EVALUATION AND MANAGEMENT OF CUSTOMER FEEDBACK TO INCLUDE MARKET DYNAMICS INTO PRODUCT DEVELOPMENT: SATISFACTION IMPORTANCE EVALUATION (SIE) MODEL

Gupta, Ravi Kumar; Belkadi, Farouk; Bernard, Alain
École Centrale de Nantes, France

Abstract

Customer's requirements fluctuate across geographical regions and type of use context for a product. In order to address dynamic market's needs, it is important to maintain an open communication channel between the users and the product design department. This communication allows customers to evaluate released products and express their opinion through in production and after-sales feedback gathering. Designers can use this pool of knowledge as a reference for future product design, so as to support frugal product design, creating product that can be adjusted to different market needs. A new SIE model is proposed for the evaluation of customer feedback to identify whether modules and attributes in a product are designed perfectly according to the market's needs. A methodology based on modular approach (modular organization of a product, product-service and product system) is proposed for the feedback formalization for a product development perspective. The product modules and attributes are evaluated to compute improvement indicators for the product in development and for the future product. The effects of these evaluations on the product development and delivery time are analyzed

Keywords: Decision making, User centred design, Integrated product development

Contact:
Dr. Ravi Kumar Gupta
École Centrale de Nantes
LS2N
France
Ravi-Kumar.Gupta@ec-nantes.fr

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1 INTRODUCTION

Customer's requirements fluctuate across geographical regions and type of use context of a product. In order to address current market's needs, it is important to maintain an open communication channel between the end users and the product design department. This communication allows customers to evaluate released products and express their opinion through in production and aftersales feedback gathering. Designers may channel from this pool of knowledge as reference for future product design, so as to support frugal product design, creating products that can be adjusted to different market needs. Frugal Innovation (good-enough and affordable product that meet the needs of resource-constraint customers) have created tremendous demand in emerging markets (Zeschky et al., 2011). The frugal innovation is slowly spreading to the western markets for improving the customer requirements' clarification and satisfaction. By this, customer involvement in the product development project is achieved as one of main success factors to reach competitive products.

The customer requirements are generally gathered and evaluated manually and require experts' knowledge. The evaluation procedures do not consider the impact of production and resource constraints at the early design stages. So, there is a need of methodology for product development considering the customers' experiences in the product development in an iterative manner using computational tools.

The current paper is to address the feedback evaluation and management and then to identify its impact on product design, production and delivery time for launching the product into the market. The aim of the proposed methodology for customer use feedback evaluation are (i) Formalized and structured process to gather feedback, (ii) Formal method for analysis of the collected feedback, (iii) Formal method for computation of improvement indicators (percentage of correction required to make frugal) to be utilized in the product design and production, and (iv) Structuring the collected feedback and evaluation results.

To do so, a new SIE (Satisfaction Importance Evaluation) model is proposed based on modular approach (ProRegio 2015-2017; Gupta et al., 2017) (modular organization of the product, product-service and production system) for the evaluation of customer feedback and requirements to identify whether a module or an attribute in a module is frugal design, poor design or over design. It is computed that if the same product is designed and produced, then what is the percentage of correction required to make it frugal. Product modules and attributes are evaluated based on frugal and cultural factors such as function, robust, user-friendly, growing, affordable, and local and thus the evaluation of the product as a whole is computed to classify the product as frugal. The modular approach (Belkadi et al., 2016a; Belkadi et al., 2016b; Gupta et al., 2017) developed for modular organization of product design and production to adopt an existing product to regional markets is used for describing the proposed SIE model and methodology for frugal product design based on feedback evaluations. Section 2 of the paper describes the current state of the art on customer feedback evaluation methods and usages. Section 3 describes the proposed feedback evaluation model for product development perspective and section 4 describes a methodology for a product development starting from gathering the feedback to the utilization. Section 5 discusses the utilization of the evaluation results in the product development. The work presented in the paper is concluded with future extensions.

2 LITERATURE REVIEW

Customer feedback as satisfaction study begins with investigation of potential reasoning to identify dissatisfaction. Customer feedback is defined as customer communication concerning a product or a service (Erickson and Eckrich, 2001). According to the current state of the art, customer's response to the evaluation of the perceived inconsistency between some comparisons e.g. expectations and the perceived performance of the product are considered as feedback (Doorn et al., 2010; Khangura and Gandhi, 2012; Haan et al., 2015).

Importance–performance analysis (IPA) is widely used for analysis and interpretation of customer satisfaction (Setijono and Dahlgard, 2007; Graf and Mass, 2008; Chen and Lin, 2013) in product and service industries. KANO model (Kano, 1984) is another widely used for analysis and interpretation of customer satisfaction and classifies customer preferences. The KANO model distinguishes between three types of product requirements as must-be, one-dimensional and attractive requirements which influence customer satisfaction in different ways.

Literature has highlighted issues in a product like innovations, geographic boundaries, and regional requirements (Petiot et al., 2008; Tiwari and Hersatt, 2012; Bound and Thornton, 2012; Stilgoe et al., 2013; Tiwari et al., 2017) but the concrete solution to directly include in the existing product design and development of a product and also to utilize the resources based on feedback received from market are not addressed. As per the changing/dynamic trends of markets, the customers' requirements are mostly driven by region, social, economic and cultural situations (Tellis et al., 2009; Prahalad, 2010; Bound and Thornton, 2012). As presented that the focused group/customers also are changing in the pyramid in different regions and time (Berger, 2013; Bhatti et al., 2013).
The available approaches for customer feedback gathering and evaluation focus on after sales (usage) feedback and how to improve product to satisfy customer based on after sales feedback. Today's customer feedback is mainly collected after-sales e.g. by interviews or online survey. The surveys do not have any tested and formalized method to integrate customers during the product development of a series of product. Customer(s) involvement in a product development and including innovations are still research issues.
Current methods lack in identification of improvement indicators (percentage of correction required in product development) based on gathered feedback, and targeted to a group of customers and integration of the feedback into product development. Adding to this, current techniques are rather plain, with no connection to the evaluated product. Towards these directions, an intriguing methodology is proposed to gather customers use feedback, analysis and evaluation of the collected feedback in comparison of the resources used. The methodology uses graphics technologies and modulated questions that can measure customers' importance and satisfaction for the whole product and each module separately. SIE model is proposed to evaluate the collected feedback. The SIE model and the methodology are explained in the following sections.

3 FEEDBACK EVALUATION FOR DESIGN IMPROVEMENT PERSPECTIVE

3.1 Satisfaction-Importance Evaluation (SIE) model

Based on current state of the art and the industries cases studies, a Satisfaction-Importance Evaluation (SIE) model is proposed for customer use feedback analysis and evaluation in a structured way and computes improvements required (percentage of correction required) in the product development. Customers' feedback is collected on modules and attributes in the product and then the representative feedback for a market segment is computed. The representative feedback is used for the construction of the SIE model.
A market segment (also referred as customer profile) is identified by a set of customers with range of specific values of customers' description. The identification of market segment helps in understand how each market segment changes requirements of frugal products and services based on customer requirements and feedback. The customers in a target group have different contributing weights (w) to analyze the feedback and compute representative feedback for that market segment. The weight for a customer depends on the customer description, environment and use context. It is important to compute representative values of multiple customers' feedback for a product of mass customization (for example domestic product) as representative of a market segment. Whereas, in the case of customer-specific product (for example Aircraft), the representative values are specific to a customer and the one received from a customer are considered. So in the case of a product of mass customization, the representative feedback for a market segment is calculated using Equation 1.

$$\left(X_j, Y_j\right) = \left(\frac{\left(\sum_{i=1}^{C}\left(w_i * x_{i,j}\right),\ \sum_{i=1}^{C}\left(w_i * y_{i,j}\right)\right)}{\sum_{i=1}^{C}\left(w_i\right)}\right) \quad (1)$$

Where, $\left(x_{i,j}\ \ y_{i,j}\right)$ = Collected feedback of ith customer for jth module or attribute in the product;
$x_{i,j}$ = value of Importance of the customer;
$y_{i,j}$ = value of Satisfaction of the customer;
w_i = weight assigned to ith customer;
C = Number of customers' feedback collected from a market segment;
$\left(X_j, Y_j\right)$ = Representative feedback for jth module or attribute in the product;
Graphical representation of the SIE model is shown in Figure 1. The SIE model has three zones (regions) separated by upper and lower bound profile curves as shown in Figure 1. Trends of these curves can be

evaluated using market trends and company policy such as correlation of utilization of resources in the development of a module to the customer satisfaction or to the module cost. The narrow range between profile curves represents that the considered modules and attributes has tight constraints for design and production. These profile curves can be different for modules and attributes considered in the feedback. The X-axis with values as 0 to 10 represents importance level and Y-axis with values as 0 to 10 represents satisfaction level of the representative feedback in the SIE model for a module or attribute in a product. For example, if the representative feedback is (Satisfaction=7, Importance=8) then the corresponding location in the SIE model is (x=8, y=7). Datum line (Figure 1) is considered as datum or reference line for the feedback evaluation. It is assumed that the datum line in the SIE model represents 100% frugal design in the produced module with respect to the customer satisfaction and optimal utilization of the resources used in design and development of the module. So the feedback on the datum line represents 100% frugal design. Distances D, Do and Dp are the shortest distances from a feedback to datum line, upper bound profile curve and lower bound profile curve respectively.

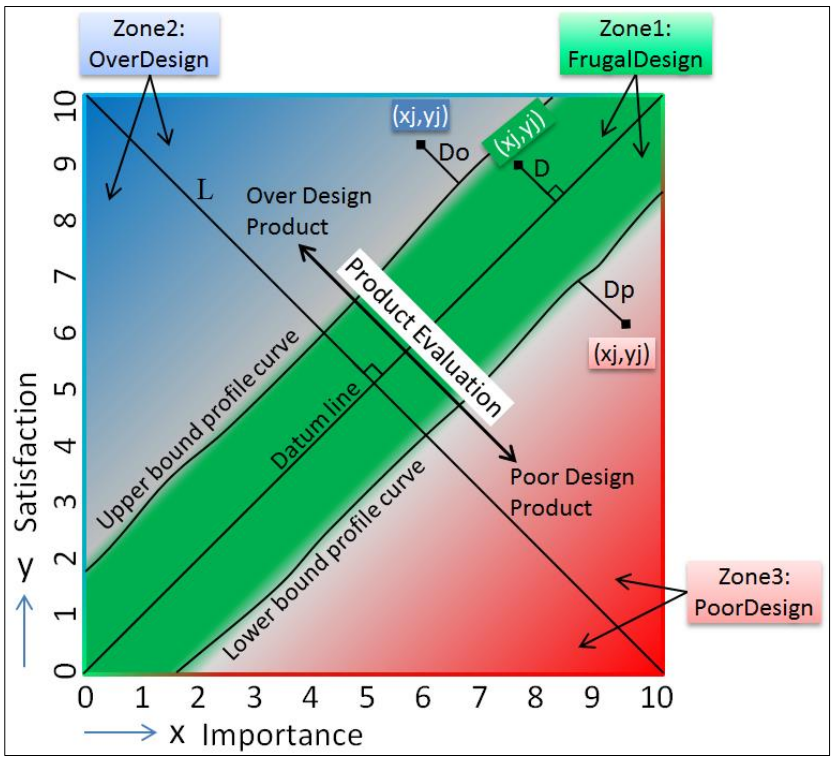

Figure 1. SIE model for customer feedback analysis and evaluation

Percentage of corrections required in the modules, attributes and product to make frugal product are computed in the proposed SIE model. This indicates that these corrections are to be incorporated in the product development in order to optimally satisfy the customer requirements against the solution proposed by the company (producer of the product). The percentage of corrections required in the product development is referred as "improvement indicators: OverDesign, FrugalDesign, PoorDesign". The percentage of customer satisfaction indicators on the modules, attributes in the product and product as a whole are also computed in the proposed SIE model. These indicators are described in the following sub sections.

3.2 Definition of Frugal Design

Zone1 (green colour region in Figure 1) represents that the feedback on a module (attribute) placed in this region is an appropriate designed module (attribute) for an identified market segment. Indicator for such kind of module (attribute) is "FrugalDesign". The Zone1 is bounded by upper and lower bound profile curves. The % (percentage) of frugal design of a module (attribute) is computed by Equation 2. If a feedback for a module is placed on datum line then that module is 100% FrugalDesign. This indicates that the module is 100% appropriate from customer point of view and also for utilization of resources for design and production of that module. A module with indicator as "FrugalDesign" can be used in a

product development without change in utilization of resources used in design and development of that module.

$$\text{FrugalDesign} = \left(\frac{\text{L}-2*\text{D}}{L}\right) * 100; \quad (2)$$

$$\text{OverDesign} = \left(\frac{2*\text{Do}}{L}\right) * 100; \quad (3)$$

$$\text{PoorDesign} = \left(\frac{2*\text{Dp}}{L}\right) * 100; \quad (4)$$

Where, L = Maximum space available for customer feedback; $\text{L} = (10 * \sqrt{2})$;
D = Shortest distance from location of customer feedback (X_j, Y_j) to the datum line;
Do = Shortest distance from location of customer feedback to Upper bound profile curve;
Dp = Shortest distance from location of customer feedback to Lower bound profile curve;
(X_j, Y_j) = Representative feedback location on the SIE model for a module or attribute;

3.3 Definition of Over Design

Zone2 (blue colour region in Figure 1) represents that the feedback on a module placed in this region is an over design module and the indicator for the module is "OverDesign". The region on the left-up side of the upper bound profile curve corresponds to over design module. The customer is highly or more satisfied with the modules located in this region. A module with indicator as "OverDesign" has the possibilities to reduce design constraints in order to save resources and time spent on production of that module. Over design module can be replaced with less expensive module to gain advantages of reduction in cost, time and resources. The percentage of improvements required in over design module is computed by Equation 3. If a module is placed in zone2 then there are possibilities to reduce design constraints, reduce resources (material, production, etc.) for the development of that module. The company may replace this module by low-cost (or economical) module according to the % of OverDesign. OverDesign models and attributes in a product indicate that this product (modules and attributes) has to be redesigned in order to achieve frugal innovation and to meet the needs of resource-limited societies.

3.4 Definition of Poor Design

Zone3 (red colour region in Figure 1) represents that the feedback on a module placed in this region is a poor design module and the indicator for that module is "PoorDesign". The customer did not satisfy with the modules located in this region. The region on the right-down side of the lower bound profile curve corresponds to poor design module. The percentage of correction required in poor design module is computed by Equation 4. A module with indicator as "PoorDesign" has to be improved in order to satisfy customers. Poor design module can be replaced (or redesigned) to improve quality, performance, material, and/or capacity as per the requirements identified to improve the customer satisfaction. This involves in improvements in design specifications.

3.5 Global indicator

Global indicator represents the overall improvements required in the product under consideration and overall customer satisfaction on the product. Two global indicators namely "OverDesign in Product" and "PoorDesign in Product" are identified to specify the % of corrections required in the product development in order to achieve frugal innovation and to meet the needs of resource-limited societies. These two global indicators are computed using Equations 5 and 6 respectively. Global indicator for customer satisfaction represents how a product supplied by a company meets or surpasses customer expectations. It is defined as an average of summation of customer satisfactions for all the modules and attributes considered in the feedback and is computed by Equation 7.

$$\text{OverDesign in product} = \frac{\sum_{\text{i}=1}^{\text{No}}(2*Do_i/\text{L})*100}{\text{N}}; \quad (5)$$

$$\text{PoorDesign in product} = \frac{\sum_{\text{i}=1}^{Np}(2*Dp_i/L)*100}{\text{N}}; \quad (6)$$

$$\text{CustomerSatisfaction in product} = \frac{\sum_{\text{i}=1}^{N}(\pm(L-2*D_i)/L)*100}{\text{N}}; \quad (7)$$

Where, No = Total number of modules and attributes placed in Zone2;
Np = Total number of modules and attributes placed in Zone3;
N = Total number of modules and attributes considered in the feedback;
$\pm(L - 2 * D_i)$ in Eq. (7) is -ve if feedback is right-down side of datum line else +ve.

The proposed SIE model provides prioritization as (i) FrugalDesign modules and attributes, (ii) OverDesign modules and attributes, (iii) PoorDesign modules and attributes, with % of corrections required in the modules and attributes. The analysis and evaluation results are then structured across the product structure by associating a module (attribute) indicator and % of corrections required to the module (attribute) in the product structure. A simplified SIE model with linear profile curves is used for further explanation. Lower and upper bound profile curves are straight lines parallel to datum line at distance d1 and d2 respectively. In this case, if Satisfaction > (Importance + d2) for a feedback on a module (attribute) than that module is placed in over design zone. If Satisfaction < (Importance – d1) for a feedback on a module (attribute) than that module is placed in poor design zone.

4 METHODOLOGY FOR CUSTOMER USE FEEDBACK GATHERING, ANALYSIS AND EVALUATION FOR PRODUCT DEVELOPMENT

The customer's requirements fluctuate across geographical regions and type of use context for a product. For example, refrigerator for Russian market is narrow, has extra egg containers and is used in kitchen whereas for Asian market, it should have extra ice makers, is used in kitchen/living room, and should prevent rats to enter in the refrigerator. So, the refrigerator design for Russian and Asian markets are different but the basic functionalities are same. These fluctuating requirements have been addressed by using global modular approach with two ways of modules identifications and product configurations (Gupta et al. 2017). The products obtained in such a way varied in design, qualities and performances, and production of some of the modules among these products. So our research proposes to collect feedback on product modules and attributes in the product under consideration. A methodology starting from feedback gathering to the use of evaluation results in the design office is presented in Figure 2. The proposed methodology consists of three steps namely (i) Gather, (ii) Analyze and Evaluate, and (iii) Utilize feedback which are described in following sub-sections.

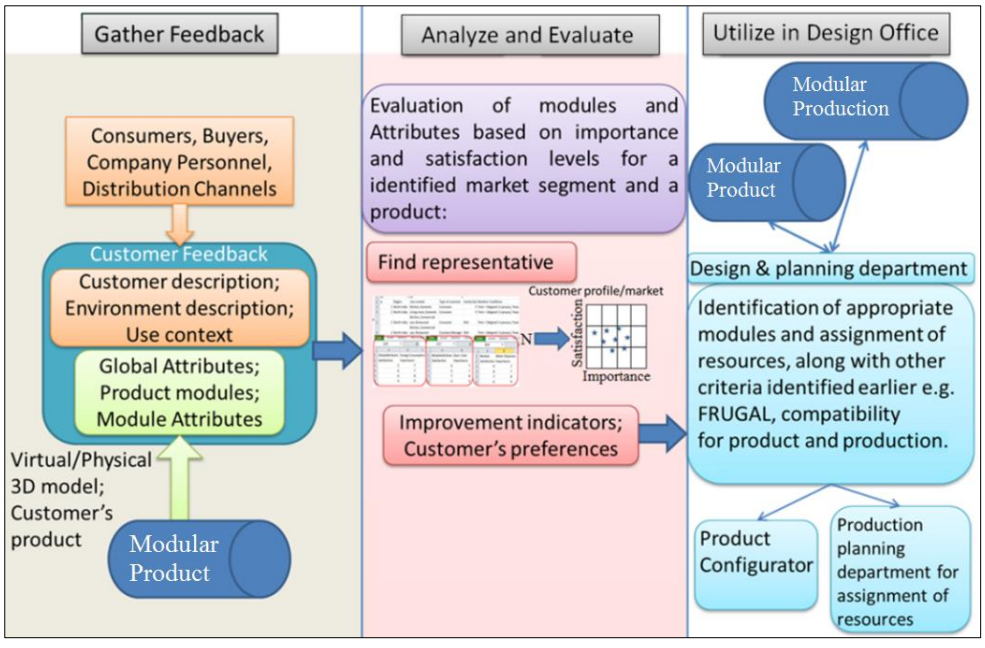

Figure 2. Proposed methodology for feedback formalization

4.1 Gather Feedback

The information collected from customers about their satisfaction and importance levels they experience on the product, attributes and modules in the product along with customer preferences if not satisfied is considered as feedback. The customers considered are consumers (end user of the product), buyers, area managers, country managers, company's inspection personal, and company's maintenance personal.

The products considered are physical product (For example: Aircraft modules, Refrigerators, Robots), virtual product (Digital model of a physical product) and maintenance service. Feedback gathering stages considered are proposal phase, manufacturing, assembly, inspection, distribution of finished product, usage and maintenance. The representation of customer and product used in the feedback gathering are presented in Figure 3. This representation is used in identification of a market segment required in the analysis and evaluation of the collected feedback.

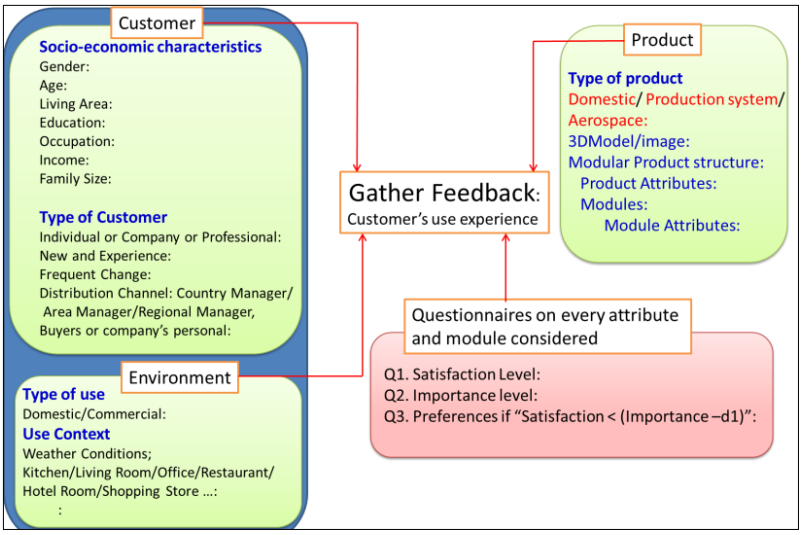

Figure 3. Representation of customer and product for the customer feedback

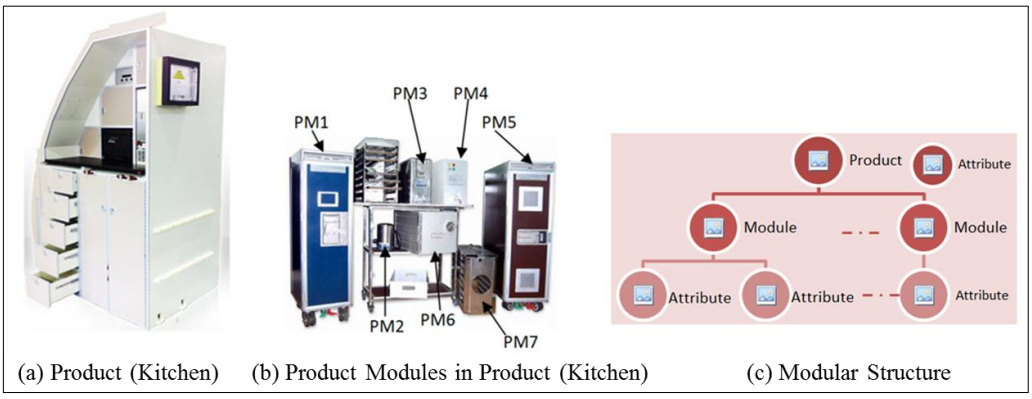

Figure 4. Modular structure with modules and attributes for a product

A customer selects a module or attribute in the product model from the product structure or selects a list of predefined attributes (in the form of customer understandable questions). The customer enters his/her satisfaction and importance levels for the selected modules and attributes. Example of a modular structure with modules and attributes for a product is presented in Figure 4. Kitchen as a product: main function of a kitchen is to store and prepare food and drinks. Presented example (Figures 4 and 5), could be a kitchen in a modern house or a hotel, or a kitchen on board of an aircraft, has modules as service carts/trolleys (PM1, PM5), water boiler (PM2), liquid container (PM3), refrigerator (PM4), storage area (PM6), waste storage (PM7). Technical specifications and specific features of a trolley are considered as attributes for example Size.Height/Length/Width, Capacity.Trays/Drawers, Structure, DoorLatches, BrakeSystem (Jones 2004). So the product (Kitchen) with its module and associated attributes can be considered for customer feedback.

A set of three questions (Figure 3) are identified to be asked on every attribute and module considered in the feedback. The first question "Satisfaction Level" captures the rating of customer's satisfaction on the proposed solution (module) to fulfil the customer's requirement. The second question "Importance Level" captures the importance of a module according to the customer. The third question "Preferences if "Satisfaction < (Importance–d1)" captures what does customer want if not satisfied, what are the modifications required in the module to satisfy the customer. Where, d1 is the shortest distance between

datum line and lower bound profile curve. The collected feedback is stored in the product structure against the selected modules and attributes.

4.2 Analyze and Evaluate Feedback

The SIE model computes the improvement indicators for further development of the same product (same as used for feedback) and also for next version of the product. The collected feedback is used to analyse and compute the representative feedback (Equation 1) for a market segment consisting specific range of values for customer description, environment and use context (Figure 3). For example, customers with description as (Small-medium families (3-4 member), medium-high income groups, domestic use, used in Kitchen/Living Room, North India) belongs to market segment as North Indian domestic market. In a market segment, weight for a different type of customer is different and depends on the customer description, environment and use context. For example country manager has higher weight than the area manager and consumer. The real values of these weights are defined by planning department of a company according to the importance of the customer, use context for a market segment. SIE model is constructed using the representative feedback as explained in Section 3.1. The improvement indicators are then computed on the modules and attributes considered in the feedback and for the product as a whole (Section 3.2 to 3.5). The evaluation results are stored in the product structure against the identified modules and attributes.

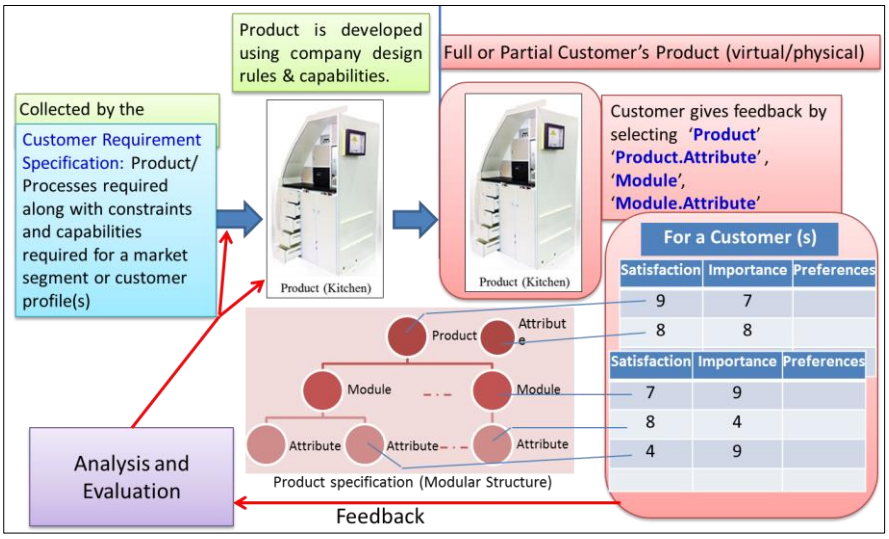

Figure 5. Scenario for product development and use of customer feedback

4.3 Utilize Feedback Evaluation

A scenario starting from customer requirements to the use of customer feedback in product development is presented in Figure 5. The company develops solution (virtual or physical model) to the customer according on his/her requirements and then the company asks the customer to give his/her feedback on the developed solution which intern is used in improving the solution developed earlier. The improvement indicators computed (retrieved from the product structure for modules and attributes considered) are proposed to be used in the product development for improving the modules, methods and tools used for design, production, packaging and transportation of the next version of the product. The producer of the product optimizes the resources used based on improvement indicators for the involved modules and attributes. The global improvement indicators can be used in identification whether the product supplied by a company can be enhanced for meeting the targeted market. The customer satisfaction can be used by marketing and sales department and also to compare the solutions available in the market.

5 DISCUSSION

To address 'more value from less resource for more people' (Prahalad and Mashelkar, 2010) and frugal innovation (Berger, 2013; Bhatti et al., 2013), the proposed SIE model is to identify improvement indicators required to be addressed in product development with respect to satisfaction and importance

levels of the customers from a targeted market against the solution provided by a company. The producer of the product optimizes the design and production resources based on the improvement indicators for the involved modules and attributes which lead to produce the next version of the product with more value to the customers involving fewer resources in comparison with the resources used in the production of original product (product used for feedback).
The proposed methodology identifies over design and poor design modules in the product which are to be replaced (or redesigned) in obtaining the next version of the product. The study says that the number of modules with over design and poor design is less as compared to the number of modules in the product (ProRegio 2015-2017). Therefore, only few modules are to be replaced in the product to satisfy targeted market requirements as compared to redesign the product from scratch which will take long time. For example, a company redesigned the product (for example: refrigerator) as new project (starting from scratch) to introduce an existing product into new market and this took more than 1.5 years according to industrial case study. Therefore, the production for only few modules (identified to be replaced or redesigned) will be changed. Whereas production of all other modules (with indicator as FrugalDesign) remain unchanged. The shifting of resources, involved in the production of FrugalDesign modules, is required to be adjusted according to the flow of material and time constraints. So, the production of next version of the product (new product) can be considered as existing production facilities only by changing the production of replaced modules in the product according to the feedback evaluations. Product thus developed is considered as Frugal Product: good-enough and affordable product that meet the needs of an identified market.
The frugal designed module in the product can be utilized in the next version of the product with the same design, production, packaging and transportation facilities used for this module. So, the time required for redesigning such modules, designing new production facilities for such modules, designing packaging and transportation for such modules can be avoided. Moreover, redesign of over design modules may results in reduction of production time. Therefore, the time spent in development of over design modules will be less as compared to original modules. In conclusion, the utilization of feedback results in the development of the next version of the product gives reduction in the delivery time in comparison with the delivery time of the original product.

6 CONCLUSION

Methodology has been presented for feedback formalization and structuring and to generate indicators with percentage values of corrections required on every module and attribute considered in the feedback, and then utilization of the evaluation results into the product development. SIE model for analysis and evaluation of the collected feedback to compute improvement indicators for the development of a series of products has been developed. The improvements indicators can be addressed in the product development of the next version of the product and services for an identified market segment and can also be used in the current product if the feedback is gathered in early stage of the design.
The utilization of feedback results in the product development of the next version of the product gives reduction in the delivery time as compared to the delivery time of the original product. The presented methodology ensures the mechanism for gathering feedback from regionally clustered customers in a formalized and structured manner and then generating the improvements indicators to be used in the product development. This has been implemented to solve the use cases requirements (ProRegio 2015-2017). The correlation of the identified improvement indicator with the improvements required/suggested in design and production will be investigated further.

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