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A Study of the Application of Design Assets in Product Development

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Abstract. The introduction of product platforms has been acknowledged as a strategic enabler for increased business competitiveness. A vast body of research has described different aspects of platforms, but little work has been done on defining or delimiting the different types of elements that may build up a platform. Design assets include platform elements that are not commonly considered as a part of a platform. Previous research has suggested the introduction of formalized design assets to systematically extend an items-based platform with intangible elements. These are transdisciplinary objects, specifically prepared for reuse between projects to provide support for a wide range of engineering activities: specialized CAD geometry, working methods, spread sheets, function models or different types of knowledge representations, among others. The presented research is part of a larger project seeking to improve the collaboration between product development and manufacturing. This paper focuses on the use of potential and formal design assets at a development department of a global manufacturer of consumer products. The results show that the application of formal design assets depends on several factors, such as the level of professional experience and individual working styles. The contribution of the paper is a description of which formal and informal design assets that are used and a discussion on how the formal assets can be better utilized.

Keywords. Product development, design assets, case study, Product Platforms

Introduction

The introduction of product platforms has been acknowledged as a strategic enabler for increased business competitiveness. A vast body of research has described different aspects of product platforms but has yet to come to a consensus on what constitutes a platform or what is included. The description of product platform range from a platform consisting of *components and modules* [1], *a group of related products* [2], *a technology applied to several products* [3], to a platform consisting of *assets shared by a set of products* [4].

The platform descriptions above all require rigorous planning and front loading of the development of product variants in the portfolio, an effort that may be too large to suit all companies. The Design Platform (DP) presents a different approach where a platform is seen as an evolutionary entity that can be developed continuously [5]. Its platform elements include various assets such as physical components, the geometry of physical components (CAD-geometry), but also traditionally unstructured assets such as design rules, processes, design information, and other resources.

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The DP approach was developed for Engineer to Order (ETO) companies who work with customized products that requires unique design, engineering and manufacturing to meet distinctive specifications for a specific customer or market brand [5]. This business model limits the ability to reuse physical parts between customers and projects, and therefore highlights the need to reuse other assets. Since then, the DP approach has also been suggested as a way to build up a platform at companies that do not have a ETO business model [6].

A key part of the DP approach is the identification and management of *design assets*, that include platform elements that are not commonly considered as a part of a platform. Previous research has suggested the introduction of formalized design assets to systematically extend an items-based platform with intangible elements. These are transdisciplinary objects, specifically prepared for reuse between projects to provide support for a wide range of engineering activities, including assets such as specialized CAD geometry, working methods, spread sheets, function models or different types of knowledge representations, among others.

This paper clarifies how mechanical designers at a product development department of consumer products use the company's formal and informal design assets in their day-to-day work.

The objective is to improve the quality of the design work by better implementation of best practice and by avoiding repeating previous known mistakes. Reuse of design assets may also increase the development speed by reducing unnecessary information searches or "re-inventing the wheel" for design features and tasks that should be standardized.

The contribution of the paper is a description of which formal and informal design assets that are used and a discussion on how the formal assets can be better utilized.

1. The role of design assets in product development

In product development, information, knowledge and learning are critical elements since the designers use these to synthesize new products. The speed in the process may also be increased if elements are reused instead of being created for each case. Moreover, the quality of the result may also be improved if the elements are well prepared and has a high quality.

The above elements can be seen as *design assets* and could be incorporated in the platform of a company [6]. These include traditional item-oriented models, product structures, various kinds of process models and activities as well as results from previous projects, e.g. modules, products, Lessons Learned etc. [5]. The term "asset" also emphasizes the value of the resource and highlight the need for proper use, development and maintenance. An "asset status" can also highlight the importance of resources that are not physical parts.

Platform assets are discussed by several authors. Levandowski [7] suggest "development platforms" that include tangible and intangible resources that are essential for supporting a holistic platform development across all stages of a lifecycle. Robertson and Ulrich [4] defines platforms as "*the collection of assets shared by a set of products*", and specifically highlight Components, Processes, Knowledge, People and relationships as constituents of a product platform.

Knowledge assets are of special interest to product developing companies because knowledge is the basis for the design of new products, processes and services. In this context, knowledge and learning serve as the basis for organizational development as stated by Stenholm, et al. [8], who presents a framework for knowledge reuse in industrial practice. This is based on *engineering checksheets* that can be reused in the organization to facilitate creation codification, and transfer of knowledge. Another way to improve knowledge assets is presented by [9] who propose using a standardized A3 format to foster concise, easy to read guidelines, and introduces a better structure and a content more adapted to the tasks at hand, thereby avoiding time consuming searches for information in guidelines, project folders and documents.

To conclude this section, from the generic asset definition of Robertson and Ulrich [4] and the design assets definition of [6], it is clear that a delimitation of what to include into the concept of assets is needed. Otherwise, everything in a company may be considered being an asset, which is not feasible. A better knowledge of what assets designers use in practice is therefore needed.

2. Research approach and company needs

This descriptive study builds on two datasets collected at one product development department. The unit of study is a department for mechanical design of consumer products. The presented research is part of the IDEAL research project, seeking to improve the collaboration between product development and manufacturing. It includes 5 companies representing different domains and disciplines, including industrial house building, automotive accessories, professional lighting, and garden products. In a previous study at the 5 companies, the need for better knowledge around the support for design engineers was identified, which narrowed the current research into the use of design assets. The starting point for the studies was the company managers' desire to improve its working processes and methods.

The first dataset was collected as structured interviews scoping the integration between product design and manufacturing by identifying working methods and tools, including knowledge assets. The second set included both structured interviews and an interactive study observing what assets designers use to do specific tasks, targeting the use of formal and informal design assets. The data collection is summarized in Table 1.

Table 1. Data collection.

	Interviews	**Workshops**	**Demonstrations /Observations**
Study 1	10	-	-
Study 2	5	1	4

Study 1 included respondents from different departments, aiming at identifying specific challenges regarding interaction between manufacturing and design, to identify available support and processes, and find suggestions for improvements. Study 2 started with interviews to identify questions and gaps between what resources that exists and what resource that are actually used. The respondents were design engineers and the data was used for formulating the tasks for the following demonstrations/observations. In this phase, also one process manager was interviewed to get an understanding on how guidelines and lessons learned are developed and maintained, of which the engineers had little information.

In study 2, four design engineers were observed when they were solving the tasks identified in Study 1. The tasks were: How do you start to design a part in a new product? What assets do you use to select a suitable screw for your part? What assets do you use to design a screw boss for your part? What assets do you use to design a "Groove and tongue interface" between two parts?

The respondents were two junior designers with less than 2 years' work experience, and two senior designers with over 20 years' experience. They were selected by their manager, and had a wide difference in experiences, thereby making the support needed for different experience levels more evident.

Document analysis of different Design Guidelines was also a part of the data collection, where the characteristics of different guidelines were analyzed.

3. The state of practice for the use of design assets

The nature of product development at the department can be characterized as incremental in the way that the products are mature in function, requirements and layout. The products are refined and evolved over product generations, with few introductions of disruptive technology. Innovations and new technologies are developed at a separate department until the technical readiness level is sufficiently high to implement it in new product development projects.

Study 2 focused on the start of the detailed design process. In this phase, most of the important design decisions regarding specific components are made, which makes this phase suitable for examining which design assets that were used. The company had a variety of formal supportive assets for design engineers, such as an extensive development process with its supporting documents, including specific methods and processes for Design for "X" methodology and for D-FMEA. There were also several Design Guidelines and Lessons Learned.

All respondents initiated the design work by identifying the corresponding parts from the previous product generation. It thus served as an informal basis for the subsequent work, but could only describe the final geometry and not its underlying requirements and motivations, i.e. its design rationale. Ideally, this rationale is described and explained in the company's formal design assets, and part of the research was to see what support that could be identified in documents and guidelines.

3.1. Current use of formal design assets

The basis of the development work is the new product development (NPD) process. It is a mature phase-gate process describing the required tasks in the complete development life cycle, starting with technology development and ending in aftermarket activities. The process is based on documents describing what tasks to perform in different phases of development and how these should be followed up in the process gates. Table 2 lists the formal design assets that were identified as being relevant for product development:

Table 2. The identified formal design assets.

Type of asset	Description	Responsibility
Lessons Learned	Learnings from projects, focusing on improvement of the design process. Often adding new task for the Lead Engineer in subsequent projects.	Lead Engineer
Design Guidelines	Learnings from projects, focusing on "best practice" for certain design tasks for, arranged around specific parts.	Design Engineer
Design for X	Standardized Design for "X" methodology for improving the producibility of the designed parts.	Lead Engineer
D-FMEA	Standardized Design FMEA methodology for risk assessment of the designed parts.	Manufacturing Engineer
Excel sheets	Ubiquitous tool, often the base for checklists or templates for other tools, such as project progress, D-FMEA etc.	N.A.
Powercopy	CAD-feature that support the creation of frequently used standard geometry.	Design Engineer
Standard part library	CAD-model library that hold frequently used standard parts such as fasteners.	Design Engineer
Skeleton model	CAD-feature that support the layout of a complete product.	Lead Engineer / Layout Engineer

Three roles were identified as the targets for the design assets. One role is the *Lead Engineer*, who is responsible for meeting the requirements in the product or product family. The Lead Engineer is also making the important central design decisions and selects the technology. Another role is the *Layout Engineer*, that coordinates the geometrical layout and packaging of the product through the Skeleton CAD model. The *Design* Engineers develops detailed design of their components, using input and requirements from different sources. One driver is the product layout, that defines the geometrical interfaces and packaging envelopes. Another driver is the physical shape, created by industrial designers, that define and constrain the outer, visible surfaces.

The focus of the paper is the support for design engineers during the initial design phase. In the NPD process, several mandatory tasks can be considered as reactive measures done after the initial CAD geometry is created, aiming to avoid mistakes and to improve the producibility of the parts. Their supporting assets are therefore not described in the paper

A majority of the activities and assets in the NPD process are controlled by the Lead Engineer. These are managed through checklists and therefore also followed up in the process gates. Examples are the analysis of manufacturing requirements through DFX and D-FMEA workshops. Worth noticing is that for Lessons Learned and Design Guidelines, there are no metrics or follow-up on how these are applied in projects, besides a general remark in the NPD process stating that these should be considered in new projects.

The assets considered are the ones used by the design engineers in table 2. These are Design Guidelines, Powercopy and the Standard part library. Lessons Learned is more targeted toward the development process and the responsibility for applying theses in new projects falls on the Lead Engineer, even if they also are available for design engineers.

3.2. Current use of informal design assets

The studies also clarified that design engineers use a multitude of support that could not be characterized as formal design assets. A lot of the work could be characterized as seeking information though personal communication. Besides communication with colleagues at the department, discussion with the test lab and with the manufacturing department was a common way to get feedback on emerging designs. CAD geometry from corresponding parts of the previous product generation was also used as informal templates for starting new designs. For the selection of screws or other fittings, the components used in previous designs was often the starting point and not the guidelines. As an example of an informal design asset, one of the respondents had compiled a personal binder with selected information on screws instead of using the formal online-support.

3.3. A summary of the use of design assets

The results are summarized in Table 3. In the case, the junior designers used more of the formal Design assets than their senior colleagues, and also used more support through communication. Moreover, the junior designers also have less interaction with external departments such as the test lab and manufacturing.

Table 3. Use of design assets. Assets used by junior designers are denoted by a J, seniors by an S.

		Engineering tasks			
		Start designing a part in a new product	**Select a suitable screw for a part**	**Design a screw boss for a part**	**Design a Groove and tongue interface between two parts**
Formal assets	Design Guidelines	J, J, S	J, J, (S)	J, J, S	S
	Lessons Learned	S			
	Power-copy				
	Standard part library		J, J, S, S		
Informal assets	Supplier documentation			S	
	Previous CAD parts	J, J, S, S	J, J, S, S	J, J, S, S	J, J, S, S
	Previous physical parts	S	S	S	S
Informal discussion	Colleagues	J, J	J, J	J, J	J, J
	Test lab	S, S	S	S	S
	Manufacturing	S	S	S	S

The Powercopy assets were not applied in this early phase of development, since this geometry exists only for a few specific 3D features such as injection molded threads. It is, however, used for creating repetitive features required in all components that are added at the end of detailed design, such as embossed symbols for material type and date stamps. Moreover, the junior designers did not suggest to use a guideline to design a "groove and tongue interface" between two parts, since they did not know that it existed.

3.4. The characteristics of formal Knowledge Assets

Knowledge Assets was considered important by the company management and the company has invested considerable resources in making these available for their employees. There were IT systems and processes in place for how to collect, arrange and distribute different types of information. Lessons Learned were captured from projects by the process improvement team and compiled into a Lessons Learned portal that was accessible for all designers.

The documents analyzed were Design Guidelines, since these are the tools targeted for design engineers. Design Guidelines are created by senior designers and describe different aspects on how to design a specific part, based on a generic template.

The character of the guidelines was inconstant, typically between 10- 70 pages in length, reflecting upon the interest and experience of the author. Most guidelines presented a rich variety of information in figures, text and tables. In a typical guideline, advice is given in a wide range of aspects, ranging from describing a good way for how to secure a specific electrical connector in a plastic cover, to what screws that was used to connect a cover in a product.

The guidelines also had an unclear target audience. Some were written as introduction to the part, having a generic character suitable for junior designers or for external consultants. Other guidelines required specific prior expertise for the advice to be used.

Another challenge was that the vast number of documents that made it hard to find relevant information. Even though the IT systems had well working search functions and filters, the respondents found it challenging to find the right support. Part of this come from the structure of the guidelines, since several design aspects were embedded in one guideline, which made it difficult to know in which guideline and where in that guideline the desired information could be found.

4. Discussion and conclusion

Management of design assets as a part of the design platform should be fundamental in all product developing companies, since design assets have the potential to improve the efficiency in the design process. Design assets may reduce rework by presenting ways to avoid previous mistakes, enabling a consistent part quality through best practice designs, and speed up development by using standardized design features.

The case company has invested considerable resources in organizing a platform for different design assets. It also includes "competence teams" used to provide a structured ownership of the design knowledge within a specific area. These teams serve two purposes, the first is to build company knowledge by updating and maintaining codified knowledge in design guidelines, the second is to provide expertise to assist colleagues. For example, there are appointed experts on material selection, screws, simulation etc.

The results show, not surprisingly, that design engineers use both formal and informal design assets when creating new products, often preferring to seek information though personal communication rather than in documents and guidelines.

The use of design assets was also dependent on personal preferences and experiences, and junior designers seemed to be more interested in using the formal support. They also had less interaction with external departments, which may be a consequence of their limited personal network within the company. Instead they relied more on communication with their closer colleagues. The senior designers relied less on discussion with close colleagues and application of design guidelines, instead they actively gathered information from individuals in other departments, such as the test- and manufacturing engineers. This indicate that more support directed towards senior designers should be developed, covering domains outside of design.

All respondents used the previous CAD geometry of the equivalent components as a starting point for the design. These therefore acts as informal templates for the development of new products. One respondent commented on the risk of using previous designs as “inheriting mistakes”. Since a CAD model only describe the final geometry, but not the underlying requirements and decisions made during the design process, it is uncertain that a redesigned part will work under new circumstances. A better connection between a part and its design rationale could therefore be valuable.

Knowledge assets could have an important impact on the output of an R&D department if they are effectively used. The case show that structure and the uneven character of the Design Guidelines often makes it challenging for designers to use them efficiently. The guidelines are often long and rich in data within different areas, which makes it hard to find the information needed. To improve the value and usefulness of the existing Design guidelines, several measures could be taken. One relatively quick suggestion would be to introduce tags in the guidelines where specific design features are described, such as *#screw tower*, *#snap fit* etc. This would facilitate searches for specific objects that do not require knowledge of which specific guideline contain the feature. Another suggestion is to divide the guidelines into thin slices of information, as proposed by Stenholm, et al. [8]. In this way, the need of a specific function could be met by displaying a set of best-practice design features in a Set-based approach [10] that present the alternatives to the designers.

The company’s goal was to get a better understanding of how design assets are used in day-to -day work and how to improve the utilization of these assets in the organization. There was, however, no collection of data or follow-up on which resources were frequently accessed. A suggestion is therefore to log the number of times an asset is accessed, and use this information for further improvements.

The contribution of the paper is a description of which formal and informal design assets that are used and a discussion on how the formal assets can be better utilized. The small sample size makes it hard to draw general conclusions for other types of industry but the results show that even in a mature, well organized company, there can be several informal assets used. These are not managed and therefore unavailable for others as a part of the design platform. A better structure could be a feasible way to increase the value and use of formal design assets, and thereby increase the efficiency in a product developing company.

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