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Cross-departmental and cross-disciplinary product development – An industry survey on the necessity and future development of cross-departmental and cross-disciplinary perspectives

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Abstract

In this publication, a study is conducted in the context of cross-departmental and cross-disciplinary product development. The focus is on the industry observable requirements and implementations of cross-departmental and cross-disciplinary perspectives. By interviewing industry experts from a broad spectrum of industries, a reflection of regarded requirements, prioritized challenges and current implementations is created. As result a current status regarding team compositions in product development, as well as emerging and challenges and relevant requirements will be identified. By analyzing the team composition, it can be shown that cross-departmental and cross-disciplinary collaboration already exists in many structures is elaborated. Thus, it can be deduced that the challenges to cross-departmental and cross-disciplinary collaboration are relevant in practice. These challenges are evaluated and prioritized according to relevance by the industry experts in this publication, which facilitates a systematically consideration in further research of challenges in product development. As a third component of the study, changes in the previous considerations of requirements towards idealized considerations across departments and disciplines are presented. The results showed that the relevance of the integration of requirements is increasing and to what extent the distribution of direct and indirect requirements can develop.

Keywords: "cross-departmental; cross-disciplinary; product developent; case study; future collaboration"

1. Introduction

Trends toward individualization, digitization and service-orientation are leading to an increasing number of product variants companies have to offer to remain competitive [1]. However, this increasing diversity of portfolio increases complexity due to the growing number of variants within the company [2].

There are several strategies to address these issues. By developing modular product families, companies are trying to reduce the variety within the company. Modular product families enable a large external variety to be provided based on a limited number of internal components [1,3].

Another strategy is the development of new business models to access new markets. In some cases, this requires establishing new partnerships. For example, companies are trying to offer technical products as services and cover customer needs for example via "pay-per-part" [4–6].

These types of business models can offer companies a way to respond to changing requirements in the future. However, these types of business models can also increase the complexity [7]. The increasing complexity of new business models and similar product requirements necessitate enhanced cross-departmental and cross-disciplinary synchronization within the company in order to be able to handle them [8,9]. One reason for this is that an individual cannot know everything required for the development of a product during the development and corresponding upstream and downstream processes. Additionally, the requirements for the development of a product also exceed individual disciplines, which increases the need for

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cooperation and synchronization between different disciplines [10].

Exemplified by the "pay-per-part" business model, the affected sales department needs new ways of analyzing the customer's problem and then configuring the offered solution. This has a corresponding impact on product development, in which it should be possible to map these properties. This affects the product development which has to already developed the corresponding properties of the product [11].

Harmonization of the cross-departmental perspectives makes it possible to align the ideas of the individual departments along a product life cycle [8].

In addition, there is supplementary potential at the level of cross-disciplinary development, for example by increasingly integrating software as a discipline that has the competence to exert extensive influence on the functionality of a mechatronic product. This means that requirements arising from the Internet-of-Things and other trends can also be incorporated into product structuring and development [12,13].

This publication opens with the description of the research objective in section 2, that is followed by introduction of the questionnaire in section 3 and the description of the data set in section 4. The results of the survey are presented in section 5 and discussed in section 6. Finally, a conclusion and outlook on further research is given in section 7.

2. Research Objective

The development of modular product families offers helpful approaches in the area of complexity reduction and the variety-oriented design of products, which have a positive influence on the handling of increasing individualization [14]. The systematic development of modular product families can thus serve as a basis for dealing with emerging business models and requirements.

Due to the focus of modularity on effective architectures for product families, also cross-departmental and cross-disciplinary collaboration has to be considered in further approaches of modular product architectures. In this publication the term of cross-disciplinary relies to the interaction across different domains or disciplines in a product life phase [15,16].

As a result of a literature review, various analyses were performed using data from databases such as Google Scholar, Scopus and Web of Science. It was possible to analyze that most of the keywords of publications, related to cross- and inter-disciplinarity in product development, refer to an educational scope. In the analysis of the sources of identified literature, authors mostly described their own ideas and no common knowledge base could be identified. A similar result was found in an analysis of the linked authors, where several smaller clusters were identified, but no common knowledge base could be derived.

The question to be analyzed is derived from the points presented:

- To what extent do cross-departmental and cross-disciplinary collaboration are considered in practice?

This question is addressed with the help of a survey among experts from industry. For this purpose, a two-stage questionnaire was developed, which is explained in section 3.

3. Survey Goal and Structure

Referring to the introduction and the subject of the study, the aim of the industrial survey is defined:

- Derivation of a perception from practice that reflects the requirements and the relevance of cross-departmental and cross-disciplinary collaboration.

Different questions are used to determine the extent to which cross-cutting structures are already implemented for product development and which requirements are incorporated into these structures. The second part of this study, which is prepared in a subsequent publication, analyses the impact these structures can have on the development of modular product families. The questionnaire was created using the online-based tool "Lime Survey". Figure 1 illustrates the structure of the survey part considered in this elaboration. First the survey focuses on the initial situation with general questions about the participants and e.g., the current status of collaboration in the company. afterwards the study addresses specific issues regarding product development.

Part of the general survey section is a query about how cross-departmental and cross-disciplinary perspectives are regarded in the general context of product development.

The intention is to first gather basic information from the participants and then to more specifically query the strategies of the companies and their attitudes towards cross-departmental and cross-disciplinary collaboration. In this context the current status of the collaboration is interrogated and the requirements from other departments and other disciplines which should be incorporated into the development are analyzed.

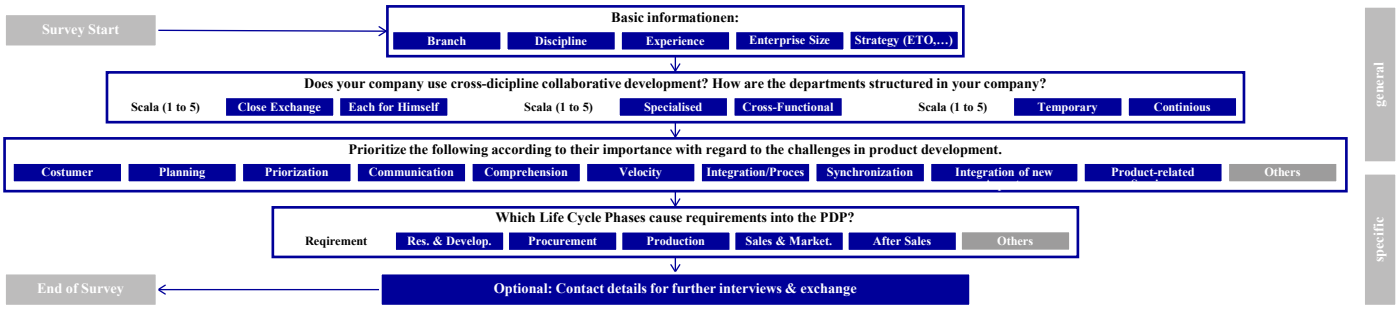

Fig 1. Survey structure with question groups and possible selections

These study results will be regarded as a basis for the second part of the study in which the participants were queried about resulting challenges in modular product development. These results are prepared in a separate publication.

4. Overview of data set

A sample of n=36 experts from the industry can be used for the evaluation of the survey. The basic data collected covers the following points:

- Size of company
- Branch of company
- Configuration Strategy of Company
- Discipline of Participant
- Work Experience of Participant

The majority of participants (55%) in the survey belong to large companies with more than 5,000 employees. Further 13% belong to companies between 1,000 – 5000 and 16% to companies between 250 – 999 employees. The remaining participants (19%) work for small and medium-sized enterprises with up to 249 employees. It is noted that the number of employees refers to the overall company and the size of the individual business units may have a lower number of employees.

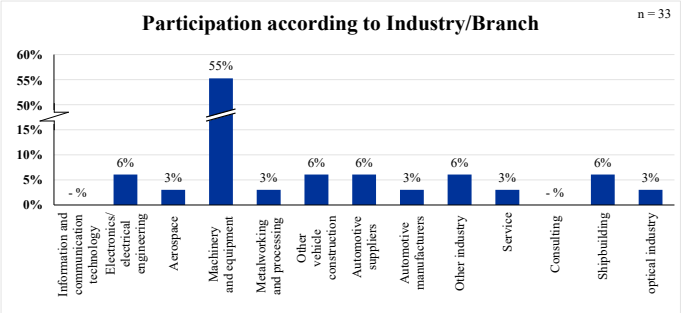

Fig 2. Distribution of participants according to company industry/branch

To ensure that the survey was as meaningful as possible, the aim was to recruit as many participants as feasible from different industries. Figure 2 shows the visualization of participants across the relevant industries. This shows that the share of machinery and equipment engineering predominates, but participants from a wide range of industries from aerospace, to shipbuilding, to automotive manufacturers nevertheless made contributions.

To enable the participants to be placed in the context of complexity, the configuration strategy was queried in the first part of the survey. Multiple answers are possible, since a company can also pursue different strategies. The distribution of strategies can be seen in Figure 3, where they are sorted in order of descending complexity, excluding "other." It is noteworthy that most of the participants come from companies that pursue the strategies "Engineer-to-Order", "Manufacture-to-Order" or "Configure-to-Order". The participant statements on the survey regarding strategy reveal that mixed strategies are also used, e.g., an ETO-based CTO approach, which is pursued in one company.

Figure 4 and Table 1 are used to assess the participants' discipline and position in the company. In Figure 4 it is shown which discipline the participants belong to. None of the mentioned disciplines is over represented, instead a broad range of different disciplines is depicted.

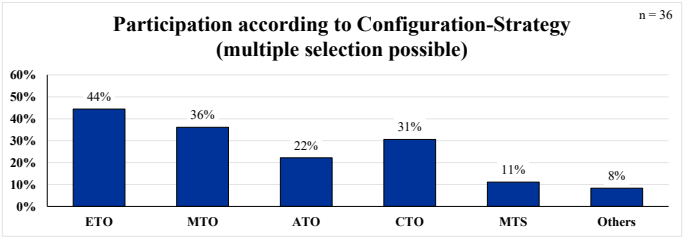

Fig 3. Distribution of participants according to configuration strategy

Table 1. Distribution of participants according to management level

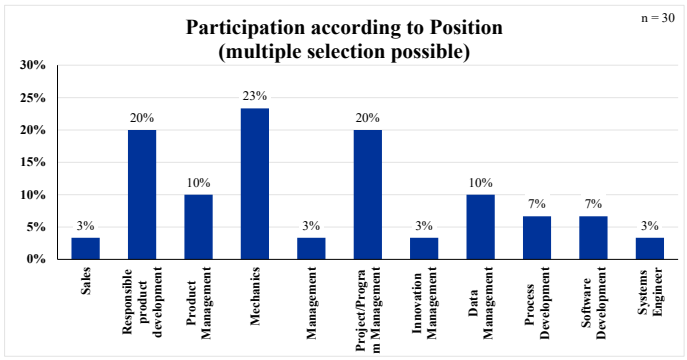

Fig 4. Distribution of participants according to position

Management Level	Participation (n=33)
Top-Management	27 %
Middle-Management	33 %
Low-Management and underneath	39 %

Table 1 shows how the participants are distributed across three management levels. In this survey, multiple choice was also possible, since different participants can work in two positions (e.g., Project Management and Sales). As shown in Table 1, the majority of participants belong to low management and below, followed by middle management. Here, the boundary is drawn to top management from the level of responsibility for R&D onwards. The answers given suggest that the information of most participants comes from situations with cross-departmental and cross-disciplinary involvement.

In order to evaluate the information given by the participants, the individual work experience is queried. Table 2 shows that 70% of the participants have more than three years of work experience. It can thus be deduced that the information provided by the participants is based on several years of experience in the surveyed context.

Table 2. Distribution of participants according to work experience

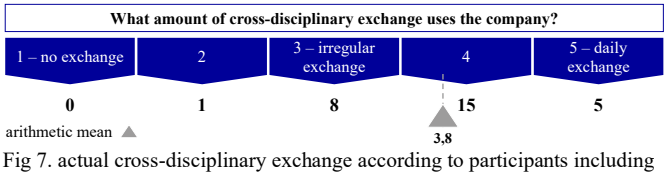

Fig 7. actual cross-disciplinary exchange according to participants including arithmetic mean (3,8)

Years of Experience	Participation (n=30)
Less than 1 year	7 %
1 to 3 years	23 %
3 to 10 years	37 %
10 to 15 years	10 %
More than 15 years	23 %

5. Survey Results

the following results describe the current state such as the current challenges in product development and the handling of requirements from different departments.

5.1. Query of the current status cross-disciplinary collaboration

In order to be able to depict a representative reflection of the current situation in the industry, the participants were asked about the current composition of the structures and the synchronization frequency in the company. Figure 5 shows the current composition of the departments. The participants were able to select on a scale of 1 (specialized group experts) to 5 (cross-disciplinary groups) how extensive the departments are structured cross-disciplinary.

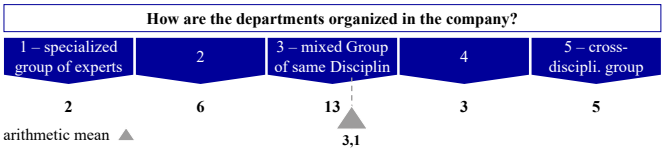

Fig 5. Actual department organization according to participants including arithmetic mean (3,1)

The data shown in Figure 5 refers to the absolute number of responses given. It can be deduced that most companies structure their departments based on disciplines (44.8%). Furthermore, the arithmetic mean of the question also indicates a discipline-specific department composition. In addition, it can be deduced that 27.6% of the respondents already work in structures aligned cross-disciplinary.

For the representative reflection, it was additionally queried how project teams are assembled. The respondents could choose on a scale from 1 to 5 how robust the team composition is. The distribution can be seen in Figure 6 based on the absolute number of responses.

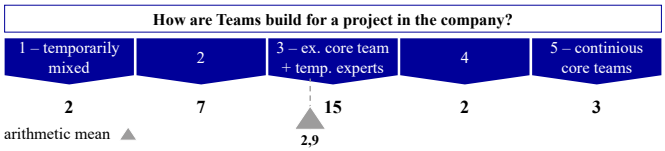

Fig 6. actual team robustness according to participants including arithmetic mean (2,9)

Figure 6 shows that the project teams are mainly (51.7%) assembled by core teams that are expanded by temporary experts. This is also shown by the arithmetic mean of the responses (2.9). In addition, it can be deduced from the distribution that the teams tend to be less robust, as 75.9% of the responses are in the range between *2* and *3*.

Figure 7 shows the current extent of cross-disciplinary exchange as indicated by the participants. This shows that there is a majority of continuous exchange between the disciplines. The arithmetic mean is 3.8 and 70.0% of the respondents work in structures with almost daily cross-disciplinary exchange.

As a result, it can be deduced that in most companies an extensive exchange between disciplines already exists (Figure 7), which goes beyond departmental boundaries (Figure 5). In addition, it can be derived that most project teams consist of a robust core team, to which experts are added as needed (Figure 6). This suggests that these teams have different requirements for interdisciplinary collaboration.

5.2. Evaluating the challenges of product development in the context of cross-department & cross-discipline collaboration.

After the current situation has been captured, the challenges of product development are inquired according to their relevance from the perspective of the participants. To offer possible answers, various sources were consulted in advance and possible challenges were derived from literature. [14,17,18].

To determine the relevance of the challenges, the participants ranked the given choices according to their priority. Subsequently, the individual prioritizations were weighted using the Fibonacci sequence and a merge of all priority tables was calculated. The weighting gives greater prominence to higher-priority challenges as displayed in Table 3.

Table 3. Challenges in product development ranked by weighted priority

Challenge (ranked)	Weighted relevance
Customer Involvement	42 %
Communication	37 %
Task Prioritization	33 %
Project Planning	31 %
Integration of new Aspects / Requirements	28 %
Cross-Disciplinary collaboration	26 %
Development process & requirement integration	24 %
Development speed	21 %
Task & Product understanding	18 %
Inter-Personal coordination	14 %
Other challenges	5 %
Integration of product-related services	4 %

In prioritizing the challenges (Table 3) it emerged that *customer involvement*, *communication*, *task prioritization*, *project planning*, *integration of new aspects & requirements*, and cr*oss-departmental & cross-disciplinary collaboration* are the most relevant (above arithmetic mean of 24% - stitched line) challenges in practice and explained below.

- With regard to **customer involvement**, the challenge is that customer requirements are not transferred directly into product development, but have to be collected and processed by upstream departments. This results in the necessary integration of cross-departmental perspectives due to implement customer integration effectively.
- **Communication** as a challenge reflects the complexity that arises due to the necessary synchronization between departments and disciplines. Empowering cross-departmental and cross-disciplinary communication can transform from a challenge into an enabler.
- **Task prioritization** is a challenge in many companies working on different projects. There are different priorities across departments. Cross-departmental and cross-disciplinary collaboration can support sharpen a uniform picture of priorities.
- The challenge in **project planning** shows intersections with task prioritization and communication. Due to the many stakeholders involved in product development cross-departmental and cross-disciplinary synchronization is required for enabling omniscient advantages.
- For the **integration of new aspects & requirements** the cross-departmental and cross-disciplinary synchronization can support collecting input from different departments into product development. Whether it is from the customer or from production.
- The sixth point, **cross-departmental & cross-disciplinary collaboration**, follows on from the previous points and reflects a cross-cutting challenge. As a result, we assume that the participants rate the prioritization lower, as the other challenges are individually more clearly in focus.

5.3. Inquiry of cross-cutting requirements into product development

To continue the analysis, survey participants are asked to rate different life stages according to their incorporation of requirements. In doing so, participants indicate in what amount requirements are incorporated into the current status quo and how requirements should be incorporated at what the participants consider to be the optimal stage. The possible selections were "directly", "indirectly" and "no requirements". In order to cover the cross-disciplinary perspective in addition to the cross-departmental perspective for product development, the development was divided into "own discipline" and "other disciplines". The results are shown in Figure 8.

Figure 8 shows all changes in the inflowing requirements. The diagram spans a space in which the relative number of directly and indirectly influencing requirements are shown. Points that were rated as less relevant by the respondents are shown closer to zero. Points, which have a higher relevance, closer to the blue diagonal line. The diagonal lines represent the indifference lines, on which the direct and indirect relevance of the requirements is indifferent.

It can be seen from the diagram that, with one exception, the relevance of the requirements increases in the desired target situation. It can be concluded that the cross-departmental and cross-disciplinary synchronization with regard to the requirements should increase.

In more detail, three categories emerge in the Figure:

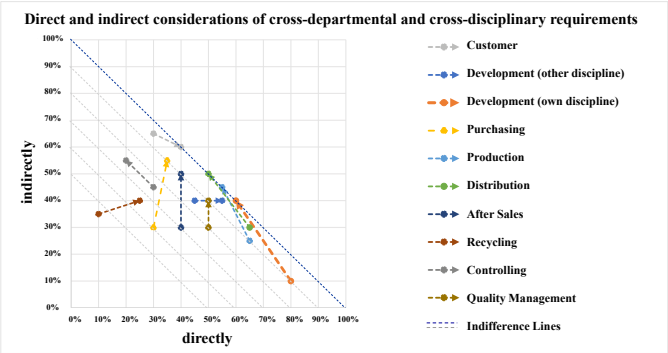

Fig 8. Analysis of the consideration of different requirements

- **Increasingly relevant** and **indirect** requirements from: *Purchasing*, *After Sales*, *Quality Management*, *Development (own discipline)*, *Distribution*, *Production*.
  This means that requirements from after sales are becoming more important for development, but according to the participants, these requirements should be integrated rather indirectly.
- **Increasingly relevant** and **direct** requirements from: *Recycling*, *Customer*, *Development (other disciplines)*.
  This can be interpreted as that the direct integration of the requirements of other disciplines in development should be increased.
- **Constantly relevant**, but **more indirect** requirements from: *Controlling*.
  This reflects the opinion, the requirements from the controlling should be incorporated more indirectly.

It should be noted that the requirements are oriented towards the middle, in the area between 40% and 60%, and approach the saturated indifference line. It can be concluded that less requirements in product development are considered "not relevant" in the desired state.

6. Discussion

The results of the industry survey provide a reflection of the current state of cross-departmental and cross-disciplinary perspectives in practice. The focus of the survey was on machinery and equipment engineering, which was also predominantly represented among the participants. Nevertheless, a wide range of different industries can be depicted from the participation. The distribution of management levels and disciplines is also characterized by a broad spectrum of participants, which allowed many different views to enter the discussion. For example, the participation of software developers, as well as developers from mechanics, enables to consider influences from different domains. However, the results have to be analyzed in more detail in further investigations, since the distribution of the individual disciplines was not even. Thus, it would be possible that a majority of a single discipline had a greater influence on the results than the minority of another discipline.

With a sample of n=36, the results provide a good basis for further discussion. Thereby, the results of department and team

composition, as well as synchronization between teams are very interesting for gaining an understanding of the current situation in practice. The results represent only a small share of the industry, but can serve as a reference for further consideration of the research topic in practice.

Although most of the survey participants come from product development, mechanical engineering and project management departments, a consistent picture emerges when it comes to the question of the importance of requirements (see Figure 8). The survey shows that requirements from all departments are currently still taken into account to differing extents. However, this distribution should be more balanced in the future, so that e.g., requirements from after sales, purchasing and recycling, should also be taken into account to a greater extent. This once again shows the growing importance of collaboration.

There are already different approaches that address the challenges mentioned in Table 3. For example, special visualizations have been developed to enable cross-departmental collaboration [19]. Alternatively, agile development methods offer the possibility of addressing several challenges simultaneously, e.g., task prioritization and project planning [20]. Nonetheless, the survey data suggests that existing approaches are not yet sufficient.

7. Conclusion

The analysis of industrial practice through the questionnaire has provided some impressions and references for further research.

With regard to team assembly, the results presented can be used in a case study in which exemplary teams in the development of modular product families are analyzed. Combined with the findings from a further downstream survey on modular product structures, insights can be gained from this with regard to the development of cross-disciplinary modules.

The relevant challenges identified in this publication can be incorporated into the case study. Thus, a focus of further considerations of challenges in a practical investigation environment is possible. For example, the challenges in cross-departmental and cross-disciplinary structures can be specifically targeted and interactions can be analyzed.

In addition, the indirect and direct requirements can be addressed. If the influences of the challenges across departments and disciplines have an impact on development-relevant requirements, these can be identified and possible solutions can be synthesized.

In conclusion, the identified results enable a more focused consideration of further investigations to identify points on how cross-departmental and cross-disciplinary collaboration in the development of modular product families can be methodically supported more effectively.

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