

Action Planning for New Product Development Projects

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Two empirical studies are presented to show how experienced project leaders execute New Product Development (NPD) projects. In the first study we interviewed project leaders from four different design firms. We discovered that inside realistic NPD projects the NPD activities seldom occur in the same order as they are described in the NPD literature. Some activities are omitted, some activities are run in parallel and some even have a seemingly illogical timing. The reasons for these 'strange' patterns are usually project-specific. The NPD project leaders distinguish four types of NPD projects. On the one hand, familiar (client well known and/or standard technology and/or re-design) or non-familiar projects (new client and/or new technology and/or innovative design), and on the other hand, the complexity of the product (simple versus complex), and they plan their NPD projects differently according to those four types. For instance, within simple and familiar projects they omit more NPD activities than in projects with a more complex and new nature. In the second empirical study we did a matched pairing study (finding NPD projects which would match each of the four types). This time we interviewed experienced project leaders from different companies, because they are probably more familiar with only one type of NPD project. We found a minimal and a 'regular' NPD process. Projects on new products (the non-familiar type) contain the most activities in the total project. Complex projects execute more activities in the first stages, and also different activities than in non-complex projects. We also found that NPD project leaders adapt an opportunistic attitude towards carrying out activities in parallel in order to gain time.

Introduction

The New Product Development (NPD) process or Product Creation Process, or more generally the Product Innovation Process, has been subject to model builders since the early to mid 1950s. The complex process of opportunity finding, idea generation, concept building, prototype testing and the market introduction of a new product has been described in many ways. However, a newly appointed project leader gets little or no support from the theory on how to plan his or her specific NPD project.

Some 24 years ago, Saren published an overview of the different types of models prescribing the different steps or activities within the product innovation process (Saren, 1984). He distinguished five different categories:

1. Departmental stage models;
2. Activity-based stage models;
3. Decision-based models;

4. Transformation models;
5. Stimulus response models.

He did not qualify the one category to be better than any other category. He also did not provide any help in selecting a category for a specific NPD project. It is all up to the project leader to find his or her way through this jungle of different models.

Since Saren's paper, no new categories have been developed (for examples of the models, see for instance the Germans Pahl & Beitz (1984), the Danes Andreassen & Hein (1985), the Englishman Cross (1994), the Dutchmen Roozenburg & Eekels (1995) and Buijs & Valkenburg (2005) or Cooper's Stage-Gate Model (1984) from Canada and Ulrich & Eppinger (1995) from the United States). Most of these models come down to a variation of a stage-gate process. The total NPD process is divided into a series of stages (e.g., pre-development, development and market introduction), and inside each stage a couple of interrelated

actions have to be executed. Each stage is completed if a pre-determined milestone is reached (e.g., 'market feasibility' or 'prototype testing'). This milestone is called a 'gate'. After getting permission (usually by higher management) to go through the gate, the next stage will be executed. If permission is not granted, usually an iteration takes place; in other words an earlier stage or stages is executed once more until the necessary quality to get through the gate has been reached. This continues until the new product has entered the market. Sometimes the results of a stage lead to the end of the NPD project.

The academic debate on these models has been concentrated on the one hand on the number of stages, the number and quality of the gates, which activities belong to which stage, and on the other hand on where the innovation process starts (with a technological idea or with the recognition of a need in the market place, a so-called opportunity) and where it ends (the first product sold or with the satisfaction of a happy customer or consumer?). Now the most recent models have added the 'fuzzy front end' at the beginning of the process, and some have added the use of the product at the end. The most advanced ones have even tied together the product use stage and the fuzzy front end and come up with a circular innovation model (for an overview of this development, see Buijs, 2003). In conclusion, the theoretical innovation process has been made longer, both up front as well as downstream.

All prescriptive models use their own jargon, use their own graphic representations and fail to show all the necessary iterations the real innovation process is famous for. All show more or less rational and logical sequences of actions. In reality, however, we rarely ever see these rational step-by-step sequences as shown in the theory books.

As long ago as 1983, Cooper published an investigation about the empiricism of NPD, and discovered that seven different patterns can occur:

1. The market oriented process.
2. The design oriented process.
3. The balanced complete process.
4. The front end dominated process.
5. The minimum process.
6. The launch with prototype process.
7. The prototype dominated process.

His research was based on an inquiry among innovation managers. He gave them a list of 20 different NPD activities known from the theory books, and asked whether an activity had taken place in their NPD process, in which sequence and what the duration time was of

the executed activities. He could not give any explanation about the reasons behind these patterns.

Comparable results were found in a study in the Netherlands among about 150 innovating small and medium-size enterprises (SMEs) (Buijs, 1984, 1987). In this study, eight different patterns were observed, not based on a *post-facto* analysis as in the Cooper study, but based on real-time observations. But once again, here also there was no explanation for these differences.

Now, nearly 25 years later, we felt the need to once again dive deep into the real world of NPD projects, and to redo some of these studies and now hopefully find some clues about the reasons behind these different patterns.

We carried out two empirical studies, one with experienced project leaders from four design agencies, and a second one also with experienced project leaders but now from 11 different companies all with their own in-house design/development department. Based on the interviews with NPD project leaders from the design firms, we discovered not only that experienced project leaders recognize different NPD patterns, but that they even have reasons to distinguish NPD projects according to two different aspects. The first aspect is the complexity of the design task, and the second aspect is the familiarity of the design task. This leads to four different categories of NPD projects: simple and familiar, complex and familiar, simple and new and finally complex and new.

In our second study, we searched for cases which matched these four categories. We interviewed experienced project leaders in 11 different firms about their NPD projects. We selected only projects which resulted in design award-winning products (to be certain of the performance of the NPD projects investigated). We asked the project leaders about the number of activities, what activities were executed in parallel and which had to be sequential, and how much time the activities took. We did indeed find different patterns of NPD processes for the four different categories of projects.

Preliminary Study: NPD Activities from the Literature

In an analysis of the differences in modelling product innovation processes, a comparison between 90 different innovation models published in the NPD literature was made by Van der Zee (2003). The models were from all over the world and from the early 1950s to

the present day. We discovered that, in total, more than 1,248 different terms were used to describe specific product innovation activities. We condensed these 1,248 into a set of 54 innovation activities.

This proved to be a difficult task because none of the original authors is very explicit about the meaning of the terms used. For instance, what is a 'product idea'? Just words on a piece of paper, a design sketch, or a fully documented idea for a new business activity including concrete market and technological information. Or take the notion of a 'prototype'. For engineers and product designers, a prototype is a physical, tangible object you can perform tests with. According to Michael Schrage in his book *Serious Play* (2000), even Excel spreadsheets function as a prototype. Or, is the meaning of the German word '*Grund-analyse*' exactly the same as 'Feasibility study' or has it more to do with 'Scanning the competitive environment'?

The way we did this convergence was to map all models against each other. The walls of our study room was covered with photocopies of all the models. All the models have at least two or three different terms for the same activity in real-life NPD. For instance, 'product idea' and 'ideation', 'detailed design' and 'embodiment design', 'market introduction' and 'product launch'. We positioned all the models against each other, using these terms with more or less equal meanings as the linking pins.

Some models start with a product idea, some with the corporate strategy; so the starting points of the models can differ greatly. Other models have different endings: some stop at the prototype, some include product use, and others include maintaining and recycling of the product. Recent models include the so-called fuzzy front end of innovation (Koen et al., 2001), the older models restrict themselves to a more limited engineering view on innovation (= product development). And depending on this length of the modelled innovation process, the models are detailed to a greater or lesser degree. 'Long' models tend to be more abstract, with fewer details; 'short' models tend to be more concrete with a lot of details. Some models distinguish only seven stages (VDI 2221, 1986), others nearly 50 (Archer, 1971).

As already stated, the convergence from 1,248 different terms to 54 more or less shared terms was a difficult one, but nonetheless a very interesting process with many discussions. We used triangulation to come up with this list. Three researchers did the convergence independent of each other. Then the results were compared. When there were differences

a discussion was held. This discussion was guided by a fourth researcher. At the end, all four researchers accepted the result. The complete list is shown in Table 1.

The sequence of the 54 activities in our list is based on all the sequences seen in all the different models, and remains open for debate. For instance, after 'appointing a project leader' (which is activity no. 5 on our list), you can easily imagine that the formation of the project team will be the next activity. In our condensed list 'forming the team' is activity no. 11. This could imply that the project leader will execute all the in-between activities (nos 6–10) individually. But it could well be that those activities are carried out by the responsible functional departments of the company and that their results will be communicated to the team that is formed later. After its formation the innovation team can build on these results.

The total list of 54 NPD activities can be divided into three groups: the pre-, core- and post-NPD activities. We noticed four activities at the very beginning of the fuzzy front end (or rather activities which should be executed even before starting a NPD project, such as doing basic technological research, hiring new staff or scanning the competitive environment). These activities are labelled the 'pre-NPD activities', our numbers 1–4. We see 42 activities as the core NPD activities (nos 5–46), and eight activities which have to do with the implementation of the results of the NPD project (activities such as manufacturing, distributing, maintenance or recycling, nos 47–54). These are labelled the 'post-NPD activities'.

First Empirical Study: Exploring Categorizations of NPD Projects

This convergence from theoretical models into 54 NPD activities does not say anything about duration time per activity or step, does not say anything about parallel processing of different activities in certain stages of the NPD process, nor does it say anything about the possibility of skipping certain activities. Based on the NPD theory, no activities can be skipped, but in real-life NPD we see that in some cases activities are deliberately skipped, accidentally neglected or stupidly just forgotten. And still new products enter the market after such 'incomplete' NPD processes. Some of them even turn into major market successes.

Cooper already indicated in his research that different patterns of innovation processes do exist in real-life NPD (Cooper, 1983). Some of the innovation activities are carried out in parallel, others sequentially. And not always all theoretical NPD activities are executed.

Table 1. The Total List of Acknowledged NPD Activities

1. Development of company's competences by carrying out technological research, hiring new staff, etc.
2. Stimulating the generation of new ideas, or new applications of existing ideas, etc.
3. Carrying out explorative market research by scanning the competitive environment, looking for trends in the market, searching for needs, scientific developments, etc.
4. Adjusting the strategic plans of the company
5. Appointing a project leader
6. Preliminary description of the idea for a new product or a new challenge in the marketplace
7. Analysing present product portfolio of the company
8. Development of preliminary programme of requirements of the new product
9. Investigating the commercial feasibility of the new product
10. Generating principal solutions for the new product
11. Forming the project team
12. Determination and analysis of the target group
13. Building and testing of experimental prototypes
14. Generating and evaluating ideas for the new product
15. Preliminary planning for the total NPD process
16. Patent search
17. Carrying out the technical feasibility of the new product
18. Developing and testing concepts for the new product
19. Analysing competitive products
20. Developing the manufacturing plan for the new product (make-or-buy decision)
21. Developing the promotion plan for the new product
22. Detailed design of the new product
23. Carrying out user tests
24. Finding and selecting suppliers
25. Building prototype
26. Testing prototype
27. Building manufacturing facilities
28. Making technical drawings of the new product
29. Developing tooling
30. Testing new manufacturing facilities
31. Debugging manufacturing process
32. Sales forecasting of the new product
33. Debugging the new product
34. Coaching the first production runs
35. Developing maintenance plans for the new product
36. Training staff in assembling the new product
37. Testing promotion plan for the new product
38. Developing maintenance documents for the new product
39. Training staff in installing the product
40. Promoting the new product
41. Training staff in maintaining the new product
42. Developing the distribution plan for the new product
43. Training users
44. Evaluating the NPD process
45. Certifying the new product
46. Patenting the new technology
47. Manufacturing the new product
48. Assembling the new product
49. Distributing the new product
50. Selling the new product
51. Installing the new product
52. Maintenance and servicing the new product
53. Recycling the new product
54. Disposal of the new product

According to Cooper's empirical research, the minimal NPD process will have at least two different sequential activities ('product design and development' and 'market launch'). Cooper's maximum NPD process scored 'only' nine different activities. Keep in mind that the abstraction levels on which the different NPD activities are described determine the lengths of the different steps. Cooper's 'product design and development' covers at least activities 8, 9, 10, 13, 14 and 17 in our list. And you can even add activities 17, 22, 25 and 26 if you want to. So what does a minimal process of only two steps mean? Comparing the different NPD models will remain tricky.

In our first empirical study we interviewed four project leaders of NPD projects. All project leaders are experienced product designers (more than five years of professional practice) and are working at four different Dutch design agencies. They were chosen for interview because they had worked on many different NPD projects for a variety of clients. We asked them to look at the activities they had executed during their NPD projects, and to compare those against the list of the 54 theoretical activities.

We had made separate cards for each the 54 activities and asked the project leaders if they (or their team) had performed this activity. Some extra cards were still blank, to allow the project leaders to add other NPD activities to the list of 54.

All project leaders are working for different design firms. For competitive reasons, these firms use their own specific words and models to describe their 'own' NPD process. So we had the same semantic problems with them as we had encountered before during our own convergence from the NPD literature. But because we now had experience with the different terminologies, we could easily discuss with the project leaders the specific content of the NPD activities and were not restricted to the labels that the design firms use to describe their own way of executing a product innovation project for a client. In the end, no new NPD activities were discovered, and most of the project leaders accepted the terminology in the list of 54 NPD activities we had condensed from the literature.

The research methodology was to ask the project leaders to place the NPD activities on a grid scorecard to find out the sequence of activities, the parallel execution of activities and more or less automatically they mentioned the duration time per activity. After the project leaders had placed all the relevant NPD activities on the grid, the yellow stickers were glued in place and the duration time was written down.

We borrowed the idea from Cooper not to use the real duration time of the NPD projects to form patterns, but to use 100 per cent as the duration time and to place the activities within this 100 per cent frame. The reason for doing this is that otherwise the patterns will be categorized according to real duration time. So the shortest projects will all be categorized together, and similarly with all the projects with the longest duration time. The categorization would then be based on differences in total duration time and not on differences in patterns of NPD activities, which is what we are really interested in. In the past we have used this research method successfully (Buijs, 1984).

In order to do this analysis properly, we developed a new version of the grid scorecard, adding five columns, each divided into 10 segments of 10 per cent of the duration time of the total NPD process. The columns are used to place more or less similar NPD activities together. The five columns are from left to right:

1. Technology
2. Product
3. Market
4. Organization
5. Miscellaneous.

The grid scorecard is shown in Figure 1.

This methodology is based on a specific model of the innovation process in which in each stage three groups of parallel NPD activities are distinguished (Buijs, 2003). Central are the product-related activities, such as *developing the programme of requirements*, or *generating ideas*. To the left, which in this circular model means the inside, are all technology-related NPD activities, such as *manufacturing* or *building prototypes*. To the right, on the outside of the model, are all market-oriented NPD activities, such as *doing market research* or *making a promotion plan*. It proved impossible to assign all 54 NPD activities to these three categories. For instance, appointing the project leader or forming the innovation team are of a different nature. Therefore, we added two extra columns: one for organizational NPD aspects and one category for the rest (= Miscellaneous). Now all 54 activities could be assigned to a relevant column. In this way, we could analyse the patterns of all different cases in an equal and comparable manner.

To show the results of this kind of analysis we will show the patterns of two different NPD projects, one for Product A and one for Product B, each from a different design agency (see Figure 2).

The NPD process of Product A has the following stream of activities. The reading starts from the top of the left figure (the start of the

Grid scorecard					
0%					
10%					
20%					
30%					
40%					
50%					
60%					
70%					
80%					
90%					
100%					
Duration time	Technology	Product	Market	Organization	Miscellaneous

Figure 1. The Grid Scorecard with the Five Columns

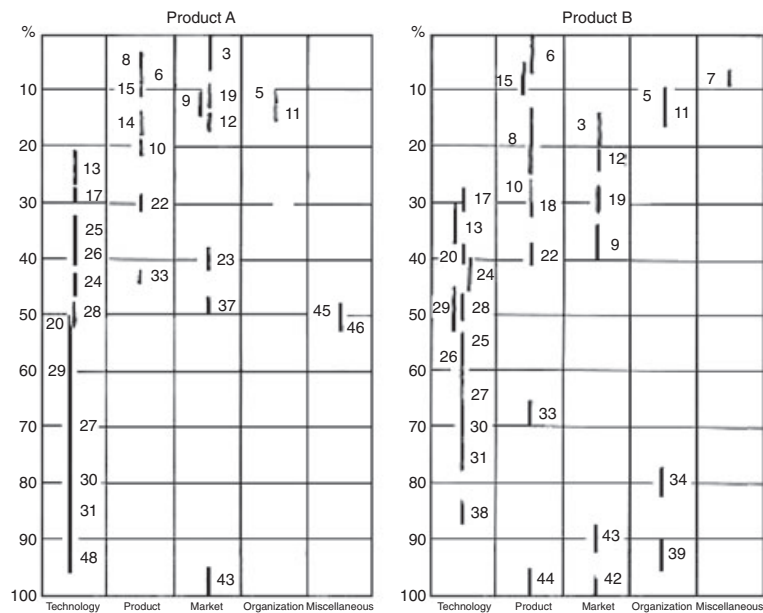


Figure 2. Two Different NPD Patterns: Product A by Design Agency X (Left), and Product B by Design Agency Y (Right)

Notes: The numbers correspond with the numbered NPD activities of Table 1. An interesting phenomenon did occur while scoring the different NPD activities on the scorecards. To put the numbers on the grid card, we used standard sheets with stick-on labels with numbers printed on. After sticking on the different NPD patterns on the grids, the unused stickers on the label sheets showed a kind of contrasting view in which the numbers left over more or less mirror the NPD patterns.

NPD process) and from left to right over the five columns. It ends in the bottom right-hand corner. In brackets we will add the type of column the activity is assigned to.

3. Carrying out explorative market research by scanning the competitive environment, looking for trends in the market, searching for needs, scientific developments, etc. [M]
8. Development of preliminary programme of requirements of the new product [P]
6. Preliminary description of the idea for a new product or a new challenge in the marketplace [P]
15. Preliminary planning for the total NPD process [P]
5. Appointing a project leader [O]
19. Analysing competitive products [M]
9. Investigating the commercial feasibility of the new product [M]
11. Forming the project team [O]
14. Generating and evaluating ideas for the new product [P]
12. Determining and analysis of the target group [M]
10. Generating principle solutions for the new product [P]
13. Building and testing of experimental prototypes [T]
17. Carrying out the technical feasibility of the new product [T]
22. Detailed design of the new product [P]
25. Building prototype [T]
26. Testing prototype [T]
23. Carrying out user tests [M]
33. Debugging the new product [P]
24. Finding and selecting suppliers [T]
28. Making technical drawings of the new product [T]
37. Testing promotion plan for the new product [M]
20. Developing the manufacturing plan for the new product (make-or-buy decision) [T]
45. Certifying the new product [Mi]
46. Patenting the new technology [Mi]
29. Developing tooling [T]
27. Building manufacturing facilities [T]
30. Testing new manufacturing facilities [T]
31. Debugging manufacturing process [T]
48. Assembling the new product [T]
43. Training users [M]
5. Appointing a project leader [O]
11. Forming the project team [O]
8. Development of preliminary programme of requirements of the new product [P]
3. Carrying out explorative market research by scanning the competitive environment, looking for trends in the market, searching for needs, scientific developments, etc [M]
12. Determining and analysis of the target group [M]
10. Generating principle solutions for the new product [P]
17. Carrying out the technical feasibility of the new product [T]
19. Analysing competitive products [M]
18. Developing and testing concepts for the new product [P]
13. Building and testing of experimental prototypes [T]
9. Investigating the commercial feasibility of the new product [M]
20. Developing the manufacturing plan for the new product (make-or-buy decision) [T]
22. Detailed design of the new product [P]
24. Finding and selecting suppliers [T]
29. Developing tooling [T]
28. Making technical drawings of the new product [T]
25. Building prototype [T]
26. Testing prototype [T]
27. Building manufacturing facilities [T]
33. Debugging the new product [P]
30. Testing new manufacturing facilities [T]
31. Debugging manufacturing process [T]
34. Coaching the first production runs [O]
38. Developing maintenance documents for the new product [T]
43. Training users [M]
39. Training staff in installing the product [O]
44. Evaluating the NPD process [P]
42. Developing the distribution plan for the new product [M]

The NPD process for Product B (the right part of Figure 2) reads as follows:

6. Preliminary description of the idea for a new product or a new challenge in the marketplace [P]
15. Preliminary planning for the total NPD process [P]
7. Analysing present product portfolio of the company [Mi]

Both processes show more or less normal steps in the NPD process (i.e., as published in the NPD literature), more or less normal sequences, such as *building manufacturing facilities* (no. 27), *testing manufacturing facilities* (no. 30) and *debugging manufacturing process* (no. 31). But both also show that certain activities are run in parallel, such as *carrying out explorative market research by scanning the competitive environment, looking for trends in the market, searching for needs, scientific developments* (no. 3), *the development of preliminary programme of requirements of the new product* (no. 8), *the preliminary description of the idea for a new product or a new challenge in the marketplace* (no. 6) and *the preliminary planning for the total NPD process* (no. 15). Both projects have used in total

30 different NPD activities to get the new product on the market. But those 30 are not the same ones!

Now we zoom out to all four cases. If we look at the 42 core NPD activities, 41 of them were executed at least once in those four cases. The only 'theoretical' activity that was not executed was activity no. 35 (*developing maintenance plans for the new product*). Only two out of the four pre-NPD activities were recorded, and only one out of the eight of the post-NPD activities was recognized (no. 48 *assembling the new product*).

We discussed our results with the project leaders in individual feedback sessions and talked about the possible explications for the different patterns in the NPD projects. For their own projects they had very specific arguments (for each case/project more or less unique) why certain activities were omitted, run in parallel or had a special sequence. There were no general arguments used by all four to find reasons for specific patterns. But interestingly enough, when we asked about planning future NPD projects, all four used the same type of reasoning. They all had two arguments to plan a new project. One reason is the familiarity of the NPD project. Is it a redesign project, is it a well-known client they had worked for before or is the technology well known. The other reason is the complexity of the product. Is it a simple product, with very few components and with only one technology, or is it a complex product, with lots of different components, with a multitude of suppliers involved and with different or new technologies?

Based on their work, these experienced project leaders distinguish four different categories of NPD projects (see Figure 3). The experienced project leaders indicated that,

according to their judgement of the category of a future NPD project, they adjusted their planning of the activities of the project. Going from type A to D they suggested that the number of activities is increasing, and that the number of parallel activities is decreasing. According to their insights, the total duration time is also increasing from type A to D. Planning NPD activities for the next project is dependent on the type of project in this familiarity/complexity grid. And a simple product means a simple project plan; a complex product needs a complex project plan. We decided to start another study to test this reasoning.

Second Empirical Study: Investigating Patterns in NPD Projects

Now, we know about the differences between the theoretical models of the NPD process, and we know about empirical evidence that real NPD projects are not executed according to these models. But what we do not know are the reasons behind these differences. Based on the interviews with the experienced project leaders, we have a hypothesis that for the four different categories of NPD projects different patterns of NPD activities might exist. Simple products have simple project structures and complex products have complex structures.

Because these differences could be caused by differences in companies, markets or technologies, we decided to look for cases which are more or less equal in design quality. In research methodological terms, we are looking for matched pairings (the empirical case should fit the theoretical category).

We have no real hypothesis about the content of the different patterns (simple

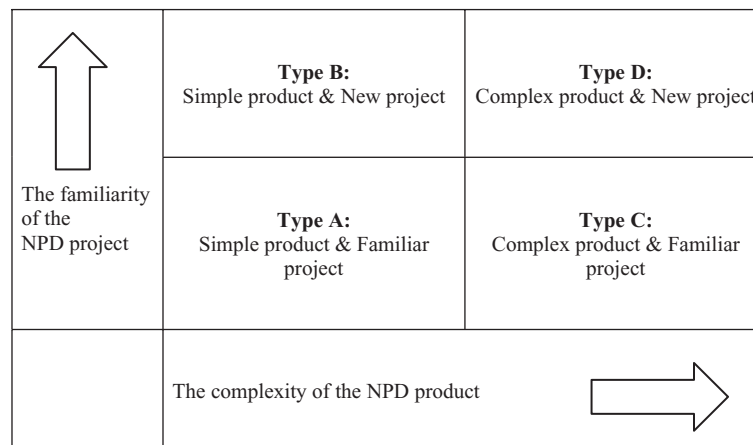


Figure 3. The Four Categories of NPD Projects

product implies simple project and complex product implies complex project, but there is no theoretical base for it). So we decided to do an exploratory study to test the four categories of NPD projects and whether these categories not only have different patterns, but also that, where these differences occur, they confirm the familiarity/complexity grid.

In this second exploratory study, we interviewed 11 experienced NPD project leaders. This time we choose to interview project leaders inside companies. The reason is that project leaders of design agencies might have experiences with all four categories of NPD projects, which could confuse their memories. In this study we wanted to focus on differences between the project categories. We also hoped to find more of the pre- and post-NPD activities because a company is responsible for the whole NPD project whereas a design firm might focus on only a part (as we have seen in the exploratory study). All 11 project leaders come from 11 different companies.

We were looking for projects in each of the four categories of NPD projects. We wanted, for comparison reasons, to guarantee a certain degree of design quality of each project and the resulting new product. Therefore, we choose to investigate NPD projects that had just won a Dutch design award for their product. All our 11 cases are prize-winning products, although in different industry sectors. With this careful selection of the cases, we tried to have NPD projects under investigation which are of the same high design quality and therefore comparable.

The distribution of the cases over the four categories of NPD projects introduced yet another difficulty. The four types are based on differences on two axes: one on familiarity of the project and the other on the complexity of the product (remember Figure 2). The complexity of the NPD product is observable from the outside; you can see it by looking at the products that are the result of the NPD project. We did a small test to see whether design students were able to judge the complexity of products just by looking at them. For this test we used the products from our first study (at the design agencies), and we compared the students' judgements with those of the original project leaders who designed the products. All the students had the same judgement as the professionals.

We did the same experiment with the degree of novelty of the project, and no student was able to make the right judgement. The reason is quite simple: novelty is based on the knowledge and experience of the project leader who is going to design the new product. And outsiders are not able to judge this aspect.

So in the case selection we had to rely on the information from the project leaders themselves to judge the scoring on the familiarity axis in order to categorize the case into the relevant category. For the complexity axis we made our own external judgement and compared that with those of the project leaders. As expected, there was a 100 per cent match.

To get cases, we categorized the prize-winning products on complexity, phoned the companies who designed these products, and asked them if they were willing to join our research. After a positive reaction, we held a preliminary interview to find out about the familiarity scoring. After a couple of attempts, we finally had our cases matching the categories. For reasons of confidentiality, we are not allowed to show pictures of the products and/or to give the names of the companies.

The research methodology used for getting the NPD activity patterns is the same as in our first exploratory study. We asked the project leaders about the number of activities, which activities were executed in parallel and which were carried out sequentially, and what the duration time of each different activity had been.

We offered the interviewees our cards of the 54 NPD activities, asked them to locate the activities on the grid and to mention the duration time per activity. We formatted everything according to Cooper's 100 per cent format and analysed the results. The interviews were executed at the offices of the project leaders. They had collected relevant data from their project files on starting dates of activities, number of participants, they showed us sketches and drawings and showed us the finished end result of their NPD work: the new prize-winning product. They proved to be very co-operative and open and were very interested in our study. The interviews usually took between 1.5 and 3 hours.

The Data

Our raw data for each case is a large piece of paper with the 100 per cent grid, the yellow stickers with the (numbered) NPD activity glued in their positions. The duration time per activity was also written on the stickers. We also had some background information about the product involved, the composition of the design team and some information about the company.

The 11 cases were evenly spread over the four categories (see Figure 4). Cases A and B executed 31 different NPD activities each. The Type B cases show a broader range: case C 29, case D only 22 (the least of all cases) and case E


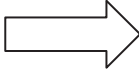
 The familiarity of the NPD project	Type B: Simple product & New project 3 (case C, case D, case E)	Type D: Complex product & New project 3 (case I, case J, case K)
	Type A: Simple product & Familiar project 2 (case A, case B)	Type C: Complex product & Familiar project 3 (case F, case G, case H)
The complexity of the NPD product 		

Figure 4. The 11 Cases Divided over the Four Categories

33. The Type C cases are more or less equal: cases F and G 28 and case H 30. The Type D cases are also diverse: case I 25, case J 34 (the case with the most NPD activities) and case K 29. The two cases from our first study (see Figure 2) scored 30 NPD activities each. The average number of NPD activities for all 11 cases is 29. Type A cases are above average, Type B cases are below average, Type C cases are average and Type D cases are just above average. An interesting finding is that in the category of the easier kind (Type A: simple and familiar), more NPD activities are executed than in the more complex ones, which contradicts the preliminary thoughts of the project leaders of the design agencies.

Results: the Existence of NPD Activities

If we compare the 54 NPD activities from NPD theory and the NPD activities executed in the various cases, we see the following results (the score per activity is put in brackets in **bold** type after the description of the activity):

1. Development of company's competences by carrying out technological research, hiring new staff, etc. **(0)**
2. Stimulating the generation of new ideas, or new applications of existing ideas, etc. **(1)**
3. Carrying out explorative market research by scanning the competitive environment, looking for trends in the market, searching for needs, scientific developments, etc. **(9)**
4. Adjusting the strategic plans of the company **(0)**
5. Appointing a project leader **(10)**
6. Preliminary description of the idea for a new product or a new challenge in the marketplace **(8)**
7. Analysing present product portfolio of the company **(6)**
8. Development of preliminary programme of requirements of the new product **(11)**
9. Investigating the commercial feasibility of the new product **(9)**
10. Generating principle solutions for the new product **(5)**
11. Forming the project team **(11)**
12. Determining and analysis of the target group **(9)**
13. Building and testing of experimental prototypes **(9)**
14. Generating and evaluating ideas for the new product **(9)**
15. Preliminary planning for the total NPD process **(11)**
16. Patent search **(7)**
17. Carrying out the technical feasibility of the new product **(11)**
18. Developing and testing concepts for the new product **(11)**
19. Analysing competitive products **(9)**
20. Developing the manufacturing plan for the new product (make-or-buy decision) **(8)**
21. Developing the promotion plan for the new product **(7)**
22. Detailed design of the new product **(11)**
23. Carrying out user tests **(6)**
24. Finding and selecting suppliers **(8)**
25. Building prototype **(10)**
26. Testing prototype **(10)**
27. Building manufacturing facilities **(8)**
28. Making technical drawings of the new product **(11)**
29. Developing tooling **(10)**
30. Testing new manufacturing facilities **(7)**
31. Debugging manufacturing process **(5)**
32. Sales forecasting of the new product **(6)**
33. Debugging the new product **(10)**
34. Coaching the first production runs **(8)**
35. Developing maintenance plans for the new product **(0)**
36. Training staff in assembling the new product **(5)**

37. Testing promotion plan for the new product (1)
38. Developing maintenance documents for the new product (7)
39. Training staff in installing the product (1)
40. Promoting the new product (1)
41. Training staff in maintaining the new product (0)
42. Developing the distribution plan for the new product (3)
43. Training users (7)
44. Evaluating the NPD process (10)
45. Certifying the new product (7)
46. Patenting the new technology (6)
47. Manufacturing the new product (0)
48. Assembling the new product (1)
49. Distributing the new product (0)
50. Selling the new product (0)
51. Installing the new product (0)
52. Maintenance and servicing the new product (0)
53. Recycling the new product (0)
54. Eliminating the new product (0)

We see that seven different NPD activities are carried out in all 11 cases. NPD activities that are essential for all cases are:

8. Development of preliminary programme of requirements of the new product (11)
11. Forming the project team (11)
15. Preliminary planning for the total NPD process (11)
17. Carrying out the technical feasibility of the new product (11)
18. Developing and testing concepts for the new product (11)
22. Detailed design of the new product (11)
28. Making technical drawings of the new product (11)

This seems to be a real minimal NPD process. You start with an NPD team, make a preliminary plan for the project, start thinking about the product requirements, generate concepts, check the technical feasibility of these concepts, start detailing the product design and finally record everything in the technical drawings. It is indeed simple, it has an engineering bias, but it could work! Probably because of the other level of abstraction, this minimal process has more steps than the minimal process Cooper reported (seven steps now compared with only two from Cooper's study).

Eleven NPD activities have not been carried out in any of the cases (nos 1, 4, 35, 41, 47, 49, 50, 51, 52, 53 and 54). This involves two pre-NPD activities (nos 1 and 4) and seven post-NPD activities (nos 47, 49, 50, 51, 52, 53 and 54). These post-NPD activities include activities for manufacturing, sales,

maintenance and recycling, which are operational activities the NPD team has normally nothing to do with. These activities are included in the theoretical list of 54, because during design you have to be fully aware of these downstream aspects. Because the products of our second empirical study were available on the market (a must for being a participant in the Dutch design competition) these post-NPD activities must have been carried out by the company, but were apparently outside the scope of the interviewees (NPD project leaders).

The two pre-NPD activities that were not carried out (nos 1 and 4) are related to corporate strategy, HRM and basic technological research. These are activities at a corporate level, which are indeed very influential for product innovation, but are also outside the scope of an NPD project leader.

The two core NPD activities that have not been carried out in our cases are no. 35 *The development of maintenance plans for the new product*, and no. 41 *Maintenance training*. Apparently, as in our first exploratory study, in our 11 cases the subject of maintenance seems not so important or is ignored.

Besides finding a minimalist NPD process, we were also able to find a kind of regular NPD process. We define regular here as the NPD process with the maximum number of activities which are executed in at least two cases in all four type categories (so the minimum score per activity should be 8).

The regular NPD process looks like this:

- Appointing a project leader (10)
- Preliminary description of the idea for a new product or a new challenge in the marketplace (8)
- Development of preliminary programme of requirements of the new product (11)
- Investigating the commercial feasibility of the new product (9)
- Forming the project team (11)
- Determining and analysis of the target group (9)
- Building and testing of experimental prototypes (9)
- Generating and evaluating ideas for the new product (9)
- Preliminary planning for the total NPD process (11)
- Carrying out the technical feasibility of the new product (11)
- Developing and testing concepts for the new product (11)
- Analysing competitive products (9)
- Detailed design of the new product (11)
- Building prototype (10)
- Testing prototype (10)

- Building manufacturing facilities (8)
- Making technical drawings of the new product (11)
- Developing tooling (10)
- Debugging new product (10)

This regular NPD process has 19 activities which represent a realistic product innovation process. There is a project leader and a team, a project plan, a product idea, requirements, generating of ideas and concepts, the target group and the competition is investigated, both commercial and technical feasibility studies are carried out, the product design is detailed, prototypes are built and tested, technical drawings are made, tooling and other manufacturing equipment is built and minor start-up problems in the new product are cured. It looks like a balanced NPD process.

If we compare the results over the four categories of NPD projects, we see some differences (see Table 2). If we look at the number of activities that are carried out in all cases per type category, we see that for the Type A cases, 26 activities are executed in all cases, 10 activities are carried out in only one of the cases and 18 activities are not carried out. If we omit the 10 NPD activities that have not been carried out by any of the cases of all four types, you could say that for the Type A cases 59 per cent of all NPD activities is equal (26 of 44), and 41 per cent is different. In the Type B cases, 15 activities are carried out in all cases, five activities are carried out in only one of the cases, so equality here is 34 per cent. For the Type C cases, the number is 17 which give an equality of 39 per cent. For the Type D cases the number is 16, which is an equality of 36 per cent. The number of activities not carried out decreases from 18 for the Type As to 15 for the Type Cs and Ds. This could suggest that Type A is less demanding than the other three. If we also include the equality over the types, then it would suggest that Type A (Simple & familiar) is different compared to the other three types of NPD projects. Is this marginal evidence

for the original suggestion of the experienced project leaders of the design agencies that simple products require a simple NPD project?

Results: Patterns in NPD Projects

We have now only analysed the existence of certain NPD activities (whether this activity was executed in one of the cases). But it is also interesting to see whether we can identify different patterns of activities. To do so, we have divided the NPD process into sub-stages of 20 per cent duration time each, and counted the activities which were carried out in each sub-stage. Activities which were present in more than one sub-stage are counted as separate activities in all the relevant stages. Compared to the analysis in the previous section, we have many more NPD activities now, because if an activity is executed in three sequential sub-stages, it is counted three times. An overview of all the sub-stages over the four types of NPD projects is shown in Table 3.

The Type As are doing the fewest NPD activities and the Type Bs the most. Type Cs are average and the Ds are doing a little more. It also shows that the As do little in the last two sub-stages and relatively more in the sub-stages 2 and 3. The Bs do a lot in the first and the last stages. The Cs are above average in sub-stage 1 and below average in sub-stages 2 and 3. The Ds are above average in sub-stage 2, and below in sub-stage 5.

We also looked at the kind of sequences in which the NPD activities were carried out. Table 4 shows an overview. This table needs some extra explanation, because the score 3–19, for instance for Type A in sub-stage 1, does not mean that all possible NPD activities between 3 and 19 were executed, but it gives an indication which kind of NPD activities were done in such a sub-stage. These sequences are derived from the theoretical list of 54 NPD activities (see Table 1). The empiri-

Table 2. Number of NPD Activities per Category

	Type A	Type B	Type C	Type D
In 3 cases	Not relevant*	15	17	16
In 2 cases	26	17	13	17
In 1 case	10	5	9	6
In 0 cases	18	17	15	15
Total no. of NPD activities	54	54	54	54

* In the Type A category, only two cases are present.

Table 3. NPD Activities per Sub-stage for the Four Types of NPD Projects

Sub-stage in %	Type A		Type B		Type C		Type D		Average	
	No.	%	No.	%	No.	%	No.	%	No.	%
1–20 (sub-stage 1)	18	29	32	35	29	34	26	29	26.25	31
20–40 (sub-stage 2)	17	25	12	13	13	16	20	23	15.50	19
40–60 (sub-stage 3)	14	22	12	13	8	10	12	13	11.50	14
60–80 (sub-stage 4)	7	11	14	15	14	17	16	18	12.75	16
80–100 (sub-stage 5)	8	13	22	24	19	23	15	17	16.00	20
Total no. of NPD activities	64	100	92	100	83	100	89	100	82.00	100

Table 4. Sequences of NPD Activities

Sub-stage in %	Type A	Type B	Type C	Type D
1–20	3–19	3–19 32*	2–24 32*	3–23 42*
20–40	8–26	13–28 37*, 46*	10–28 45*, 46*	8–24 32*, 37*
40–60	20–33 45*, 46*	9–32	13–28	15–29 45*
60–80	27–33	9–32 40*	20–29 43*	21–38 45*, 46*
80–100	34–48	16–46	20–44	21–45
Total no. of NPD activities	64	92	83	89

* indicate exceptional NPD activities for that sub-stage.

cal data, however, show that inside those sequences a lot of the activities are carried out in parallel. But no sub-patterns emerged. It seems as though project leaders use a very opportunistic attitude: they try to execute as many activities in parallel as possible. The opportunities are neither type-based nor type-specific, but are mainly the result of the availability of resources.

Based on the raw data, we see that the Type As carried out 18 NPD activities in the first sub-stage. Those 18 range from activity no. 3 'Exploratory market research' to no. 19 'Analysing competitive products'. Six activities were executed in all Type A cases (=12) and six others (makes the total 18) were carried out only once, but not necessarily in one case.

The exceptional scores are labelled exceptional because the activity was carried out at a time that was strange compared to its place on the original overall list, which is following more or less the logical order of the NPD process. An interesting result in this respect is,

for instance, activity no. 32 'Sales forecasting of the new product', which on the original list is placed near the end of the NPD process, but in two of the cases it was carried out during the first sub-stage. The same is true for activity no. 42 'Developing the distribution plan' which is also logical towards the end, but for one Type D case (New & complex product) it was found important to start thinking about the way to distribute this new product quite early, because that could influence the packaging design of the new product. This table is only meant to show different sequences of related NPD activities.

A tentative conclusion could be that the two types which score high on the newness axis (Types B and D) execute more NPD activities than the other two. Looking to the NPD sequences shows that Types C and D (high on complexity) execute in the first sub-stage more and different activities than the other two types. While the others start detailing the design (activity no. 22) in sub-stage 2, the two

complexity types start doing that already in sub-stage 1. Once again, does this represent some small support for the original suggestion, that complex products need a complex NPD project?

Conclusion and Discussion

In the preliminary theoretical study we distinguished 54 different NPD activities that describe the commonalities of 90 different theoretical models on NPD. According to this summarized overview, the maximum NPD process can have 54 different activities.

In the first exploratory empirical study, we analysed these activities. Most NPD projects do not use all theoretical activities to the full. Our four cases together covered nearly all activities, but the two detailed cases described used only 26 and 27 different activities. The theoretical NPD models are much broader than NPD reality requires. Our minimal NPD process shows only seven different activities, whilst our 'regular' process uses 19 different NPD activities. These are rather smaller numbers than the theoretical 54!

We also discovered how experienced project leaders from design firms categorize their projects in a very specific way before they plan and organize them. They use the 'complexity of the product' and 'the familiarity of the project' as main drivers to guide their planning and timing of activities for future NPD projects. Doing so, there are four categories of NPD projects: Type A familiar + simple, Type B unfamiliar (new) + simple, Type C familiar + complex and Type D unfamiliar (new) + complex. Based on their experiences, the idea was that simple and familiar cases need fewer steps and less duration time than the complex and new cases. They used this idea to plan their future NPD projects.

In the main empirical study we checked this planning idea and also looked for more details between the four categories of NPD projects. Analysis of NPD activities and their duration times of 11 detailed cases of prize-winning NPD projects executed within 11 different companies shows interesting differences and commonalities between the four categories.

We can conclude that a familiar NPD project on a simple product (Type A) differs strongly in the number of NPD activities that are executed in comparison to the other types of NPD projects (Types B, C and D). In this respect it supports the original planning idea that simple projects require a simple process, but the differences between the other three categories are less clear and the results are inconclusive.

We have found a minimal NPD process, where you start with an NPD team, make a preliminary plan for the project, start thinking about the product requirements, generate concepts, check the technical feasibility of these concepts, start detailing the product design and finally record everything in the technical drawings.

We also found a process that we indicate as a 'regular' NPD process, that has 19 activities and looks very convincing as a realistic product innovation process. There is a project leader and an NPD team, a project plan, a product idea, requirements, generating of ideas and concepts, the target group and the competition is investigated, both commercial and technical feasibility studies are carried out, the product design is detailed, prototypes are built and tested, technical drawings are made, tooling and other manufacturing equipment is built and minor start-up problems in the new product are debugged.

On the patterns of NPD projects we can conclude that in all types of NPD projects most activities are carried out at the early stages of the project. NPD projects on new products (Types B and D) contain the most activities in the total project, with a peak in the beginning and at the final stage of the project. Complex NPD projects (Types C and D) execute even more activities in the first stage of the project, and also different activities from projects that are not so complex. For instance, in complex projects we found that '*detailing the design*' started already in the first stage of the project. We also found that NPD project leaders adopt an opportunistic attitude towards carrying out NPD activities in parallel in order to gain time. Their message is: if you can do activities in parallel, please do.

The results from these two empirical studies provide extra 'luggage' for applying carefully the well-known theoretical models of the NPD process. The experience provided by 11 successful project leaders may help novices to build their own expertise in a more profound and reflective manner. Now the real action planning for NPD projects can begin! We hope this exploratory study will give fuel to other empirical studies on the NPD process in order to balance the prescriptive NPD theorists, which will help NPD practitioners with their difficult work.

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