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**Downstream and upstream extension
of the House of Quality**

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Executive summary

1. During 1993-94 the authors followed a product development process in a Danish butter cookie company. The process was structured according to the Quality Function Deployment technique House of Quality. Originally, the intention was to study the prototyping process that we and the company had expected to take place during the project period. Well into the project, it became clear that a prototyping process would not be established. At that point, the project was revised with a view to being able to study and analyse what actually happened. Customer attributes were derived from a discussion in a diabetics end-user focus group. During a series of meetings, the production manager and the sales manager transformed attributes into characteristics and constructed Houses of Quality for a sugar-free cookie.

2. Downstream on its way to the end-user, the product passes through a chain of users, eg distributors and retail chains. To the extent that a company relies on information from one of the intermediary users, it may be kept unaware of those end-user wants which are thought by the intermediary to be incompatible to its own. In order to reveal and depict such incompatibilities as input for product development, we suggest adding an *incompatibility matrix* to the traditional House of Quality.

3. Upstream, most product characteristics were deployed to internal company functions. In addition, some characteristics were deployed to potential suppliers. In this way the departments and firms that seemed best suited to enter the phase of product development interaction, and eventually to form the production network, were identified. The traditional Houses of Quality were modified accordingly into an upstream fan-shaped range of linked houses. One house for each member of the development network.

4. The transformation processes and characteristics constituting this fan were based on the knowledge possessed by the company before entering into development interaction with suppliers. If it is these characteristics which are used to express the demands of the company in the subsequent interaction process, much information may be lost. We suggest that in development interaction with a supplier, a company should dispense with the initial transformation processes which motivated it to initiate interaction with the particular supplier, and rather initiate interaction on the basis of end-user attributes in their original forms, making new transformation processes into characteristics based on the joint knowledge of the members.

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1. Introduction

In intra-company QFD the upstream deployment of the voice of the end-user to various company functions is essential, and many studies have focused on the cross-functional problems arising from such processes (reviewed by Moenaert, Souder, De Meyer and Deschoolmeester, 1994).

In inter-company QFD demand is also deployed through a company to its suppliers. An example of cross-capability interaction on the basis of such information is discussed in Kristensen (1992a).

Furthermore, whereas it is preferable for upstream interaction to take place within geographically narrow clusters, the need for sophisticated market information makes it appropriate for downstream interaction to take place over long geographical distances (Kristensen, 1992b) between companies located in such a way that their key functions have access to “sticky information” (von Hippel, 1994).

When local upstream product development interaction is directed in this way towards an end-user demand which is very unfamiliar to local suppliers, demand is normally represented by the company’s derived demand and not by the voice of the end-user.

Even on its way to a completely homogenous segment of end-users, a product normally passes through a long chain of downstream actors in which each of them are *users* and must be considered customers.

Accordingly, user-interaction can involve interaction with users who store, transport, repair, and even recycle the product. If the interaction between the producer and his end-user results in a product which does not ultimately satisfy the wants of the other key-users in the chain, or if the interaction with retailers has resulted in a product which does not satisfy the wants of the end-users, the commercialisation phase of an innovation may fail.

In product development, market analysis is ideally directed towards several actors in the downstream chain (Koppelman, 1987). In Quality Function Deployment (QFD) the expression ‘the voice of the customer’ may accordingly be interpreted as the voice of any customer or any number of customers on the different links of the downstream chain.

In the same way as it is common to find incompatible wants expressed by the individual user, we may expect to find incompatibilities between the wants expressed by the different downstream users (Smith & Laage-Hellman, 1992 p. 47). If found, these incompatibilities may reveal opportunities for product development. *The question we address on the downstream side is:* how can we depict such incompatibilities as a formal input for product development; an input that might lead to product uniqueness, as it presents the company with market wants which do not manifest themselves to the individual users.

When we look upstream, an ideal network for cross-capability interaction in product development has to match:

- 1) the supply of capabilities, some of which require decades of experience to be competitive, (Hayes & Pisano, 1994)
- 2) the unceasing flow of new product ideas (Day, 1994) and
- 3) the frequent requirement of new capability constellations for new products (Womack & Jones, 1994).

Facing this task, traditional product development team building based on existing partnerships may constitute a starting point which is too narrow for new product development. In the same way that “cross-functional teams can create horizontal silos just as isolated...as vertical silos have been” (Pine, Victor & Boynton, 1993 p. 114), cross-capability teams based on the usual traditions for partnership may run the risk of petrifying into silos, thus narrowing the participants’ view of the new product development possibilities which can be realised within the scope of existing and potential capabilities of the partnership itself.

To avoid this, the first phase of product development team building should be to make the decision as to which capabilities are needed by the interaction partners, regardless of whether they are possessed – or can in the future be acquired – by the traditional partners. Not until then can it be decided whether the present task calls for reconfigurations (Normann & Ramirez, 1993) of the product development network.

The question we address on the upstream side is: how can end-user need specifications be used as an outline for such reconfigurations towards the lean enterprise.

2. The House of Quality

In 1972 the Mitsubishi Shipyards in Kobe developed a technique in which customer wants were linked to product specifications via a matrix format. This technique is known today as The House of Quality and is one of many techniques of Quality Function Deployment, which can briefly be defined as “a system for translating customer requirements into appropriate company requirements” (Simintiras & Lancaster, 1994 p. 389).

The purpose of the technique is to reduce two types of risk: First, the risk that the product specification does not comply with the wants of the predetermined target group of customers. Secondly, the risk that the final product does not comply with the product specification.

To reduce *the first type of risk*, the product specification takes its point of departure in ‘the voice of the customer’. In order to preserve ‘the voice of the customer’, and thereby avoid the kind of misinterpretation which can result from rephrasing and editing the wants of the customers, verbatim customer quotations are used whenever possible. Customer wants are subsequently transformed into product specifications. Thus, the House of Quality can be perceived as a graphical format for transforming *customer’s criteria to producer’s criteria*.

The second type of risk is reduced via additional transformations of the product specification to, eg product parts, elements and processes, and production specifications. Thus, via the additional Houses of Quality the producer's criteria are transformed to 'input factors'.

In summary, QFD can be described as a market-oriented product planning or development technique which seeks to increase interfunctional communication and integration through the application of one or more Houses of Quality. The technique is thus not an end in itself, but a means to achieve increased communication and integration in the product planning process and to reduce the two types of risk mentioned above.

A simple way to implement QFD (Hauser & Clausing, 1988) is by building a system of four successive Houses of Quality:

- 1) In the first house customer wants are linked to quality characteristics. These characteristics can be regarded as technical specifications.
- 2) In the second house quality characteristics are linked to product component characteristics. Thereby, the ways in which requirement specifications can be met are identified.
- 3) In the third house, product component characteristics are linked to processes.
- 4) In the fourth house the processes are linked to production planning.

The four-house model is the most common, presumably because it is the easiest to implement. This is especially the case in the electronics, engineering and automobile industries in which the physical products can be described as several components assembled into a finished product, and in which the development processes can be said to be compatible with the four-phase model.

A more comprehensive way of implementing QFD (King, 1989) is to construct as many as 30 different houses, besides the four houses mentioned, which can be used, should a company find the four most common houses insufficient. This method largely entails that the company custom-selects the houses specifically needed for each developmental project. The deliberate absence of guidelines underscores the necessity that the technique be custom-designed to the individual company, as well as the fact that QFD and HoQ share only an underlying idea.

One reason why there has not been a larger emphasis on adapting QFD to the individual company is supposedly that most applications have concentrated on the first house, and the following houses – be they three or thirty in number – have only been used in a minority of cases. King (1989) estimated that less than 5% of QFD applications go beyond the first house. In Japan it is estimated that approximately 50% of applications go beyond the first house. According to King another reason most QFD projects do not extend further is that the first phase alone gives a company an incredible amount of information. The transformation from customer criteria to producer criteria is considered valuable regardless of whether or not producer criteria is later linked to input factors.

A second reason is that the first house often becomes so large that there is neither the time nor the resources to go on to the next.

A third reason is, that as long as the method is new for a company, the proficiency in its application will be inadequate. As a result, the work will consist of many repetitive revisions of the first house which never reaches a level of satisfaction necessary to be used as input for a second phase.

The results most often referred to stem from Toyota's experience with the introduction of QFD since 1977. The results stated are: increased customer understanding, fewer and earlier design changes, shorter delivery time, fewer start-up problems, decreased costs, improved product quality, improved productivity, fewer customer complaints, increased customer satisfaction, increased market share, and improved communication, "at Toyota they have developed such heightened communication skills that they no longer even have to write all the stuff down on paper" (Sullivan, 1986). Taking this list of alleged results into consideration, it is understandable that the QFD idea has gained recognition in the West. But after a decade of experience it remains difficult to find documented results that compare to those of the Japanese. Griffin (1992) found that 27% of the developmental projects studied achieved tactical, and 83% achieved so-called strategical process advantages by applying QFD. It was demonstrated that QFD 1) structures decision-making processes across functional groups, 2) builds a solidly organised, highly motivated team and 3) moves information efficiently from its origin to the ultimate user.

Griffin and Hauser (1992) concluded that the application of QFD results in more effective communication both within the QFD group, and between the group and the respective suppliers. On the other hand, the study also concludes that the application of QFD decreases communication between the QFD group and the rest of the organisation.

3. The study

Aim of the study

The aim of the study at its inception in 1990 was to study prototyping by observation.

The empirical section of the study was to begin in 1993. During the intervening period the aim of the study was made more precise, and special emphasis was placed on the exchange of tacit information during the phases of the prototyping process. It was also decided that in this particular company, which did not have its own experience with QFD, a classic action research approach would have too much influence on the process. For this reason, funds were found in the budget to employ a person (the first author) whose function it was to help company employees in the practical application of QFD during the project.

The scene was thus laid for an ambitious project in which a considerable amount of luck was required if the product development process, which we had contracted with the company to

study, was to develop during the project period in the way we and the company expected. In other words, that a prototyping would take place which would allow for the study of the exchange of information.

It would later be seen that we did not have such luck.

During the preliminary meetings it was, in fact, ascertained that some of the conditions necessary for the desired study had been met. The company had planned a third baking line especially designed to produce a small prototype series. A project (sugar-free cookies) was selected which was already on the drawing board in the company, and in which a German purchaser existed who was interested in participating in the development of the product. Moreover, according to the company, it had experience working with prototyping in co-operation with actual retailers.

However, the third baking line was not established in the company. And when the German purchaser backed out, attempts to establish contact with another customer were unsuccessful. This meant that the process, which was carried out and studied in actual practice, did not evolve as far as a prototyping in interaction with a purchaser. Considering the original aim of the study, this was an essential lack. When we realised that this was the case, the total budget of the project was cut in half. In this way a reasonable balance was resumed between the effort going into the project and its anticipated results.

Of the originally formulated sub-goals, the study of the cross-functional work with the transformation problem within the company, and the analysis of downstream and upstream implications were realisable.

The following is a presentation of the study in its altered form.

Company

The Danish company, which produces Danish Butter Cookies in colourful packaging, has 80 employees. The company was chosen for two main reasons:

- 1) it exports more than 99% of its production to primarily the United States, Germany, Japan and the Far East. The company's major suppliers are located in the same non-central region within a radius of 20 miles. At the beginning of the study we made certain that the company usually applied prototyping when adapting products to the needs of the customers. Thus, the company is typical of the companies discussed in Kristensen (1992b) in the sense that it combines an equidistant view on the downstream market with a Euclidean upstream view.
- 2) it agreed to provide all information needed and comprehensive employee participation in the pilot study. A formal MAPP-contract was therefore signed, and the project started in 1993.

Until 1993 product development in the company focused on incremental product modifications and minor adaptations to specific demands within the individual markets for Danish Butter Cookies. The cross-functional experience of the employees derives from the work on such minor adaptations and from the daily running of a small company.

Development team

The House of Quality technique is normally carried out by a cross-functional task force in which both the marketing and the production functions are represented. In the present study the task force consisted of the sales manager and the production manager. Both had many years of experience in their respective functional fields in the bakery business.

Development task

The point of departure of the House of Quality technique is a predetermined product concept and target group. Therefore, it was necessary to determine these before starting on the actual development. The development task was identified through personal interviews with the sales manager and the general manager in the company in the spring of 1993. The product development task faced in this pilot study was a genuine task in the sense that the company had put the product idea to paper and elaborated it prior to the present study.

The idea originated from German retailers. The company had never produced a sugar-free cookie but decided to do so. The concept was to produce a small cookie, ie not a biscuit. The central development task was to make the cookie taste good, an attribute that, to put it mildly, does not characterise the existing products in this market. The company baked several versions of sample cookies which were tasted by the diabetic friends of the employees as well as the employees themselves. In this way, four versions of sample cookies were baked using progressively better recipes during six months. The last version was presented at a food fair in Cologne in early 1993. Following the standard development sequence of the company, further development of the concept was to take place in interaction with a retailer who would eventually introduce the product on the market. As mentioned this proved impossible to implement in this particular case. Therefore we had to approach the task from another angle, ie as a pilot study based on the sales manager's knowledge of the typical retail customer and, later, on data from a Danish end-user focus group.

During the project we familiarised ourselves with the terminology and processes in the baking industry through visits to, and interviews with, the suppliers of ovens, equipment, chocolate and sweeteners.

Retailer input

The company was used to developing and modifying products according to the wants expressed by retailers, and the sales manager was thus used to represent the voice of the direct customer. Thus we assumed that he was able to represent the voice of the German customer. However, at a meeting on 15 September, 1993, with both the production manager and the sales manager, we realised that the initial list of customer wants prepared by the sales manager would not suffice as input to the House of Quality technique. We therefore asked the sales manager which wants were actually expressed by the German customer. Unfortunately, as the sales manager had not obtained sufficiently detailed knowledge of the wants of the customer at the initial stage of the development process, this approach also proved unsuccessful. We finally concluded that in order to generate a useful set of customer wants, we had to extensively supplement the sales manager's list. Because no market analysis had been formally documented we decided to conduct a focus group study ourselves.

End-user input

We agreed with the company that for this purpose a Danish focus group would form a sufficient basis for the present study, in the sense that it was expected to represent the core attributes of an end-user demand for sugar-free cookies unknown to the company. Whereas one advantage of this was that we were able to avoid the problem of translating the end-user wants, the choice of Danish end-users naturally implied that the resulting wants were not representative of the predetermined target group.

If the purpose of the study had been to develop an actual cookie to be introduced on the German market, this approach would naturally have been unacceptable, as it would have been based on an assumption which was probably flawed, namely that German and Danish diabetics have similar wants. However, as the purpose was to study an intra-company cross-functional transformation process, we decided that end-user wants from a Danish focus group would suffice. Thus, we assumed that if the end-user wants we collected were a true representation of end-user wants, the process-related outcome of the study would be valid.

We contacted the Diabetes Association, as we expected that active members of the association would be able to articulate wants better than arbitrarily chosen diabetics.

The Diabetes Association referred us to various local representatives who helped us find members, who we contacted by telephone. The participants were all diabetics living in Copenhagen. In order to generate a wide range of attributes, the selection of participants aimed at variation in age, sex and user habits.

In the preliminary screening we made sure the participants met the following requirements:

- 1) had diabetes
- 2) had previously tasted cookies for diabetics
- 3) had no professional experience with either cookies or marketing.

The six participants were informed about time, place, length and general subject. The telephone recruitment was followed up by written confirmation.

All of the recruited participants were present. At the group discussion a variety of sugar-free cookies available on the Danish market were placed on the table. This was done because we assumed that it would be easier for the participants to recall earlier experience when presented with sugar-free cookies, some of which they had probably tasted before. Furthermore, this would enable them to link their comments directly to the cookies. The cookies in question were: Irma's Mixed Cookies (250g, transparent plastic tray), BBC Struer Mixed Cookies (200g, semi-transparent bag), VENO Vanilla Wreaths (200g, transparent plastic tray), and VENO Coconut Wreaths (200g, transparent plastic tray).

The participants were welcomed, received a short introduction to the subject, and were informed as to the purpose of the group discussion. Afterwards the participants were asked to introduce themselves, and the discussion was opened by asking the question "How often do you eat cookies?". During the course of the discussion, various inducement methods were employed, including 'probing' and the direct presentation of additional products and packaging with particular connections to the various subject matter, including: VENO Cherry Wreaths, Schneekoppe Schokogebäck, Boots Chocolate Chip Cookies, as well as various boxes and containers.

The group discussion took approximately two hours, during which time the moderator made sure that all items in the topic guide were sufficiently covered. The participants received a transport allowance and a small gift. Furthermore, we asked the participants if we could contact them again if further end-user information on the subject was needed.

The group discussion was tape-recorded and subsequently transcribed. The transcripts were then read through, and the passages of text in which the participants expressed wants for a sugar-free cookie were copied onto cards.

Even though one of the basic ideas behind QFD is that a company should be able to react to the true voice of the customer, the customer remarks are often re-worded into wants or wants-sentences, as these are more operational. One reason for the re-wording is that importance weightings and perceptions of performance are later to be attached to the wants (or wants-sentences) and furthermore, the importance of end-user wants is to be used when calculating importance weightings for quality characteristics.

Whereas potential customers sometimes express direct wants or wants-sentences, focus group discussions do not always produce this kind of output. Actually, the participants sometimes

express opinions that might give insight to the company in the development process, but which are not operational wants or wants-sentences to which importance weightings and perceptions of performance can be directly attached.

As the end-user input did not represent the true voice of the end-user (it was the true voice of a pseudo end-user group), we did not see any point in attaching importance and perceptions of performance to the wants, as only the outcome related to the interaction process would be valid. Therefore we were able to use the genuine, not-edited voice of an end-user.

The output from the focus group discussion consisted of a number of cards, each with a customer quotation.

Observation and registration

The team had not used the House of Quality technique before, so it was decided that one of the authors should act as moderator/facilitator and the other author should act as observer.

The applied method consisted of observing the team's reaction and actions when presented with information which would be transformed via the QFD format. All observations, meetings, etc, were recorded on video or tape.

The purpose of our meticulous registration of all intermediate results, (eg affinity diagrams and Houses) and of the communication processes between these results was to document the basis for our analysis, and of course to be able to look at the material over and over again in order to ensure correct understanding.

4. Results

Affinity diagram

The sales manager and the production manager created an affinity diagram based on the quotations from the group discussion.

The identified customer remarks can be difficult to work with, among other things because they contain different levels of detail. Consequently they are structured by way of an affinity diagram. The affinity diagram is a group consensus technique used for organising a large set of unstructured data, eg quotations from a focus group, into a smaller set of groupings, each consisting of data items with an intuitively close affinity. The method is carried out by a cross-functional team with sufficient experience in the field under investigation, and is standard procedure for organising consumer data prior to the application of the House of Quality technique.

In the present study the steps were:

- 1) Verbatim quotations from the focus group discussion were transcribed onto separate cards which were subsequently shuffled.
- 2) At a meeting on 5 October, the sales and the production managers (ie the cross-functional team) were briefed on the steps of the method. The cards were presented one by one to the managers who then jointly grouped the cards which naturally seemed to belong together. Concurrently with the grouping process, the team established group headings. The process of grouping and regrouping continued until all cards had been separated into groups, and the team had reached a consensus regarding the appearance of the affinity diagram.

We made a fair copy of the affinity diagram, thereby giving it a format which could immediately be used as the left-hand column of the first House of Quality. To make sure that the structure of the end-user needs was correct, we sent a copy of the affinity diagram to the sales manager and asked that he and the production manager jointly go through the structure to correct possible misplacement. A few corrections were made, and by 20 October, 1993, the final structure of the affinity diagram had emerged.

Incompatibility matrix

A company like the one we studied here, with a tradition for relying solely on knowledge of end-users in the form provided to them by retailers, can only guide product development towards the wants of the end-users to the extent that these wants are presented to the company by the retailer.

However, the retailer acts as a filter. He, especially, cannot be considered a reliable transmitter of knowledge about the specific end-user wants, as some will be incompatible with his own. Yet the costs of obtaining knowledge about end-users are high. And although the possibility of incompatible wants is certainly known to everyone involved in product development, it is simply disregarded in the daily practice of a small company.

In the present study, the company was confronted with end-user data for the first time, and in this situation the incompatibility between the retailer wants recognised by the sales manager, and the end-user wants expressed by the focus group, became apparent.

However, we made this observation after finishing the empirical phase of the project. Based on the existing data we are not able to make a thorough discrimination between the retailer- and the end-user wants in the diagram. But we can illustrate the problem:

Example:

The diabetic end-user want expressed in quotation no 69: "As they intend it for diabetics, they could make the text more legible, because we all have problems with our eyes to some extent." The sales manager's reaction to this was: "The size of the section [on the package where the product description is located] has to be

5 x 10 cm. . . . let us say that it has to be written in large letters, ie 12 point". This end-user want was incompatible with the retailer want known to the sales manager as shelf appeal. In his own words: "Well, it is an awful rigmarole which has to be written there. I wish we could place it on the side of the package, but that can probably not be done. It is related to the fact that we think it is smart. Our customers [the retailers] agree and we are able to place it like this and like this [several sides of the package can face the end-user when the product is on the shelf]" . . . "you know, it is the stores that have to deal with the problems of displaying the product, and of the products having to appeal to the customers".

This kind of incompatibility may only be possible to identify by confronting the different types of wants. Incompatibility may offer valuable guidance regarding which areas to address in development to obtain superior product quality.

We suggest that this kind of inter-customer incompatibility of wants can be identified through the application of the House of Quality format in a step-by-step approach:

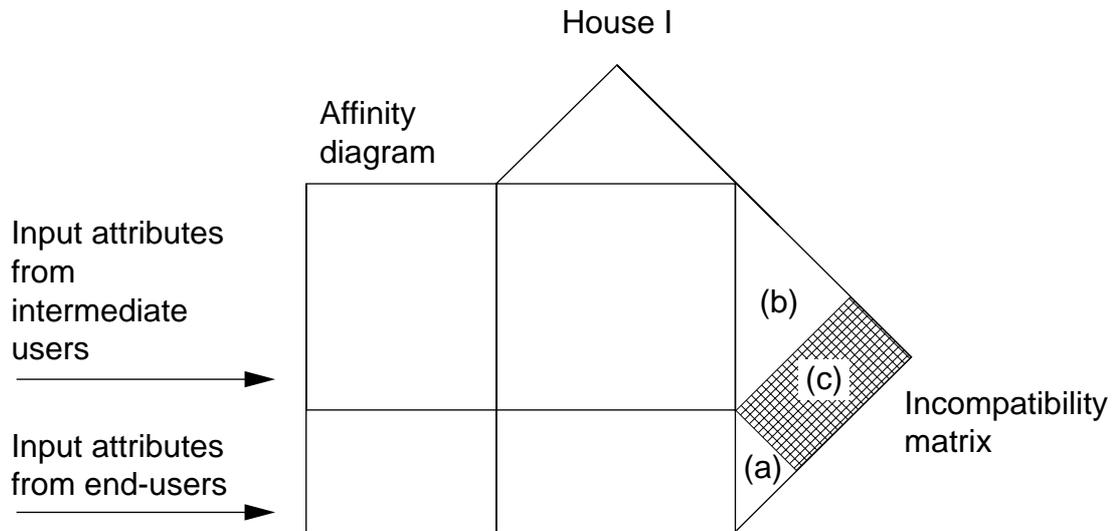
- 1) Identify the chain of customers in the downstream chain of distribution
- 2) Identify the wants of the respective customers
- 3) Identify incompatibilities between the wants of different customers
- 4) Formulate the development problem: obtain compatibility
- 5) Deploy the development problem: transmit information on incompatibility to internal departments and external suppliers.

During the process of constructing the affinity diagram, the left-hand column of House I was added, thereby allowing user want incompatibility to be simultaneously identified. So instead of immediately moving on to fill out the matrix in House I, we suggest that a triangle be added to the right of the house.

In figure 1 two user groups are shown, and the triangle is divided into three sections in the same way as the top-roof is divided in Bech et al. (1994, Figure 6 p. 11). In triangle (a) possible compatibilities and incompatibilities between the attributes demanded by end-users are identified. In triangle (b) the same is done for the attributes demanded by retailers.

Depicted in the matrix (c) between the two triangles are the possible compatibilities and incompatibilities between the attributes demanded by end-users and retailers respectively. Such are often neglected, as they are expressed neither by end-users nor by retailers. They appear for the first time when the two parties' respective demands for attributes are confronted in the same House of Quality. Here, the incompatibilities between the attributes the product has to offer to different downstream customers manifest themselves as a development task, eg to develop a product with both a copious product description, written in large letters and shelf appeal.

Figure 1. Incompatibility matrix



A transformation from independent attributes to interdependent characteristics in the matrix is therefore replaced by a transformation from interdependent attributes to interdependent characteristics.

House I

Following the structuring of the end-user quotations, the task was to establish quality characteristics on the basis of the quotations-level of the affinity diagram.

As the output of the development process is to be evaluated against the target value of the quality characteristics which are established later on, quality characteristics must be objectively measurable. Furthermore, the quality characteristics must directly affect the end-user perceptions of the product (ie they must not be ingredients which affect end-user perceptions only through their impact on for instance taste or consistency). Thus, the complete set of quality characteristics are equivalent to a product specification, and the target values of the quality characteristics are the equivalent of target values to which the products have to conform during a quality inspection of finished goods.

At the primary level in the affinity diagram two general groups were established: *Content of the packaging* and *Packaging*.

During the first meetings at which both managers had been present, we observed that an overlapping between the respective knowledge of the sales manager and the production manager were practically non-existent. The sales manager handled packaging matters, the production manager handled all matters concerning the contents of the packaging, ie the cookie. The

primary-level division emerging from the affinity diagram process distinctly reflected the functional division.

The cross-functional phase thus led to an arranged functional division, which was subsequently achieved by dividing the remaining transformation process into two concurrent transformation processes that could be carried out by the sales and production managers respectively.

We informed the production manager of his task: to establish measurable quality characteristics on the basis of the end-user quotations that related to the cookie.

Because the focal company is used to developing products by applying the prototyping methodology, the production manager was not able to establish measurable quality characteristics immediately, but listed ingredients. In connection with the baking of test cookies for the Cologne Fair prior to this study the production manager had been in contact with possible suppliers of ingredients with the desired properties. Thus he had searched for suppliers of ingredients with the properties which, in his opinion, were necessary to bake a cookie conforming to the product concept: a tasty, sugar-free chocolate-chip-cookie to be sold to German diabetics.

However, when the production manager grasped the nature of quality characteristics (ie that they must be directly measurable and not technical solutions eg ingredients), he began generating quality characteristics compatible with the House of Quality methodology. As it was necessary for the production manager to constantly focus on the measurable properties of the quality characteristics, he simultaneously established measurable target values for each quality characteristic.

Example:

One end-user remark was, “sugar-free are more dry”. The managers transformed this information into the characteristic ‘crispness’, and the corresponding measurable value “will break at a certain pressure at a certain temperature”.

Furthermore, as he, in accordance with the prototyping methodology, was used to thinking of technical solutions, he also indicated the ingredients and process characteristics (ie technical solutions) that would, in his opinion, produce a cookie which conformed to the quality characteristics and the affiliated target values. At a meeting on 2 November, the production manager transformed the remaining end-user quotations into quality characteristics, target values, ingredients and process characteristics.

In the same way we asked the sales manager to generate quality characteristics on the basis of the end-user quotations which had been placed at the primary level ‘packaging’ of the affinity diagram. At a meeting in November we made an observation that would later prove to be essential to our analysis of upstream deployment. The sales manager tried to transform the end-user quotations into quality characteristics, target values and process related characteristics according to our instructions. However, he only succeeded in re-wording the original end-user quotations.

The final step consists of filling out the roof, at which point the connections between product characteristics are identified. The purpose of this is to determine the interconnections of product characteristics in a way that reveals the positive and negative ways in which the product characteristics influence each other.

House II

The quality characteristics from House I comprised the input for House II. The managers again worked on the transformation from quality characteristics into recipe and process characteristics. Furthermore, each recipe and process characteristic was specified in more detail at the bottom of House II, thus indicating the production manager's view concerning the critical properties of the ingredients and processes.

Example:

The quality characteristic 'crispness' is affected by a vast number of recipe and process characteristics. The ingredients affecting crispness are 'shredded coconut', 'bulk sweetener', 'flour', 'fat', 'nut products', 'raising agents', 'chocolate', 'fibre contributing products' and 'water content'. The processes affecting crispness encompass 'the ratio of steam/extraction', 'the ratio of surface/weight', 'thickness', 'shape' and 'breakages during production and packing'.

When we look at the resulting houses, we find that the output of the transformation process was a compound mixture of quality characteristics, target values, ingredients, target values for ingredients and process characteristics.

While it is not uncommon to have difficulties distinguishing quality characteristics from solutions (ingredients and process characteristics), we were faced with the problem of dividing the various characteristics according to their nature. We therefore had to identify the structure of the data which seemed appropriate for the company, and the nature of the product in question. Therefore we had to adapt the House of Quality to the specific needs of the product development task.

As mentioned, the production manager had initially solved the transformation problem by indicating ingredients and processes. However, according to the House of Quality technique it is imperative that the quality characteristics are not considered concrete solutions. We therefore insisted that he try to formulate objectively measurable quality characteristics which were not solutions. In a like manner, the sales manager had initially indicated that he wanted to delegate most of the transformations to third parties ie laboratories, the packaging supplier, design agencies, etc. However, we also insisted that he should try to come up with measurable quality characteristics.

Using the compound data, we decided on the placement of the different characteristics according to the normal House of Quality guidelines and the special nature of the study.

The outcome of this process was:

- 1) measurable quality characteristics (the top of House I)
- 2) target values for the quality characteristics (the bottom of House I)

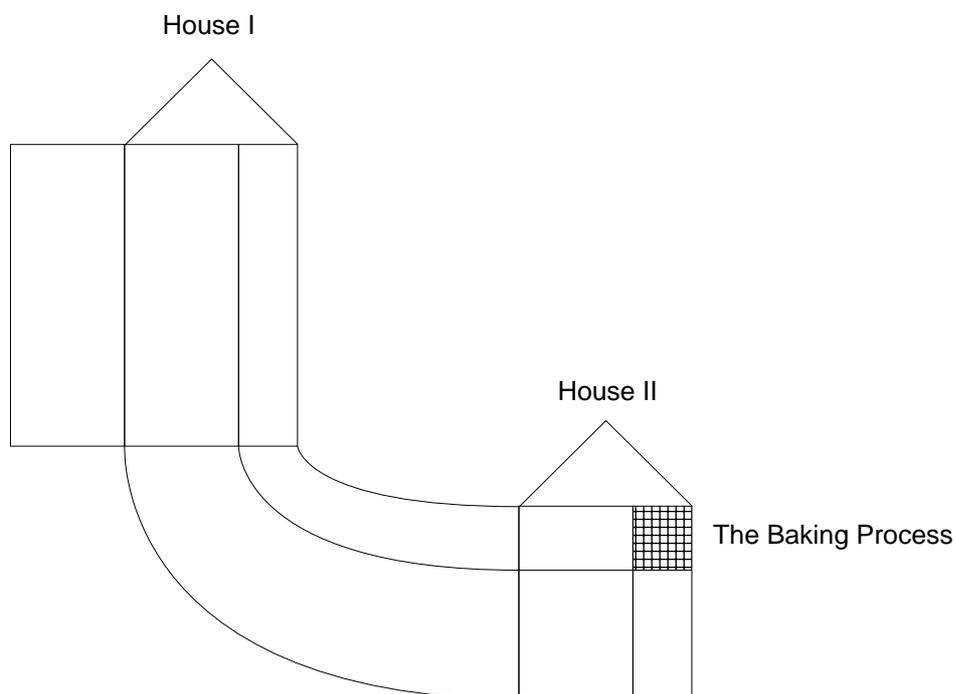
Furthermore, we placed the solutions in a consecutive House:

- 1) ingredients and process characteristics (the top of House II)
- 2) target values for ingredients and process characteristics (the bottom of House II)

Whereas the production manager had identified solutions for some of the quality characteristics, the sales manager had not identified any solutions. His solution was to delegate the transformation of quality characteristics to suppliers.

We therefore decided to establish supplier Houses of Quality, thus indicating that the further transformation of the quality characteristics was to be carried out by external suppliers.

Figure 2. In-house capability (Example: The Baking Process)



For Houses with detailed attributes, characteristics, and target values, see: Kristensen and Holmen, 1994 pp. 818-819 (in Danish).

The City of Quality

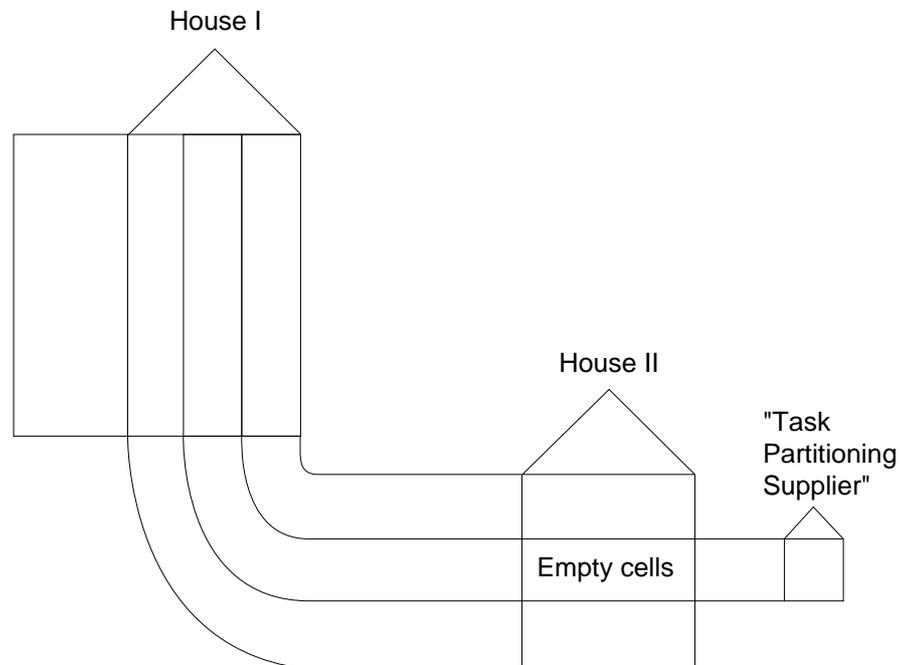
Throughout the study of the construction of Houses I and II, it appeared that within the network of a small company and its suppliers, what is often referred to as the cross-functional problem consists of a cross-functional, as well as a cross-capability, problem.

The analysis of House II shows that some quality characteristics were identified by the managers as input for transformation into recipe and process characteristics which the company was able to produce **in-house**, ie the company’s distinctive capabilities.

Example:

The baking process is fully in-house.

Figure 3. No need for interaction with suppliers capability (Example: Carton Supplier)



In addition, some quality characteristics were identified which the company had no intention of producing. In fact the company even delegated the transformation into recipe and process characteristics to suppliers. These quality characteristics are shown as lines in the middle of House II. In figure 3 we illustrate how they are input for the houses symbolising the **suppliers** with whom the company intends to rely on for non-interactive **task partitioning**.

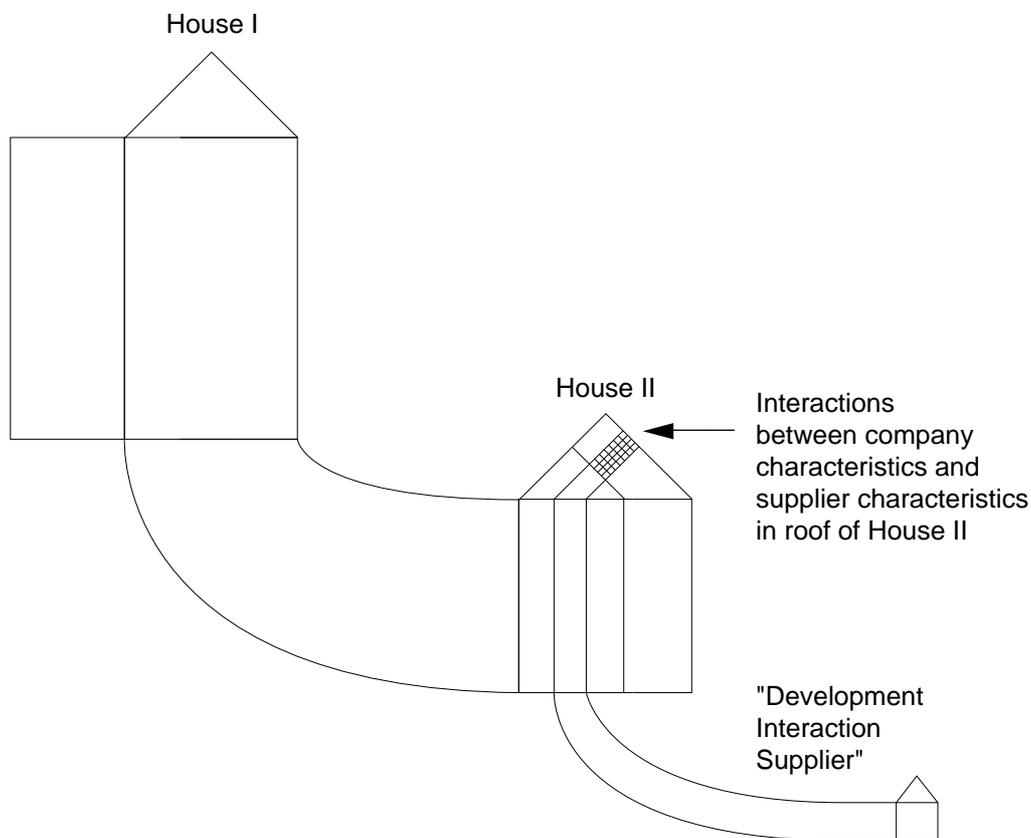
Example:

Task partitioning can be observed in the deployment of the characteristics of the carton for the cookies. The interaction between the carton and the cookies is negligible. Because of this the company chooses to use their traditional packing

supplier in the detailed development of the carton. The characteristics are presented as a derived demand, and the dialogue concerning the details of the actual appearance of the carton is not expected to progress into anything which resembles interactive development.

Finally, some quality characteristics can be identified as input for transformation into recipe and process characteristics for raw materials and equipment, and as input in which interaction exists between the characteristics (on the roof of the House). In figure 4 these characteristics are shown as columns in House II, from which point they can be deployed as input for the houses symbolising the suppliers with whom the company might find it profitable to establish development interaction.

Figure 4. Need for interaction with suppliers capability (Example: Chocolate supplier)



Examples:

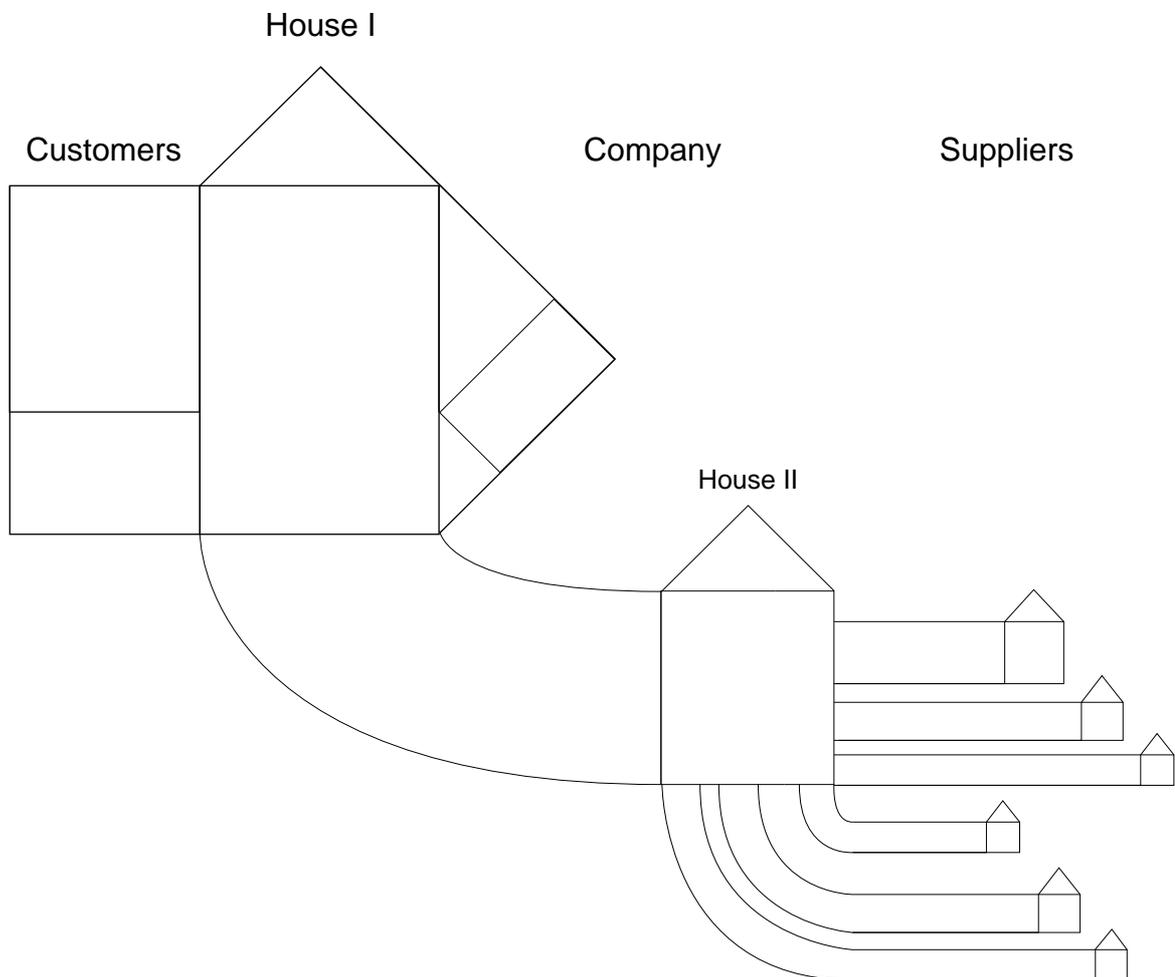
A need exists for a new raw material from an existing supplier, ie chocolate that is both sugar-free and firm during the baking process. Interaction exists between the baking process and the firmness of the chocolate. This indicates the need for entering into development interaction with the existing supplier regarding the development of the chocolate.

A need exists for a new raw material from a new supplier, ie a sweetener which is courser than the fine powder currently on the market. Interaction exists between the particle size of the sweetener needed to obtain the required structure, and other ingredients in the cookie. Consequently, the company must enter into development interaction with a new supplier to develop a courser sweetener for the cookie.

Development network

Used in this way, the City of Quality provides a network outline in the form of a fan-shaped range linking the potential participants (Figure 5).

Figure 5. The City of Quality



The next step would be to establish the suggested interaction processes. Ideally, a product-derived customers-company-suppliers network would eventually emerge from these efforts.

Results for the company

Looking back at the objectives put forth in the project in 1990, we must note that the company did not as planned establish a third baking line, the purpose of which was to produce small series for prototyping. As a result the company, contrary to expectations, did not have the production capability necessary to implement a systematic prototyping. Neither did the company establish contact with a purchaser – a precondition for acquiring prototyping experience in the course of the project. Furthermore, the end-user input which we could contribute to ourselves came from Danish diabetics, and thus could naturally not be used as an indicator of the German market.

What the company could expect from the actual pilot study was training of two of its management employees who assisted in the construction of the diagram and the houses. Their work was to concentrate on the central problems expected in upstream and in-house development when the company eventually found an interested retailer, and to prepare the company to enter into down-stream interaction with the aim of adjusting the product to the specific market and retailer's product line.

In order to assess whether or not the company and the participating employees received the benefits intended from the project, we asked a colleague with experience in this field, Associate Professor, Dr. phil. Lennart Nørreklit, to visit the company after the project was completed and interview management and other employees as to the received benefits. The manager and one of the two participating employees were interviewed.

Nørreklit reported back that it was his impression that, on the whole, the company had benefited from the MAPP-projects. Regarding the benefits of this particular sub-project, however, one employee interviewed expressed that he had not acquired any essentially new knowledge which could be used in his daily work at the company. Nørreklit's interpretation as to what went wrong was that the project as implemented was too removed from the day-to-day life of the company.

In short, the company did not come to function as a 'learning organisation' with respect to the project. This may be due to the following circumstances: after realising that the company could not as expected secure what was necessary to implement prototyping in interaction with a foreign customer, we changed the project as described above. And when the immediate connection between the project and the day to day life of the company disappeared we failed to take into consideration the need to discuss in a formal way and perhaps even make use of the learning process within the company during the course of the project. And afterwards it was too late.

5. Discussion and implications

Discussion

Downstream, we have illustrated how incompatible wants can be identified as new product development tasks, and made suggestions as to how they can be tackled within a House of Quality framework. But based on the present observations we are not able to elaborate as to the extent to which this can be done in practice.

When assessing the results **upstream**, it must be kept in mind that the study took place in a company which is part of a well-established industrial network. Therefore, it was undoubtedly easier to find the fan among companies in this case than it would be in a larger company with many in-house capabilities. But this has also highlighted the fact that such a fan does not only describe deployment from end-users to different in-house departments, but is in principle a completely new outline for the required configuration of capabilities, in-house and out of house. In this way the fan-shaped range of houses in figure 5 reveals the familiar intra-firm cross-functional processes, and the locations of potential inter-firm cross-capability interaction processes.

Research implications

The problems which were formulated in the theoretical phase of the project, and later to be studied in the empirical phase, were well-founded and important. The fact that the process, which was the object of empirical study, developed in a way which rendered the problems impossible to study, does not mean they cannot be studied. It is clear that the project must be approached differently – by us or by others.

The condensed version of the study we were able to conduct provided an empirical foundation for analysis which revealed various new possibilities for applying the House of Quality technique. We found that the division of the upstream flow in particular merits further study – especially taking into account its management implications.

Management implications

We do not suggest that a company cannot develop successful products without looking **downstream** for incompatibilities. In practice, the chains of users adapt to many other non-fulfilled wants. Still, data from end-user market analyses only provides developers with a suggestion as where the product has to go (ie end-user inbound logistics and final consumption), and data from retailer interaction only suggests a way for the product to follow downstream (ie the retailers' inbound and outbound logistics and the product's 'shelf appeal'). We suggest the model in figure 1 for combining these two bodies of knowledge in a way which formally reveals incompatibilities and thus transforms them into one of the explicit inputs which guide developers in the traditional House of Quality product development model.

When we look **upstream** the present study seems to indicate that, in a product development process, the House of Quality is a technique which can be used to specify the need for capabilities both inside and outside the company. This specification will indicate: 1) whether the company's own distinctive capabilities are utilised. This will not be the case if characteristics in the second house are specified to be met by in-house capabilities, but are then deployed to suppliers, and 2) whether the company is planning production but does not possess or plan to acquire the required capabilities. This will be the case if the second house shows empty lines without deploying the corresponding characteristics to suppliers.

The transformation process and characteristics constituting the fan of linked houses can be based on the company's limited fund of knowledge before entering into development interaction with suppliers. If these tentative characteristics are also used to express the company's demand in the subsequent interaction process, much user information may be lost. Instead a company may be wise to cancel the initial transformation processes it made in order to identify the requirements for capabilities, and start interaction from scratch on the basis of user attributes in their original form, turning new transformation processes into characteristics. These will then be based on the joint knowledge of interacting parties.

If we return to the ideal match of 1) supply of slowly developing capabilities, 2) fast flow of new product ideas, and 3) ever-changing requirements for capability constellations, we find that companies where product development projects 1) depart directly in the analysis of current end-user needs, 2) transform these needs through Houses of Quality into a City of Quality outlining the configuration of actors representing the state of the art within the required capabilities; and finally 3) establish a product specific development network, may be able to face the short term task of profiting from the ever-changing current demand without departing from the companies' commitments to long-term development of their respective capabilities.

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