8. Product Development and Design Research

Research Into Architects as Component Designers

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8.1 Introduction

In Design Research, a lot of energy has been put in the generalisation of the design process. Practising designers however, state they do not see much profit from this knowledge. As a response to research aimed at generalisation, Lawson (1994) started to describe individual design processes of architects. This research showed that besides general conclusions, clear differences in work methods can be distinguished.
From these experiences with generalisations on design processes, I drew the conclusion that describing a general outline for a product development process does not serve practising design professionals accurately. A certain event will never repeat itself exactly (Waldorp 1992). But certain elements form similar events that can be lumped together as themes or patterns. Themes are elements in events that can be seen as resource or constraint for product development processes. Patterns are reactions on a theme, or actions from other persons, affecting product development processes.
Within the frame of my PhD research I reconstructed effective development processes of new building components initiated by architects. Themes and patterns found were used to construct a theory. Architects can profit from the knowledge accumulated on themes and patterns. Elements from this theory that they feel are relevant to their approach can be integrated into their private work methods. The aim is to stimulate architects to develop more new building components and come to a more effective and efficient way of component design. Before going into the results, I will outline the research methodology and the theoretical framework.

8.2 Methodology

At first the aim of my doctoral research was to catalogue and describe the product development processes in the building industry. First a case study research was carried out that focused mainly on manufacturers. Six initial cases revealed that architects play an important role in initiating product development by requesting manufacturers to supply special non-existent components to realize their projects. It also turned out that manufacturers use some of these ideas to generate new standard products. In contrast to the development processes of standard products in the building industry, special product development initiated by architects is a virtually uncharted territory. I therefore decided to make this the central subject of my doctoral research.

8.2.1 Cases and additional research data

Since very little research had been done into special product development in the building industry, the obvious choice was to use an exploratory research method. In principle, it would

be possible to use exploratory, descriptive or explanatory research strategies. On the other hand, these strategies have different characteristics which makes the one more suitable for a particular study than the other. The decision to opt for case study research was based on Yin's (1989) considerations.
Semi-structured interviews were held with employees of manufacturing companies and architectural practices. The sensitising concepts underlying the interviews came from business administration literature on innovations and design research. The literature study produced tools to get to grips with product development in the building industry. An overview is to be found in a state-of-the-art report (Oostra 1996). The case studies investigated to what extent the sensitising concepts could be applied to component design. This approach is based on a long tradition of the grounded theory methodology that originated in the social sciences (Glaser and Strauss 1967).
The case study results will be supplemented with statements made by 118 architects, manufacturers, contractors, constructors, project developers and researchers who were not part of the case studies. The research results were linked together using the game theory.

8.3 Theoretical basis

In the first instance it is important to make a distinction between two product categories: standard products and special components (inspired by Eekhout (1997)). A standard product can be manufactured independently without a client being involved. All products are identical, even though a manufacturer can include a number of varieties in his range, differing for instance in colour or measurements. He will know for certain precisely what requirements the product in question must comply with. In the case of a special component a manufacturer may get a request from a client that he cannot resolve with a product from his range. A completely new product must be developed for a specific building task.
There is an essential difference between the parties who take the decision whether or not to make a product. A manufacturer decides on the making of a new standard product. In the case of special components it is the client who decides that he wants to use a non-existent product. Clients may play different roles in the building process, for example a principal, contractor, consultant or an architect. This paper focuses on the situation in which it is the architect who decides whether or not a new product should be made. From now on, I will use the term component design to refer to an architect's contribution to the development of special products.
For present purposes an architect is defined as someone operating alone or on behalf of a group of individuals, usually a firm of architects, who designs a plan for a building and looks after its realization. The aim of an architect is to design or redesign and realize buildings or other objects in cooperation with people outside his own firm. The building process is the process by which an initiative towards a building project is converted into a physical building. The achievement of this goal requires many different types of expertise, generally represented by individuals from different companies. This paper proceeds from a 'traditional' building process in which an architect directs the other parties involved in the project on behalf of a client. Participation in a building process is a precondition for being able to initiate the development of special components.

8.3.1 The manufacturer's perspective

The literature from the perspective of the manufacturer of standard products has a long tradition (Bruce and Biemans 1995, Hollins and Pugh 1990, Clark and Wheelwright 1994, etc.) This perspective is recently being broadened. Von Hippel has introduced the consumer

active paradigm (CAP) as a counterpart of the manufacturer active paradigm (MAP) (von Hippel 1988). His research suggests that clients in the business-to-business market usually look for a manufacturer who is able to make the product they have in mind. Clients thus respond to technology capacity in general and a company's capacity in particular (Hutt and Speh 1995). Something similar is also taking place in the building industry.
Also in the building industry manufacturers are seen as the ideal product developers (Pries 1995). However, other parties also make important contributions to product development. Architects for example play an important role in initiating the development of component parts in specific building tasks (Oostra 1998). Architects who come up with an idea and initiate product development fit in with Von Hippel's consumer active paradigm (CAP).
In planning a building, architects come across elements that cannot be realized with standard products. In situations like this they have the choice of adapting the design to existing products or initiating the development of new products. To achieve good results with the development of special components, an architect must be open to collaborating with others (Oostra 2000). He needs production facilities, and hence must collaborate with a manufacturer. In most instances he will also need complementary expertise in the preparatory phase from other people such as constructors or other advisors.

8.3.2 Game theory

The game theory perspective was used to interpret and link together the data generated in the context of this study. Historians date the origins of game theory as far back as 1654 (Colman 1995). Game theory initially began as an abstract mathematical invention, the theory of probability. Since then it has evolved into a model for all kinds of interdependent decision-making processes. The social sciences began to use game theory to explain and predict behaviour.
In their book "Actors and Systems", Crozier and Friedberg (1980) show that games provide an excellent frame to study companies and industries. According to the authors, the creation and use of structured games is one of mankind's more important inventions, making possible the achievement of common goals, which require the cooperation of many different individuals. Contributing to a common goal also allows each individual to advance his own interests. The way in which an industry and companies are organized, however, has an important influence on the behaviour of the individuals involved. People are not controlled by the rules of the game but by its structure. In other words, there is scope within the rules for the players to determine their own strategies that will allow them to play in the way they personally find satisfactory. Usually they will only be able to achieve their own goals as long as they go on contributing to the common goal.
Following Crozier and Friedberg, I have distinguished between resources, constraints and strategies. Architects have certain resources at their disposal to use in a product development process. They will encounter difficulties that they will have to overcome if the process is to be brought to a successful end. Deliberately or otherwise, architects use certain strategies to take full advantage of their resources, or to sidestep or get around any difficulties. How architects see their resources, constraints and strategies depends in part on the 'frame' (Schön 1983) they use to assess their own situation.

8.3.3 Project management

Architects employ strategies to manage the available manpower, means and information in the development process of a special product. They have to operate within the margins of the

building process. The general knowledge of these strategies comes under the discipline of project management.
Wijnen, Renes and Storm (1988), who are authorities in the field of project management, categorize the aspects to be controlled in managing a project into: (a) Time, (b) Money, (c) Quality, (d) Information, and (e) Organization. Other aspects that are emphasized in the literature are communication (Robbins 1996) and monitoring the work sphere in which trust among team members plays an important role (Bennis 1994). These aspects provide a basis to divide the strategies used by architects to direct project development into the following categories: 1) Time, 2) Money, 3) Quality, 4) Information and communication, 5) Organization, and 6) Atmosphere.

8.4 Research findings - themes

8.4.1 Resources

Important resources to help realise special products are time, money, information and access to facilities. Since an architect does not have extensive knowledge about the appropriate technologies to manufacture a special product, he needs other parties to collaborate with him. In this context, the aim of collaboration is to have knowledge and manufacturing and testing facilities at one's disposal.

Product development budget

There is a link between the commissioning of a building project and the budget allocated for its construction. The prevailing opinion among architects is that a higher than average budget for a building, or a higher than average fee for an architect, is a precondition for initiating the development of new components. An example to show that this need not be the case is a young product development company oriented towards the building market. The money that had been put aside to purchase standard light fittings for an office was used to develop new fittings. Development costs and the manufacturer's fee came well within the budget reserved for light fittings.

Time

The time allocated to a building process may in part be spent on developing new components. The planning of design work determines the time available for product development. It could be that a building has to be completed in such a short space of time that there is no room left for an architect to design a new building component.

Information and facilities

An architect depends on the support of other parties, those who have the knowledge and facilities that are needed to realise a new product. For this, an architect needs at least a manufacturer who is willing to make a new product. One of the cases proved that this collaboration is not always as obvious as it seems. A manufacturer, who specialised in sports goods, was not interested in delivering building products. It took much power of persuasion to move this monopolist to collaborate.
Because the parties involved in a building process do not see the development of new products as an essential part of it, an architect will have to motivate the parties whose collaboration he needs to develop a product. Money can play an important role in this respect. But other reasons could also motivate a person or an organisation to contribute to product development.

The following motives for cooperative behaviour towards architects have been observed:

- A client organisation: Because product development is appropriate to its declared aims.
- A researcher at a university of technology: Because he is involved in research into the material in question.
- An institution concerned with the development of steel structures: Because it is prepared to subsidize a project where it sees the possibility of encouraging the use of steel in buildings.
- A structural engineer: Because he is very interested in applying the material in buildings, or because he enjoys thinking about something new.
- A supplier: Because he would enjoy being involved, while he does not see the project as an immediate financial success for his company ('hobbyism').
- A supplier: Because he sees opportunities to increase his turnover.

Since the crucial role of having relevant information available, this study looked into the matter of information exchange in closer detail. The exchange of information relevant to component design has different characteristics depending on the sort of information. In this connection two sorts of information mentioned by Colin Davidson (1998) are interesting: (1) project-related information and (2) general information. He defines them as follows: "Project-related information, as its name implies, denotes information that is particular to an individual project and is accumulated during the project-related processes of design, manufacture and construction. General information is, at least in principle, available to nourish the processes of any construction or any research project; it is accumulated constantly as more and more is learnt about building-related technology, and about the application of the human and natural sciences to building."

These two systems of information are found in different contexts and time scales. In the case of standard products it is in the producers' interest that potential specifiers are aware of the existence and advantages of these products. It is of his immediate advantage to make his new product known as widely as possible among those involved in the building industry who exercise an influence on the choice of building products. His aim is to make knowledge of his products part of the reservoir of general information of the industry.

The different members of the building team build up project-related information at the start of a building assignment. These members also have to find a common form in order to communicate for the duration of the project. When the project is realized and all decisions concerning it have been taken, this information largely disappears. Only a part is stored in archives or kept for maintenance purposes. The same goes for a part of the information linked to the development processes of special products. This information has not disappeared but it only remains in the form of experiential knowledge for the people concerned.

The information needed for developing a new product is a combination of these two sorts of information. As a result a distinction needs to be drawn between these two sorts of information in fostering innovation in building. Architects use general information in the development process for special products as a step to find producers. Besides drawing from their own experience, they use trade literature with this end in view. This literature is however inadequate for this use. To stimulate the development of special products by architects additional information has to become available. That is now mainly part of the project-related information reservoir. Because of the fact that is reservoir is hard to access, there is a need for an intermediary between architects and producers. This role is being taken on by a number of newly emerging firms, but these only reach a small group of architects. To encourage product

innovation on a larger scale, relevant information needs to be made generally available. A database via the Internet is ideal here. An independent body would have to make an inventory of the various projects using special components already realized. Information would need to be provided about the parties concerned together with a short description of the product developed. Ideally there should also be a survey available of the production facilities of the different producers involved in the building industry, with an assessment of their technical knowledge. In Holland the firm of Boosting has the potential for this. They have the proper contacts and objectives even though they do not yet have the financial means to realise such a database.

8.4.2 Constraints

When architects design components, they will for instance have to check for the codes and standards of the industry that might stand in the way of the development and application of new products. Insurance companies, clients, financiers, producers, contractors, politicians, project developers and even fellow architects may place obstacles in the way of architects' initiatives to develop new components (Oostra 1999) Innovation goes hand-in-hand with uncertainty (Crozier et al 1980), particularly in the initial phases. And innovation requires people to adjust their habits. In general the other players will try to keep such uncertainties under control and try to escape limitations that others try to impose on them (Crozier et al 1980). In a defensive reaction, a constructional engineer will stick to the usual methods of calculation, a manufacturer to the usual methods of production and a contractor to the products and constructional techniques with which he is familiar (Argyris and Schön 1996). Architects whose aim it is to develop special products need other parties to collaborate with them and to offer their expertise. However, the same parties could also obstruct the component design process. Architects should be prepared to anticipate and respond to possible obstruction in the product development process. Examples of such instances are the following:

- An insurer may impede the application of existing products in an unconventional way, let alone the application of new products.
- There may also be problems if suppliers have set up a cartel with the aim of dividing the market between them. Things can be difficult if there turns out to be only one supplier who can supply what an architect requires but that supplier is barred from doing so by the terms of an agreement with his fellow suppliers. As a consequence, the required products will not be forthcoming.
- One last example: Any attempt to cut out subcontractors will discourage innovation, as low prices do not guarantee the quality of a subcontractor's work. Particularly when a subcontractor contributes to a new component cutting him out can have an unfavourable effect. This situation may also result in a worsening of mutual relationships, which in turn would affect communication between the parties involved. The end result will be problems in the co-ordination of the various different activities and products.

8.5 Research findings – patterns

An inventory has been made of what made architects want to develop new building components in the first place and their roles in product development and strategies they use to steer product development processes.

8.5.1 Motivation

Although architects may initiate the development of new products, their main interest is not focused on the individual product but on the complete building project. Products are secondary in the sense that they are only the means by which (parts) of buildings are realised. But this central preoccupation with the realisation of the building can provide a motive to create new products. Frustration may be the trigger here. For example, it may not be possible to realise part of a building design using existing standard products in a way that satisfies the architect. If the discrepancy between the desired result and the available solutions is big enough and there is time available, then the architect will explore the feasibility of product development. The architect must consider product development to be an option in the first place, though. Some architects will only use products already available on the market.
Another motive to design new components can be the desire to distinguish themselves from their colleagues. Architects have to compete in order to get their building assignments.
A third reason to innovate among architect is interest in technology and their quest for new and improved solutions for design problems. In this case the architect is interested in exploring new possibilities and will try to gain more in-depth knowledge. He will look for occasions in a building design process to utilize these new insights and ideas.

8.5.2 Roles

Architects choose between possible solutions for their building designs and so are in a position to persuade their partners to cooperate in product innovation. Taking on the role of initiator of the development of project related product development makes adopting the role of motivator inevitable since other parties, such as the client and the contractor, have to be convinced of the need for the new product. The architect also has to find at least one manufacturer, who may or may not operate in the building industry, willing to develop and manufacture a new product based on his idea and at an appropriate price.
Architects usually play an active role as designers in the product development process. Although not responsible for all design tasks, architects make the final decisions concerning the appearance of new products. They can therefore take up a position as client or as co-designer (and occasionally as co-developer), depending on how much they rely on the aesthetic abilities of the manufacturer.

8.5.3 Strategies

Component design processes are incorporated in design processes of buildings. The development of a component is thus embedded, or in other words nested in another process (Kendall 1990), the building process. This imposes limiting conditions on a product development process. The fact that component design is embedded in the building process forces an architect to use his strategies at two levels and so exert a favourable influence on a development process, that is:

- At the level of the building process.
- At the level of product development.

Many architects find it difficult to manage product development. Embedding it into the building process is seen as a stumbling block. Although some architects would certainly like to develop a new product, a number of circumstances prevent them from actually doing so.
Architects can learn from the strategies their fellow architects use in managing development processes for special products and so achieve components which are better adapted to their own and their clients requirements and demands. A résumé of the strategies found in this study is presented in the following table.

TABLE 8.1

Strategies used in the building process to manage product development
Time • Persuade a client to increase the amount of time for the creation of new products by convincing him of their advantages. • Start the product development process as early as possible in the building process, so increasing the amount of time available.
Money • Reserve part of the building budget. • Reallocate costs in the building budget. • Persuade a client to increase the budget by convincing him of the advantages of the new products. • Inquire about possible subsidies. • Look at different kinds of manufacturers when determining the price to ensure that the price is in line with the market. This means looking at the cost of alternative solutions. An architect who goes about this cleverly, by example by thinking carefully about the product description or the way in which he invites tenders, may achieve a more favourable price.
Quality • Call on the knowledge of third parties - competing manufacturers or product developers - to overcome problems.
Information and Communication • Have an open-minded attitude towards a manufacturer to make it easier to exchange information about a product's feasibility and the way in which it is composed. • Ensure that a client remains enthusiastic not just about the building project but also about the component to be developed. This is important. If there is any uncertainty about possible risks he may reconsider his decision.
Organisation • Consider whether product development can or should be kept separate from the building project. • Come up with new forms for the organisation of the building process which are more favourable for initiating product development.
Atmosphere • Involve people in the building process who are receptive to new ideas. • Improve motivation in the pre-tendering phase by paying for any development work.

8.6 References

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