FACING THE OPEN INNOVATION DILEMMA – STRUCTURING INPUT AT THE COMPANY'S BORDER

Andreas Kain[1], Rafael Kirschner[1], Alexander Lang[2], Udo Lindemann[1]
[1] Institute of Product Development, Technische Universität München
[2] iman solutions GmbH, Munich

ABSTRACT

Open innovation makes the company's border permeable for knowledge exchange with outside world. Various ways exist on which ideas can flow into the company's product development process as well as flow out into the market. Each direction faces its own challenges. However bringing input to the company poses the problem to prepare the input in the expected way and to identify the proper receiver within the company. Here we show that a framework supports pre-clustering and evolvement of input before transferring it into the company. From a conducted case study we learnt that the contributed ideas mainly concerned the embodiment level, but also principle and function level. Our results demonstrate how the framework can be instantiated for a specific tool. The framework is not method specific and thus can be applied to various open innovation approaches aiming into the company.

Keywords: open innovation, empirical study, method, structure, requirements engineering

1 THE OPEN INNOVATION DILEMMA

(…) Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation respectively [1]. Several approaches and methods support exploiting knowledge and experience from outside the company in Product Development (such described in [2], [3]). Chesbrough details knowledge from his perspective mainly in technology [1], whereas Thomke and Hippel detail in need and solution information [4], which can enrich early product development. During the time period from 2008 to 2009 we conducted 34 interviews with innovation managers and project directors of different German manufacturing companies in the context of customer integration. Practitioners state, that open innovation carries two main challenges: (a) defining the sources for input and making them provide input and (b) structuring and enriching this input in a way, that the company can make use of it taking into account its constraints e.g. its organizational structure.

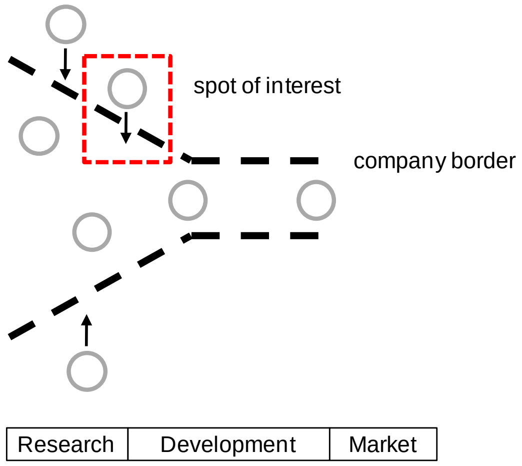

Figure 1. Open Innovation Paradigm [1]

Several approaches, methods, methodologies exist to tackle the first challenge of allocating sources, along the product development process such as Lead User Methodology in early phases [4] or tool kits for early and late phases [5, 3, 6].
Various key measurement indices take into account the effort of shifting the input over the company's borders. They qualify the open innovation readiness of companies from an organizational point of view as discussed in [7].
The subsequently following challenge of how to cope with differing input in an open solution space (as discussed in [7]) is not yet as considered and researched.
Product Development and especially New Product Development has to deal with information that varies in way of formulation, degree of maturity, sources etc. even in closed innovation processes.
Thus, from a holistic point of view, requirements engineering was established and implemented successfully e.g. in early phases such as ideation, idea management supports coping with internal input.
In closed innovation the company's strategy influences or even determines evaluation criteria within the innovation process. Open innovation approaches open e.g. the ideation phase for input from outside the company and also support questioning the selected evaluation criteria, in order to incorporate an external point of view. Companies might lose control but become aware of the big picture.
Tackling the issue of structuring open innovation input to product development would (a) enable the outside world to discuss and elaborate contributions and (b) support incorporating open innovation input to product development.
Particularly we focus on the scenario of developing a new product or enhancing existing products by applying open innovation methodology in early ideation phase due to industrial relevance identified in expert discussions.
This paper has the objective of composing and evaluating a framework to pre-structure open innovation input synchronously to contribution in order to support (a) evolvement of contributions by the outside world and (b) support incorporating contributions to product development.
Section 2 presents core ideas of requirements engineering and presents the test bed for validation. Section 3 derives the method on a generic level and details it, to make it applicable in a specific open innovation project. Section 4 contains the empirical study that describes results of an open innovation project in an industrial environment. Section 5 discusses the results. Section 6 concludes the contribution.

2 BACKGROUND

This section presents a short introduction to requirements engineering and idea management. A pre-study with an open innovation tool illustrates key-learnings motivating for the research.

2.1 Requirements Engineering and Idea Management

In open innovation the company faces knowledge and experience from outside the company. Within methods like requirements engineering and idea management are established to support internal processes.
DIN 2330 defines the term "characteristic" as attribute and a value. It can be classified in (a) functional, (b) quality specific, and (c) organizational characteristics [8]. This classification exactly meets the classification of requirements according to [9], where requirements comprise wishes, aims of users, as well as constraints and characteristics of the system under development.
Hrastinski et al. reviewed a sample of 51 systems that were design to support open innovation [10]. They point out that these systems could be classified in supporting (a) idea submission, (b) problem submission, (c) problem solving and analysis and (d) evaluation. Various methods for idea generation exist. As one example which is in industrial use Rohrbach describes the method 6-3-5, which intends to elaborate ideas by stimulation and refining ideas in a team process [11]. In this method the content is further elaborated within the team session. Collecting various ideas from various stakeholder, such as e.g. users or customers, requires a management of ideas. Hrastinski et al. also found that therefore in the open innovation systems predefined categories enabled clustering the ideas, often based in current challenges [10].
Flynn et al. discuss idea management and suggest a structured and holistic approach to managing idea generation exemplified for organizational innovation [12]. They ground their

work on an extensive survey on innovation and creativity. Vanderbosch et al. identified five archetypes of idea management (consensus builder, searcher, debaters, assessors), which can be characterized through four axial codes: inquiry approach, impetus for idea generation, relationship to others and evaluation approach. [13].

2.2 Pre-study Immersive Product Improvement (IPI) Tool and key-learnings

This new method bases on a crowd sourcing approach. Our validation experiment was conducted with a software implementation of this method. This implementation allows all participants to examine online different views of a certain product, i.e. pictures of this product from different perspectives. When the participant wants to comment, improve, criticize, or praise a certain functional part of the product, he just has to click on the corresponding area in one of the product pictures. A short dialog box then appears to cluster this comment and to guide him during the commenting process. We call all comments that refer to a single functional part a *thread* in the known sense of email or forum applications.

In spring 2010 an early Version of the IPI tool was presented at a major European industry fair. One purpose was to get an impression, how users get on with the product illustration as access to provide input/ feedback on existing products. The early version of the tool was mainly capable of attaching a new comment point to the picture by pointing into the picture and then attaching a new free text comment to this point. Or if already comment points existed, one could read already attached comments to the thread of comments of this specific comment point.

The illustrating example was an automotive dashboard of a car. The task was to give comments based on personal experiences.

Despite the excitement of nearly all tool users, we could finally conclude some drawbacks (db) of the tool:

- The quality of the comments with regards to contents varied enormously (db1)
- Due to the partially symmetric user interface of the dashboard (e.g. nearly identical outlet nozzles on the left and right) a lot of redundant comment points were attached. (db2)
- Within a thread belonging to a comment point users put comments regarding several topics. (db3)
- It is not always possible to attach a comment referring to a specific function to one particular part, because functions are often realized by several mechanical parts. (db4)

Finally the key-learnings of the pre-study depict the statement made in the beginning of this paper, that converting input from open innovation into a representation that a company really could make use of it is exhausting and time consuming.

3 A FRAMEWORK TO PRESTRUCTURE OPEN INNOVATION INPUT

This paper has the objective of composing and evaluating a framework to pre-structure open innovation input synchronously to contribution in order to support (a) evolvement of contributions by the outside world and (b) support incorporating contributions to product development.

The approach needs to take into account the inherent differing perspectives from within the company (e.g. the engineering designer) and from the outside world (e.g. the customers or users) inherent to open innovation. The skills of expressing product related input vary amongst the customers and do not match the engineering designer’s expectations and skills. In order to support the flow or even exchange of information across the company’s border, the approach also needs to interlink the customer’s application based perspective on the product as well as the engineering designer’s product definition based view. Thus an approach to literally let the customers and engineering designers meet would not work properly. The following subsections present the generic concept of the suggested framework and the instantiation of the framework for the specific IPI Tool for evaluation.

3.1 Generic description of the Framework

The core element of the concept is an intermediate level interlinking the customer’s and the engineering designer’s perspective. Customers can project their application based point of view on the product and express their input to other contributors of the outside world in order to enable rating and evolving the input by others. The engineering designer could recognize the outside world input related to the product definition based view and could therefore directly incorporate it in product development without taking upon himself tedious effort for e.g. clustering. Kirschner et al. present evaluation of the IPI method in [14].

For composing the framework in the following we assume that the open innovation project is initiated by the company. In case of new product development at least organizational information already exists to support structure the intermediate level. In case of improvement of existing products also some engineering documents already exist: e.g. the product structure, such as functional structure, component structure. These also provide the base for setting up the intermediate level from the company's perspective. Also the product structure concerning mechanical/ electrical/ electronic components or bought-in parts/ in-house produced parts determines the intermediate level.
Getting familiar with the measures for structuring the intermediate level from the company's view requires efforts the customer would not take due to resources, lack of previous knowledge and/ or interest. Furthermore this would result in the disclosure of engineering documents e.g. to competitors. Moreover in order to provide input to the company related to his experiences and knowledge, and to communicate needs and solution information it is not necessary for the customer to attach his input directly to engineering documents at all. It is sufficient for the customer to attach his input to structures he can recognize easily and implicitly, such as e.g. a rough component structure, or product appearance. However it is necessary to provide a measure for structuring customer input on the intermediate level from the customer's view. Therefore we apply the basic idea of formulating requirements as an object, specified by an attribute and a specific value to structure customer input from the customer's perspective on the intermediate level.
On the company's side of the intermediate level, the company itself triggers the clustering of information according the required complexity at the intermediate level.
Thus it is not necessary to incorporate and analyze all of the input from the outside world within the company, because the contributions are already pre-clustered beforehand triggered by the company. The contributions are accessible for other contributors from the outside world that can subsequently rate and evolve these contributions (see Figure 2).

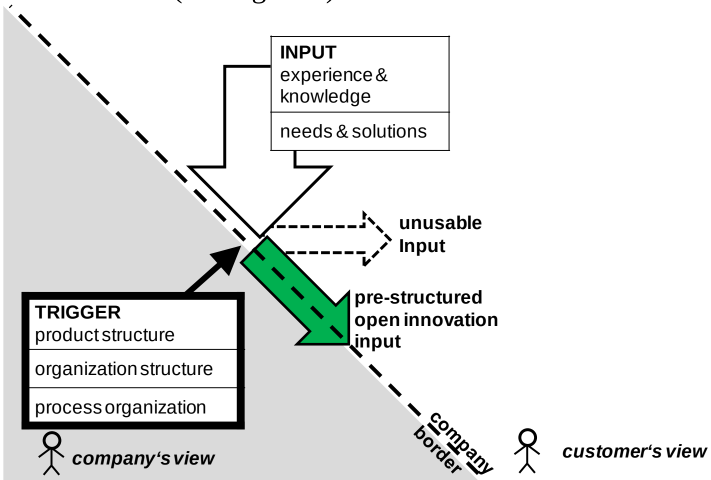

Figure 2. Generic model for open innovation spam filtering (oisf)

The intermediate level thus is able to filter unusable customer input right before incorporating the input to the company. It is a kind of mirror, that reflects unusable input back and therefore works like an open innovation spam filter (oisf).
In order to evaluate the framework in an empiric study the following subsection instantiates the framework considering a specific open innovation method IPI.

3.2 Tool-Specific implementation of the Framework

In this contribution we illustrate the instantiation of the suggested framework on the previously presented IPI method. The IPI Tool enables customers to give product centered feedback on existing products [see 14 for validation of the method].

The IPI Tool has been enhanced by implementing an input container consisting of one object (db4), which can be discussed in several categories (db3), in each by several comments (see Figure 3). One comment point in the product illustration refers to one object. When clicking into the picture the

software suggests the already generated objects (db2, db4). A rating system enables a pre-selection of the provide input (db1).
Furthermore in order to realize the intermediate level connecting the customer's view and the engineering designer's view, the product itself is separated in different sections according to the demands of the company. The engineering designer's view founds on these sections rebuilds company specific product structure and process organization.

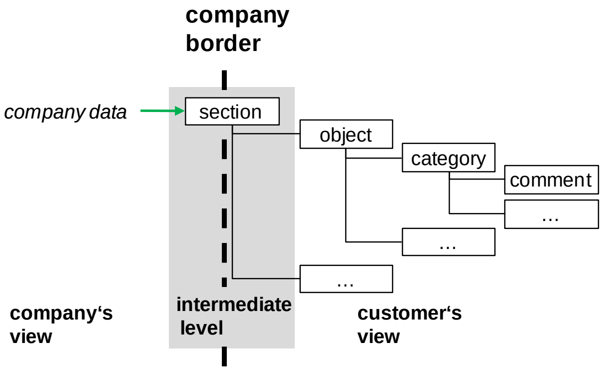

Figure 3. Structure Input Container

Figure 4 presents a screenshot of the software prototype. It consists of a product picture, where users create objects and place comments in categories. Users can rate existing categories and comments, and also create comments on already existing objects in already existing categories.

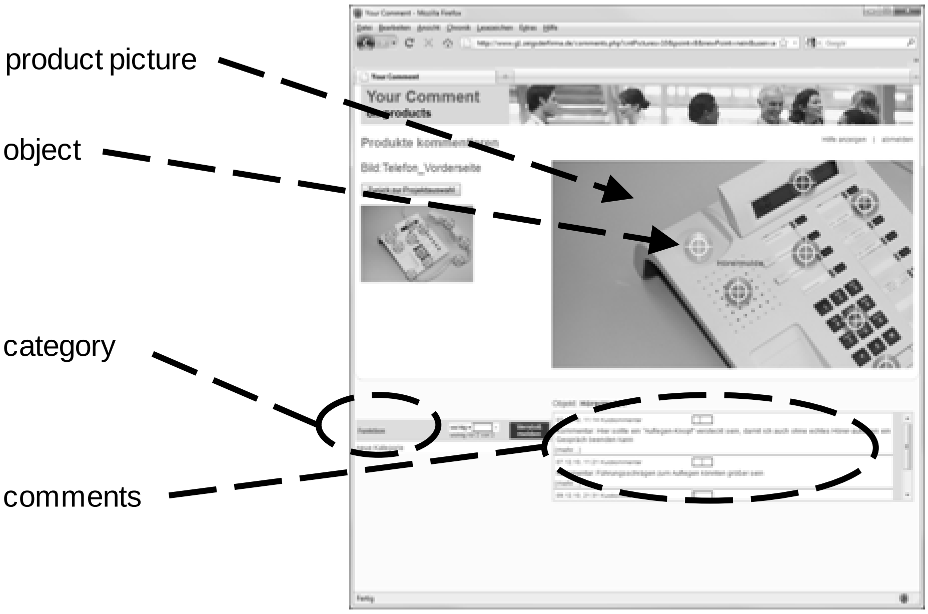

Figure 4. Screenshot IPI Software Prototype

The following section describes the empirical case study.

4 EMPIRICAL STUDY

We conducted an empirical study in order to evaluate whether the suggested framework does support (a) evolvement of contributions by the outside world and (b) support incorporating contributions to product development. Therefore the suggested tool-specific framework was implemented to the IPI Tool.

4.1 Experimental Set up

24 people participated in the study in a closed industrial environment. They accessed the IPI Tool via a web-interface with personalized user accounts. Overall the web-interface was 7 days online and accessible.

The participants gave their comments on a common office telephone, which is the standard phone in the company. Everybody uses the exact same model for daily work. The participants had a lot experience in using the phone and were all motivated by a small incentive.

A graphical illustration of the telephone was the starting point for commenting. The participants could structure their input via the above explained input container (generate objects, create categories, set a comment, rate content) which was illustrated by one exemplary statement. The company's view took into account the product structure and the level of detail of the input. Figure 5 illustrates the instantiated framework.

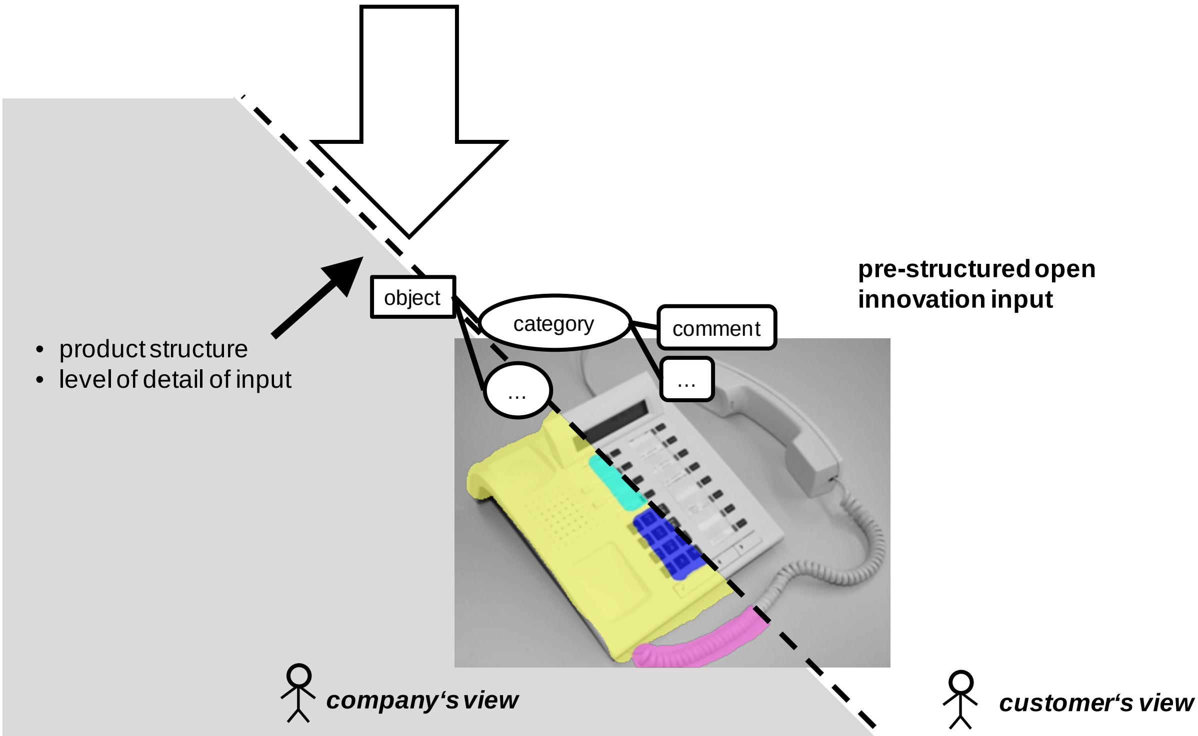

Figure 5. Tool specific model

4.2 Result

The participants created overall 20 objects, 21 different categories, in which they placed 55 comments concerning the product. Figure 6 shows an overview of the objects allocated to the telephone and the connected categories and comments.

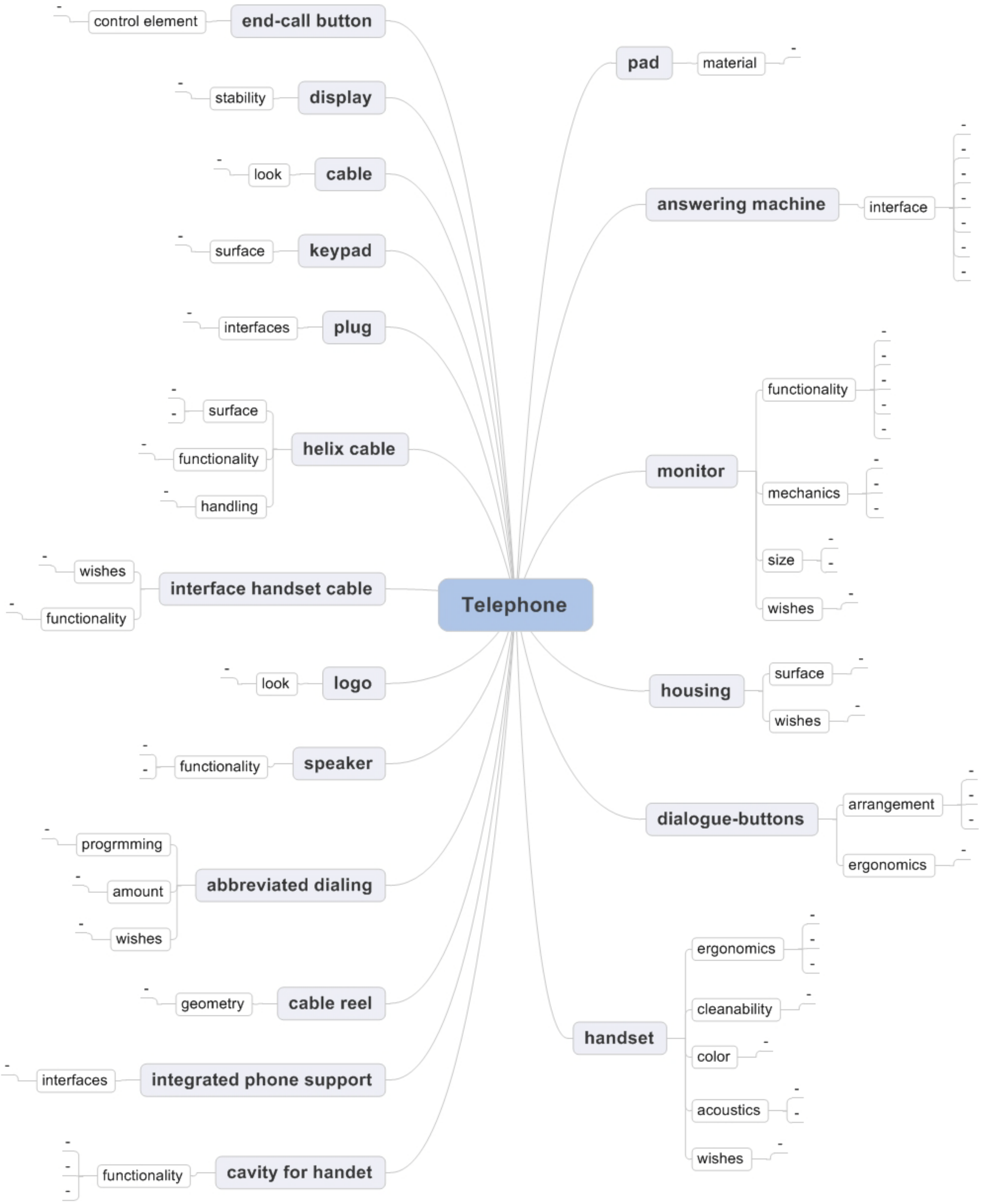

Figure 6. Overview objects-categories-comments

5 DISCUSSION AND INTERPRETATION

This section discusses the data, which was collected in the empirical study. It analyzes the data in regard to the question, whether the suggested framework would support (a) the evolvement of contributions by the outside world and (b) support incorporating contributions to product development.

5.1 Evolvement of contributions

3 Examples show that the participants indeed elaborated already attached comments (see Table 1 to Table 3). In all 3 examples the users extended and detailed the contents of previously stated comments in different ways. Analysis hereby was driven as summarized in [15].

The first example concerns the object display and the category mechanics (Table 1). The first comment issues that the mechanical functionality does not work properly (*"folding down is not really smoothly"*). The second comment repeats the statement and adds a personal opinion (*"... appears cheap"*). Additional context is provided by an explanatory statement (*"expensive brand"*). The third comment questions the necessity of the functionality (*"why folding up and down at all"*) and provides additional specifications (*"have a display, which you can read from different perspectives"*).

Table 1. Evolving comments example 1

Date & Time	comments concerning object **display** and category **mechanics**
07.12.10, 12:17	Folding up is okay, but folding down is not really smoothly
07.12.10, 16:57	The folding mechanics get stuck easily and appears cheap I expect from an expensive brand product a higher quality!
07.12.10, 19:52	Why folding up and down at all? I'd like to have a display, which you can read from different perspectives

The second example concerns the object display and the category functionality (Table 2). The first comment provides a suggested functionality (*"should react inertially"*) a specification (*"should display the number for some time"*) and provides a scenario for justification/explanation (*"so I e.g. write it down"*). The second comment repeats the suggested function detailing it to the recently dialed number (*"the last dialed number should be saved"*). It poses an additional specification (*"for at least 30 min"*) and explains the purpose (*"for redialing"*).

Table 2. Evolving comments example 2

Date & Time	comments concerning object **display** and category **functionality**
07.12.10, 11:12	The display should react inertially; after a phone call it should display the number of the caller for some time so I can e.g. write it down
07.12.10, 11:20	The last dialed number should be saved ready for redialing at least 30 min.

The third example concerns the object answering machine and the category interface (Table 3). The first comment suggests a concrete addition for a specific part (*"label buttons"*). The second comment repeats this suggestion and states two reasons for explanation (*"would be helpful, if I didn't listen to the message carefully enough"*, *"or don't want to listen to the message"*).

Table 3. Evolving comments example 3

Date & Time	comments concerning object **answering machine** and category **interface**
07.12.10, 20:01	Label buttons for rewind and wind!
08.12.10, 12:05	Label buttons for rewind and wind; this would be helpful, if I didn't listen to the message carefully enough or I don't want to listen to the message.

These three evolved comments contain different elements, which embody the input: statement, opinion, functionality, specification and explanation. Table 4 summarizes the combinations of elements which are applied during evolving the comments.

Table 4. Overview

Example	Combinations
1	Statement statement + opinion functionality + specification
2	functionality + specification + explanation functionality + specification + explanation
3	statement + specification statement + specification + explanation

These combinations differ in the kind of used element and the combination of elements. During evolvement, the number of used elements increases in example 1 and 3. Contrary in example 2: the combination exactly equals before and after evolvement. In this case the content of the elements differ before and after evolving the comment (the scope of the term function slightly changed as well as the explanation).
Nevertheless, only the 3 presented comments have been evolved by 4 following comments. The pure number of comments per category indicates if comments refer to the same object in the same category. On the one hand 48 comments have not been elaborated. But on the other hand the average amount of categories per object is 1.7 (min 1, max 5) and participants placed an average number of 1.6 comments per category (min 1, max 7). Taking these numbers into consideration, comments indeed cover a wide range of categories. Obviously there was a broad discussion starting and participants of the study rather contributed their input than evolving existing input further and thus participants discussed only some categories ample. May be an extended duration of the study would have led to more evolved contributions.

5.2 Support incorporating contributions to product development

The level of structure of the open innovation input influences incorporating contributions to product development. Thus this section discusses whether the participants structured their input reasonable according to a company's view.
Considering a branched structure with the product in the center, in the object level 20 branches, on the category level 33 branches (with categories counted more than once), and on the comment level 55 branches exist. Content analysis reveals, that

- there is 1 misuse of the object-category-comment structure by inserting a function (detect phone call stop) as object, category as object (button) and comment as comment
- 1 object assigned as redundant (**display** and **monitor** refer to the same component)
- 1 category does not match one assigned comment (**headset**, **acoustics**, *"(…) integrate Bluetooth for wireless phoning")*
- 2 comments are praising (e.g. **handset**, **color**, *"is ok"*)
- 1 comment is grumbling (**answering machine**, **interface**, *"catastrophe, awkward, time consuming!"*)
- there are 2 times ironic comments (**display**, **functionality**, *"unbelievable, but true …"*).

The category "wish" was used 3 times to place each time one comment (e.g. handset, wish, *"cordless handset"*). Despite the creativity of the participants, further analysis showed that these wishes could have given impulses to threads of other categories assigned to the same objects.
Maybe a combination of carelessness of the participants and a partly confusing graphic user interface caused some of the failures mentioned above. One participant told afterwards, that it was not always easy to define an adequate category for the comment.
The level based three dimensional space of product development according to Rude [16] supports assessing the level of concretization of the provided input. The model concretizes artifacts from function level to principle level and embodiment level. Within a workshop experts analyzed the contents of the comments, and assigned to the model (see Table 5).

Table 5 Classifying input according to level of concretization

Level	% Inputs	example
Function	15	**Display**, **functionality**, 07.12.10, 19:53 Display illumination desirable
Principles	6	**Helix cable**, **handling**, 20.12.10, 09:49 (…) connect cable and handset by a turning element.
Embodiment	79	**Cavity for handset**, **functionality**, 07.12.10, 11:21 The guiding chamfer could be smoother to support laying down headset better

About 80% of the provided input concerns the embodiment level. But 2.5 times more input concerns the function level than the in between level of principles. Maybe it is easier for the customers to provide input on the embodiment level they can touch and on function level to fulfill their needs. Validity of the results was assessed by two workshops. In the first workshop the results were presented to a German manufacturer of business phones. 10 engineers discussed the structured input regarding the presented input in comparison to the existing engineering documents. They agreed on the feasibility to integrate the collected and structured input to product development process.

In a second workshop 4 experts experienced in product development processes and product development tasks assessed feasibility of the approach to products others than the presented one. They stated that the clustering and the intermediate level of sections indeed would support the incorporation of the input to a product development project carried out in an industrial environment.

6 CONCLUSION AND FUTURE WORK

Analysis of the empirically collected data showed that contrary to results of the pre-study, customer input has been collected in a structured manner. The instantiation of the suggested framework supported tackling the issue of structuring open innovation input to product development before crossing the company's border. Analysis highlighted the evolvement of customer's contributions by rearranging and completion of elements carrying information. Participants of the study not only provided input on the level of embodiment, but also on level of principles and function, thus it can support early phases of product development on all levels of concretization.

The instantiation of the framework specific to the IPI tool addressed the problem stated by experts and experienced in a pre-study. It successfully pre-structured open innovation input synchronously to contribution in order to support (a) evolvement of contributions by the outside world and (b) supports incorporating contributions to product development. Due to pre-structuring and already further elaborated open innovation input, we reduced the effort to analyze the input on crossing the companies border. Due to eliminating steps of preparing the data within the company it is possible to utilize the input in product development right on crossing the border. Thus it was possible to put spin on the input towards the ongoing process prior to crossing the company's border (see Figure 7).

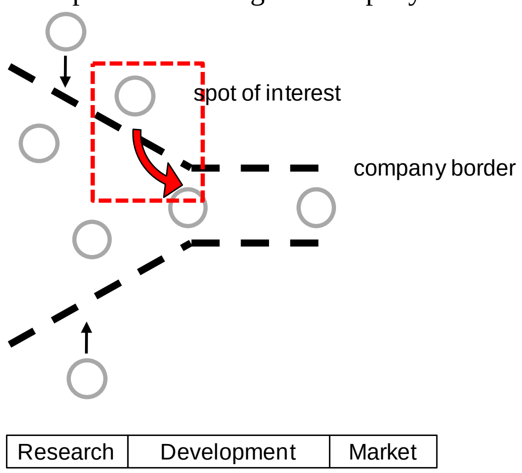

Figure 7. improved input with spin (adapted from [1])

Concerning the instantiated framework for the IPI Tool it seems fruitful to integrate measures for the degree of maturity of contributions. Additionally we suggest an intuitive rating system from the customer's point of view in order to strengthen the quality of assigned categories and comments. Another case study in a larger scale could also reveal dependencies to other, even more complex products than the telephone. Furthermore this contribution discussed the instantiation of the framework to a specific tool. Future work will concern instantiation for other open innovation methods and tools. Despite that the tool will be applied to overcome not-invented-here syndrome (see [17]).

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AUTHORS

Andreas Kain graduated as mechanical engineer at the Technische Universität München in 2007. He now works as a Research Associate at the Institute of Product Development at the Technische Universität München, Germany. His scientific work focuses on methodical support of customer integration in new product development and systematic approaches towards describing product application.

Rafael Kirschner graduated in mechanical engineering at the Technische Universität München in 2006. He now works as a Research Associate at the Institute of Product Development at this

university. The focus of his research is the integration of customers into innovation processes.
Alexander Lang is consultant and supports industry in open innovation projects. He attended a wide range of innovation projects beginning from automotive industry to medical engineering.
Udo Lindemann is a full professor at the Technische Universität München, Germany, and has been the head of the Institute of Product Development since 1995, having published several books and papers on engineering design. He is committed in multiple institutions, among others as Vice President of the Design Society and as an active member of the German Academy of Science and Engineering.

CONTACT

Andreas Kain
Technische Universität München
Institute of Product Development
Boltzmannstr. 15
D-85748 Garching
Germany
+49.89.289.151 26
+49.89.289.151 44
andreas.kain@pe.mw.tum.de
www.pe.mw.tum.de