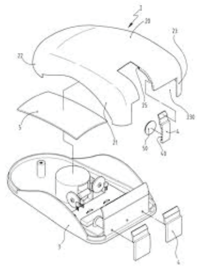
Definition

Pointing device that functions by detecting two-dimensional motion relative to its supporting surface.

Market research

Genius   Microsoft   TACENS

Structural analysis



Functional analysis

1st Function: allow the user to manipulate and interact with a non tactile interface.
2nd Functions: scroll up and down, lateral shifting...

User & Environment

Formal analysis

Market portfolio ↔ Related products

Computer accessories

Tablet accessories

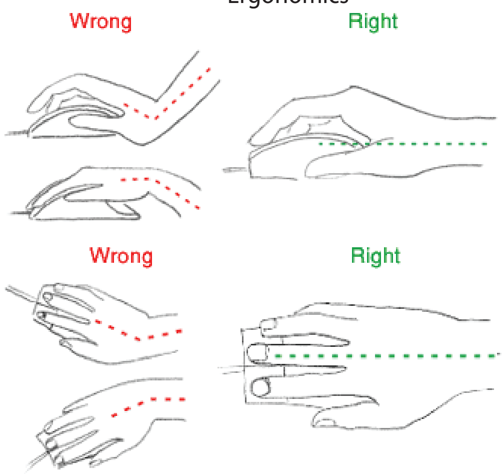
Digital home products

Gaming

Music

Business

Ergonomics



Conclusions → Integrated conclusions ← Conclusions

Integrated conclusions → PDS

PDS

· Wireless laser computer mouse.
· Free scroll
· For right and left-handed users.
· Frequency of X Gigahertz
· Appearance in concordance with Logitech corporate identity
· Improve the ergonomics of previous designs
...

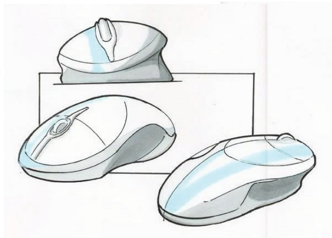
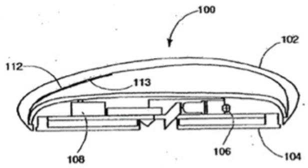
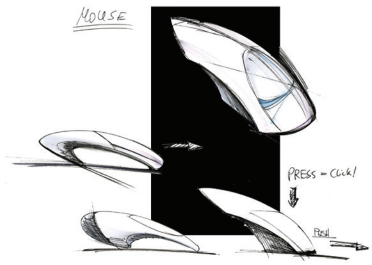
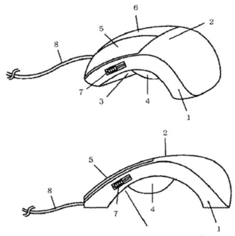
Concept generation

Concept finding

Concept design — Embodiment design

Selection

Evaluation

Concept	Embodiment design
Concept 1	
	
Concept 2	
	

PDS	Concept 1	Concept 2
· Wireless laser computer mouse.	✓	✓
· Free scroll	✓	✓
· For right and left-handed users.	✓	✓
· Frequency of X Gigahertz	✓	✗
· Logitech appearance	✓	✗
· Improve the ergonomics of previous designs	✓	✓

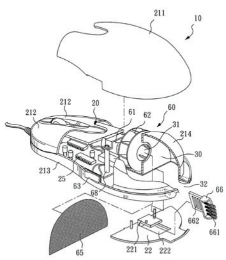
Concept 1

The concept is evaluated. If it is feasible we continue to the next stage, if it is not there is the feedback possibility to check and change whatever the designer considers necessary.

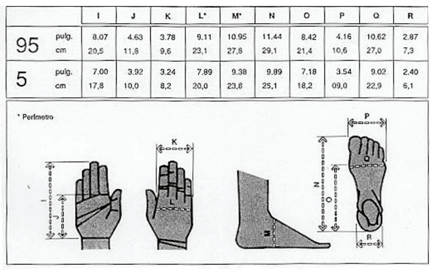
Development stage

Embodiment + Measurement

3D modelling



+



		I	J	K	L*	M*	N	O	P	Q	R
95	pulg.	8.07	4.63	3.78	9.11	10.95	11.44	8.42	4.16	10.62	2.87
	cm	20,5	11,8	9,6	23,1	27,8	29,1	21,4	10,6	27,0	7,3
5	pulg.	7.00	3.92	3.24	7.89	9.38	9.89	7.18	3.54	9.02	2.40
	cm	17,8	10,0	8,2	20,0	23,8	25,1	18,2	09,0	22,9	6,1

* Perímetro

Development stage

Materials & processes

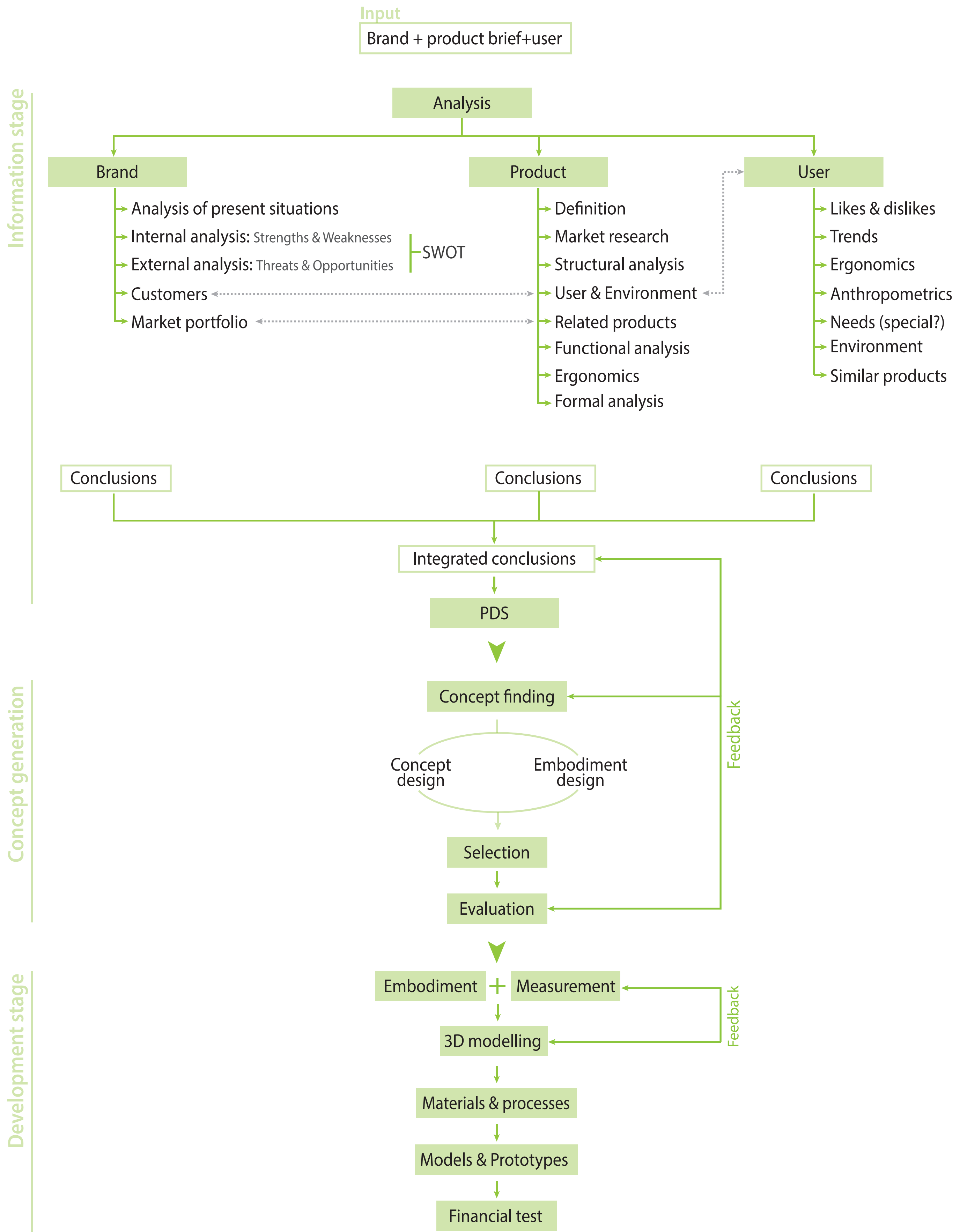
Models & Prototypes

Financial test

Pieces	Material	Process
· Case	· ABS	· Injection
· Scroll	· Rubber	· Moulding
...	...	...

The production costs are analysed as well as the profits that the design may imply for Logitech. According to the results from the financial tests some changes might be added to the manufacturing process or during the design steps.

8.2. Providing brand + product + user



Explanation

The inputs of this sort of project are the brand and the product itself.
In the **information stage** it is necessary to study the three inputs. Thus, we will be making a parallel analysis.

First, the **brand** is analysed, as we did in the previous case, we study its present situation, external and internal circumstances (defined by the SWOT), its market portfolio to make a first approach and its current customers that we will later relate to the target of our product.

Secondly, the **product** itself is analysed. It is necessary to collect information about its definition, market research, structural analysis, functional, formal, user and environment, related products and ergonomics.

Thirdly, the provided **user** is analysed. It is really important to know the target we are designing to in order to cover their needs as good as possible. Their likes and dislikes will be analysed, using a psychological standpoint; the trends that the user follows, the culture he/she is involved and the determining factors; the ergonomics aspects as well as the anthropometrics; the user surroundings and similar products that the user already uses. The information of the target will be related to the characteristics of the brand's current customers and with the general user of the product we are designing.

Summing up this information some **conclusions** will be extracted. As in the previous case, the conclusions must be integrated to identify new design possibilities. These integrated conclusions will be likely oriented in one direction so it will be possible to draw the PDS from them.

The **concept generation** stage begins with the concept finding. The correct way to work here is simultaneously with the concept and the **embodiment design.** By this way the designer can constantly check if his concepts are structurally correct. There will be different options and the one which best fits the PDS will be **selected.** Then, an **evaluation** will be carried out to check all the concept possibilities and if it is feasible. As we have mentioned previously, in this step there is a **feedback** option to start the stage again.

During the **development stage** the **detailed embodiment design** that we have already explained is carried out. As in previous cases, it is developed at the same time that the **measurement** of the product and the **3D,** in order to be able to change whatever the designer may consider necessary. Once the 3D is finished, **materials and manufacturing processes** are selected and **models and prototypes** are made afterwards. Finally, a **financial test** is done to check the product feasibility.

Example

The inputs in this kind of project are the same than in the previous one adding the user information. To illustrate this example, the data will be the same plus the user information. Thus, we will check how many different paths a project can take and the different results that may be obtained.

Information stage

Input

Brand + product brief+user

"Design a computer mouse for Logitech for gamers"

Logitech

Analysis

Brand

Analysis of present situations

· Logitech markets and sells computer hardware/ peripherals. The company has faced recent challenges due to lower demand in Europe, Middle East, and Africa.

· In July 2011, Logitech acquired the mobile visual communications provider, Mirial.

Internal analysis: Strengths & Weaknesses

External analysis: Threats & Opportunities

SWOT

Strengths

· Well known around the world.
· It has a worldwide market.
· Diversified patent portfolio.
· Known as a leader of innovation and design.

Opportunities

· Review the packaging style guides across all categories.
· Focus the product offerings.
· Provide more focused information to help customers.

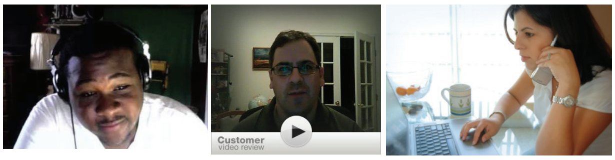
Weaknesses

· It is mostly well known thanks to mice and trackballs.
· Overall design sometimes inconsistent.

Threats

· Manufacturers may offer better interfaces.
· Customers may feel that the device does not fit their other devices' appearance.

Customer



Product

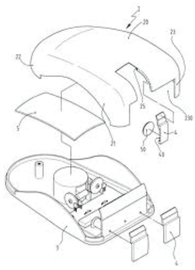
Definition

Pointing device that functions by detecting two-dimensional motion relative to its supporting surface.

Market research

Genius Microsoft TACENS

Structural analysis



Functional analysis

1st Function: allow the user to manipulate and interact with a non tactile interface.
2nd Functions: scroll up and down, lateral shifting...

User

User & Environment

Formal analysis

Information stage

Analysis

Brand | Product | User — Gamers


Likes & dislikes

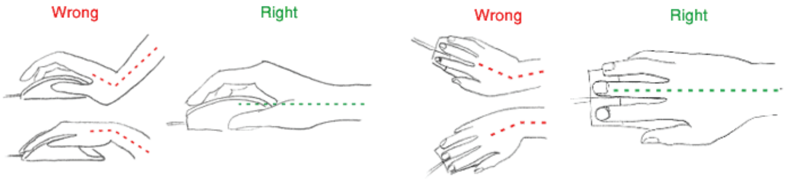


Windows® Internet Explorer 9

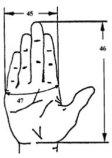
Trends

- PC
- 360
- PS3
- Wii
- Wii U
- DS
- 3DS
- VITA
- iOS

Ergonomics



Anthropometrics



45 Hand breadth. The breadth of the hand, measured across the ends of the metacarpal bones (metacarpal-phalangeal joints).

Sample			Percentiles 1st	5th	50th	95th	99th
A	Men	cm (in)	8.1 (3.2)	8.4 (3.3)	9.0 (3.5)	9.8 (3.9)	10.0 (3.9)
B	Women	cm (in)	7.1 (2.8)	7.3 (2.9)	7.9 (3.1)	8.6 (3.4)	8.9 (3.5)

46 Hand length. The distance from the base of the hand at the wrist crease to the tip of the middle finger.

Sample			Percentiles 1st	5th	50th	95th	99th
A	Men	cm (in)	17.3 (6.8)	17.9 (7.1)	19.3 (7.6)	21.1 (8.3)	21.9 (8.6)
B	Women	cm (in)	15.9 (6.3)	16.5 (6.5)	18.0 (7.1)	19.7 (7.8)	20.5 (8.1)

47 Hand circumference. The circumference of the hand, measured around the knuckles (metacarpal-phalangeal joints).

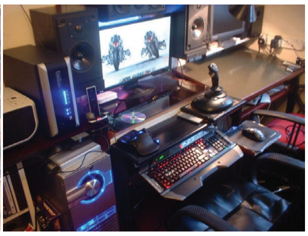
Sample			Percentiles 1st	5th	50th	95th	99th
A	Men	cm (in)	19.2 (7.6)	19.9 (7.8)	21.3 (8.4)	23.0 (9.1)	23.7 (9.3)
B	Women	cm (in)	16.7 (6.6)	17.3 (6.8)	18.6 (7.3)	20.0 (7.9)	20.7 (8.2)

Needs (special?)

- Ergonomic joystick/mouse
- Easy to memorise each button function
- Button directly related to the game possibilities

Environment

Similar products

Information stage

Conclusions | Conclusions | Conclusions

Integrated conclusions

PDS

· Buttons directly related to the game possibilities
· Graphics which show each button function
· Appearance according to gamers' trends
· Wireless
· Light to avoid injuries
...

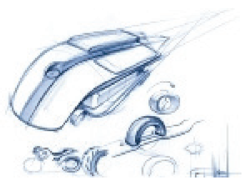
Concept generation

Concept finding

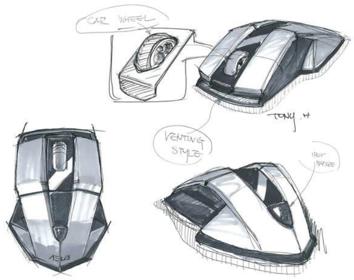
Concept design — Embodiment design

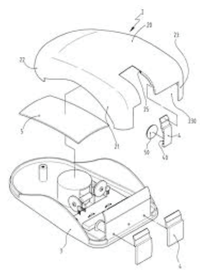
Concept	Embodiment design
Concept 1	

Concept 1



Concept 2





Selection

PDS	Concept 1	Concept 2
· Buttons directly related to the game possibilities	✓	✓
· Graphics which show each button function	✓	✓
· Appearance according to gamers' trends	✓	✓
· Wireless	✓	✓
· Light to avoid injuries	✓	✗

Concept 1

Evaluation

The concept is evaluated. If it is feasible we continue to the next stage, if it is not there is the feedback possibility to check and change whatever the designer considers necessary.

Development stage

Embodiment + Measurement

↓

3D modelling

↓

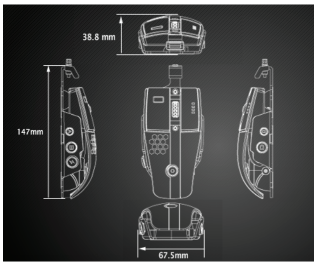
Materials & processes

↓

Models & Prototypes

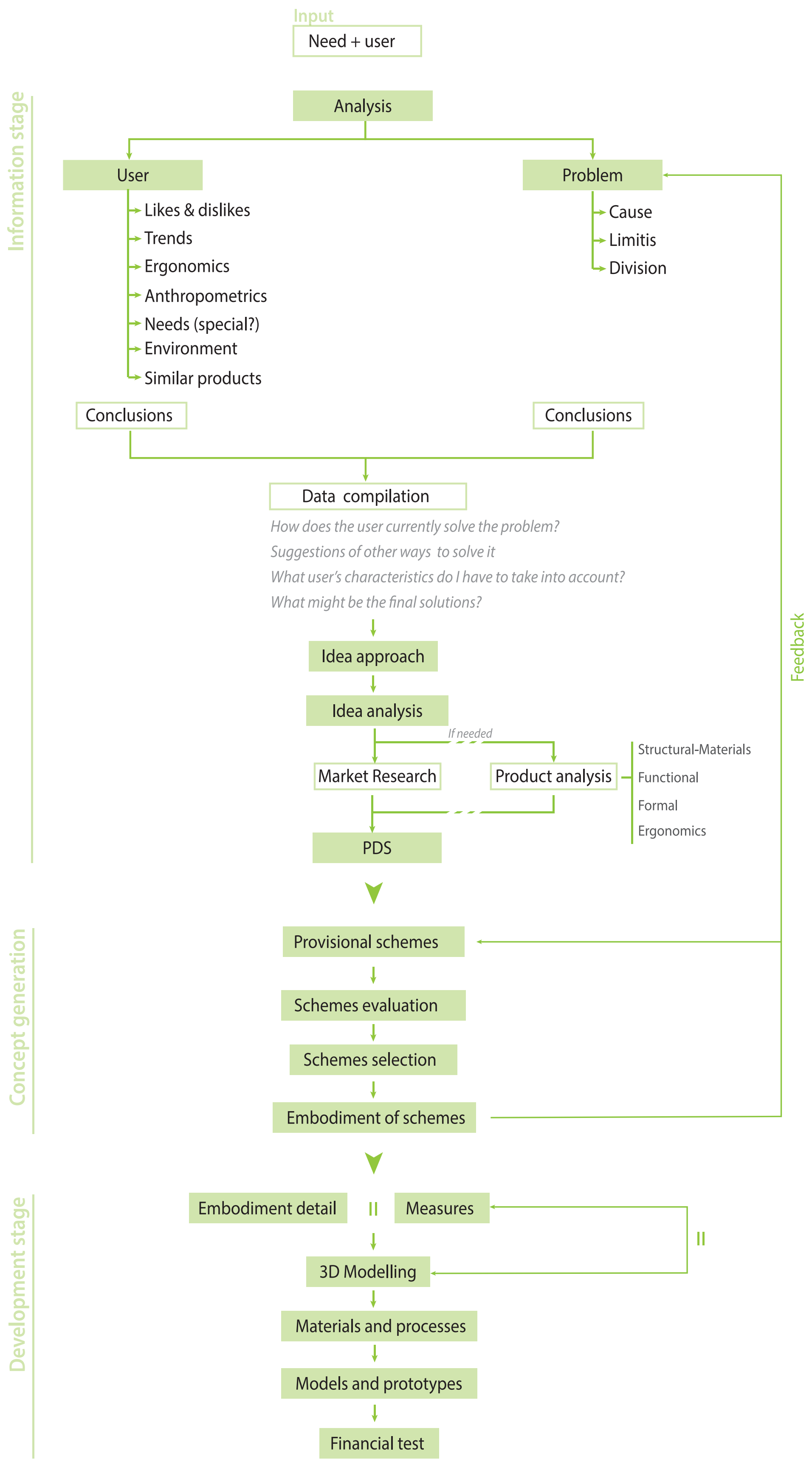
↓

Financial test



Pieces	Material	Process
· Base	· Aluminium	· Moulding
· Coating	· Rubber	· Finishing
...	...	...

8.3. Providing problem + user



Explanation

This kind of project provides the designer with a need or a problem and the user as inputs.

Logically, the **information stage** starts with two simultaneous analysis of that need and that user. Depending on the kind of project it might be more proper to start by the user analysis or the problem analysis. The designer is the one who must decide this.

About the need, a general **problem analysis** is carried out, focused on detecting the cause of the problem which will help to suggest ways to solve it; the limits of the problem, to know how far we can solve it and if the designer counts with some boundaries; and the division of the problem into sub-problems, because, as we have already mentioned, solving small problems is easier that trying to solve a big one.

Concerning the **user**, the same analysis than in the previous project will be carried out: Their likes and dislikes, using a psychological standpoint; the trends that the user follows, the culture he/she is involved and the determining factors; the ergonomics aspects as well as the anthropometrics; the user surroundings and similar products that the user already uses. The information of the target will be related to the characteristics of the currents brand's customers and with the general user of the product we are designing.

We will separately obtain **conclusions** from each analysis and then we will compile them. By integrating them in the data compilation step the designer will be able to identify new design opportunities to explode in further stages. The questions that we suggest to write down this **data compilation** are:

· How does the user currently solve the problem?
This question is oriented to see how the user manages to overcome the existing problem. By knowing this, the designer will better understand the problem and it will help him/her to find new solutions.

· Suggestions of other way to solve it
Here, a list should be written down. This list should contain all the ideas that the designer come up with, even non-sense ideas because they may have a right background that he/she can use in further steps.

· What user's characteristics must the designer take into account?
A deep user analysis is taken, and a lot of information will be collected. In this step, it is necessary to sum up that information and to select what we need for our future design.

· What might be the final solutions?
Once we have answered the previous questions the designer may launch some possible solutions which will be later evaluated and selected.

Thanks to the last question we will end with a solution that, according to the designer, is the best one to solve the problem according to the user needs. This possible solution will be explained in the **idea approach** and later it will be deeply analysed in the **idea analysis** step, looking for some extra information if needed. Once we have all this clear enough, we proceed with the **PDS** writing, requirements that helps to focus our efforts on one direction and make the further development easier.

Regarding the second stage, **the concept development**, we start by **generating** new concepts based on the previous idea approach. This concepts will be listed, compared and **evaluated**. The schemes that the designer considers that best fit the project requirements will be **selected**. Then they will be taken to the **embodiment** step; and once the embodiment is validated it is possible to start with the third stage of the project.

In the **development stage**, a more **detailed embodiment design** is carried out; it means that, as the previous case, the designer will have to indicate clearly the placement of the pieces as well as their function, calculations if needed, suggested materials and processes... Likewise, the **dimensions** of the product must be settle down here, working simultaneously with the embodiment design since it is necessary to check it constantly. Having the embodiment and the measures the designer is able now to start with the **3D**, being always possible a feedback to modify measures if needed. After the modelling, we have eventually to choose the **materials and manufacturing processes** based on all the information we already count with. Similarly, the **models and prototypes** stage is the next logical step since we will have everything settled to start with them. In the end, as in other sort of projects, a **financial test** will be done in order to check the profitability of the project as well as a calculation of the costs.

Comments

In this kind of projects where both the need/problem and the user is provided, the designer can face different situations.

There are sometimes projects where it is necessary to analyse simultaneously the need and the user and then integrate their conclusions to come up with new design possibilities. However, there are situations where the problem must be studied as an isolated element. There, the designer must study and divide the problem and then check how this problem affects the user, so the user study is inside the problem analysis.

Example

Information stage

Input

Need + user

" Old people have difficulties to serve themselves water at the table"

User

Elderly

Likes & Dislikes

They are home-loving, they like TV shows, family and conversation.

...

Trends

Elderly lives more and more often in retirement and nursing homes.
The elderly percent of the population will continue increasing for the next years.

Ergonomics

We study the movements that a old people can and can not do. In which activities they have more problems, and how other designs solve it.

Anthropometrics

We look for an anthropometric scale based on old people, where we may check later the needed measurements.

Special needs

We see that there are quite old people with vision problems, so we should take care of that.
Also we find some problems with Parkinson and the movements that this people can do.
Products can not be very heavy because do not have strength in his hands.
Arthrosis, arthritis, osteoporosis, Alzheimer are other illness related to elderly

Environment

Basis of the problem our work environment would be kitchens, living-rooms, and dining rooms of private houses and nursing homes.

Similar products

We look for the different products that we find in the table at lunch time.

Conclusions

The extremities do not bend in the same way as a youth person.
Their movements are slow and calm so products can't required precision movements.
Due to the sight difficulties the product shouldn't have small characters and the shape has to be as clear as possible.
We have to take care of the weight that the user has to hold. They can't raise heavy products.

Information stage

Problem

Elderly can not serve water at the table properly when they are having lunch.

Cause

The actual products are too heavy and the required movements are quite hard for the physical abilities of old people.

Limits

We have to design a new system to serve water which solve the current problem.
We are designing for Europeans clients so the features to take into account would be the ones of European elderly.
We have to respect so far as possible the actual steps to serve water. Old people is not favourable to changes.

Division

They can not manage current jugs.
They are to heavy.
When they are full is even more difficult.
They usually have a hight capacity and are served completely full.
Old people has illness who are detrimental for physical activities.
They cant raise weight.
They can't move the wrist in a proper way.
...
...

Conclusions

We must reduce the weight that the user has to rise to serve water.
We should improve the needed movements to serve water.
We can decrease the capacity of the jugs.
...

Data compilation

This implies that to raise a water jug and fill a glass became harder and harder with the age.
· **How does the user currently solve the problem?**
Some elderly people has lost the ability to do it and they have to be helped by someone.
· **Suggestions of other way to solve it**
We could think in some autorefilable system. In jugs with hoses or mechanic systems to fill the glasses.
· **What user's characteristics must the designer take into account?**
Due to the age, old people has restricted movements, that can be aggravated by some illness like Parkinson or arthritis.
They have loosen strength in their muscles what implies that they can not raise weights.
To solve these problem we have to take into account the elderly features like movements and measures
· **What might be the final solutions?**
As we want to continue with the same steps to refill a glass, we think in a jug with some fulcrum to support the jug weight.

Information stage

Idea approach

We think in design a jug wich could serve water without the need to raise it over the table.
We think in some fulcrum, support or some balance with counterweights.

Idea analysis

Market Research

PDS

It has to reduce the effort to the minimum.
It has to contain at least 1 litre of water.
The measures of the handle have to correspond to elderly anthropometrics.
It has to fill a 250ml 10cm hight glass.
...

Concept generation

Provisional schemes

Schemes evaluation

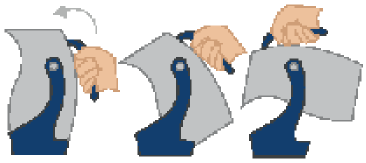
Desirable features	Concept 1	Concept 2	Concept 3
· A	✓	✓	✗
· B	✓	✓	✓
· C	✓	✓	✗
· D	✗	✓	✗
· E	✓	✓	✓

Schemes selection

Concept 2 is selected because it better achieves the PDS explained before.

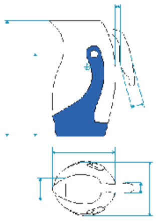
Concept generation

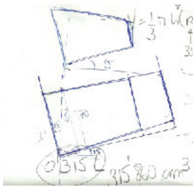
Embodiment of schemes



Development stage

Embodiment detail || Measures





3D Modelling

Materials and processes

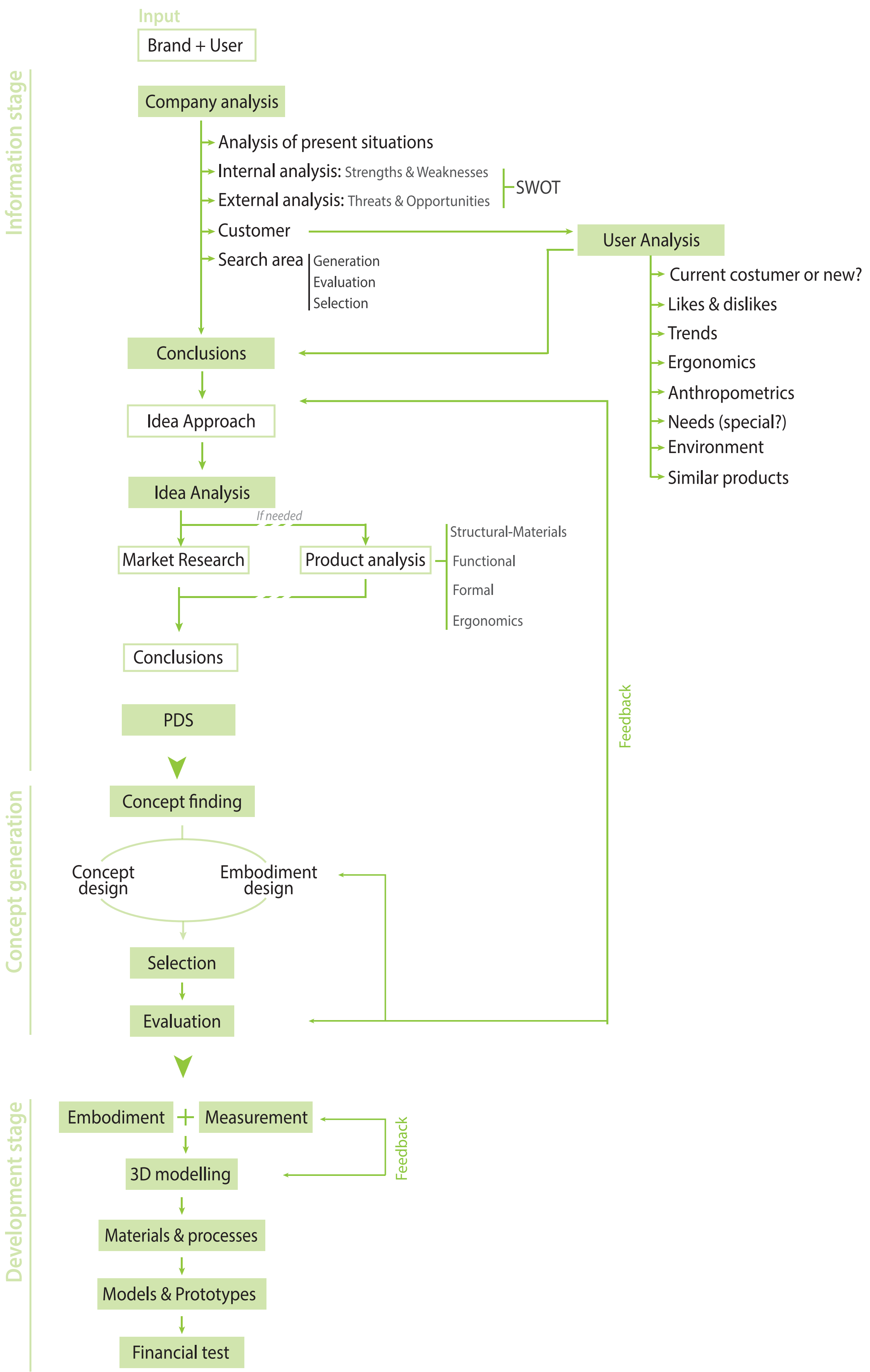
Pieces	Material	Process
· Jug	· PP	· Injection
· Base	· PVP	· Injection
...	· ...	· ...

Models and prototypes

Financial test

The production costs are analysed as well as the profits that the design may imply to the company. According to the results from the financial tests some changes might be added to the manufacturing process.

8.4. Providing brand + user



Explanation

The brand and the user are provided now as inputs.

The **information stage** starts with the inputs analysis. Firstly, the brand is analysed: its present situation, how the company is working now; its external and internal situation; SWOT analysis to come up with the ideas for the next stage; its market portfolio, to know all the products the company offers as well as their features; and its current customers, to know them and be able to identify future potential users.
Thanks to the conclusions from the SWOT analysis, the designer will start with the **"search area"** points. The search area generation combines a strategic strength and an external opportunity to come up with an idea that could be the base of a future product. After this, an evaluation of these ideas has to be done.
A study of the current costumers of the brand allow the designer to know the features of the actual clients, and to identify they buy behaviour.

Then, the provided **user** is analysed to know the target we are designing to, in order to cover their needs. Their likes and dislikes will be analysed, using a psychological standpoint; the trends that the user follows, the culture he/she is involved and the determining factors; the ergonomics aspects as well as the anthropometrics; the user surroundings and similar products that the user already uses. Also it will be studied the experience that the given user has already had with the brand, if he is currently a consumer or if he has had any experience with it. The information of the target will be related to the characteristics of the brand's current customers.

After these analyses, conclusions are written down. They will be the start point of the idea approach which specifies what the designer decides to study. An idea analysis will provide extra information about the market and the product.
These will be likely oriented in one direction so it will be possible to draw the PDS from them.

Then the designer starts with the **concept generation stage.** Firstly with the concept finding, working in parallel with the concept and embodiment design, allowing the designer to check if his concepts also fit in a structural view. The different concepts are compared and the one which best fits the requirements is **selected**. We check the selected concept and **evaluate** it according to the requirements or by using some recommended methods. There is a feedback possibility in the case that we find that the concept is not good enough.

The **development stage** is similar to the previous one. It is begun by a **detailed embodiment design** working in parallel with the product's **measures**. Likewise, the **3D** modelling is carried out more or less while these stages to allow the designer to make changes. Once the 3D is finished, **materials and manufacturing processes** are selected and **models and prototypes** are made afterwards. Finally, a **financial test** is done

Input

Brand + User

" Toy company *Imaginarium*" for kids under 1 year old

Information stage

Company analysis

Analyses of present situation:

Spanish toy company present in 27 countries. Own design and brand, a guarantee of safety and quality. Pioneer in developing the concept of educational game.

In full growth and international expansion Imaginarium is continually renewing its catalogue

Internal analyses:

Strengths

- It has a worldwide market
- Own design and renewed catalogue
- Leader in educative toys
- Loyal customers

Weaknesses

- Still not really known abroad
- Over leveraged fiancial position

Threats

- Competence has lower prices
- Economical crisis
- Competence starts developing educational toys as well

Opportunities

- Baby market not really exploited
- Parents more aware about education

Customer:

Customers are families with children from 0 to 10 years old.

User Analysis

Current costumer or new?

It is a current customer so the company could provide us with more information.

We know that the customer is currently satisfied with our products so we do not have to make a extreme change of the catalogue.

Likes and dislikes

Soft products as cuddly toy with soft colours.

Animal related product.

Toys with sounds

Chewing toys

Trends

There are more and more focused in stimulate the baby senses.

Ergonomics

Babies rather can do any specific movement, they have to start to improve their psychomotricity

Anthropometrics

We have to check the body part measures of babies below 1 year old.

Needs

They can manage objects properly.
They tend to put in their mouth everything they get so products can't have any toxic component or small pieces.
...

Environment


Conclusions

We have to continue with the company philosophy of educational toys
If we design for babies we have to consider their behaviour and physical characteristics.
We never have to forget that the buyer are the parents
We must design to improve the sense of the baby
...
...

Idea Approach

We think that best option would be to design a "play area" where the baby could explore all the accessories by himself.
Imaginarium has some "play carpets" for kids but we think we could improve the one for babies.

Idea Analysis

Market Research




Information stage

Conclusions

The area is about 2sqm
There are made in a soft background but with powerful details
They have complements to play with.
Some ones have hanged toys to allow the baby to play lie down.
...
...

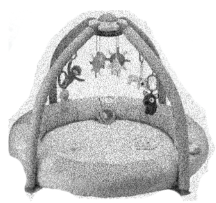
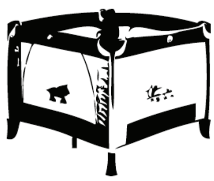
PDS

It will be covered with fabric
It has to be soft
I mustn't have any small component
It mustn't have any toxic material in it
It will be arround 1-1.5sqm
...

Concept generation

Concept finding

Concept design ⇄ Embodiment design

Concept	Embodiment design
Concept 1 	
Concept 2 	

Selection

PDS	Concept 1	Concept 2
-A	✓	✗
-B	✓	✓
-C	✓	✗
-D	✗	✗
...	✓	✓

Concept 1 is selected because it better achieves the PDS explained before.

Evaluation

The concept is evaluated. If it is feasible we continue to the next stage, if it is not there is the feedback possibility until the PDS and the problem identification.

Concept generation

Embodiment

Having an initial embodiment it is possible now to develop it to a more detailed embodiment design so that all the structural features can be checked.

Development stage

Embodiment + Measurement

We give measures to our design and we fix all the assembly connexions and other details.

Materials & processes

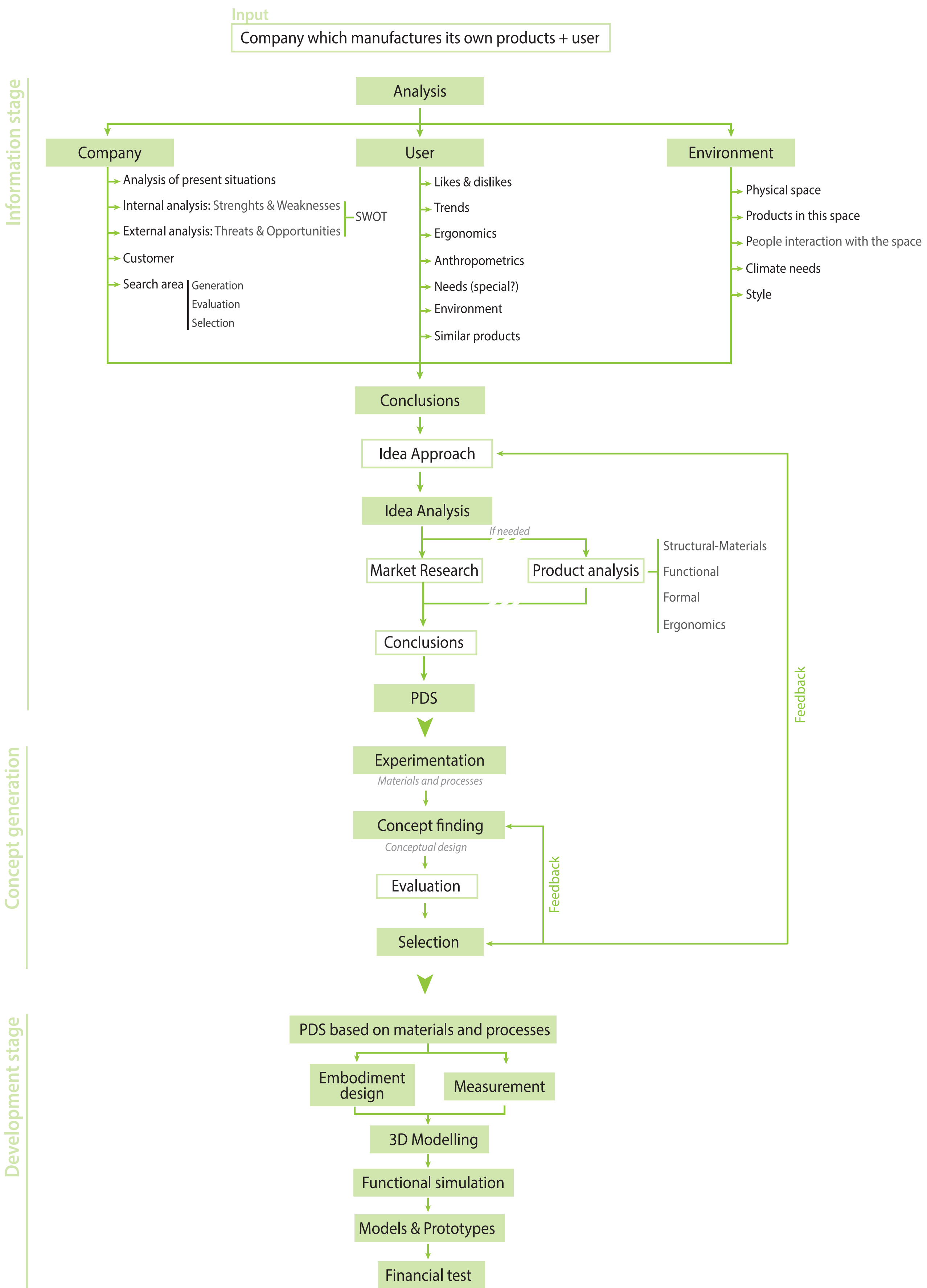
Pieces	Material	Process
·Base	· Fabric	· Spinning
· Poles	· Polyethylene	· Extrusion
· ...		

Models & Prototypes

Financial test

The production costs are analysed as well as the profits that the design may imply to the company. According to the results from the financial tests some changes might be added to the manufacturing process.

8.5. Providing material + manufacturing process



Explanation

The inputs which are provided in this kind of projects are the company (brand) and the user. In this case the company manufactures its own products so the material can be inferred from this information.

The information stage starts with the analysis. It is necessary to study the company, the user and the environment simultaneously.
Firstly, the **company** is analysed. The present situation and how they work; an external and internal analysis by using the SWOT tool, checking their current market portfolio to get a perspective about their current products and to be able to study their customers.
The SWOT analysis will provide with some conclusions that the designer may use to start the "search area" step in order to start to generate basics ideas, evaluate them and select them.

In addition, a **user** analysis is carried out. We analyse all the aspects that the designer considers useful for the project. Their likes and dislike, using a psychological standpoint; the trends that the user follows, the culture he/she is involved and the determining factors; the ergonomics aspects as well as the anthropometrics; the user surroundings and similar products that the user already uses.

Eventually, the **environment** must be studied as well. Concerning the environment, it is necessary to study the environment itself, understood as a physical space where the product will be used; also the products where are used there as well as their appearance; how the people interact there, which actions or activities they do there and how they do them (ergonomics); the climate factors must be taken into account; and also the general style of the place.

With these three analysis some **conclusions** will be generated. Thanks to them, the designer will have his/her first **idea approach.** A more detailed study of the idea is carried out in the **idea analysis** step where the designer will explain the direction he wants his design to take. As we have explained above, there are sometimes that an extra information research is needed, in the case that this idea analysis suggests it or the designer considers it necessary. Finally some **PDS** are written down so the requirements of the project are clear enough to start with the second stage.

Concerning the concepts generation stage, the most different and important step is the experimentation. Before coming up with new concepts it is useful to experiment with the materials and processes that the company count with in order to better understand their properties and potential possibilities. The experimentation of materials and techniques allows to collect information on new uses of a product. After this, the concept finding is the next logical step, followed by an evaluation and a selection of the one which best suits our requirements. As usual, there is the feedback possibility in the case that the designer considers the selected concept is good enough. It would be possible then to go back until the design brief writing if needed.

In the development stage the designer should firstly create a **PDS list based on the materials and manufacturing processes** conclusions in order to make clear and specify the possibilities of creating the product. Taking into consideration these PDS and the selected concept the designer can start with the embodiment design. As usual, this **embodiment design** works simultaneously with the **measurement** step and followed by the **3D modelling stage**. From there, it is possible to come back to the measurement so that the product' characteristics can be constantly checked. Since we are dealing with materials and manufacturing processes the designer should carry out a **functional simulation** to check the material properties on his product. After this there is only left the creation of the **models and prototypes** and the **financial test.**

Example

These inputs (the manufacturer company and the user) have already been used. To illustrate this example we will use the company information that we collected previously of GlassPack and we will add a new user so that the result will be different again.

Input

Company which manufactures its own products + user

"Design a new product for GlassPack related to female grooming"

Information stage

Analysis

Company analysis

User

Environment

→ Materials & Manufacturing processes

Glass study

· Composition
· Properties: physical, chemical, optical...
· Applications
· Existing products

...

Glass production in GlassPack

· Blow and blow method
· Press and blow method
· Cold end: coatings

→ Market basket & Positioning

Food

Jars

Juices

Bottles

Liquors

Refreshments- Beers

Wines - Champagnes

Closure systems

Metal lid Twist off

Cork stopper

Screw aluminium lid

→ SWOT analysis

Strengths

· Lack of competitive pressure in the field.
· Abundance of raw material
· Innovation

Weaknesses

· High manufacturing process costs
· Limited economy

Opportunities

· Recycling promotion
· Glass packaging is recommended over plastic packaging: quality.

Threats

· Possible troubles with ecologists groups

Analysis

Company analysis

User

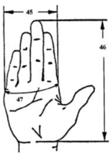
Female user, varied age oriented to a the grooming field.

Likes & dislikes

Trends

MAYBELLINE NEW YORK
CLINIQUE
L'ORÉAL
VICHY LABORATOIRES

Ergonomics
Anthropometrics



45 Hand breadth. The breadth of the hand, measured across the ends of the metacarpal bones (metacarpal-phalangeal joints).

	Sample		1st	5th	50th	95th	99th
B	Women	cm	7.1	7.3	7.9	8.6	8.9
		(in)	(2.8)	(2.9)	(3.1)	(3.4)	(3.5)

46 Hand length. The distance from the base of the hand at the wrist crease to the tip of the middle finger.

	Sample		1st	5th	50th	95th	99th
B	Women	cm	15.9	16.5	18.0	19.7	20.5
		(in)	(6.3)	(6.5)	(7.1)	(7.8)	(8.1)

47 Hand circumference. The circumference of the hand, measured around the knuckles (metacarpal-phalangeal joints).

	Sample		1st	5th	50th	95th	99th
B	Women	cm	16.7	17.3	18.6	20.0	20.7
		(in)	(6.6)	(6.8)	(7.3)	(7.9)	(8.2)

(Percentiles)

Strength max. thumb/4 fingers

Needs (special?)
Environment
Similar products

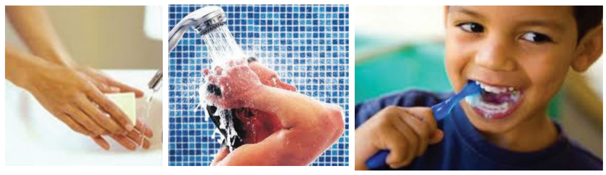
Environment

Places where users might take care of their hygiene.

Physical space

Products in this space

People interaction with the space



Climate needs
Style

Information stage

Conclusions

· The company has never had anything related to the female grooming field.
· Cosmetics, make ups flasks, etc. would be something interesting to design.
...

Idea Approach

· Cosmetics flask.

Idea Analysis

If needed

Market Research

Product analysis

- Structural-Materials
- Functional
- Formal
- Ergonomics

Conclusions

PDS

·Flask of X millilitres of capacity.
· Transparent so that the content can be seen.
· Shape that allow the user reach all its content.
·Lid in the same material
...

Concept generation

Experimentation

Materials and processes

In this step we start to experiment with GlassPack manufacturing processes and the glass material. We have to be aware of all the possibilities that the processes offer as well as the properties of the material, in order to optimize the process.

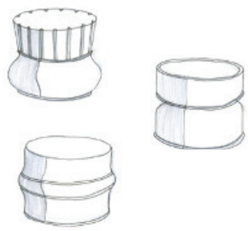
Concept finding

Conceptual design

Concept

Concept 1

Concept 2



Concept 3

Concept generation

Evaluation

↓

Selection

PDS	Concept 1	Concept 2	Concept 3
· Flask of X millilitres of capacity.	✓	✓	✓
· Transparent	✓	✓	✗
· Shape to reach all its content.	✓	✓	✗
· Lid in the same material	✗	✗	✗

Concept 2

The concept selected is evaluated. If it is feasible we continue to the next stage, if it is not there is the feedback possibility until the concept finding, where the designer would have to start again with the concept generation; or until the idea approach, because maybe it is more profitable to carry out other idea.

Development stage

PDS based on materials and processes

↓

Embodiment design | Measurement

↓

3D Modelling

↓

Functional simulation

↓

Models & Prototypes

↓

Financial test

9 Conclusions & recommendations

The conclusions of the results will be explained here as well as some recommendations about how to use them in a proper way. A short summary of the initial problem us made here as well as some conclusions from the results and the analysis chapters.

As we have mentioned before the problem because of which this thesis took place is that there are many design methodologies and authors recommendations related to design methodologies but what we miss are some standard and general guidelines to follow in order to obtain the best result depending on the kind of project we are dealing with.

We have identified twelve kinds of projects depending on the inputs that are given to the designer. This identification was made thanks to the existent methodologies and to our own experience. This kinds of projects were the base to create twelve diagrams which show the main guidelines to follow when developing the corresponding project.

Thanks to the analysis of methodologies and the templates we created twelve different methodology for each kind of project that we identified. Each methodology includes a complete explanation of its steps and stages as well as a practical example to make it clearer, which also helped us to verify the content of the diagrams.

Having our results the next questions arise:

How to use them?

In order to make our thesis useful by everyone we have created a catalogue. This catalogue is not included in the current thesis, it is an extra book where a person who is about to start a design project can check to look for help. In this catalogue the different diagrams that we created are shown and explained.

How to proceed?

As we have already mentioned, it is completely necessary to know the kind of project we are dealing with. In order to know that, we should check the inputs we count with. Once we have categorised the project, we have a starting point so we can easily get the diagram that we need. When we are in front of the diagram and it is the first time that we are going to try this methodology, we should carefully read its explanation. If we still have doubts once the explanation has been read, we can check the examples from this thesis work. To sum up, these are the steps to follow:

1. **List the inputs that we have.**
2. **Categorise the project we are dealing with.**
3. **Look for the corresponding diagram.**
4. **Read the explanation.**
5. **Start with the guidelines**

If this work had to be retaken in the future we would recommend to make a deeper study of the methodologies or even taking into account more methodologies which cover wider fields. Furthermore, it would be really interesting to evaluate this methodologies with real students. We would suggest to take two different groups of students from the same study programme (people who have always been working similarly) and offer them a project. One group would have to work as they usually do and the other applying the methodologies which are offered in this thesis work. By comparing the results and their way they have been achieved our results could be eventually been verified, or completed in the case of any lack.

The guide where we have gathered our results has been thought as a tool to help designers/students during all or some stage of a project design project when there are questions about how to face a project, to check if every necessary step has been carried out.

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11 Appendices

Design methods

During the study of the different authors and methodologies we have been recommended many methods to achieve different methodologies. Here we explain the most interesting ones classified in three sections:

-Creating a design goal: where we can find methods to analyse the design problem, and the formulate of a design specification.

-Creating product ideas and concepts: Where are explained methods to start the concept design, a process of creative thinking, of developing initial ideas into concepts and offering realistic solutions to the design problem.

-Decision and selection: Methods to compare alternatives on predefined criteria to facilitate a decision-making process.

These methods are used along the entire design process in its different sections.

The aim of this Annex is to complete the methodologies discussed above with the different methods that can be used. It is the opinion of the designer to decide which are most appropriate given the inputs and the situation at the time.

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Creating a design goal

Strategy wheel | 2
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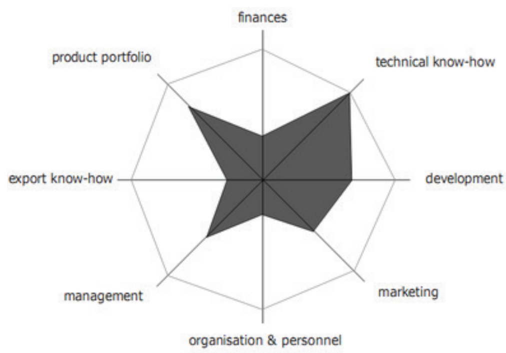
Creating a design goal

A product design process is preceded by a product planning process. Sometimes the product ideas are already mentioned explicitly in the design brief, and sometimes the product design process starts with a search for relevant product ideas. The product design process always begins with a stage in which the design problem will be analysed, wich serves the formulation of a design goal or goals. Design goals are broad declarations of intent that can be elaborated into more specific goals.
In this section, creating a design goal, various methods are presented that facilitate the first stage of a design process: the analysis of the design problem, and the formulation of a design specification.

1. Strategy wheel

What is it?

A visual representation and a quick tool to review a company's strengths. It presents the company's competencies on the axes, and the scores of the competencies on those axes. By using the diagram, you obtain a quick understanding of the company's strategic strengths.
A thorough analysis of the current situation of a company yields an understanding of the company's strategic strengths (for example: technical know-how, product portfolio, development, financial position, export know-how, marketing, organisation and personnel, management).



When?

It is usually applied in the beginning of a new product development process in order to present the strategic strengths of a company.

How to?

Starting point
The results of an internal analysis: a clear understanding of the company's strategic strengths in relation to its direct competitors.

Expected outcome:
A visual representation and a better understanding of the company's strategic strengths.

Possible procedure:
1_ Determine the company characteristics that you want to evaluate.
2_ Determine a value for each of the characteristics. Comparing the company with its direct competitors.
3_ Create a diagram, a strategy wheel of the scores on the characteristics.
4_ Optionally, put down the values of the competitors on the same characteristics in the same diagram.
5_ Analyse the diagram, to assess the company's strengths and weaknesses (in comparison with its direct competitors).

2. Trends analysis

What is it?

Trends are an important source of inspiration for thinking up new product ideas. Trends are used to identify customer/market needs, which a company can meet with new products or services.. Trends analysis could be a rich source of inspiration, but could also determine the risks involved when introducing new products. Trends analysis tries to find answers to the following questions: what developments in the fields of society, markets and technology can we expect over the next 3 to 10 years? How do these developments relate to each other? Where do they stimulate each other and where do they block each other? What are the resulting threats and what are the opportunities? Which ideas for new products and services can we think of now on the basis of the trends?.

For an analysis of the trends, a trends pyramid can be used. In a trends pyramid, four levels are distinguished at which one can look at trends:

The microtrend is on a product level and has a time horizon of 1 year.

The miditrend is on a market level and has a time horizon of 1 to 5 years.

The maxitrend is on a consumer level and has a time horizon of 5 to 10 years.

The megatrend is on a societal level and has a time horizon of 10 to 30 years.

When?

In the beginning of a design project or in the strategic planning process. With a trends analysis you can identify new business opportunities or new product ideas. You can also use it to identify preferences of the target group.

How to?

Starting point

Corporate/strategic vision.

Expected outcome:

Potential customer/market needs for which new products and services can be thought up.

Possible procedure:

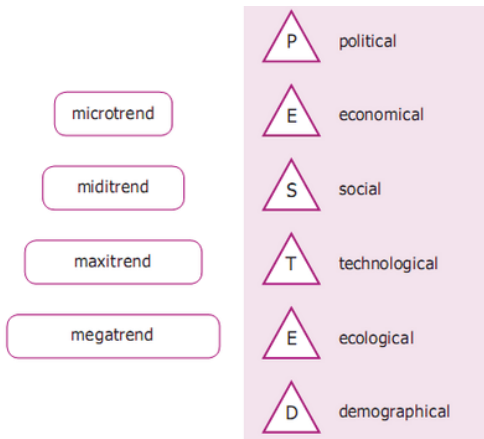
1_ List as many trends as you can think up. Identify trends from magazines, television, the Internet, etc.

2_ Determine a value for each of the characteristics. Comparing the company with its direct competitors.

3_ Remove trends which are similar; identify hierarchy in trends. Identify whether trends are related and define this relationship.

4_ Place the trends in a trends pyramid. Set up various trends pyramids according to the PESTED structure: P = Political; E = Economic; S = Social; T = Technological; E = Ecological; D = Demographic.

5_ Identify interesting directions for new products or services based on trends.



3. Collage techniques

What is it?

A visual representation made from an assembly of different forms, materials and sources creating a new whole. A collage may include newspaper clippings, ribbons, bits of coloured or hand-made papers, portions of other artwork, and pictures. Making collages you make visual representations of the context, user group or product category. A Mood Board displays typical lifestyle elements (such as brand preferences, leisure activities and product type preferences) of the users, but also their dreams and aspirations.

When?

The use of collages serves different purposes in the design process:
Determining the colour palette of the product ideas and concepts.
Presenting a particular atmosphere or context that you want to capture in the form of the new concepts.
Determining and analysing the context in which the product will be used.

How to?

Starting point
First, is to determine what the collage is used for. What will be displayed in the collage: the user's lifestyle, the context of interaction, or similar products?

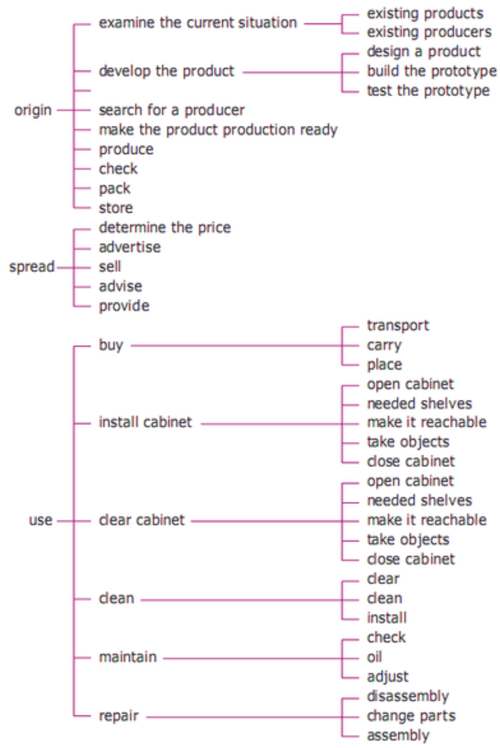
Expected outcome:
A visualisation of an aspect of the problem context, e.g. the lifestyle of users, the context of interaction or the product category.

Possible procedure:
1_ Determine which magazines and/or imagery will produce the most suitable material.
2_ Group together the imagery that concerns the target group, environment, handling, actions, products, colour, material and so on. At the same time, make a selection according to usable and less usable images.
3_ For each collage decide the orientation of the background.
4_ Try by means of small sketches to set down the structure of the composition.
5_ Make a provisional composition of the collage with the means at your disposal.
6_ Paste the collages once the picture meets your expectations and contains most of the characteristics and they are identifiable.

4. Process tree

What is it?

A schematic diagram of the processes that a product goes through during its life. Making a process tree forces you to think ahead: in which situations, places, activities will the new product turn up? Who is doing what with the product then? What problems are to be expected? What requirements do these situations necessitate? A process tree forces the designer to systematically think through all the subprocesses that a product goes through: production (including development), distribution, use and disposal.



When?

A process tree is preferably made in the beginning of the problem analysis..

How to?

Starting point

A product, or a product group.

Expected outcome:

a structured overview of the important processes that a product goes through. This overview helps in setting up requirements and defining functions.

Possible procedure:

1_ Define the product, or product group.
2_ Identify the relevant stages in the lifecycle of the product. Use the following stages as a start: production, distribution, use, maintenance and disposal.
3_ Describe all the processes that a product goes through in the determined stages.
4_ Visualise the process tree

6. Who, What, Where, When, Why, and How

What is it?

Analysing a problem means obtaining a thorough understanding of the problem. An important notion in problem analysis is deconstruction of the problem: by asking yourself a multitude of questions, you are able to deconstruct the problem systematically. Consequently, you can review the problem and set priorities.

When?

Define the preliminary problem or draft a design brief.

How to?

Starting point
A product, or a product group.

Expected outcome:
Greater clarity about the problem situation (the problem context), better understanding of facts and values of the problem, and more insight into problems underlying the initial problem.

Possible procedure:
1_ Write down the initial design problem.
2_ Ask yourself the following WWWWWH questions in order to analyse the initial design problem.
3_ Review the answers to the questions. Indicate where you need more information.
4_ Prioritise the information: what is important? why?
5_ Rewrite your initial design problem

7. Problem definition

What is it?

An expected situation in the future does not have to be accepted. You can try to do something about it, by acting now. For defining a problem this implies that it is not sufficient to describe the existing state. Therefore, we speak consciously of the situation that someone is or is not satisfied with. As a result, a description of the situation is a description of a state plus the relevant causal model(s), including the assumed patterns of behaviour of the people and organisations involved. A situation is only a problem if the problem-owner wants to do something about it.

When?

A problem definition is usually set up at the end of the problem analysis phase.

How to?

Starting point
Information gathered in the problem analysis stage. The different aspects surrounding the design problem have been analysed and should be taken into account in the problem definition.

Expected outcome:
A structured description of the design problem, with the goal of creating an explicit statement on the problem and possibly the direction of idea generation.

Possible procedure:
Answering the following questions will help to create a problem definition:
1_ What is the problem?
2_ Who has the problem?
3_ What are the goals?
4_ What are the goals?
5_ Which actions are admissible?

8. Product Design Especifications (PDS)

What is it?

The Design Specification consists of a number of requirements. The design of a product is 'good' in so far as it complies with the stated requirements. A requirement is an objective that any design alternative must meet. The programme of requirements is thus a list of objectives, or goals. Goals are images of intended situations, and consequently requirements are statements about the intended situations of the design alternative. Design alternatives should comply optimally with the requirements. Many requirements are specific; they apply to a particular product, a specific use, and a specific group of users. There are also requirements with a wider scope, as they are the result of an agreement within a certain branch of industry or an area of activity

When?

Normally, a design specification is constructed during the problem analysis, the result being some finished list of requirements. However, a design specification is never really complete. During a design project, even during the conceptual designing stages, new requirements are frequently found because of some new perspective on the design problem.

How to?

Starting point

The analyses that take place during the stage of problem analysis.

Expected outcome:

A structured list of requirements and standards.

Possible procedure:

1_ List as many requirements as possible.

2_ Make a distinction between hard (quantifiable) and soft (wishes) requirements.

3_ Eliminate requirements which are in fact similar or who do not discrimate between design alternatives.

4_ Identify whether there is a hierarchy between requirements. Divide between lower-level and higher-level requirements.

5_ Operationalize requirements: determine the variables of requirements in terms of observable or quantifiable characteristics.

6_ Make sure that the programme of requirements fulfils the following conditions:

-Each requirement must be valid.
-The set of requirements must be as complete as possible.
-The requirements must be operational.
-The set of requirements must be non-redundant.
-That the set of requirements must be concise.
-The requirements must be practicable.

Creating product ideas and concepts

After the phase of problem analysis, the conceptual design phase begins. Conceptual designing means the creative act of thinking up product ideas and concepts. Once a design problem and requirements have been formulated, product ideas and concepts have to be generated. An idea is a first thought that comes to mind, usually in the form of a simple drawing, without dimensions, proportions, shape and materials. Concepts are more developed, have materials, dimensions, shape, details and technical solution principles. Conceptual design is a process of creative thinking, of developing initial ideas into concepts and offering realistic solutions to the design problem.

Creativity techniques

What is it?

Creativity techniques are very useful in the design process, generating large amounts of ideas in a short time. There are many different creativity techniques, often classified according to:

1_ Inventorying techniques: Techniques used to collect and recall all kinds of information around an issue. This helps in making an inventory of what we have in terms of ideas, or data, or whatever.

2_ Associative Techniques: Great numbers of ideas and options are generated through association within a relatively short time. Association techniques encourage spontaneous reactions to ideas expressed earlier.

3_ Confrontational Techniques: ideas are generated by thinking outside one's familiar frame of reference. By identifying and breaking assumptions you are able to open up a wider solution space. New connections are made between the original issues in hand and a new idea through bisociation or force-fit.

4_ Provocative Techniques: With provocative techniques, assumptions and preconceptions are identified and broken from inside the familiar frame of reference by asking questions like: "What if not?" and "What else?". Provocative techniques make use of analogies, metaphors and random stimuli. Ideas will seem strange at first, but when force-fitted on the original issues they provoke new insights.

5_ Intuitive Techniques: Developing a vision, or a new perspective on the original issue in hand. Intuitive techniques are useful for letting go: to guide the idea generation techniques by whatever comes to mind. It is a technique that allows for spontaneous and intuitive idea generation and reflecting upon the generated ideas.

6_ Analytic-Systematic Techniques: The analysis and systematic description of a problem, the drawing up of an inventory of solutions, variants to subproblems, and the systematic varying and combining of these solution variants.

1. How to's

What is it?

Problem statements written in the form of "How to…" (How to carry luggage in the airport? How to transport deep-frozen food in a shop?) The idea is to create a wide variety of problem descriptions. In this way different perspectives are briefly shown, and the problem is described from these different points of view. The How to's are open questions that stimulate your creativity almost immediately.

When?

At the start of idea generation. With 'How to's' the problem is reformulated in many different ways and ideas come up easily.

How to?

Starting point

The starting point is the result of the problem analysis stage. Often it is a short description of the problem or a problem statement

Expected outcome:

Various problem reformulations in the form of How to's. The problem reformulations reflect different points of view towards the problem.

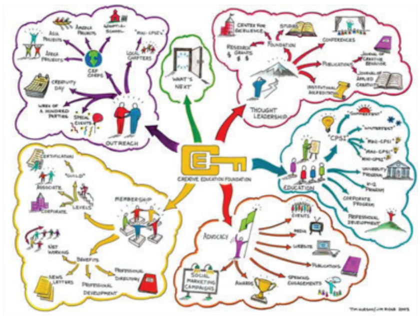
Possible procedure:

1_ Provide a short description of the problem and invite to name all important aspects of the problem.
2_ Invite the group to name as many 'How to's...' as possible, seen from the different points of view.
3_ Evaluate the most important common elements of the 'How to's..'.
4_ Select a number of 'How to's...' that cover the different points of view.
5_ Formulate "one single concrete target"

2. Mind map

What is it?

A graphical representation of ideas and aspects around a central theme, and how these aspects are related to each other. With a mind map one can map all the relevant aspects and ideas around a theme, bringing overview and clarity to a problem. It is especially useful for identifying all the issues and sub-issues related to a problem. But mind maps can also be used for generating solutions to a problem.



When?

It is often used in the beginning of idea generation. Setting up a mind map helps one to structure thoughts and ideas about the problem, and connect these to each other. However, a mind map can also be used in the the problem analysis phase of a design project.

How to?

Starting point
Central theme, for example a problem or an idea

Expected outcome:
Structured overview of ideas and thoughts around a concept or a problem, represented graphically.

Possible procedure:
1_ Write the name or description of the theme in the center of a piece of paper and draw a circle around it.
2_ Brainstorm each major facet of that theme, placing your thoughts on lines drawn outward from the central thought.
3_ Add branches to the lines as necessary.
4_ Use additional visual techniques: different colours, circles around words that appear more than once, connecting lines between similar thoughts...
5_ Study the mind map to see what relationships exists and what solutions are suggested.
6_ Reshape or restructure the mind map if necessary.

3. Brainstorm method

What is it?

Brainstorming as a method prescribes a specific approach with rules and procedures for generating ideas. It is one of many methods used in creative thinking to come up with lots of ideas to solve a problem. This method consist roughly of the following steps:
-Diverging from the problem.
-Inventorising, evaluating and grouping ideas.
-Converging: choosing a solution.
Diverging from the problem
Brainstorming is done with a group consisting of 4-8 people. A facilitator leads the brainstorm session, and asks the group provocative questions. The group's responses (the ideas) are written down on a flipover. The stages that the group goes through in a brainstorm session are methods on their own, and different alternative methods are possible within a brainstorm session.

When?

In the beginning of the idea generation, with the goal of producing a large number of ideas with a group of participants.

How to?

Starting point
A problem statement

Expected outcome:
A large number of ideas.

Possible procedure:
1_ Develop a statement of the problem and select a group of 4-8 participants. Draw up a plan for the brainstorm session, including a detailed time line, the steps written down, and the methods used.
2_ Have a preparatory meeting together with the participants, whereby the method and rules are explained, the problem, if necessary, is redefined.
3_ Write, at the beginning, the statement of the problem clearly visible to everyone on a blackboard .
4_ The facilitator should ask provocative question to the group, and write down the responses.
5_ Once a large number of ideas are generated, the group should make a selection of the most promising and interesting ideas.

4. Syntetics

What is it?

Synectics concentrates on the idea generation steps with the use of analogies. Analogies allow for moving away from the original problem statement and making a forced fit to develop solutions on the basis of these analogie..

In the preparatory stages, there is a problem briefing, an extensive problem analysis phase through questioning by the participants, and definition of a problem statement into 'one single concrete target'. After this, a purging phase takes place in which known and immediate ideas are collected and recorded. From this point on, analogies are used to estrange yourself from the original problem statement and come up with inspirations for new solutions and approaches. These analogies can be:

-Direct Analogy: Starting from some aspect in the problem, one looks for comparable or analogous situations

-Personal Analogy: What if you were an element in the problem, e.g. a planning problem?

-Nature Analogy: What kind of situations in nature does this remind me of?

-Fantastic Analogy: Can you place the problem in a fairy tale or other mythical situation and develop it from there?

-Paradoxical Analogy: Characterise the issue in two words which are each other's opposites.

When?

For more complex and intricate problems.

How to?

Starting point

An initial problem statement.

Expected outcome:

A limited number of preliminary yet surprising ideas

Possible procedure:

1_ Analyse the problem. Restate the problem. Formulate the problem as one single concrete target.

2_ Generate, collect and record the first ideas that come to mind.

3_ Find a relevant analogy in one of the listed categories of analogies.

-Ask yourself questions in order to explore the analogy. What type of problems occur in the analogous situation? What type of solutions are there to be found?

-Force-fit various solutions to the reformulated problem statement.

-Generate, collect and record the ideas.

-Test, and evaluate the ideas. Use the itemised response method to select from among the ideas.

-Develop the selected ideas into concepts.

-Present your concepts in a manner that is to the point.

5. Function analysis

What is it?

Method for analysing and developing a function structure. It describes the functions of the product and its parts and indicates the mutual relations. The underlying idea is that a function structure may be built up from a limited number of elementary functions on a high level of abstraction. In function analysis, the product is considered as a technical-physical system. The product functions, because it consists of a number of parts and components which fulfil subfunctions and the overall function. By choosing the appropriate form and materials, a designer can influence the subfunctions and the overall function. The principle of function analysis is first to specify what the product should do, and then to infer from there what the parts - which are yet to be developed - should do.

When?

At the beginning of idea generation.

How to?

Starting point

-A process tree, which can be drafted from scratch or based on an existing solution of the design problem

-A collection of elementary (general) functions.

Expected outcome:

Thorough understanding of the functions and subfunctions that the new product has. From functions and subfunctions the parts and components for the new product can be developed.

Possible procedure:

1_ Describe the main function of the product in the form of a black box.

2_ Have a preparatory meeting together with the participants, whereby the method and rules are explained, the problem, if necessary, is redefined.

3_ Make a list of subfunctions. The use stage of a process tree is a good starting point.

4_ Elaborate the function structure. Fit in a number of `auxiliary' functions which were left out and find variations of the function structure so as to find the best function structure. Exploring various possibilities is the essence of function analysis: it allows for an exploration and generation of possible solutions to the design problem.

6. Role-playing techniques

What is it?

They can help in developing and determining the interaction between user and product. In a role-playing technique, designers perform the tasks of the interaction by means of re-enactment. Role-playing is just like theatre acting: by acting out the tasks the user has to perform, you reach a better understanding of the complexity is reached, and different ideas for the interaction can be developed.

When?

Throughout the design process, for developing ideas about the interaction with a product idea.

How to?

Starting point
With a first idea about the interaction between product and user.
Expected outcome:
Good conceptual idea about the interaction, as well as visualisations or written descriptions of the interaction.

Possible procedure:
1_ Determine the actors and the goal of the actor or the interaction.
2_ Determine what you want to portray in the role-playing technique. Determine the sequence of steps
3_ Make sure that you record the role-playing.
4_ Divide the roles amongst the team members.
5_ Play the interaction, improvise. Be expressive in your movements. Think aloud when enacting motivations.
6_ Repeat the role-playing several times until different sequences have been enacted.
7_ Analyse the recordings: pay attention to the sequences of tasks, motivations and factors that could influence the interaction.

7. Story board

WHAT IS IT?

It provides a visual description of the use of a product that people from different backgrounds can 'read' and understand. A storyboard not only helps the product designer to get a grip on user groups, context, product use and timing, but also to communicate about these aspects with all the people involved. With a storyboard the powerful aspects of visualisation are exploited. At a glance the whole setting can be shown: where and when the interaction happens, the actions that take place, how the product is used, and how it behaves, and the lifestyle, motivations and goals of the users.

WHEN?

Throughout the entire design process, from ideas about the interaction with a product to ideas and concepts and also for product concept evaluations

HOW TO?

Starting point
A first idea about the interaction between product and user.
Expected outcome:
good conceptual idea about the interaction, as well as visualisations or written descriptions of the interaction.

Possible procedure:
1_ Start from the following ingredients: ideas, simulations, a user character.
2_ Choose a story and a message: what do you want the storyboard to express? Limit your story to a clear message.
3_ Create sketchy storylines.
4_ Create a complete storyboard. Use short captions to complement (not repeat) the images.

8. Written scenario

What is it?

To write a scenario, you need a basic understanding of the tasks to be performed by the user. You also need to have an understanding of the users and the context of use.
It describe the interaction that needs to take place. You should also have the scenario reviewed by users to ensure that it is representative of the real world. Use scenarios during design to ensure that all participants understand and agree to the design parameters, and to specify exactly what interactions the system must support.

When?

Throughout the design process, for developing ideas about the interaction with a product idea.
Scenarios can also be used for presenting ideas and concepts, and are used in product concept evaluations and product usability evaluations.

How to?

Starting point
A first idea about the interaction between product and user.

Expected outcome:
Good conceptual idea about the interaction.

Possible procedure:
1_ Determine the actors. The actor has an active role in the scenario.
2_ Determine the goals the actor has to complete.
3_ Determine a starting point of the scenario: a trigger or an event.
4_ Identify stakeholders and their interests.
5_ Determine the number of scenarios that you will create, based on the number of actors and their goals.
6_ Write the scenario. Work from starting point towards completing the actors' goals. Be specific about tasks, subtasks, context and the actors' motivations to complete the goals.

9. Checklist for concept generation

What is it?

Checklists are a series of simple questions, which can be used either individually or in groups. The checklist aims to encourage a systematic development of concepts. The questions on a checklist need a point of focus, which could either be an existing solution or proposed concepts to a design problem. The questions should be taken one at a time, to explore new ways and approaches to the problem.

When?

Best applied when developing an idea into a concept. As stated earlier, the technique needs a point of focus. This point of focus should be a product idea, already with material features, shape and dimensions.

How to?

Starting point
A well-defined product idea, or existing product.

Expected outcome:
A well-defined product idea, or existing product.

Possible procedure:
1_ Define a product idea into detail, including material features such as shape, dimensions etc.
2_ Search for and select a checklist for concept development. Use more than one checklist.
3_ Systematically work through the checklist by answering the questions on the checklist. Note: this is a trial and error process; apply the question to the product idea and verify whether the product idea is improved. If not, try something else.
4_ Iteratively, improve you idea by answering the questions on the checklist over and over again.
5_ Present your developed idea in a explanatory sketch.

10. Context mapping

What is it?

Contextmapping is a user-centred design technique that involves the user as 'expert of his experience'. By providing the user with design tools and approaches, he or she can express a particular experience.
All the factors that influence the experience of product use, such as: social, cultural, physical aspects as well as goals, needs, emotions and practical matters. he acquired information should work as a guiding map for the design team.

When?

It should help designers to understand the user's perspective and to translate the user's experience into a desirable design solution..

How to?

1_Preparing:
Determine what you want to learn and the topic of study. Capture your preconceptions in a Mind Map. Start selecting participants. Make a planning

2_ Sensitising:
Some time before the session, users receive a sensitising package, which helps them to observe their own lives and reflect on their experiences of the study topic. It can consist of various elements derived from cultural probe packages, such as an exercise book, postcard assignments, fill-in maps and cameras.
The user is encouraged to spread the assignment throughout the week, which gives him or her the opportunity to generate memories and associations and sharpen their sensitivity to the topic.

3_ Meeting:
After the sensitising step, the researcher and user meet. This can be in a group session with typically up to six users, or an interview at the user's home or work location, whereby one of the researchers facilitates the process and the other makes notes and observes.

4_ Analysing:
Sessions and workbooks provide large amounts of data, which must be interpreted to find patterns and possible directions. Researchers sift through the material, make selections and interpretations and try to find patterns of similarities and differences. The researcher typically creates a rich visual environment of interpretations and categories which he or she then analyses.

5_ Communicating:
In practice, designers often do not meet the users. Therefore the researchers have to translate the 'user experience' to the designer and convey the user's perspective, needs and values.

6_ Conceptualizing and beyond:
Communications often serve to improve idea generation, concept development and further product development. Users are often highly motivated to look at the results again and can build on the knowledge they generated many weeks after the original study.

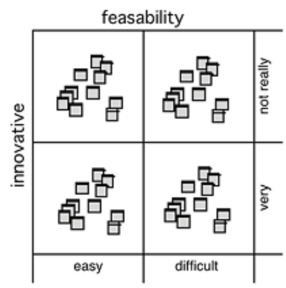
Decision and selection

Design is a process of working from a large number of ideas to a single detailed design. intuitive decision-making is not always successful. Decision methods aim to help people in making a decision. In decision methods, you compare alternatives on predefined criteria. You look at how well an alternative performs 'on the criteria' and assign a value to this performance. By bringing together the totality of the values of each of the criteria, you calculate an overall score of the alternative. Calculating the overall scores of each of the alternatives and comparing the alternatives facilitates a decision-making process. This is what decision methods are about..

1. C-Box

What is it?

We use a C-Box to generate an overview from a multitude of early ideas. The C-Box is a 2 x 2 Matrix. Two axes are determined that represent criteria according to which the ideas are evaluated.
In a C-Box usually the criteria 'innovativeness' and 'feasibility' are used. A C-Box has four quadrants based on these axes. You are able to judge quickly whether ideas are immediately feasible or not, and whether they are highly innovative or not.



When?

Used in early idea generation, in case of a surplus of early ideas (for example 40+ ideas) generated in a brainstorm session.

How to?

Starting point
The starting points of a C-Box is a multitude of early ideas (40-60 ideas).

Expected outcome:
An overview of the early ideas, clustered in four groups based on criteria set to the axes of the C-Box.

Possible procedure:
1_ Create two axes (innovativeness and feasibility) on a large paper and construct the 2 x 2 C-Box with those two axes.
-Functionality: one end is the familiar, the other end represents highly innovative.
-Feasibility: one end is not feasible, the other end represents immediately feasible.
2_ Make sure all ideas are written down, or drawn on a small piece of paper.
3_ With a group, review and discuss the ideas, and place the ideas in one of the four quadrants.
4_ Make sure that ideas in one quadrant are situated closely to the criteria they meet best.
5_ Working out the most promising ideas and dropping the bad ideas (not innovative and not feasible).

2. Itemised response and PMI

What is it?

The **Itemised Response** method is used to judge ideas quickly and intuitively. For each idea, the positive and negative features are listed. These positive and negative features can serve to elaborate on the positive aspects. Also, the negative aspects can be evaluated and improved. This method is used to evaluate and work out a moderately large selection of ideas.
The **PMI** Method (Plus, Minus, Interesting) is used to evaluate early design ideas in a quick and systematic way. PMI is essentially a tool that helps to bring structure to a set of early ideas. Per idea the pluses, minuses and interesting aspects are listed:
Plus (+): positive aspects,
Minus (-): negative aspects, and
Interesting (I): interesting aspects and features.

When?

The Itemised Response method can be used to select ideas for concept developments.
The PMI method is essentially a technique used in a brainstorm setting .

How to?

Starting point
A limited number of ideas, resulting from the stage of idea generation (not more than 10).

Expected outcome:
Evaluation of ideas and a decision as to which ideas could go into concept development.

Possible procedure:
1_ For each idea, list the positive features and the negative features in the form of a list with pluses and minuses. Per idea, answer the following questions:

-What is good about the idea (Plus)?
-Which aspects would you need to improve (Minus)?
-What makes the idea interesting (Interesting)?.

2_ You now have per idea:

Plus: these are the good aspects of the idea, worth developing further (into concepts) or taking advantage of.
Minus: these are bad aspects of the idea, not worth developing further.
Interesting: these are interesting aspects of the idea, but they need more development in order to become good ideas. .

3_ Decide upon your course of action: do you develop the good ideas into concepts? Maybe combine certain good ideas?, or do you continue with the early idea generation.

3. vALUe

What is it?

The vALUe Method (Advantage, Limitation, Unique Elements) is used to evaluate a large set of early design ideas in a quick and systematic way. By explicitly writing down the ideas in terms of advantages, limitations and unique elements, the ideas have a common vocabulary which makes further selection easier.

When?

Because it allows ideas to be described in common terms, the vALUe method is best applied in the beginning of the design process, during early idea generation. The vALUe Method works best just after selecting from among a large number of ideas (20 to 50 or more back to 7 +/- 2)..

How to?

Starting point

A large number of early ideas or principal solutions (20 to 50 or more)..

Expected outcome:

A common description of early ideas. Better understanding of interesting and promising ideas, but also of bad ideas.

Possible procedure:

1_ Generate a large set of early ideas or principle solutions.

2_ Per idea, answer the following questions:

-What are the advantages of the idea (A)?

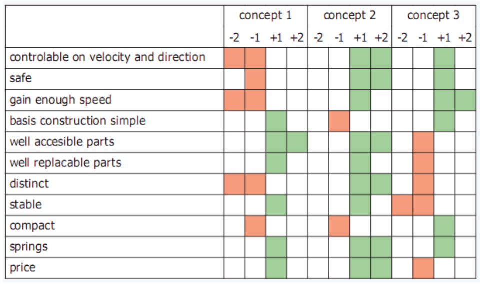
-What are the disadvantages of the idea (L)?

-What are the unique elements of the idea (U)?

4. Harris profile

What is it?

A graphic representation of the strengths and weaknesses of design concepts. Per design alternative a Harris Profile is created. A number of criteria are used to evaluate the design alternatives. A four-scale scoring is used for all criteria. The decision-maker should interpret the meaning of the scale positions (i.e. -2 = bad, -1 = moderate, etc.). Thanks to its visual representation, decision-makers can quickly view the overall score of each design alternative on all the criteria, and compare these easily.



When?

Whenever a number of alternatives of product concepts need to be compared and consensus/an intuitive decision needs to be reached.

How to?

Starting point

Alternatives for a product, in some stage of development.

Expected outcome:

One chosen/selected alternative from a group of alternatives. Overview of the advantages and disadvantages of the selected alternative.

Possible procedure:

1_ Criteria should be selected according to which the design alternatives should be compared.

2_ List the criteria and create a four-point scale matrix next to it. The scale is coded -2, -1, +1, and +2.

3_ Create a Harris Profile for the design alternatives you want to compare. Draw the profile by marking the scores in the four-point scale matrix for all the criteria.

4_ When the Harris Profiles of the design alternatives are completed, the profiles can be compared and a judgment can be made as to which alternative has the best overall score.

5. Datum method

What is it?

A method for evaluation of design alternatives. One of the alternatives is set as datum to which the other alternatives are compared for a range of criteria. Three judgements can be given: ‘worse’, ‘same’ or ‘better’ expressed in ‘–’, ‘0’ and ‘+’. The sum of each of these three values will then help to make a decision. The value of the alternatives is guessed on the basis of the ‘intuitive’ judgements of the decision-makers.

			
Social Happening	D	--	+-
Usability	A	+-	--
Innovative	T	+-	--
Introduction	U	--	--
Dilmah/Madal Bal	M	+-	--
Result		+: 3 - : 7	+ : 1 - : 9

When?

Whenever a number of alternatives of a product concept need to be compared to reach consensus in the evaluation or to make an intuitive decision.

How to?

Starting point
Product concepts, developed to an equal, and thus comparable, level of detail.

Expected outcome:
. One or more strong concepts for further development, confidence in the decision for the chosen concept(s).

Possible procedure:
1_ Arrange the concepts and criteria in a matrix
2_ Choose one of the concepts as ‘datum’. Compare the other concepts to this datum and give a score for each criterium at the time (+ = better than datum, – = worse than datum and s = similar/same).
3_ Indicate ∑+, ∑S and ∑–.for each concept. Usually at least one concept will show more ‘–’ and less ‘+’. Usually a few concepts have minor differences. Discussion can start.
4_ When the outcome does not distinguish enough, the process should be repeated until it does. Each time another concept should be taken as datum, leaving out the concept which was definitively worse.

6. Weighted objectives method

What is it?

Evaluation method for comparing design concepts based on an overall value per design concept.
The Weighted Objective Method assigns scores to the degree to which a design alternative satisfies a criterion. However, the criteria that are used to evaluate the design alternatives might differ in their importance.

When?

Best used when a decision has to be made between a select number of design alternatives, design concepts or principal solutions.

How to?

Starting point
A limited number of concepts.

Expected outcome:
A chosen concept.

Possible procedure:
1_ Select the criteria according to which the selection will be made.
2_ Choose 3 to 5 concepts for selection.
3_ Assign weights to the criteria. The criteria should be appointed weights according to their importance for the evaluation. To determine the weight factor of the criteria it is recommended that you compare the criteria in pairs to attribute a weight factor. Rank each of the weights on a scale from 1 to 5. Make sure you discuss the trade-offs between the criteria. Trade-offs will have to be made when weights are assigned to the individual criteria.
4_ Construct a matrix, with the criteria in rows, and the concepts in columns.
5_ Attribute values to how each concept meets a criterion. Rank the scores of the concepts from 1 to 10.
6_ Calculate the overall score of each concept by summing up the scores on each criterion.
7_ The concept with the highest score is the preferred concept.