Emotion and Perceived Quality Guidelines for Industrial Designers

Research Project: CONEMO – Consumer Evaluation Measurement for Objectified Industrial Use

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1 Executive summary

Nowadays the importance of user-orientated design enhancing customers' perception and Perceived Quality increases, especially in high-wage countries. Globalization causes low-wage countries to have increasing technical competence thus competing with products of local SMEs (small and medium enterprises). To maintain manufacturing successful products they have to be distinguishable and of a higher Perceived Quality than the competitors.

The perception of product quality is linked to emotions and these are affecting the purchasing decision. Therefore it is crucial for a company's success to measure customers' emotions objectively and integrate this awareness into processes of emotional product design. The question evolves which decisions are needed in order to design a product that evokes a positive emotional response. It is very important that emotional information about products should be gathered and applied as early as possible in product development. Especially the semantic meaning and the visual impression of a product are relevant for perception in early phases. There is a need to combine visual impressions with different modalities for capturing and objectifying emotions. Rules are necessary to define a sufficient level of data as well as to communicate data to the person responsible for product development.

The research project CONEMO aims primarily at SMEs that produce products or services where customers' Perceived Quality is of vital importance. These SMEs often have strong budget limitations and thus need to reduce and prevent possible failures in the design process. In Europe 99% of the companies in the manufacturing industry are small and medium-sized regardless which sector they are situated in. For that reason CONEMO has a multi-sector approach. It has the potential of significant savings and increased effectiveness in the design process as well as savings in failure costs due to early involvement of customers and systematic use of Quality Gates. To meet the diverse requirements of these companies CONEMO aims at a standardized procedure with an easy-to-follow guideline.

The users' perception of products and services is one of the cornerstones in today's companies' success. Technical excellence combined with great Perceived Quality ensures good chances on the market which is affected by high market dynamics, pricing pressure and changing customers' needs. Involving customer target groups is a standard procedure to help companies in the design and product development process (PDP).

Currently, the most usual approach is to use self-reporting methodologies like questionnaires to gather information about products from a customer. However, this approach has strong limitations, because it only measures what customers consciously think or want to think about a product. It does not give on-line information about unconscious reactions, thoughts or feelings towards the product which are the foundation of Perceived Quality measurement.

In the CONEMO project it is now the goal to show methods to obtain unconscious information, measure them objectively and show their importance in quality perception.

Therefore, testing methods adjusted to the needs of SMEs are presented that are able to measure customers' emotions.

This guideline gives a short overview on how to use emotions and quality perception for decision-making for an individual customer-centered product development. Step by step, it shows which aspects have to be considered and how to successfully deal with them. It is based on a Quality Gate systematics that can be used concurrent to the PDP and contains descriptions, requirements, measurement parameters, product structure and function.

The main aspects of this guideline are:

- Explanation of Emotion Evaluation
- Explanation of Product Development Process (PDP)
- Presenting the importance of integrating Emotional Quality Gates into the PDP
- Integration of Perceived Quality in early phases of product development
- Defining the strategy structure with the help of semantic concepts
- Defining the product structure with a systematic approach towards quality perception
- Usage of an extended Quality Gate systematics to insure successful advancement of the developing product
- Outlook on an easy-to-use tool to assess and integrate affective design within the PDP

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3 How to use the guidelines

These guidelines offer a methodology for SMEs which deals with the question of how to develop a product that becomes more successful than the competitors' product by creating higher Perceived Quality. Therefore, the guidelines recommend to measure customers' emotions objectively, and to use these results for the development of new products.

The contents of the guidelines start with chapter four "***assessing emotions***". A general understanding of the classification of emotions is required to measure customers' emotions. Chapter five deals with the topic "***product development process and Quality Gates***". These are tools which can help to manage the complexity during the launch of a new PDP which focuses on the integration of customers' emotions and perception.

Chapter six "***definition of the strategy***" offers a general understanding of the determination of a product strategy and explains that a consistent assessment of customers' expectations and expectations of the SME are crucial. Chapter seven "***semantic concepts***" describes the importance of semantics in order to describe the product strategy. Furthermore it will be shown how semantic concepts can be applied in the early phases of product development in particular and how they can affect the design process.

Chapter eight "***product structure***" contains an overview of relevant procedures based on the assembling of product characteristics as well as the disassembling of products. Product characteristics can be prioritised related to a good customer perception.

Chapter nine "***linkage between strategy and structure and design evaluation***" represents an alignment between the results of chapter six and eight in order to give first design suggestions for the new product development.

Each chapter is organised and systematically structured in three parts.

1. Goals
2. Overview and procedure
3. Main concepts

The first part is the topic *Goals*. It describes the aim of each chapter. The second part includes an overview of relevant information and the procedure of the section's subject. The third part is called *Main Concepts*. It summarizes briefly the results which were obtained within each chapter.

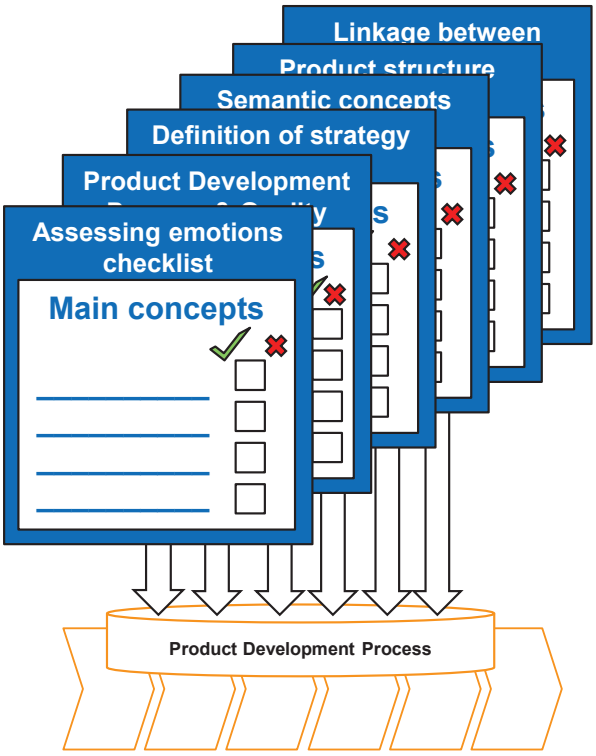


Figure 1: Structure of the guideline

During the application of the methodologies and measurements presented in chapters four to nine a lot of information and data to enhance affective design are obtained. In conclusion, all these results are integrated into the Quality Gate approach in chapter ten that is structured the same way. Chapter ten "***emotional quality gates"*** represents an outlook to transfer results of chapters four to nine in a criteria catalogue that contains descriptions and requirements, measurement parameters, product structure and product functions structure and summarizes them in a Quality Gate systematics (Köhler, Falk, and Schmitt 2014a/b)

4 Assessing emotions

One way of thinking is that the mental process of decision-making is, or should be, rational. In fact, emotions could be considered as irrational occurrences that may distort reasoning. However, it is clear that emotions have an important role in decision-making. Customer satisfaction is more than a rational issue. Emotional processes can guide (or bias) behaviour, particularly decision-making. Therefore, the success of a product could depend on the emotional evaluation.

4.1 Goals

The aim of this chapter is:

- to introduce the different approaches in order to understand and classify emotions,
- to discuss the relation between design, Perceived Quality and emotions and
- to explain the main physiological signals related with emotions.

4.2 Overview and procedure

Emotions and design

Since people use products to accomplish their goals and satisfy their needs, one of the issues involved in design and manufacturing is trying to fit product specifications with user goals and needs. This is one of the main objectives of customer-centered design (Gould and Lewis 1985).

The usual approach in product development of SMEs describes the influence that a product has on the customer through customer satisfaction. That approach says little about what actually happens in the interaction between customer and product. A more profound description would take into account how the product makes the customer feel. If, for example, we look at dissatisfaction, it could be used to describe anything that does not please the customer. The customer may be irritated or disappointed. By looking at the characteristics of customer–product interaction one by one rather than in combination, we can derive more useful information that could help us in developing new products.

Emotions play an important role in product design. In fact, the customer's perception on any product or service can be obtained by analysing their feelings. If one product makes a good impression on the customer, then it will elicit positive emotions. Therefore, customer preferences can be understood by analysing customer's emotions. To perform this analysis one may use quantitative or qualitative methods (Jordan 2002).

There are several examples of quantitative methods such as Kansei Engineering (Nagamachi 1995), which describes the relationship between the customer and the product looking for the relations between the design features with the customers' feelings. This method was developed in Japan in 1970 and was described by its creator as a technology to translate customer feelings in product design elements. The products are evaluated using semantic differential scales (Osgood, Suci, and Tannenbaum 1957)

and are classified according to their attributes (color, shape, etc.). After this process, statistical methods are used to find the relationship between product attributes as perceived by the customers and their feelings. These statistics are used in the development of new products to infer the feelings generated with the new design. We will learn more about this methodology in the next chapters.

An example of a qualitative framework is suggested by Jordan (Jordan 2002), who suggested a hierarchy of product appreciation similar to Maslow's hierarchy of needs (Figure 2). In Jordan's hierarchy

- the basis is functionality,
- the second level in the hierarchy is concerned with usability and
- the third and final level is denoted ''pleasure'' and has to do with appreciation based on aspects that are harder to anticipate, e.g. cultural values and personal preferences.

Jordan describes how products can evoke social, ideological, physiological or psychological pleasures. As competition increases, it becomes more important to meet the higher objectives in the hierarchy. Speaking solely about different pleasures may be limited, and provides only slightly more information than an approach focusing on satisfaction or delight. In reality, humans display a wide variety of different emotions in relation to product interaction, and these emotions may influence both the general well-being of the customer and the purchase decision.

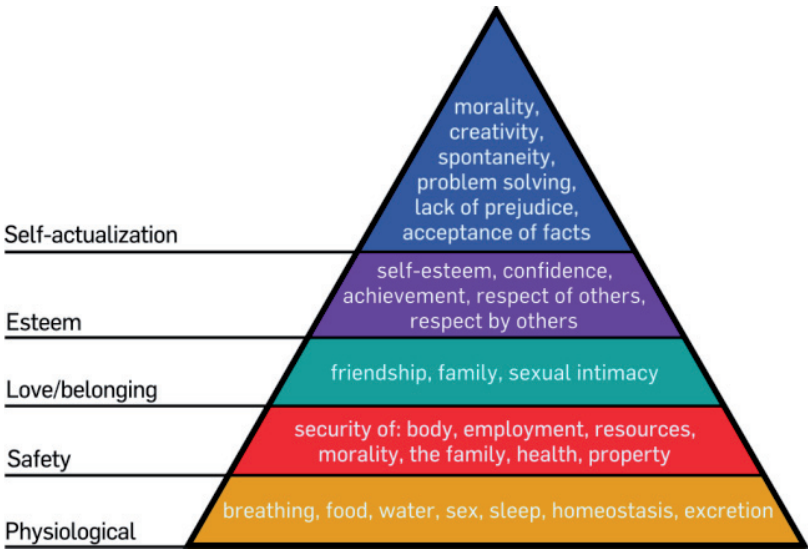


Figure 2: Maslow's hierarchy of needs

In fact, humans are able to display a wide variety of different emotions related to the interaction with products, and these emotions can influence both the general welfare and the customers' purchase decision.

How to classify the emotions. Physiological signals.

The complexity in the definition and understanding of emotions has led to the emergence of many theories that have attempted to explain the nature, causes and object of emotions. In fact, there are over 500 theories about emotions (Strongman 1996). This guide intends to be practical, not theoretical. For this reason, it will describe how to classify and measure emotions in a practical way, with focus on product design.

Emotions can be characterized as either discrete categories or continuous dimensions. Regarding the first characterization, previous studies have suggested a discrete framework of basic emotions (see Figure 3). For example Desmet (Desmet 2002) studied the emotions related to product images, developing an instrument that measured emotions related to product appearance: Seven are pleasant (desire, pleasant surprise, inspiration, amusement, admiration, satisfaction, fascination), and seven are unpleasant (indignation, contempt, disgust, unpleasant, surprise, dissatisfaction, disappointment, and boredom). However, there are many possible classifications and the classification can be difficult. This approach is not suitable for the objectives of the guidelines.

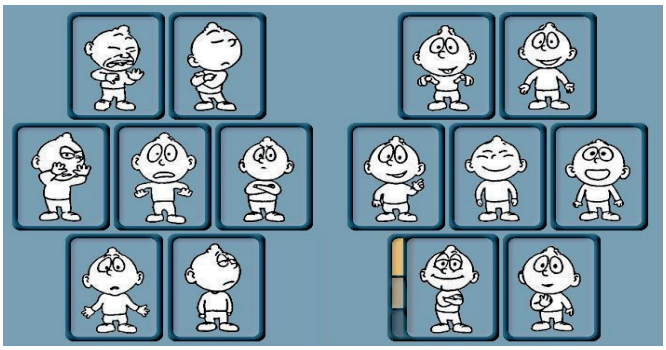


Figure 3: Emotion categories

Most of the methodologies that try to classify emotions rely on questionnaires aiming to convert subjective data (user's opinion) into more objective data. However, these methods are insufficient and depend heavily on individual circumstances. On the one hand, customers may have problems in deciding between two products, because the differences are very subtle or the decision is rather complex. On the other hand, customers may deliberately modify their opinion if they do not want to express their true feelings, feel inhibited, or feel unconsciously influenced by the experimenter. Unconscious processes affect decision-making processes and the decision-making process also has an implicit stress component that can distort the customer's opinion.

Regarding the second characterization, emotions are defined as a set of bipolar dimensions (see Figure 4). Two of the more accepted are arousal and valence (Cacioppo et al. 2000), and arousal and approach withdrawal (Coan and Allen 2004). In both representations, the arousal parameter represents emotion activation and is similar to emotion intensity. Valence determines whether an emotion is positive or negative. Approach withdrawal determines whether emotions make a person tend towards the cause of the emotion or not.

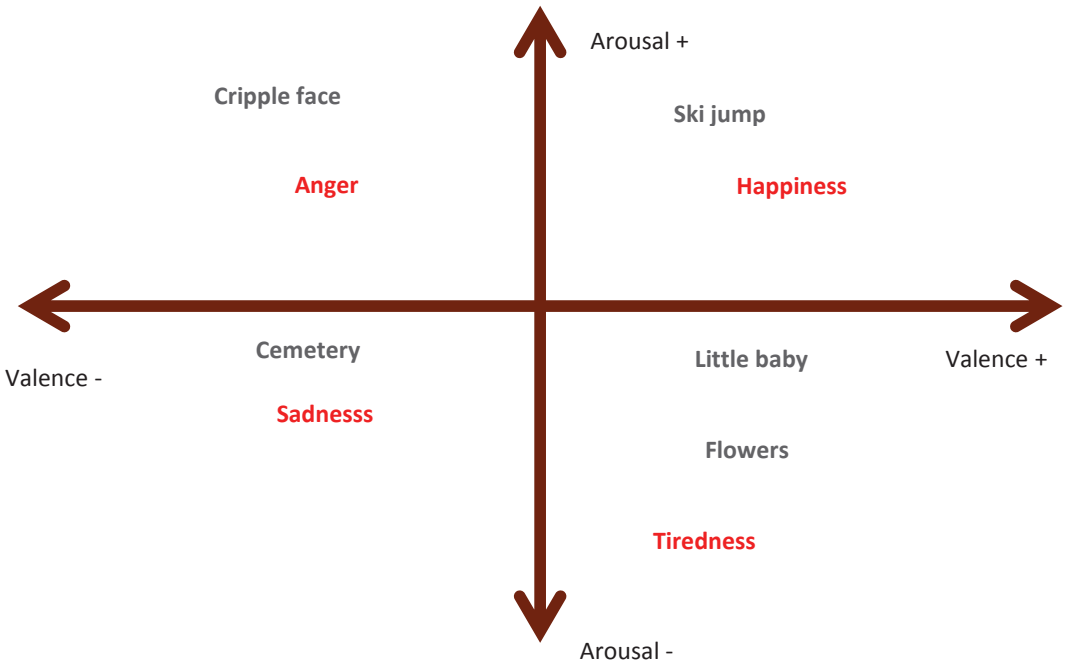


Figure 4: Dimensional approach

The dimensional approach is especially suitable for emotion recognition using physiological signals. The use of physiological signals has some advantages compared to questionnaires in order to obtain customers' information.

Questionnaires only measure the conscious part and that it is not enough. Self-reporting is limited to the subset of conscious feelings that can be accessed by cognitive processes of representation and self-monitoring. Nevertheless, unconscious psychological processes may occur independently to conscious feelings. And these unconscious processes have observable affective reactions. Moreover, subjective measurement does not provide on-line information. Due to study time-dependence, it is necessary to repeat the same questionnaire a number of times being quite invasive in terms of modifying what has to be measured and also having a very low time resolution.

Facial electromyography (EMG) and galvanic skin response (GSR) are commonly used for emotion recognition:

- GSR measures the level of arousal. Skin conductance, also known as galvanic skin response (GSR), electrodermal response (EDR), psychogalvanic reflex (PGR), skin conductance response (SCR) or skin conductance level (SCL), is a method of measuring the electrical conductance of the skin, which varies with its moisture level. This is of interest because the sweat glands are controlled by the sympathetic nervous system, so skin conductance is used as an indication of psychological or physiological arousal. Higher GSR means more intensity or stress.
- Facial EMG differentiates valence. Facial EMG is useful in studies of emotions that are so weak that facial action coding is insensitive (Laparra-Hernández et al.

2009; Schmitt et al. 2014). There are two muscles involved in emotion recognition: the zygomaticus major, related to smiling, and the corrugator supercilii, related to frowning. Unpleasant images elicit higher activity of the corrugator supercilii and pleasant images in turn elicit higher activity of the zygomaticus major.

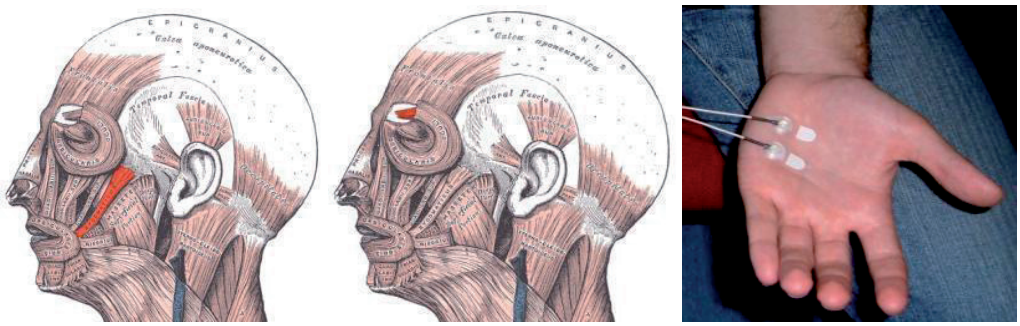


Figure 5: Zygomaticus (left). Corrugator (centre). GSR sensors (right)

The advantages of physiological signals are:

- Measurements can be performed continuously with high temporal resolution.
- Many of them are indirect and thus are supposed to be objective.
- The measurements offer indices of mental states, including emotion.
- They provide information of emotional unconscious requirements.
- They have potentials to be easily connected with design parameters.

4.3 Main concepts

From this chapter it is important to remember:

Emotion Evaluation – Checklist	
	• The dimensional classification of emotions with physiological signals is more objective than categorical classification with questionnaires. • Main dimensions are valence (like-dislike) and arousal (intensity). • Higher GSR means higher arousal. • High Zygomaticus EMG with low Corrugator EMG implies higher valence (like). • Low Zygomaticus EMG with high Corrugator EMG implies lower valence (dislike).

5 Product Development Process and Quality Gates

The Product Development Process (PDP) is the core process of manufacturing companies and significant to the companies' success (Köhler and Schmitt 2012). By transferring requirements into products with a high degree of Perceived Quality manufacturing companies are able to differentiate themselves from their competitors and increase their sales quantity. SME often find themselves operating in a global environment characterized by high market dynamics, pricing pressure, quick technological change, fast changing customer requirements and uncertain situation on the capital and sales markets. Nevertheless SME always seek solutions to manage this complexity and to get it under control. The use of a well-structured PDP could help reduce this complexity.

On their way to generate a continuous and robust process of developing products with high Perceived Quality, SME need a tool which is able to monitor and ensure the defined procedure and organization of the development process. In this context, the application of a Quality Gate systematics could be appropriate to implement the aforementioned demands.

5.1 Goals

This chapter

- provides an overview of the general understanding of a PDP for SMEs,
- contains the interdependence of PDP and costs,
- illustrates the interdependence of PDP with two different perspectives of product quality,
- sensitizes SMEs for the potential of a systematic use of a PDP in order to improve their product development and
- presents how the organisation and the procedure of the PDP could be ensured and monitored by a Quality Gate systematics.

5.2 Overview and procedure

Firstly, the definition of a PDP is mentioned, its phases are briefly described and the dimension of failure costs regarding the PDP is explained. Secondly, the two perspectives of product quality are introduced and their potential regarding the integration of customer emotions into the PDP. Thirdly, approaches of PDP for physical and non-physical products are discussed. Furthermore, the topic of Quality Gates during the PDP as a classical approach safeguarding quality of new developments is described.

5.2.1 Product Development Process

The PDP defines the product on basis of an abstract *product idea* which adapts desirable product characteristics to customer demands. The subsequent step is the *product development* conducted on the basis of an approximate concept of the product and its stepwise *design* and realization (Beaujean et al. 2011).

Figure 6: Product Development Process (Beaujean et al. 2011) and (Ehrlenspiel 2009)

Moreover, *component development* and process planning are necessary in order to *realize prototypes* as well as the *pilot production* (Ehrlenspiel 2009). As the PDP proceeds, the determination of product characteristics restricts the companíes' possibilities for design alterations and technical adjustments and subsequently it is crucial to focus early phases since the expenses for the correction of failures are relatively low (Lindemann 2005; Schmitt and Pfeifer 2010).

Failure costs during the Product Development Process

The economic dimension of the PDP indicates that 75 % of the future production costs are determined during the phases of *product development* and *product design* and simultaneously 75% of all product failures (errors) are caused before start of manufacturing. In 80% of the cases the correction of failures takes place after the start of manufacturing during the testing and deployment phase at the customer. (Schmitt and Pfeifer, 2010)

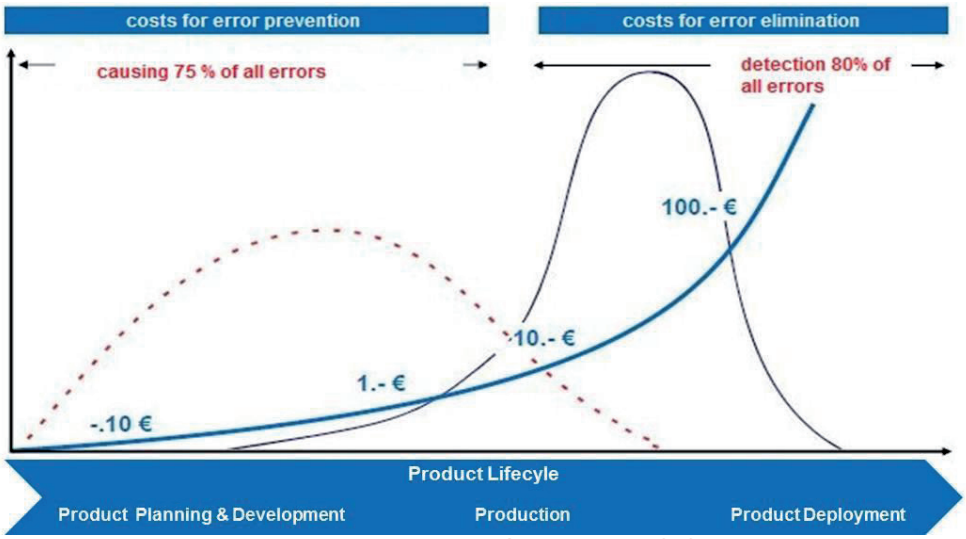


Figure 7: Failure costs (Schmitt and Pfeifer 2010)

These failure costs are caused by poor quality during the PDP. Quality Management during the PDP tries to prevent this effect and is essential for identification of customer requirements. This applies in particular to the following tasks:

- Identifying customer requirements
- Planning product characteristics
- Planning technical specifications
- Planning conditions for implementation

Hence, the awareness about customers' needs, attention and emotions at early phases increases the possibility to connect technical innovative proposals, generated by the development department with customer emotional perception, and avoids costs arising from a lack of emotional design. The early integration of customer target groups and data about their emotional perception help to choose fact-based between alternatives during the PDP.

5.2.2 Two perspectives on product quality – Perceived and Protective Quality

Product quality is composed of the inseparable dimensions of Protective Quality and Perceived Quality (Figure 8). Protective Quality, as the traditional view of quality, ensures the usability of the product and protects against product failure. Product processing, product reliability and product lifecycle are basic requirements of technical and functional compliance which are assumed by the customer. However, the fact that products are useful, usable and durable is not sufficient for success and will decline in the future.

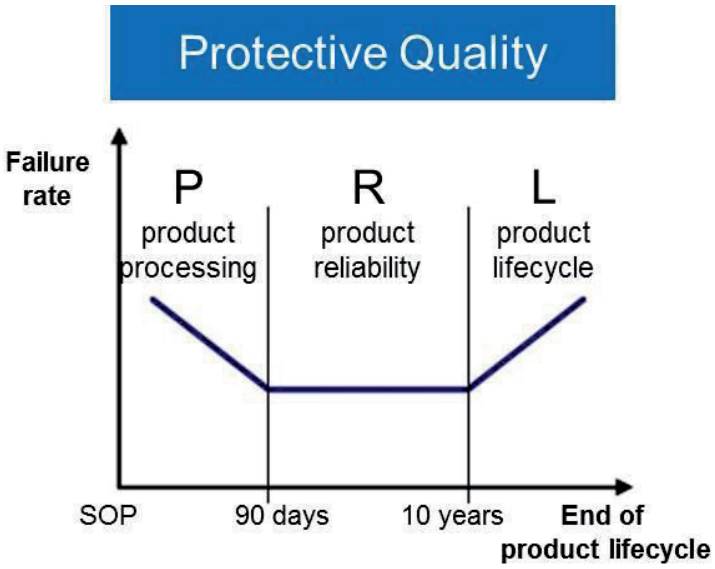


Figure 8: Protective quality (Prefi 2003)

Purchasing decisions, however, do not only depend on Protective Quality (basic customer requirements). Whilst Protective Quality is based on the technical functionalities, Perceived Quality tries to secure that customers' experiences and emotions are affected positively by the product. Thereby, Perceived Quality is influenced by all five human senses (Table 1).

Sense	Unit
Optics	Shape
Acoustics	Noise
Haptics	Surface
Smell	Smell of products
Taste	Taste

Table 1: Perceived Quality – the five human senses (Prefi 2003)

The active design of Perceived Quality enables a company to produce a product which technically meets the basic requirements and additionally fosters emotionally inspiring product characteristics (Schmitt and Pfeifer 2010; Kano et al. 1984).

The product success depends on two conditions. Transferring explicit customer requirements into a new product is the necessary condition (Figure 9). However, anticipating emotional customer requirements (excitement) and implanting these insights into the PDP, as early as possible, describes the sufficient condition (Kano et al. 1984).

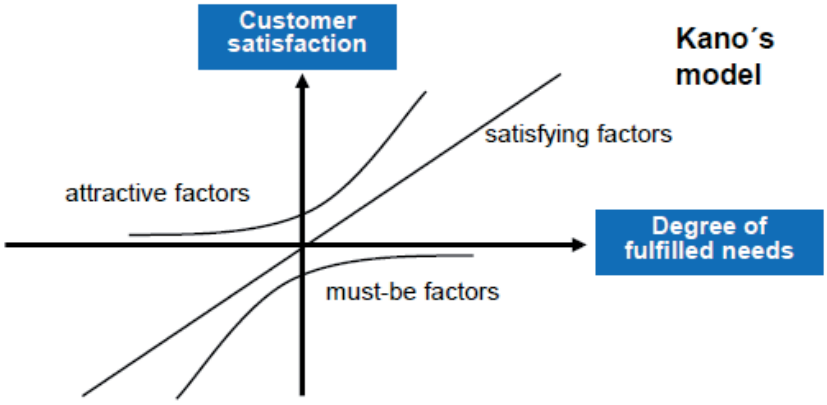


Figure 9: Kano's model (Kano et al. 1984)

Transferring emotional requirements, which are implied needs of the customer helps to differentiate your company from competitors. Identifying and transferring emotional customer requirements into the PDP is a critical success factor especially in those markets with little difference in technology.

It turns out that the quality of a product in classical understanding as a technical excellence might no longer be adequate to delight customer. For this reason, the early identification of customer requirements regarding emotions and perception as well as successful implementation in product characteristics present a change and a massive challenge for companies to differentiate against competitors at the same time. The key of satisfying people's subjective and emotional lifestyles and values is the early implementation of methods related to Perceived Quality.

5.2.3 Two types of Product Development Processes

The development of a physical product is hardly comparable to the development of a non-physical product. The choice of a reference model for product development must take into account of this fundamental difference. The following section presents two diverse approaches: a PDP for physical products is suggested first and followed by a PDP for non-physical products.

Product Development Processes for Physical Products

The classical PDP concentrates on the development of physical products (e.g. watches, cars, bicycles). In this context, the product development faces many challenges like the complexity of product requirements, the product planning, the product quality or the risk

of an increasing development time. For this reason, it is essential to use a reference PDP which fits the requirements and masters the mentioned challenges.

Figure 10: PDP - Physical products (Beaujean et al. 2011) and (Ehrlenspiel 2009)

For physical products, a generic PDP could be divided in 6 phases:

- Product Idea: Product strategy is defined on basis of an abstract idea
- Product Concept: By identifying functional and emotional requirements the product structure is determined
- Product Design: Designing of subsystems and overall drafts
- Component Development
- Prototype Realization
- Pre-series Production

Product Development/Design Processes for Non-Physical Products

The use of software in the industry has become an inherent part in every company. To meet these demands, it is necessary to determine a PDP for non-physical products (understood as software in this guidline) because the development of software and hardware are very different. The PDP for non-physical products is divided into four phases (see Figure 11).

Figure 11: Product Development Process - Non-physical product

The presented four phases are briefly described in the following section and visualized in Figure 12.

- **Analysis**

During the first phase of the PDP for non-physical products the strategy, the objectives, the customer target groups and general conditions are identified and determined.

- **Requirement specifications**

During the second phase contents, information structure, function and usability are analysed and specified.

- **Modeling**

During the modeling phase the technical software development is implemented.

- **Test & Evaluation**

The Test & Evaluation phase enables prototyping of the software regarding usability and functional structure at any time.

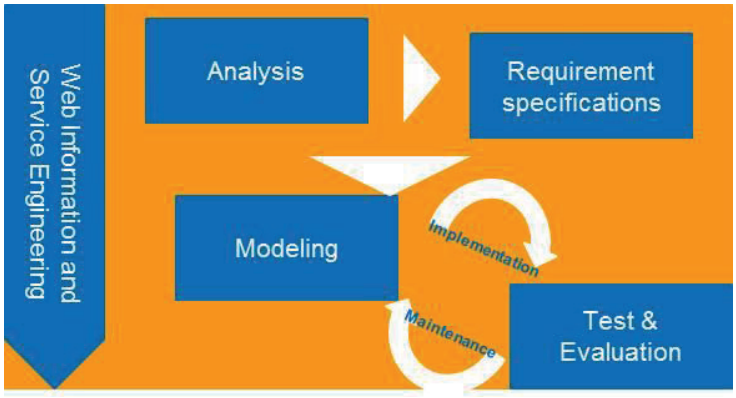


Figure 12: PDP stages (Wissen 2005)

5.2.4 Quality Gates during the PDP

Quality Gates or Gating (Prefi 2003) is often used in industry as a monitoring and controlling systematic during development processes. It has been established as a key factor in processes of product development and launch management. Quality Gates help to avoid failures in achieving management, business- or technical-orientated performance agreements. Quality Gates increase the efficiency and eliminate unnecessary performance and idle time. Using Quality Gates avoids error propagation and synchronizes parallel-running sub-processes during the PDP.

The stage-gate-process (Cooper 1994) is an often used systematics, which stipulates clear and effective rules for a successful PDP, from an initial idea to the launch of a new product. These rules are essential, because nearly 80 % of the development performance during a product development project consists of information procurement, communication and coordination (Schmitt and Pfeifer 2010).

Stages are phases in which activities are bundled and performance and results are achieved. Gates are decisions and checkpoints which subdivide the PDP. According to Cooper the PDP is divided in four to seven stages and gates. It is important to mention that the costs of failures in each phase are more expensive than in the previous one.

Critical success factors for defining Quality Gates are:

- Implementing Quality Gates on critical positions of the PDP
- Defining internal customer-supplier-relationship
- Appropriate evaluation model

- Continuous application

Main attributes of the Quality Gate systematics are shown in Figure 13:

- Input
- Performance of activities
- Criteria catalogue/ checklist
- Output

Figure 13: Main attributes of Quality Gates (Prefi 2003)

There is the same procedure that applies for each phase. First the development team determines the criteria catalogue which includes the measured parameters. Later these parameters are compared to the measured output value during the monitoring at the Quality Gate. To meet the demands of criteria with different urgency and rating, it is helpful to differentiate criteria in “must-meet” and “should-meet”.

If the output meets the criteria at the Quality Gate, the process will continue to the next phase. If this is not the case, there will also be a procedure for outputs which were not able to meet the demands of criteria. For this case, it is necessary to implement a category system for different output categories. Outputs are results and decisions of the Quality Gate systematics which can be graded into the following categories (Cooper 1994):

- Go: Project has met all requirements for this Quality Gate, can pass the gate and proceed to the next phase.
- Kill: Project has not met the applicable requirements for this Quality Gate, has to be stopped and there will not be further investigation.
- Hold: Project has met all requirements for this Quality Gate, can pass the gate and proceed to the next phase. Since there is a lack of resources, the project is on hold.
- Recycle: Project has not met the applicable requirements for this Quality Gate. It will be possible to pass the gate if the project repeats the last phase and finishes successfully (loopback).

At each gate, the product is assessed by a relevant authority. The objective of having checkpoints after each development phase is to reduce the probability of failure.

In the following section the integration of a Quality Gate systematics is presented in 8 steps according to Schmitt and Pfeifer (Schmitt and Pfeifer 2010). During the first three steps the organization of the PDP, the objectives and sub-objectives are determined as well as Quality Gates are positioned on critical process interfaces. These three steps only need to be run once.

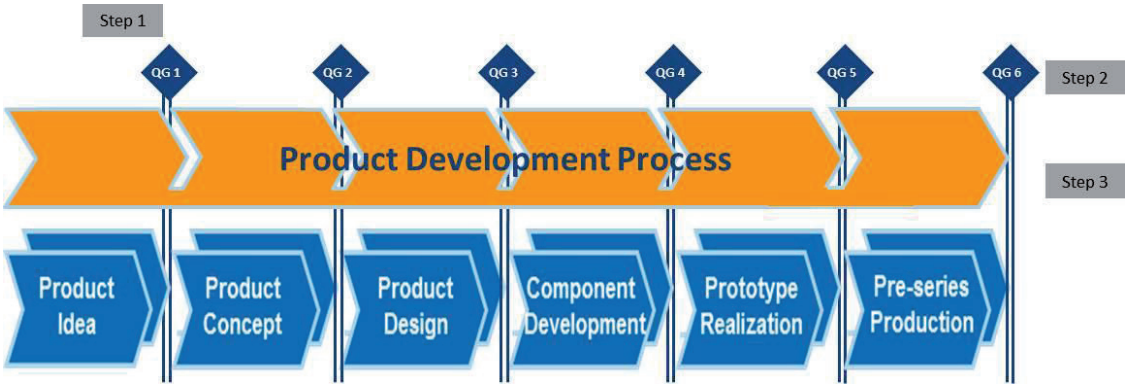


Figure 14: Integration of Quality Gates into the PDP (first 3 steps) (Schmitt and Pfeifer 2010)

- Step 1: Determination of the project organization
  - Determination of project-related structures and procedures
  - Determination of relevant customer-supplier relationships
- Step 2: Dividing the process chain in different phases
  - Facilitates the control of critical process interfaces by positioning measuring points, Quality Gates (QG), on critical process interfaces
- Step 3: Definition of the project objectives
  - Decomposition of the main objectives in phase-related sub-objectives
  - Definition of measured parameters for the sub-objectives; later defined parameters are controlled regarding the maturity level
  - Determination of a specific agreement between customer and supplier

The following five steps must be done during any phase of the PDP:

- Step 4: Reconciling the demands
  - Each Quality Gate concludes with a checklist of results and performances. The checklist is a criteria catalogue and the checklist's contents are the targets, which have to be obtained during the stage in order to pass the gate and proceed to the next phase.

- Contents of the checklist are communicated to the developer

- Step 5: Ensuring the process route
  - Tasks and activities of development teams are planned
- Step 6: Synchronizing the process progress
  - Step 5 & 6 are controlled and the process progress is ensured
- Step 7: Controlling the development quality
  - Gatekeeper gets information about the process progress and the measured parameters as well as criteria, finished activities and results
  - Furthermore, a comparison between the criteria listed in the checklist and an overview of finished tasks during this phase decides whether to pass the gate (step 8) or not (step 1)
- Step 8: Utilizing the process experience
  - Important information and “Lessons Learned” are documented due to the continuous improvement process

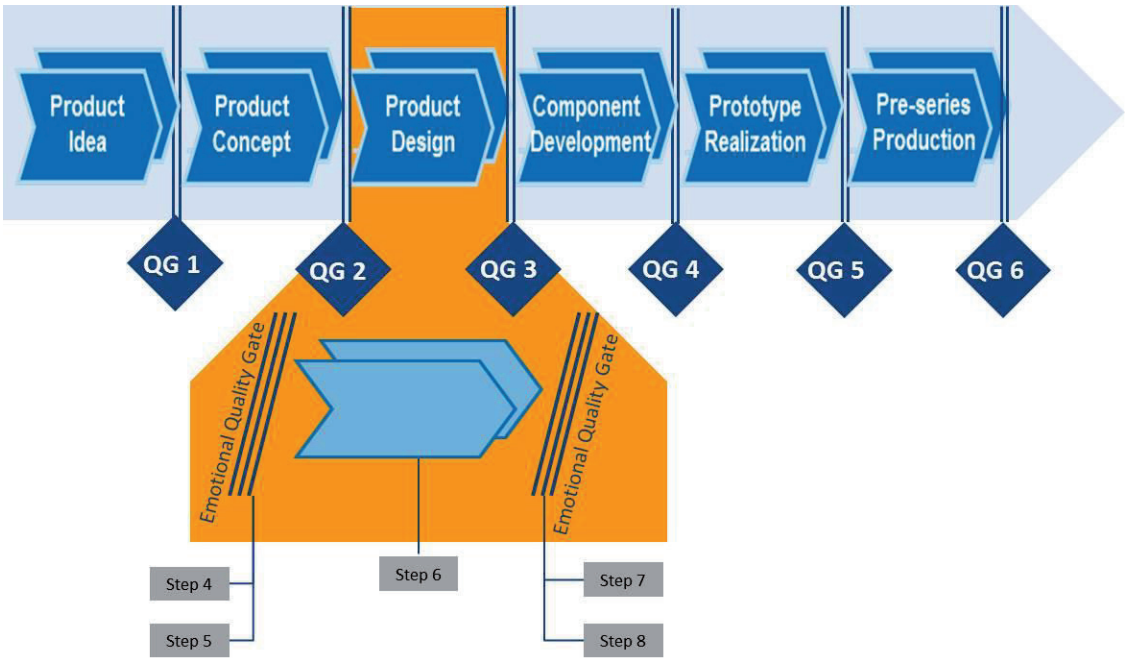


Figure 15: Integration of Quality Gates into the PDP (step 4-8)

5.3 Main concepts

From this chapter it is important to remember:

Product Development Process and Quality Gates – Checklist	
	• The use of a well-structured PDP could help to reduce complexity. • The application of a Quality Gate systematics could be an appropriate tool to monitor and ensure the defined procedure and organization of the development process. • PDP can be seen as a established procedure during the project. • A well structured PDP ensures the realization of customer requirements as well as technical and functional ideas. • Therefore the development process should be split into different development activities and assigned to different departments. • Providing a reference process which creates transparency for all persons involved in the project ensures the quality of the development process, sub-processes and of the developed product. • Quality Gates ensure the monitoring of actual and target performance at the end of each phase of the PDP. • The effect of Gating ensures that a developing process will only be able to move to the next phase if it has got the required maturity. • If there is a deviation between the actual performance and the target performance, the continuation of the project will be stopped until the deviation is solved and all objectives regarding the integration of customers' emotions are obtained.

6 Definition of the strategy

As mentioned before, it is of importance to integrate the customers´ emotions into the PDP as early as possible. Before measuring emotions that are linked to different product elements, one should first define the strategy of the company as well as of the product. In these guidelines the focus of the product strategy is not limited to the point of view of the company but includes also the customer target group.

In the past, companies decided on a strategy with only few people having an influence on the final outcome. Thus, many products have been manufactured and brought to market without customer demand. In some cases there was simply no need for a product or in other occasions, single aspects or parts of the design had made a product undesirable. To prevent early mistakes in the process of setting a strategy companies lately invited customers into their planning process. Therefore, one objective of the guidelines is to take the customers' point of view into consideration as early as possible, even in the phase of setting the companies' strategy.

6.1 Goals

The main goals of this chapter are:

- the reconciliation between the product strategy determined by the company and the emotional demands of the customer target group and
- setting a cornerstone for upcoming tasks.

6.2 Overview and procedure

Defining the strategy

At first the product strategy is determined from the companies' perspective. This is done in relation to the companies' strategy by determining a semantic concept. Workshops and semi-structured interviews with representatives of the company are methods which support the development of a semantic concept that is suitable to the company's product. (e.g. Köhler and Schmitt 2012)

The customers' wishes and expectations for the new product shall be determined as early as possible. By including customers into the process of finding the companies' strategy the company can save both time and money. Furthermore, both standardized and open interviews or surveys with the customer target group provide insights to the customers' perspective of the companies' product strategy.

A previously developed semantic differential questionnaire reduces the amount of semantic concepts by applying statistical analysis (see Chapter 7). A semantic concept is deleted if it is misunderstood by the customer in relation to the new product as well as if it does not seem compatible with the customers' understanding of the new product. The reduction by a semantic concept always brings a loss of information with it. Thus, it is important to choose these concepts wisely and better replace one word by another before discarding it without substitution.

The following section shows the relevant influences on the product strategy. The product strategy can be represented by semantic concepts described in the following chapter. This is a combination of the company's and customer's perspective of the product. The idea is that the product strategy can be described more directly and efficiently with few but significant words. It already includes the next step – determining semantic concepts – which will be explained more in detail in the next chapter.

For ensuring this, it is important to survey customers' and business representatives' perspective on products via applying different methods in order to generate necessary inputs for the definition of the product strategy.

- Results of business representatives' survey
    - What is the company's strategy?
    - How does the company want the new product to be?
    - What possibilities does the company have?
- Results of customer survey
    - What does the customer actually want?

After having generated the inputs the procedure continues by aligning product strategy from companies' point of view and customers' requirements

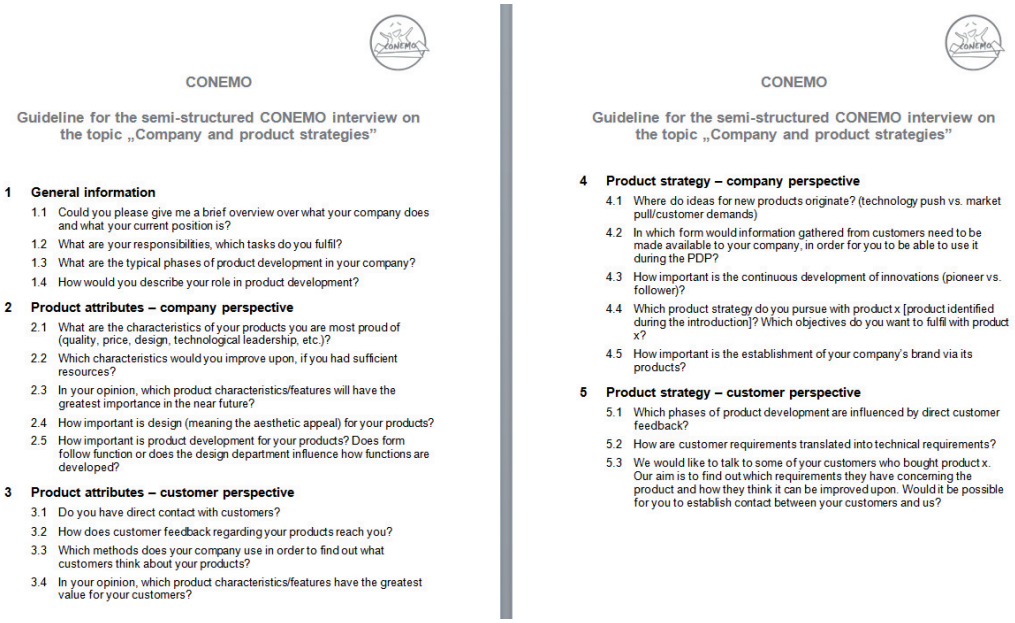
- Using semantic concepts to include the result of customers' survey with the representatives' survey. How to use sematic concepts will be explained in (chapter 7).

The result of this step is a list of the most relevant semantic concepts (see chapter 7) representing the strategy as well as sub strategy to secure that a product meets customer requirements.

Gathering relevant information

There are guidelines for gathering all relevant information and how to communicate with the company and the target customer group. A semi-structured interview guideline was developed and applied asking e.g. the following questions (see Figure 16):

- Where do ideas for new products originate? (technology push vs. market pull/customer demands)
- How important is the continuous development of innovations (pioneer vs. follower)?
- How important is the establishment of your company's brand via its products?
- Which product strategy do you pursue with your product? Which objectives do you want to fulfil with that product?



CONEMO

Guideline for the semi-structured CONEMO interview on the topic „Company and product strategies"

1 General information

1.1 Could you please give me a brief overview over what your company does and what your current position is?
1.2 What are your responsibilities, which tasks do you fulfil?
1.3 What are the typical phases of product development in your company?
1.4 How would you describe your role in product development?

2 Product attributes – company perspective

2.1 What are the characteristics of your products you are most proud of (quality, price, design, technological leadership, etc.)?
2.2 Which characteristics would you improve upon, if you had sufficient resources?
2.3 In your opinion, which product characteristics/features will have the greatest importance in the near future?
2.4 How important is design (meaning the aesthetic appeal) for your products?
2.5 How important is product development for your products? Does form follow function or does the design department influence how functions are developed?

3 Product attributes – customer perspective

3.1 Do you have direct contact with customers?
3.2 How does customer feedback regarding your products reach you?
3.3 Which methods does your company use in order to find out what customers think about your products?
3.4 In your opinion, which product characteristics/features have the greatest value for your customers?

CONEMO

Guideline for the semi-structured CONEMO interview on the topic „Company and product strategies"

4 Product strategy – company perspective

4.1 Where do ideas for new products originate? (technology push vs. market pull/customer demands)
4.2 In which form would information gathered from customers need to be made available to your company, in order for you to be able to use it during the PDP?
4.3 How important is the continuous development of innovations (pioneer vs. follower)?
4.4 Which product strategy do you pursue with product x [product identified during the introduction]? Which objectives do you want to fulfil with product x?
4.5 How important is the establishment of your company's brand via its products?

5 Product strategy – customer perspective

5.1 Which phases of product development are influenced by direct customer feedback?
5.2 How are customer requirements translated into technical requirements?
5.3 We would like to talk to some of your customers who bought product x. Our aim is to find out which requirements they have concerning the product and how they think it can be improved upon. Would it be possible for you to establish contact between your customers and us?

Figure 16: Semi-structured interview guideline

Several methods exist to elicit customers' perspective on product strategy. It is important to communicate with the potential customer target group even in this very early step of PDP in order to anticipate real customer needs.

- Semi-structured interviews
- Questionnaires, e.g. What properties do you find important in a new car? (1 - not important, 5 - very important)

Example: Questionnaire asking for the importance of a concept

	1 – not mportant	2	3	4	5 – very important
Modern					
Reliable					
Dynamic					

- Mail
- Telephone
- Eye-Tracking with follow up questionnaire (see Chapter 9)
- Internet based surveys

With all the right information there are two perspectives that should overlap (Figure 17). On the left hand side the customer's perspective and on the right hand side the company's perspective. The common area is now the most relevant part for the *Product*

Strategy, because it combines the demands, wishes and expectations of the customer with the goals and intent of the company.

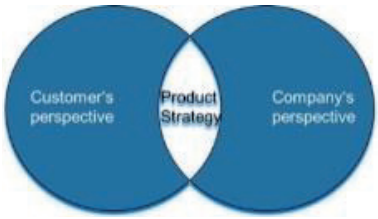


Figure 17: Overlap of customer's and company's perspective

6.3 Main concepts

From this chapter it is important to remember:

Definition of strategy – Checklist
• Common understanding of product strategy based on semantic concepts describing this strategy.
• Knowledge of what the customers want and what the company can deliver can be combined in one product strategy.
• This chapter introduces several methods to elicit company's as well as customers' product understanding.

7 Semantic concepts

People want products that are functional, usable and attractive at emotional level. They describe products using words. These words reflect the feelings and opinions of the customers and can be grouped in semantic concepts. Gaining knowledge about the relationship between the product features and the words used by customers will help to design more attractive products and satisfy the customers.

7.1 Goals

This chapter provides an introduction of semantic concepts applied to the product design and product evaluation. You will learn:

- How to find out the words used by your customers and your competitors.
- How to transform the words in concepts that you can use in order to design products or analyse existing products.

7.2 Overview and procedure

Introduction to semantics

Semantic differential is a type of a rating scale designed to measure the connotative meaning of objects, events and concepts. The connotations are used to derive the attitude towards the given object, event or concept. Charles Osgood, an American psychologist, connected scaled measurement with the connotative meanings of words. In the early 1950s, Osgood and colleagues constructed bipolar scales based on semantic opposites, such as "good-bad", "soft-hard", "fast-slow," "clean-dirty," "valuable-worthless," "fair-unfair," and so on. Osgood called these scales "semantic differential" scales, because they differentiated attitudinal intensity based on a person's subjective understanding of the connotative meaning of words. As a result, Osgood defined the concept "semantic space" with three measurable underlying attitudinal dimensions that everyone uses to evaluate everything in their social environment, regardless of language or culture. These three dimensions are (Osgood, Suci, and Tannenbaum 1957):

- Evaluation: This dimension is associated with the adjective contrasts: nice-awful, good-bad, etc.
- Power or Potency: This dimension corresponds to a scale that contrasts "powerful, big" with "powerless, little".
- Activity: This dimension contrasts "fast, noisy, active" with "slow, quiet, inactive".

The three dimensions are known as EPA, and subsequent experimentation by many investigators around the world confirmed the reality of the semantic space and its cross-cultural validity (Japan, Scandinavia, Germany, Ireland etc.)

Basically, the subject is asked to rate a given concept. Subgroups of the scales can be summed up to yield scores that are interpreted as indicating the individual's position on three underlying dimensions of attitude toward the object being rated. These dimensions

have been identified by using factor-analytic procedures (factor analysis is a statistical method of finding the common element or elements that underlies a set of measures) in examining the responses of many individuals concerning many concepts or objects.

The concept of “semantic space” has been included as a part of what is called affective or Kansei Engineering. The concept of Kansei Engineering was developed by Professor Mitsuo Nagamachi (Nagamachi 1995). It aims at the development or improvement of products and services by translating customers’ psychological feelings and needs into product's design domain (i.e. design parameters). Kansei Engineering is defined as a "translating technology for consumer's feelings” (Kansei in Japanese) about the product into the design elements.

The first step of Kansei Engineering is to grasp the consumer's feeling about the product in terms of ergonomic and psychological estimation. The main technique to grasp the customer's feelings is semantic differential.

How to define the semantic concepts

Before defining the semantic space, you should use the strategy defined previously (see chapter 6) and select a sample of products. The strategy is necessary in order to concrete the product evaluation.

A semantic study helps to recognize the cognitive structure of a particular product. The quality of the results of the study will depend on the establishment of correct specifications. When selecting a product for the application of a semantic differential, its definition can be more or less general, depending on the desired application. It is always better to choose a specific product or service to be certain that the results will be interpretable.

The user profile (target group) will depend on the defined strategy. This profile is based on potential customers. The user profile can be as specific as possible, keeping in mind that the results will be linked to that profile. Parameters can be set both objective (demographic and socio-economic, such as gender, age etc.) and subjective related to the personality or habits of the user.

The company has to select a sample of its products to be used in the evaluation. It is highly recommended to complete the sample with other similar products in the market. You have to perform an analysis of magazines, shops, blogs, etc. Product selection must cover the whole range, from highest to the lowest.

When you have a defined strategy, the first step to obtain the semantic space is to gather as many words and expressions as possible, used by people to express the attributes of the product or service (Example: hot, ergonomic, innovative, cool, rich). For the accomplishment of this activity it is necessary to perform the following tasks:

- Online search for manufacturers, distributors and companies related to the product: Searching for magazines and press specialized in the sector

- Accomplishment of surveys with a minimum of 20 users that belong to the target group
- Words that the company contributes (vocabulary used by the design or commercial department, sales arguments, advertisement)
- Netnography[1]

All the adjectives that come up are taken into account, even when they appear similar to existing adjectives. The process finishes when no new words arise. Depending on the particular field, the final set of words can vary between 50 and 600. This initial set of words is called the "initial semantic universe". A typical initial semantic universe consists of 300-350 words.

Afterwards, you have to reduce the adjectives to a reasonable number. There are several techniques for making this reduction. One of these techniques is the **affinity diagram.** The affinity diagram is a powerful tool for organizing qualitative information. It provides a hierarchical structuring of concepts. The hierarchy is built bottom-up, and the relationships between concepts are based on the intuition of the team creating the diagram (Cohen 1995). For semantics, we can use this tool in order to group the semantic descriptions according to their affinity. To do this reduction certain criteria have to be followed:

- Adjectives related to materials and specialized terms are excluded
- Adjectives and expressions that indicate an intention or purpose are excluded
- Adjectives and expressions that identify a decorative style are excluded
- Terms that are clear synonyms or antonyms of other terms included in the semantic space are excluded
- Terms that describe the product objectively (ex: red, heel shoes, with buttons…) are excluded

We recommend a team of 3 to 6 people with different levels of experience and variety of perspectives in order to apply the technique of affinity diagrams. The steps are:

1. Sort the items into groups. You can use a set of cards containing the terms to classify, or as many sets of cards as users participate. Either way, it should generate a classification agreed by all the participants. A reasonable number of groups are approximately 5 to 9.

[1] Netnography is the branch of ethnography that analyses the free behaviour of individuals on the Internet that uses online marketing research techniques to provide useful insights. The word "netnography" comes from "Inter[net]" and "eth[nography]"

2. Create titles for each group. These headings should define concisely the information covered in each group.

3. Draw the affinity diagram with the relationships between the different groups and subgroups (as a concept map or organizational chart).

4. Delete terms. During the discussion, decide which terms can fulfil exclusion rules listed above, for example by being considered synonymous.

The results obtained in the affinity diagram help to reduce the number of words. They also help you get an idea of whether the product or service is well represented by the words in all the attributes that are important.

Example of reduced semantic space for a mattress

Comfort	Practical	Firmness	Fresh	Good finishing
Healthy	Good thickness	Innovative	Volume	Breathable
Quality	Durability	Fashion	Luxurious	Serious

The dimension of the reduced semantic space should have a maximum of 50-60 words or expressions.

After the definition of the reduced semantic space, you have to select the sample of products. You must take in account:

a) The size of the reduced semantic space:

   The number of products must be similar or higher than the reduced semantic space.

b) The complexity of the product:

   The inherent variability of a product will determine whether you need a smaller or larger sample size. The sample must represent the variability of the product in the market.

Once you have identified the emotional terms (words) that define the product and the product sample to be studied, you can proceed to the semantic evaluation. To do this, you should choose a sample of users according to the profile previously defined. 25 users is a reasonable sample size to obtain conclusions about the emotional perception of a product.

For the evaluation of the product sample, you have to use semantic differential scales consisting of 5 or 7 level Likert scales where extremes correspond to the terms of the reduced semantic space and their negations.

The format of a typical five-level Likert item could be:

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly agree

Each user must fill out a questionnaire for each product. The questionnaire contains all terms that have been included in the reduced semantic universe.

Example of questionnaire

		OPTION A	***++ A***	***+ A***	***0***	***+ B***	***++ B***	***OPTION B***
1	The mattress is …	COMFORTABLE	☐	☐	☐	☐	☐	NOT COMFORTABLE
2	The mattress is …	HEALTHY	☐	☐	☐	☐	☐	NOT HEALTHY
3	The mattress is …	FRESH	☐	☐	☐	☐	☐	NOT FRESH
4	The mattress is …	BREATHABLE	☐	☐	☐	☐	☐	NOT BREATHABLE
5	The mattress is …	GOOD QUALITY	☐	☐	☐	☐	☐	BAD QUALITY

The questionnaires can be filled out individually or collectively, so that the sample of products is exposed and the users rotate to complete the questionnaires. The evaluation of the products follows a random order between users to avoid any learning influence. The words of the reduced semantic space should be randomized as well.

Figure 18: User assessing a picture of a mattress.

The product's semantic space is obtained grouping the adjectives or highly correlated terms in order to extract a set of concepts that summarize the information contained in the initial semantic space.

The factor analysis (FA) is the most used methodology to extract the semantic space. It is a statistical method used to describe variability among observed, correlated variables by a potentially lower number of latent variables called factors. In other words, it is possible that variations in three or four observed variables mainly reflect the variations in

fewer latent variables. The observed variables are modelled as linear combinations of the potential factors, plus "error" terms. The information gained about the interdependencies between observed variables can later be used to reduce the set of variables in a dataset. Computationally this technique is equivalent to low rank approximation of the matrix of observed variables. Factor analysis originated in psychometrics and is used in behavioural sciences, social sciences, marketing, product management, operations research and other applied sciences that deal with large quantities of data. In this case, the observed variables are the terms of reduced semantic space.

Each factor obtained through the FA contains terms that are related to each other, both positive and negative. Moreover, the words that best describe the factor have more statistical weight in the factor than the rest.

Example: Semantic concepts (or factors) for the mattress

Concept	*Words of the reduced semantic universe included in the concept*	*Name of the semantic concept*
1	Healthy, comfortable, strong, durable, quality	COMFORT
2	Luxurious, stylish, with good workmanship, innovative	LOOK
3	Serious	SERIOUSNESS
4	Fresh	FRESHNESS

7.3 Main concepts

From this chapter is important to remember:

Semantic concepts – Checklist

- Select a team of 3 or 6 persons from different areas (development, marketing, production, etc.) to gain a certain amount of semantic concepts to differentiate between design alternatives.
- Reduce the number of concepts of the semantic universe by valuating each concept(e.g. by company oriented questionnaire) Maximum 60.
- Define your customer target group as precisely as possible.
- Select a sample of 25 to 30 customers from your target group to relate different product alternatives with different feelings represented by the semantic concepts.

8 Product structure

This chapter's objective is to show how a product can be broken down and structured especially in terms of Perceived Quality. It is a breakdown either by technological properties or by perceptive clusters based on physiological means. It shows the composition of the product with the single components and their respective functions. It is important how a product is visually perceived and which clusters of perception customers might think of.

8.1 Goals

The main aspects of this chapter are:

- structuring the product into single components,
- presenting a graphic overview over the whole product and its components,
- gathering knowledge about the different functions and
- analysing quality features.

8.2 Overview and procedure

The breakdown of a product into its single elements is necessary to implement the product strategy into the product (see chapters 6, 7 and 9). In the early PDP the technical specifications are deducted from the customer's demands. The engineers in the development department design and craft single parts of the product. Thus the customer demand, attribute and function of the product have to be projected on single parts of the product (sub strategies).

Therefore, it is important to break down the product into the correct product structure. For the determination of the product structure a technical method called System and Function Analysis should be used. System and Function Analysis are also an essential part of the Failure Mode and Effect Analysis (FMEA). Another approach is a structured approach towards quality perception that represents a structured way to subdivide a product beginning from the overall product impression perceived by a customer down to the technical parameters. Regardless of the applied approach, it is important not to pass an appropriate level of detail (Schmitt and Pfeifer 2010).

The following procedure shows the necessary steps to determine the desired quality features: In order to conduct a breakdown of the visual product structure, necessary inputs are at least product drafts, an overview about insights in development and data about customer's perception.

Important steps of the procedure to derive the product structure from drafts, pictures etc. that have been applied are e.g.:

- The definition of structure elements via applying system analysis and

- Defining components that are relevant to customers' perception via using Eye-Tracking or/and questionnaires and adjusting them with a structured approach towards quality perception (Köhler and Schmitt 2012; Köhler, Falk and Schmitt 2014b).

As a result of this task, one gets an overview about a product and its components as well as its quality features that are most important for quality perception and, subsequently, for emotional design (see chapters 9, 10).

8.2.1 Determination of the product structure

As mentioned before, two different approaches in determining the product structure are recommended. On the one hand, the System Analysis uses an existing product and breaks it down using its technical properties. On the other hand, the model of Perceived Quality uses the customers' stages of perception in breaking down the product into its components. This is the preferred approach as it takes the Perceived Quality into account.

System and Function Analysis

- The System and Function Analysis can be divided into two single analyses, the System Analysis and the Function Analysis. The aims of the System Analysis are: Getting a clear overview of the product.
- Capturing and structuring all relevant components of the product.
- Distinction and rating interface.
- Determining responsibilities.

The system analysis allows companies to subdivide their products into fractions like subsystems and sub-subsystems. It is a powerful tool to get an insight on how the product is set together and how every component is assembled from other parts. The structure of the product gets well-known and possible weak spots can be localized accurately. The aims of the Function Analysis are:

- Overview of the functionality of the product.
- Understanding cause and effect relationships.
- Verification of product specification catalogue.
- Groundwork for analysing mistakes.

The Function Analysis uses the structure of the System Analysis to assign functions to the single components of the product. It shows the dependence of the different parts of

the product as well as cause and effect relationships which can be used for analyses of mistakes.

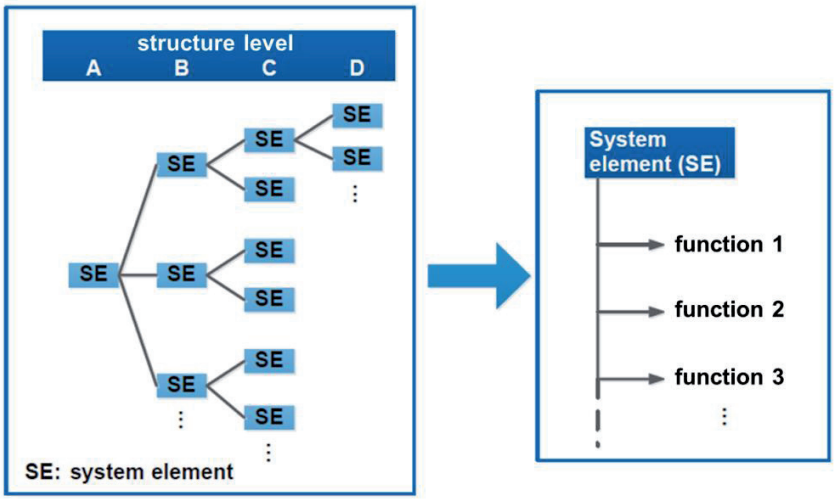


Figure 19: System and Function Analysis (cf. Schmitt and Pfeifer 2010)

Both, System and Function Analysis are linked to each other. In order to apply them, a step-wise procedure is recommended:

1. The product is completely structured into subsystem and components which is the base for the function structure.

2. The function analysis defines the function for every element.

3. All functions of subordinated system elements influence the functions of higher system elements.

While analyzing product functions three different kind of functions are distinguished:

- “Outgoing functions”: Functions of an element that have an influence on higher system elements.
- “Incoming functions”: Functions of an element that have an influence on subordinated system elements.
- “Inner functions”: Functions which are neither influenced by nor have an effect on other functions.

8.2.2 Structured Approach towards Perceived Quality

Schmitt and Pfeifer (Schmitt and Pfeifer 2010) provide an approach to subdivide a product beginning from the overall product impression perceived by a customer down to technical parameters (Figure 20). Elements that are perceived as one entity are called perceptive clusters, which again can be divided into quality features. The quality features are described by descriptors and their correlation with technical parameters leads to

physical quantities. Customers looking at a certain product do not look at every single part of the product rather than grouping certain areas to clusters of perception. These clusters are firstly perceived as one system element and are situated in a high structure level e.g. a door or the hood of a car.

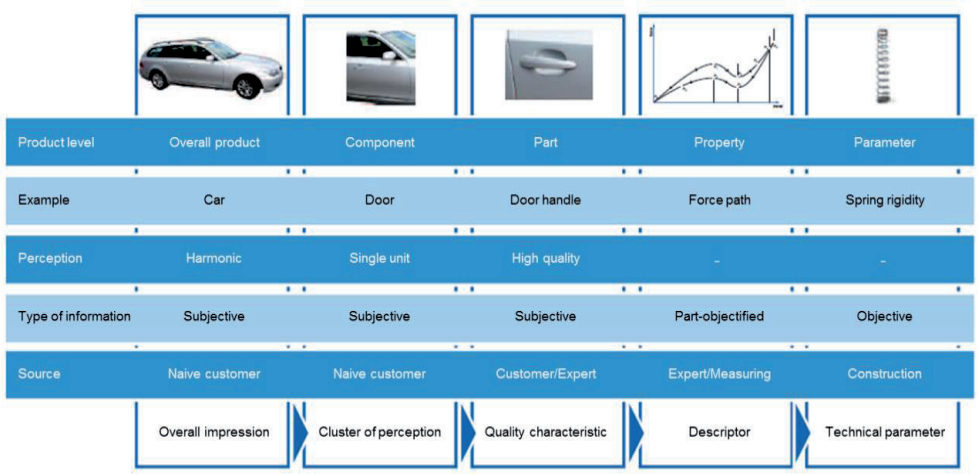


Figure 20: Structured model of Perceived Quality (Schmitt and Pfeifer 2010)

Clusters of Perception in Eye-Tracking

In order to capture and analyse the visual impression of products and components objectively an appropriate measurement is gaze-tracking. Different research questions can be answered analysing the duration of fixations, the order of fixations and the quantity of fixations, e.g. (see e.g. Schmitt et al. 2014; Köhler, Falk, Schmitt, 2014a/b; Köhler, Falk, Schmitt 2013; Schmitt et al. 2013; Köhler & Schmitt 2012):

- Comparing similar design alternatives, which alternative is attending a higher perception? (overall impression)
- Which components might form a cluster of perception? (cluster of perception)
- Which parts or components do customers look at? (product features)
- Which components are attending users' perception more than others? (product features)

By answering these questions, it is possible to link the different product levels in order to analyse the overall impression respectively the overall product design (see Köhler, Falk, Schmitt, 2014b):

1. Overall Product (overall impression)
2. Component (cluster of perception)
3. Part (product characteristics)

Clusters of Perception are various similar areas in a product that can be grouped. In this example of a watch it is not so much important at which number exactly a customer looks rather which zone he looks at (Figure 21). These different so called “look zones” can be used to generate clusters of perception. Here it is important that the look zones are big enough minimizing mistakes due to a tolerance in the Eye-Tracking process.

Figure 21: Example of possible look zones

The overall impression is on the level of the overall product – in this example a watch. Clusters of perception could be e.g. the bracelet, the clock face and the casing. The clusters can further be subdivided, e.g.: cluster “outer ring”, cluster “inner ring”and cluster “watch hand and date”. This illustrates how the product’s components are perceived by a customer, how the clusters of perception correlate with the product structure and how it can be used for Eye-Tracking purposes. However, it is important not to go too far into detail. (Köhler, Falk, Schmitt, 2014b)

8.3 Main concepts

From this chapter it is important to remember:

Product structure – Checklist	
	• The product can be structured by using the preferred approach of system analysis or structured approach towards quality perception. • All elements that are relevant to customers’ perception have to be determined by analysis functions and dependencies. • Capture quality features using Eye-Tracking to define relevant product characteristics. • The overall impression, product characteristics and clusters of perception has to be structured.

9 Linkage of strategy and structure and design evaluation

The linkage between strategy and structure is important to consolidate the semantic concepts (chapter 6 and 7) and the relevant quality features (chapter 8). The linkage

between structure and strategy is substantial in the process and contains three steps (presented in 9.2).

9.1 Goals

The aims of this chapter are

- to combine strategy (semantic concepts) and product structure elements,
- to set up a matrix to link strategy and quality features,
- to collect and evaluate customers' emotion and
- to analyse the data and deduct design suggestions.

9.2 Overview and procedure

Firstly, the semantic concepts and the quality features are merged in a matrix of strategy and quality features. Secondly, to cover the entire customers' opinion, the customers' emotions resulting from perception are being collected and evaluated. Finally, the generated data is analysed and design suggestions can be deduced.

9.2.1 Setup strategy- quality features matrix

To gather objective information about the customers' subjective perception of the implementation of single product strategies in structure elements, the customer target group is shown drafts of different design alternatives on a screen. During and after inspection of the product conscious and unconscious impressions are collected with different methods (see chapter 9.2.2).

In order to set-up a matrix of strategy and quality features it is crucial to use the semantic concepts from chapter 7 for the rows in the matrix and to insert the different components of the product structure from chapter 8 for the columns. Figure 22 gives an example of a strategy- quality features matrix. This is the example of a car with the semantic concepts powerful, elegant, and modern. The components are side mirrors, wheel rim, door, headlights and hood. The matrix will be filled with data that are derived with the methods presented in chapter 7 and 8. Each cell displaying the relevance of the components regarding the semantic concepts as perceived by the customer. (Köhler & Schmitt 2012; Köhler, Falk, Schmitt, 2014b)

	Side mirrors	Wheel rim	Door	Headlights	Hood
Powerful					
Elegant					
Modern					

Figure 22: Example of a strategy quality features matrix for a car (based on Köhler & Schmitt 2012)

9.2.2 Collection of customer emotion

The data about customers' emotion gives information about how much the person associates a semantic concept with a quality feature or product's part. Basically an emotion can be described by the direction, the intensity and the content of the emotion.

To get the full picture of customers' perception the emotion must be completely captured. The sole connection between a component and a semantic concept only shows the direction of attention, which can have various reasons. Therefore it is important to find out if there is a positive or negative association. There are different ways to collect information about customers' attention and emotions – each of the following ways is combined with capturing the visual impression of products by involving customers of the potential target group into studies:

- Questionnaires.
- Eye-Tracking.
- Physiological signals.

Since there is a focus on objectifying visual impression in early phases of the PDP, some practical advices should be taken into account in order to design an appropriate study. Whilst preparing these drafts there are some points that have to be considered.

- The number of pictures depends on the design possibilities or combinations:
    - E.g. if for one part of the product 2 different colours and 3 sizes are possible, 6 combinations are needed (6 pictures). More possible design factors also result in more pictures needed.
    - Fractional factorial design of experiment is a technique to reduce the number of necessary combinations.
- The number of pictures shown during an experimental session should be limited to 10 because people tend to get tired after exploring about 10- 15 images and the emotional response disappears.
- The pictures must be prepared carefully:
    - There shall be a consistent background for every picture. Different backgrounds can have a significant influence on the Perceived Quality. It shall not direct the customers' view away from the product.
    - The background must be neutral, without symbols or colours that can provoke distractions.
    - It is also important to eliminate texts or logos of brands, unless the logos are a design option too. People often stare at logos and texts. Moreover, people could have a good or bad emotional response due to their feelings about the brand, and not because of the design changes.

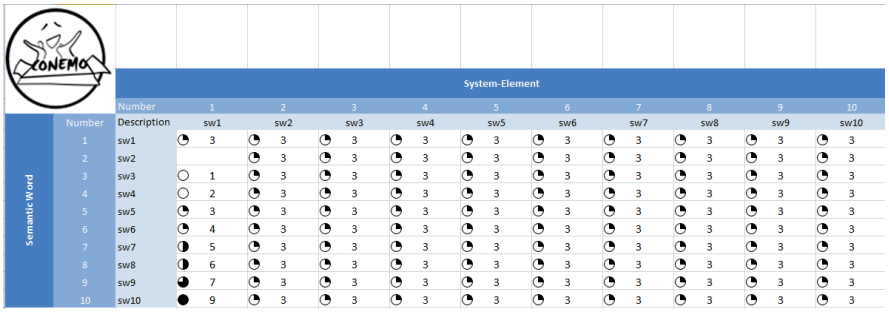
- The pictures can be shown in the display of any computer or in a screen with a projector:
    - The different product variations shall all be presented from the same angle.
    - Every variation should be shown as large as possible and in the same size as other pictures.
    - The quality of the pictures must allow to show the design changes as detailed as possible.
    - The environment where you show the pictures is very important. It must be quiet and comfortable. In addition, you have to avoid sounds or colours that can provoke distractions.
- It is important to randomize the order in which the images are shown. You should use a different order for each person. The images must last around 10-15 seconds, and you must insert a black image in between each design. The purpose of these black slides is to separate the response between pictures, to avoid signals elicited by one picture from affecting the next.
- Fewer differences make it easier to allocate the difference in Perceived Quality to a single component.
    - When the pictures differ in only one component, the difference between perceived qualities can be assigned to that component, which subsequently can be optimized.
- Nevertheless, interactions caused by the variation of several quality features are important and should also be taken into account via applying Analysis of Variance. (see Köhler, Falk, Schmitt, 2014b; Schmitt et al. 2014; Schmitt et al. 2013)

9.2.2.1 Questionnaires

The use of questionnaires is the standard procedure when obtaining information from probands. It is a simple but powerful tool and can be executed very easily with only few resources. It is the basis for further and more detailed collection of customers' emotion. Questionnaires are a direct approach to gather information about emotion; these will be complemented with indirect forms of gathering information.

- In questionnaires the target group is directly asked and responds consciously.
- The semantic concepts from chapter 7 can be linked to elements from chapter 8 for a linkage between strategy and structure (e.g. via asking: According to a special product, please name, which product characteristics you correlate to a special semantic concept?) (see Köhler, Falk, Schmitt, 2014b; Schmitt et al. 2014; Schmitt et al. 2013)

- Strategy- quality features matrix can be used to signalize dependencies (Figure 23)



		System-Element									
	Number	1	2	3	4	5	6	7	8	9	10
	Number	Description	sw1	sw2	sw3	sw4	sw5	sw6	sw7	sw8	sw9	sw10
Semantic Word	1	sw1	3	3	3	3	3	3	3	3	3	3
	2	sw2		3	3	3	3	3	3	3	3	3
	3	sw3	1	3	3	3	3	3	3	3	3	3
	4	sw4	2	3	3	3	3	3	3	3	3	3
	5	sw5	3	3	3	3	3	3	3	3	3	3
	6	sw6	4	3	3	3	3	3	3	3	3	3
	7	sw7	5	3	3	3	3	3	3	3	3	3
	8	sw8	6	3	3	3	3	3	3	3	3	3
	9	sw9	7	3	3	3	3	3	3	3	3	3
	10	sw10	9	3	3	3	3	3	3	3	3	3

Figure 23: Example for a Matrix for Strategy and Structure (based on Köhler and Schmit, 2012)

9.2.2.2 Eye-Tracking

With Eye-Tracking as a non-verbal measuring method we can obtain implicit information which the customers are not aware of. The advantages compared to the sole use of questionnaires are immense. The customers' attention is being recorded objectively, so that the customer does not have an actual influence on what he expresses subconsciously. Customers consciously express emotions very subjective and biased, one "feels what he wants to feel". This source of irritation is now eliminated.

- Images shall be presented about 10-15 seconds to capture the first impression.
- Products show automatically and disappear after a previously set time.
- A randomized order has to be used when different alternatives are presented.

Besides selecting the best designs, it is interesting what parts of the product are more relevant for the customers (see chapter 5.2). This information is useful e.g. for the marketing department for designing catalogues and publicity. You can measure how visual attention is distributed among different elements of the products. The procedure consists of defining areas of interest (AOIs or look zones) in order to measure the number of fixations and the average duration of the fixations[2]. The AOIs or look zones for each product should be defined according to the design areas (Figure 24). (Schmitt et al. 2014; Köhler, Falk, Schmitt, 2014b; Köhler, Falk, Schmitt 2013; Schmitt et al. 2013; Köhler & Schmitt 2012):

[2] Fixation or visual fixation is the maintaining of the visual gaze on a single location.

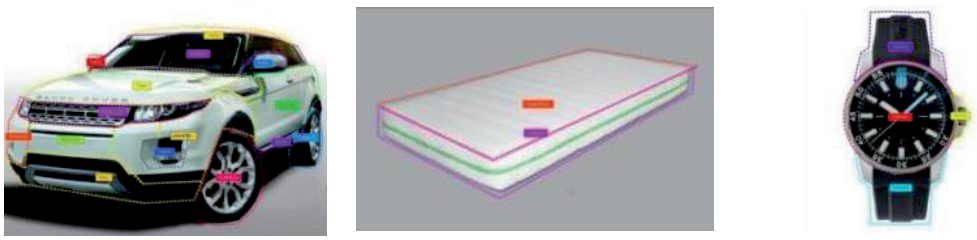


Figure 24: Areas of interest in three products

One of the best manners to show the results of Eye-Tracking are maps of fixations (Figure 25). These maps are very useful in order to select the areas that are more relevant for the customers. Another very important result for product design is the knowledge of the gaze-track that means the order in which the customer looks at the areas / product characteristics.

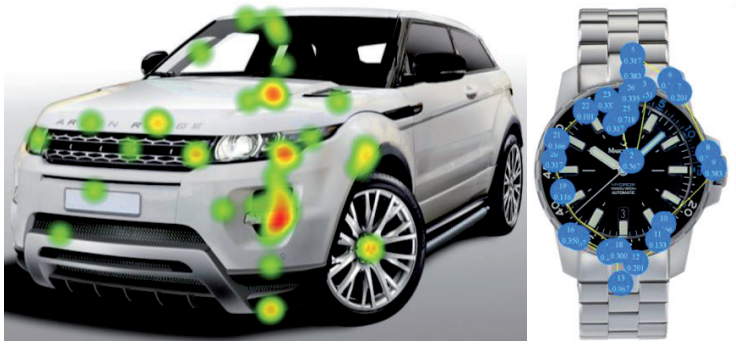


Figure 25: left: Map of fixations. Red colour means more fixations; right: gaze-track

9.2.2.3 Measuring Physiological signals to analyse emotions

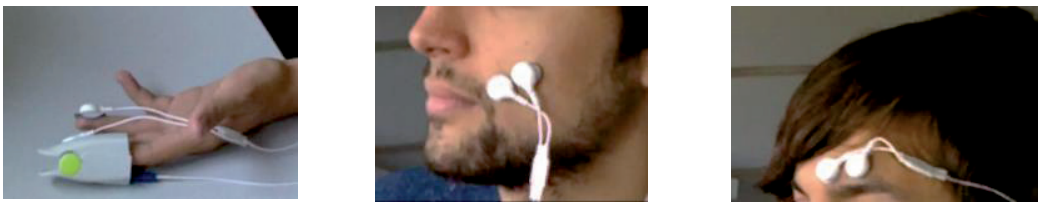
Once the product structure and design factors are defined, the next step is to select the best alternative. The best design alternative is the design that provokes the most positive emotional response in the customers. This response can be captured via applying questionnaires (see chapter 9.2.2.1), but the disadvantage of the sole elicitation of customer's emotion applying questionnaires was presented, since they are only representing the articulated user opinion and not the latent opinion.

However, the emotional response can be measured by means of physiological signals too. The main signals are facial electromyography (EMG) and galvanic skin response (GSR) (see chapter 4). Specific devices and experience are necessary to allocate the sensors. The aim of this chapter is to provide generic recommendations about the application of emotion analysis, without entering scientific and technical details.

The advantages of emotion analysis are:

- It is more powerful than questionnaires: You need less people to find differences between designs (usually 10 – 12 subjects).
- It is more objective than questionnaires.

The main disadvantage is that you need special equipment and technical knowledge. As an example, Figure 26 shows the sensors needed: (a) Electrodes attached on the left hand for extracting GSR signal. (b) Electrodes attached over the zygomaticus major on the left side of the face for extracting EMG signals. (c) Electrodes attached over the corrugator supercilii on the left side of the face for extracting EMG signals.



(a) (b) (c)

Figure 26. Electrode positions.

As it is explained in the chapter "assessing emotions" (chapter 4), the physiological signals provide a bi-dimensional measurement of emotions:

- The valence: Like – Dislike, or Good - Bad
- The arousal: Intensity of the emotion, also related with stress.

The emotion analysis will compare design alternatives. This analysis does not provide an absolute scale. Therefore, you should always compare one option against another. The emotion reflects a global opinion of the customer. The emotional answer will not provide a reason. If one design provokes better emotional signals, you can say *"Customer prefers design A".* However, you cannot say *"Customer prefers design A because it is more modern"* or "*...because it is more sportive*".

The procedure in order to compare design options consists of preparing pictures or drawings with the different options. The customers look at the different pictures while the researcher measures the physiological signals.

The valence is measured with facial electromyography. You can say that design A is better than B if one or two of the following conditions arise:

- Activity of the muscle that controls smile is higher when customer explores A.
- Activity of the muscle that controls the frown is lower when the customer explores A.

The intensity of the emotion is measured with the galvanic skin response (GSR). More GSR implies higher emotional intensity. However, the relation between emotional intensity and best designs is not obvious. It will depend on the type of product (chapter 8), your strategy (chapter 6) and the target customers. E.g.: If you are selling a mattress or an armchair to relax, it would be better to provoke a relaxing emotion, what implies low GSR. If you are selling a snowboard or equipment for extreme sports, it would be better to provoke an intense emotion which implies high GSR.

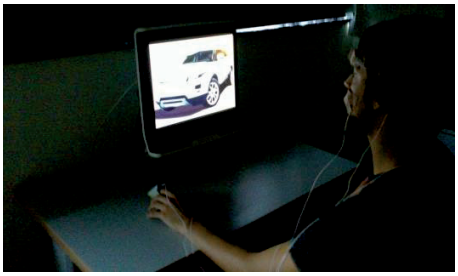


Figure 27: Set up for emotional evaluation

9.2.3 Analysis of the data

After collecting the data about the visual perception for the different product alternatives and their evaluation the following step is to analyse the data with regard to different questions that are relevant for product design in early phases of the PDP. These questions have to be determined to have a basis for the analysis. For example the following questions can be asked (Schmitt et al. 2014; Köhler, Falk, Schmitt, 2014a/b; Köhler, Falk, Schmitt 2013; Schmitt et al. 2013; Köhler & Schmitt 2012):

- Which quality features are most relevant regarding perception?
- Which quality features are most important when realizing the companies' product strategy?
- How do the results from conscious perception differ from the results taken by non-verbal unconscious perception?
- Does the company successfully integrate the strategy into the product from customers' point of view and how do customers rate this integration?
- Which design suggestions can be deducted for the components of the product alternatives?
- Which design alternative of a component is favoured for a certain product strategy?

By analysing the gained data from 9.2.2 and the combined analysis of perception values and emotional values (rated on scales via applying questionnaires or measured by physiological signals) reasonable design suggestions can be deduced.

9.3 Main concepts

From this chapter it is important to remember:

Linkage between strategy and structure – Checklist

- The most relevant quality features regarding perception have to be determined.
- Eye-Tracking and physiological signals should be applied to collect unconscious information.
- Finally, specific design suggestions can be deduced.

10 Quality Gates for emotional design

Chapter 10 deals with the application of the main concepts worked out in the previous chapters 4 to 9. The integration of the main concepts into the PDP of SMEs describes the main aim of this chapter. To integrate the main concepts of the guidelines, an easy-to-use approach is essential in order to raise the awareness of the main concepts' contents for the SMEs' development teams and control the systematic integration of the main concepts into the PDP. This approach is based on a criteria based Quality Gate systematics (see chapter 5.2.4) and is extended for the application in SMEs' PDP in order to integrate aspects for emotional design. (Köhler, Falk, Schmitt, 2014a; Köhler, Falk, Schmitt 2014b; Köhler & Schmitt 2012)

10.1 Goals

After understanding and implementing all activities of this guideline in order to measure customers' attention and emotions and to use these results for the development of new products, this chapter aims at

- presenting the main procedures in order to integrate the main concepts into the PDP of SMEs,
- sensitising SMEs and raising the awareness for the importance of customers' attention and emotion during the PDP and
- developing an easy-to-use approach to match these requirements.

10.2 Overview and procedure

All main concepts are summarized (chapter 10.2.2) and their potential for the implementation into an easy-to-use approach is shown in order to manage challenges of emotional design for SME (chapter 10.2.1). Moreover, specific requirements of the easy-to-use approach and of emotional Quality Gates are illustrated (chapter 10.3 and chapter 10.4) in order to finally implement a prototype of a tool (chapter 10.5).

10.2.1 Challenges of emotional design for SME

The implementation of the main concepts into the easy-to-use approach evokes some general and specific challenges regarding the early integration of customers' emotions into phases of the PDP. General questions regarding the integration of customers' emotions into early phases of the PDP:

- How can users be emotionally touched by new products?
- What designs are good to ensure the success of future products?
- How can SMEs' PDP implement the main concepts?
- How can the application of the main concepts and its suggested methods be ensured during the SMEs' PDP?
- Which of the SMEs' departments are actively involved (Marketing, Procurement, Design, Research) during the PDP?
- Which phases of PDP do SMEs have?
- Which activities have to be accomplished during these phases?
- In which phases of the SMEs' PDP is the customer actively involved?
- etc.

Definition of the strategy & semantic concepts

- How can SMEs transfer their company strategies for upcoming products into describing words (semantic concepts)?
- Which appropriate methods or tools should SMEs use in order to identify customers' requirements?
- How can SMEs achieve the consistency between customers' and their own requirements regarding a common understanding on upcoming products?
- Which are the essential aspects for the determination of a product strategy regarding a strong focus on products with a high degree of Perceived Quality?
- How do SMEs identify the customers' requirements?
- How can SMEs manage the process organization for the determination of this alignment? (responsibilities, internal customer-supplier relationships)
- etc.

Product structure

- How can SMEs assemble relevant system elements?
- How can SMEs disassemble their product into its subcomponents, and further in clusters of perception and quality attributes? (methods or procedures)
- Which are appropriate methods or procedures for SMEs in order to define relevant structure components and subdivide products into perceptive clusters?
- How can SMEs manage the process organization for the definition of the product structure? (responsibilities, internal customer-supplier relationships)
- etc.

Linkage between strategy and structure

- How can SMEs align the product understanding (consists of generated semantic concepts) with the product structure (gained from clusters of perception)?
- Which appropriate methods can SMEs use for the alignment of structure and strategy for upcoming products?
- How can SMEs gain design rules for the development of new products?
- How can SMEs manage the process organization for the linkage between product strategy and product structure? (responsibilities, internal customer-supplier relationships)
- etc.

10.2.2 Issues to be considered during the PDP for SMEs

This section offers an overview of a potential use of the presented main concepts during the product development.

The main concepts for ***assessing emotions*** (see chapter 4.3) help the SMEs' development teams to raise their awareness for the importance of customers' perception in the context of product development. The easy-to-use approach determines a compulsory development team meeting before the PDP begins by using a first Quality Gate. By imparting the following topics, the development teams will increase their

awareness for the importance of customers' emotions: The dimensional classification of emotions with physiological signals is more objective than categorical classification with questionnaires. Main dimensions are valence (like-dislike) and arousal (intensity):

- Higher GSR means higher arousal.
- High Zygomaticus EMG with low Corrugator EMG implies higher valence (like).
- Low Zygomaticus EMG with high Corrugator EMG implies lower valence (dislike).

The main concepts for the ***definition of the product strategy*** (chapter 6.3) help the SMEs' development teams to raise their awareness for the importance of aligning customers' and companies' product understanding. This common product understanding is essential for developing a product with high Perceived Quality. Therefore, the easy-to-use approach determines the creation of a semantic framework as an essential progress in adopting a product strategy. The approach describes the procedure and the methods which should be used by the development team in order to get an aligned semantic product understanding from companies' as well as customers' point of view.

The main concepts of ***product structure*** (see chapter 8.3) help SMEs' development teams to identify relevant product attributes in order to define product alternatives. The main concepts of Chapter 9 help SMEs' development teams to ***link/ align the product strategy with relevant components*** (see chapter 9.3) in order to suggest design rules for the development of new products.

The approach presents an overview of essential procedures and methods which are used in order to determine the most relevant quality features regarding the customers' perception, to determine important quality features regarding the product strategy and to collect unconscious information with the help of Eye-Tracking and by means of physiological signals. (see Köhler, Falk, Schmitt, 2014a; Köhler, Falk, Schmitt, 2014b)

10.3 Challenges of the Quality Gate systematics

The implementation of the main concepts of emotional design into the easy-to-use approach evokes some general and specific challenges regarding the early integration of customers' emotions into phases of the PDP by using a Quality Gate systematics.

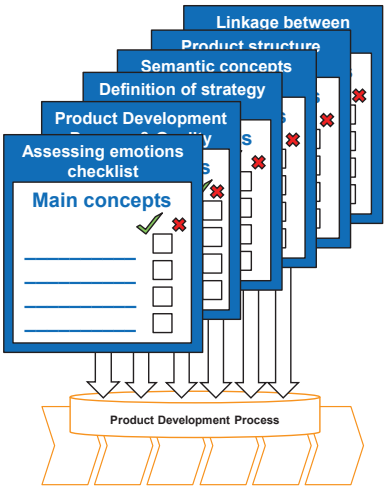


Figure 28: Using main concepts of the guidelines to manage challenges of early phases of PDP

The challenges can be subdivided into three areas: SME specific challenges, challenges with regard to product design and Quality Gate challenges.

10.3.1 SME specific challenges

SMEs face various challenges during product development and design as recognized in interviews with many SMEs during the CONEMO project. Nevertheless, there are three main characteristics that are essential for the definition of SME specific challenges in relation to a Quality Gate systematics.

Firstly, SMEs usually have a lack of resources (e.g. financial resources). Therefore, the Quality Gate systematics and the relating methods should demand minimal monetary efforts.

Secondly, SMEs base decision making on intuition or experiences of recent product development processes. Although good instincts and creative tolerance are favourable during the product design in relation to development tasks. Management decisions require a sustainable and profound basis of decision-making, which is based on knowledge and data analysis. The main problem is a lack of objective key figures and expertise in respect to measuring valid customer requirements. As a consequence of this set of problems, the Quality Gate systematics has to sensitize the management to focus on profound and reliable customer requirements for decision-making (Köhler, Falk, Schmitt, 2014a/b).

Thirdly, SMEs generally consist of a flat hierarchy. Advantages such as personal relationships, instructions and controls, short and direct communication of information and small degree of formalization lead to a high level of flexibility. In order to preserve this high level of flexibility, the Quality Gate systematics has to be flexible too.

The lack of expertise and financial opportunities with regard to the use of methods of market research such as customer questioning or multi-sensory measuring of perception necessitate analyses of benefits and efforts in order to find the optimal method for a

specific product development. Moreover, the acquisition of required metrologies such as Eye-Tracking has to be analysed in detail.

In conclusion, the following SME specific challenges can be determined.

Check list – Challenges SME	Requirements
Monetary efforts for SME	The use of the Quality Gate systematics should be affordable, user-friendly and easy to use.
Strategic decision-making	Strategic decision-making should be based on objectively generated data.
Flat hierarchy	The contents of the Quality Gate systematics should be flexible and adaptable. There is a need for a documentation of all product development projects.
Benefits and efforts analysis	The use of methods of market research necessitates analyses of benefits and efforts

Figure 29: SME specific challenges

10.3.2 Challenges with regard to product design

The product design, which is an essential distinguishing feature in terms of business competition, plays an important role for the development of the Quality Gate systematics (Köhler, Falk, Schmitt, 2014a). Results of CONEMO show that SMEs have a big interest in the customers' perception of their products. Therefore, the challenge for the Quality Gate systematics is to integrate an approach for objectifying visually Perceived Quality within the Quality Gate systematics. Requirements, approaches and criteria of measurement will be assigned to the methodology by the following check list.

Systematic Consumer Evaluation Mesaurement	Check list – Challenges in Emotional Product Design		
	Requirements, e.g.:	Methods, e.g.:	Criteria, e.g.:
Semantic framework	■ Alignment of company and customer perspective	■ Customer surveys ■ Cluster analysis ■ Affinity diagrams	■ Semantic words
Determination of the product structure	■ Product tear-down in relevant components	■ System analysis ■ Structured approach towards Perceived Quality	■ Outline of the product divided into enumerated quality features
Alignment of strategy and structure	■ Alignment of semantic words and quality features	■ Customer surveys ■ Eye Tracking ■ Strategy-quality feature matrix	■ Design recommendations ■ Reducing design alternatives
Capturing and evaluating emotions	■ Measuring customer emotions	■ Customer surveys ■ Mesauring physiological signals	■ Validated decision in favor of design alternatives
Implications for the PDP	■ Customer Emotional Quality Gates		

Figure 30: Challenges product design (based on Köhler and Schmitt 2012; Köhler, Falk, Schmitt, 2014a/b)

10.3.3 Quality Gate challenges

The challenges with regard to Quality Gates are similar to the previously mentioned steps of Quality Gates (Chapter 5.2.4) and are shown in the following check list:

Procedure to design Quality Gates	Check list – Challenges for the Quality Gate systematics Requirements
Defining a reference Process	Content and process-oriented segmentation of the product design by a reference process
Postitioning of the Gates	Postitioning of Quality Gates at critical interfaces of the process
Operational structure	Dedicating responsibilities and identification of customer-supplier relationships
Defining requirements	Defining requirements regarding service, criteria of mesaurement and supporting approaches
Assessing achieved progress	Setting a systematics of assessing services
Documentation	Choosing a suitable documentation

Figure 31: Challenges of Quality Gate systematics

10.4 Challenges, criteria of measurement and methods for Quality Gates for emotionl design

As mentioned in chapter 5, a well-structured PDP reduces the complexity of developing a new product. Especially in the first periods of the PDP, it is essential to focus on a customer-oriented design. As a consequence, the Quality Gates of product idea, product concept and product design should be analysed in detail.

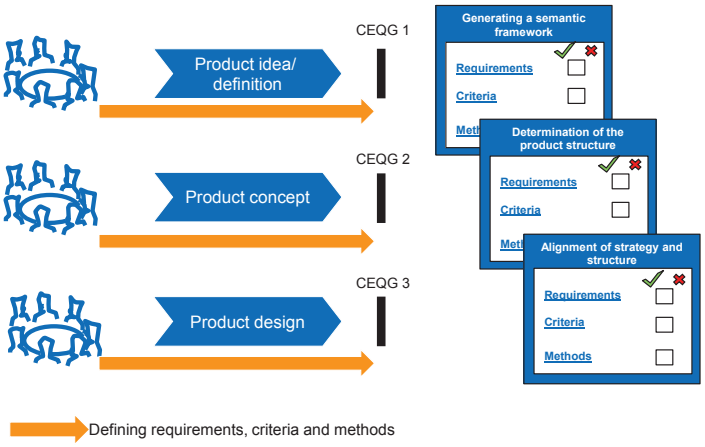


Figure 32: Using requirements, criteria of measurement and approaches to integrate Quality Gates into the PDP

In the following, exemplarly three check lists are presented which summarize the most important requirements, criteria of measurement and approaches concerning the first three Quality Gates.

Quality Gate 1 – product definition/ produt idea	
Requirements	The main aspects in the period of product idea are to ensure a customer orientation as early as possible. This can be achieved by the use of semantic concepts. As a result, you can determine a common product understanding which is focusing on the enterprise strategy as well as on customers' requirements.
Criteria of measurement	A specific amount of semantic concepts which describe the upcoming product, is classified as an undisputable criterion of measurement. Adjectives are preferable because of their describing character. By semantic concepts the customer and the enterprise get a coinciding understanding of the upcoming product.
Approaches	The next step defines the necessary approaches. By using the semantic concept, questionnaires with customers as well as cluster analysis, affinity diagrams or a Kano study are important devices to decrease the amount of semantic concepts.

Quality Gate 2 – product concept	
Requirements	Within the product concept the structure of the product is defined. Technical description helps to align the structure of the product to customers' requirements. The product should be subdivided into visually and perception relevant product components (quality characteristics). (Köhler, Falk, Schmitt, 2014b; Köhler and Schmitt 2012)
Criteria of measurement	One appropriate criterion for measurement is a list which consists of all numerated quality characteristics (clusters of perception).
Approaches	The product can be subdivided into its technical features by a function and system analysis. The use of the structured approach towards quality perception can help to determine a cluster of perception by using Eye-Tracking, questionnaires or physiological measurements.

Quality Gate 3 – product design	
Requirements	Product strategy and structure have to be adjusted by semantic concepts and the defined quality features.
Criteria of measurement	One criterion of interest is to identify design recommendations which are based on thephysiological signals evoked by design alternatives.
Approaches	Important approaches are customer questionnaires, Eye-Tracking, measuring physiological signals and strategy-quality matrices.

10.5 Implementation of the Quality Gate systematics for emotional design

The implementation of the Quality Gate systematics aims at supporting SMEs by a computerized tool which collects, edits and provides information that is relevant for

objectifying customers' emotion systematically. This information should be used in the early periods of the PDP. The tool consists of a layout that differs from the usual project management. It rather sensitizes SMEs to focus on emotional product design by integrating Quality Gates.

10.5.1 Choosing a suitable software

With regard to the challenges of chapter 10.3.1, a suitable development environment has to ensure low (financial) efforts concerning usage, development and service. Moreover the approach should be easy to use and neatly arranged regarding interface and usability. As a result, the approach was developed for Microsoft Excel © as it is used in nearly all SMEs.

10.5.2 Implementing the approach step by step

The approach was developed with regard to the challenges from chapter 10.2.1 and 10.3 and consists of several sheets.

First, the kind of product, physical or non-physical product has to be determined (1), in order to define the appropriate reference process (2) for product design. The user has to enter how many tasks are planned for each period (3). After that, the user can go to the next sheet.

Figure 33: First sheet of the approach

The second sheet is called "project plan of the emotional design" and generally consists of the following columns:

Topic of the column	Explanation/ Content
Description of task	Description of the task to be performed
Objective	Objective of the task
Measured	Result of the task that is used as input for later tasks
Approaches	Possible approaches that support achieving the objectives
Responsibility	An overall responsible authority, a co-responsible authority and an authority that has to be informed for each task
Customer (intern / extern)	The subsequent task that is dependent to the result (Output) of the task.
Supplier (intern / extern)	The predecessor whose output is the input of the current task.
Check list	Helps to collect further documents that are relevant for the task.

As soon as the cells (4) are filled with information by the user, the next sheet can be displayed.

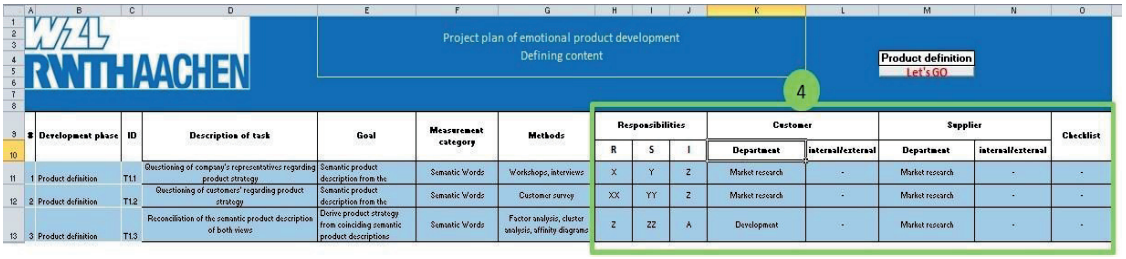


Figure 34: Project plan on the second sheet

Now the user is within the first period of the reference process (product idea). The user can switch back to the project plan and choose all periods of the reference process (10). In the middle of the sheet the user can see the reference process and the corresponding Quality Gates (5). The considered period is highlighted (6). Under the reference process, the objective of the whole period is displayed (7). Right below, the status of the emotional design process is visualized, supported by a traffic light systematics (8). The assessment of the status depends on the status of the product idea process.

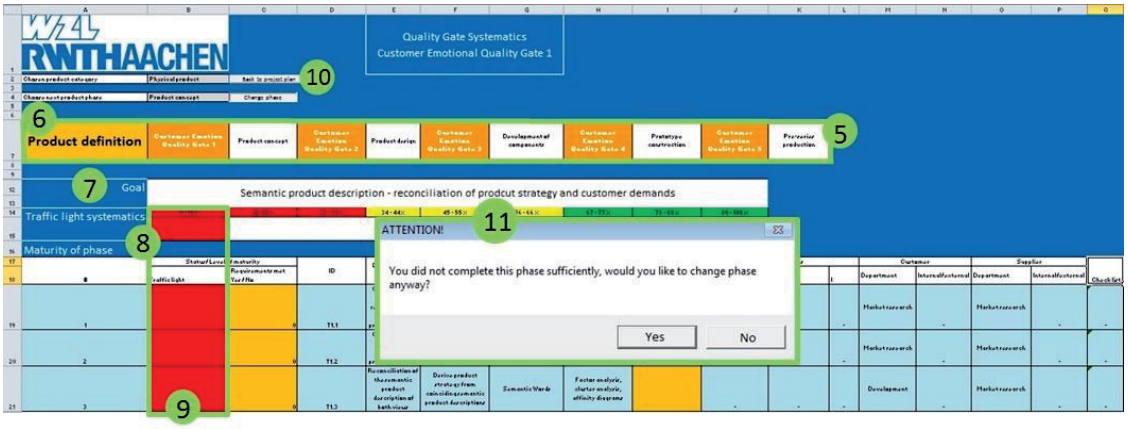


Figure 35: Period of the product idea on the third sheet

The known project plan of the previous sheet will now be added by the topics “status/level” and “used approaches” (9).

Topic of the column	Explanation/ Content
Status / Level	Gives an overview of the status of a certain task and has influence on the assessment of the main status (8)
Requirements met	When the requirements are met and the objective can be **(Y/N)** described by data, the user confirms meeting the requirements by entering “1” into the cell (9), otherwise “0”
Used approaches	Documentation of the used approaches while working on the task

The confirmation of achieving the objective by the user is one of the key functions and influences the traffic light on the left. A green status of a cell means that the task was successful; otherwise the cell will stay red. Each task which was successful has an influence on the status of the whole period. If the user wishes to switch to the next period of the PDP, he will be able to by clicking on “change period” (10). However, if the user does not reach a green status by achieving enough objectives, he will see a warning message on the screen (11). This message emphasizes that the user has neglected too many tasks and probably, will design a product with a low degree of Perceived Quality if he proceeds. Even though, the warning message does not mean a stop. The user is able to go back in order to meet more requirements for an emotional design or to proceed if he wants to. This procedure is meant to be a sensitisation for focussing a user-orientated product design. The following sheets for the next periods of the PDP have the same layout. There are only differences in the tasks content and the main objective. (Köhler, Falk, Schmitt, 2014a)

10.6 Main concepts

From this chapter it is important to remember:

Quality Gates – Checklist	
Main concepts	• Identifying product attributes which are essential for customers’ emotions offers a potential for cost savings and increases the satisfaction of customers. • The Quality Gate systematics secures emotional products throughout the product development. • This Quality Gate systematics provides a good basis for a flexible and adaptable PDP which enables a good adjustment of product development projects. • Most of the SMEs lack the ability of quantifying customer’s emotions and perceptions. • SMEs have to estimate how much effort it takes to use the methodology: In the case that SMEs have got a lack of capacity or know-how regarding the use of the methodology, it could be a win-win situation to hire services which offer the ability of quantifying customers’ subjective data. • The integration of further measurement technology is possible during each stage of the PDP because of the adaptable Quality Gate systematics.

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12 Brief summary of the research project CONEMO and acknowledgements

In a time of globalized markets and the increasing technical competence of low wage countries the importance of user centred design that enhances customers' perception and Perceived Quality increases dramatically. A good understanding of user perception could be the difference between success and failure. This is especially important for European SMEs, because they cannot afford (time, money etc.) trials of different prototypes and re-design procedures. The SMEs need a methodology that enables them to assess customers' emotions.

The main goals of CONEMO are to develop

- a new testing service for SMEs, able to measure customers' emotions and
- a Quality Gate systematics based on a criteria catalogue that contains descriptions and requirements, measurement parameters, product structure and product functions structure that secures a good consumer perception.

The aims of the research project CONEMO were successfully achieved.

In this project the customers' perception of a product was investigated by means of objective parameters using physiological signals. Based on the results the researchers developed a new methodology and its implementation in the process of product design. The research investigated which parts of a product are in fact important to the customer and how an arrangement of parts will impress him.

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Further information about the project CONEMO are available via: **conemo.ibv.org**