DRM: A Design Research Methodology[1]

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1 Introduction

In this paper we propose a systematic methodology for doing engineering design research, grown out of increasing concerns about the efficiency of design research and the effectiveness of its outcomes.

The aims of design research are the formulation and validation of models and theories about the phenomenon of design, as well as the development and validation of knowledge, methods and tools - founded on these theories - to improve the design process. Design research must be scientific in order for the results to have validity in some generic, practical sense. For this, design research has to develop and validate knowledge systematically. This requires a research methodology. The characteristics of design and the aim of engineering design research to change the present for the better, requires design research to have its own methodology based on elements of methodologies in other research areas.

Sadly, although design is one of the fastest growing areas of research, the status of research into its own research methodology is, with a few exceptions, poor. Few publications on design research methodology exist and little is written in research papers about the methodological issues that were involved. In effect, little guidance exists as to how to do design research, leaving it to the individual to find an efficient, effective and rigorous approach. Many different methods can be, and have been, used to address the various issues involved in design research. We consider a commonly accepted research methodology, such as the one we propose, as

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one of the main characteristics of an established area of scientific research. This paper outlines the methodology; details can be found in (Blessing and Chakrabarti, 2002).

2 The aims of design research and the need for a methodology

The overall aim of engineering design research is to support industry by improving our understanding of engineering design and, based on this, developing knowledge, in the form of guidelines, methods and tools that can improve the chances of producing a successful product (see Section 4 for different types of research).

This aim raises a number of important questions that form the basis for design research activity:

- What do we mean by a *successful* product?
- How is a successful product *created*?
- How do we *improve the chances* of being successful?

The first question leads to issues such as what *criteria* should be used to judge success, as these can be used as measures to determine whether our research has been successful. The second question leads to issues such as the identification of the influences on success, how these influences interact and how they can be measured. Investigating these issues will increase our understanding of design, which is needed to improve the design process. The third question gives rise to issues related to how this understanding can be used to develop *design guidelines, methods and tools* and how this design support can be evaluated. Evaluation is needed to determine whether the *application* of this support indeed leads to more successful products as determined by the criteria.

To address these issues in an integrated and systematic way, a research methodology is needed. Such a methodology should help in identifying research areas and projects, and in selecting suitable research methods to address the issues. Based on our work with engineering design researchers, we observed that many experience problems because methodologies existing in related areas and books on 'how to write a thesis' do not address all the research issues dealt with in design research.

A typical characteristic of design research is that it not only aims at understanding the phenomenon of design, but also at using this understanding in order to change the current situation. The latter requires more than a model (or theory) of what exists; it also requires a model of what would be desirable and how the existing situation could be changed into the desired. Design research thus has research (improving understanding) as well as development aspects (development of guidelines and methods), each requiring different methods and a different approach. The latter may be one of the reasons why two streams of research have evolved that, unfortunately, have not really merged: those that focus on increasing our understanding of designing and those that focus on developing support for designers.

A second characteristic that results in a need for a variety of methods, is the complexity of design, involving artefacts, people, tools, processes, organisations, market and society. Each of these aspects is dealt with in a specific disciplines, e.g. engineering science deals with artefacts, cognitive and social sciences with people,

computer science with computer tools, etc. Each discipline has its specific research methods and, equally important, underlying paradigms and assumptions. Unfamiliarity with many of these methods is a serious problem in design research; methods are not applied correctly or unsuitable methods are applied.

A third characteristic are the numerous influencing factors related to the each of the aspects (see e.g. Hales, 1987) and the interconnectivity between these (see e.g. Frankenberger and Badke-Schaub 1998). Separating groups of factors for research purposes is extremely difficult and multiple research methods have to be used.

These characteristics of design have resulted in an extreme variety and little coherence in terminology, approaches and results. Due to the many different aims and units of analysis there are few contradicting findings – all do something different. This diversity was illustrated in a workshop (Cross *et* al, 1994) in which all authors were given the same tapes of a conceptual design process, and asked to analyse the tapes.

The aim of the methodology presented in this paper, is to piece together the various types of research, to encourage a reflection on one's own research, and to provide pointers to methods in other disciplines that can be used. This builds on the approach first presented in (Blessing *et al*, 1992).

3 Methodological framework

Figure 1 shows the overall Design Research Methodology (DRM). A simple example will help clarify the terms that are used. Note that individual research projects usually focus on one or two stages only, and that iterations between stages will take place. A more detailed description of each stage is given in sections 4-7

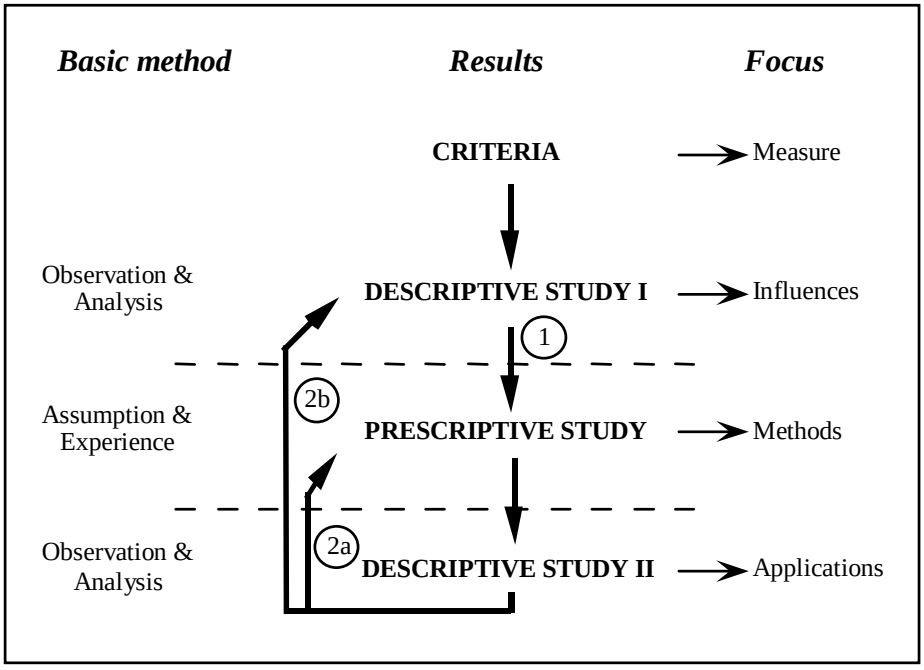

Figure 1 – DRM framework and links largely missing in current research (links 1, 2a and 2b)

3.1 Example of a simple research project following the methodology

Criteria definition

Based on some discussion, profit is taken as the overall criterion for success for the project. Profit is considered too difficult to measure within the timescale of the project and literature is consulted to find the factors that influence profit. One of the factors found to contribute strongly to profit and to fall within the discipline of the researcher is a short time-to-market. It is decided that time-to-market will be the measurable criterion, that is, the measure against which the results of the project will be judged.

Descriptive Study I (DS-I)

In the next stage, literature is used to obtain an understanding of the various factors that influence, directly or indirectly, the measurable criterion (see also section 3.2). Because literature does not provide enough detail, the researcher decides to undertake a descriptive study of designers at work. Literature and observation reveal: that insufficient problem definition relates to high percentages of time spent on modifications later in the process; that the modifications early in the process cost less; and that insufficient problem definition has certain characteristics. No hard evidence can be found that more time on modifications increases time-to-market, but logical reasoning supported by findings in literature suggest that this is an acceptable assumption.

Prescriptive Study (PS)

The outcome of the descriptive study is used (link 1 in Figure 1) to generate a scenario of the desired situation (in this case: improved problem definition leading to fewer modifications lateron in the process, and thus reducing time-to-market). It is decided to develop a method to realise the desired situation: in this case, a method to encourage and support problem definition. Assumptions, and where possible experience, are used to develop the future scenario and the method. During the development and at the end of this stage, the built-in functionality and consistency of the method is tested by the researcher, the socalled method/tool evaluation.

Descriptive Study II (DS-II)

A second descriptive study is undertaken to evaluate the application of the method developed in the prescriptive study. This includes two tests. The application evaluation assesses the functionality from a user point of view, that is: can the support be applied; does it indeed addresses those factors it is supposed to address directly; are these factors affected as expected. In our example, this test would focus on whether the quality of the problem definition has improved (a comparison with the focus of the Prescriptive Study, link 2a). The last and most difficult test, success evaluation, is to check whether this reduces the number of modifications and indeed reduces the measurable criterion time-to-market (a comparison with the chain of influencing factors resulting from Descriptive Study I, link 2b). Due to side-effects of applying the method, e.g. the amount of time required to apply the method, these evaluations may fail. The link with overall success is not tested but reasoned using the identified link between the measurable criterion and the success criterion.

The results of the second descriptive study are suggestions for: improvement of the method, or its training; introduction of the method in practice; and a change in the network of influencing factors.

3.2 Network of influencing factors

A schematic picture of the network of influencing factors involved in design, and the focus of the various stages in our methodology are illustrated in Figure 2.

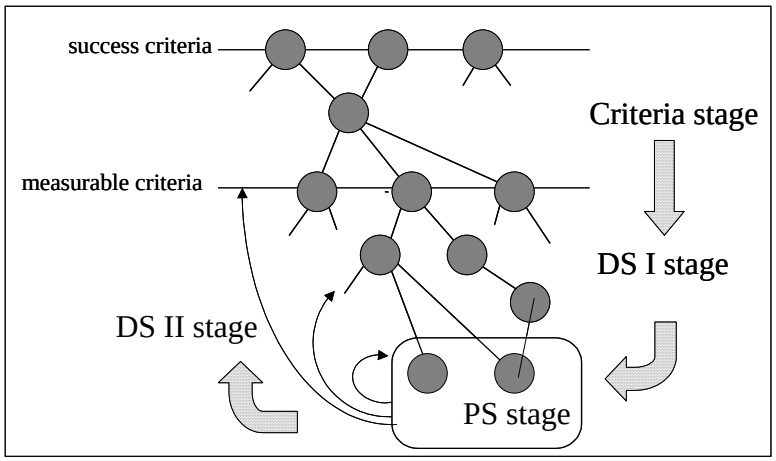

Figure 2 – The network of influencing factors and the stages of the methodology.

We have found that using the DRM-framework from the beginning of a research project helps provide a direction to the research at hand, and identify the areas that need addressing and are most likely to be theoretically and practically useful.

4 Different types of research

It cannot be expected that each of the stages of the methodology will be executed in depth in every single project: most projects have to adhere to specific time frames. Besides, it is not always necessary to go through every stage in depth: where possible one should build upon existing research. In some cases, literature provides sufficient material for a particular stage, in other cases, a research project may address only one stage because it is part of a larger project. Importantly, DRM is not supposed to be a sequential process. Many iterations take place, and some stages may run in parallel. An example is the need to consider which aspects of an envisaged computer tool have to be evaluated (DS-II) in order to be able to choose the hardware, software and scope of a demonstrator system (PS). Several variations of the methodology are possible and necessary to suit the focus and constraints of a particular project. The main variants are presented in figure 3.

In any project the overall methodology should be kept in mind: the links between the stage(s) that are the focus of a research project, and the other stages in the methodology should at least be addressed when planning the project and when drawing conclusions. For example, figure 2, line 2, indicates that a study of

particular influences on the design process (Descriptive Study I) should be based on a review of literature to determine the criteria and at least indicate how the results of the Descriptive Study can be used to improve design, i.e. an initial Prescriptive Study should take place. An exception is given in Line 1, which focuses on a descriptive study of criteria. Line 3 indicates that the development of design support (Prescriptive Study) should involve a review of the factors that are addressed by the support and their link to success. Furthermore, intial evaluation should take place, so that at least something can be said about the measurable criteria. In our opinion, all of these aspects have not been addressed rigorously in design research. The subsequent sections describe each of the DRM-Stages in more detail.

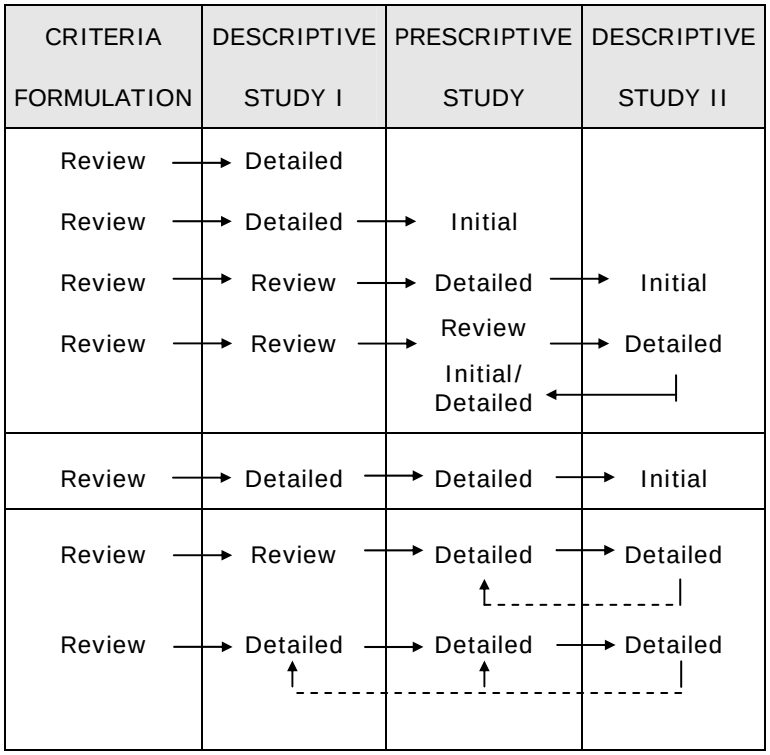

Figure 3 – Different types of design research derived from the proposed methodology.

5 Criteria

For a research area, such as design research, that aims ultimately at improving a situation, determining success criteria is essential. Only then is it possible to determine the factors that have a negative or positive influence on success and develop support (guidelines, methods, tools) to remove or reduce the negative influences and support the positive ones. Defining criteria is important for all stages of a research project:

- to identify the aim that the research is expected to fulfil and the focus of the research project;
- to focus Descriptive Study I on finding the factors that contribute to or prohibit success;

– to focus the Prescriptive Study on developing support that address those factors that are likely to have most influence;
– to enable evaluation of the developed support (Descriptive Study II).

Therefore, the chosen criteria strongly influence the research approach and methods that are most suitable.

Success criteria refer to the overall aim of the research, the practical 'why' of the research. Success criteria are typically related to business or market success. They may be 'technical', such as reduced leadtime, or more political, such as improving company image. Most studies we have analysed state their overall aim, but the link between the criteria used to assess the research outcomes and the aim is not made explicit and often seems to be based on assumption rather than evidence. Take for example the often mentioned aim 'to improve the effectiveness of the design process'. In most cases it will not be possible to show at the end of the research project that this aim has been achieved. Indeed, in most studies, despite mentioning the aim, no attempt is made to find supporting evidence. Often the reason is a practical one: the time-scale of a research project does not allow, if measurement were at all possible, an improvement of the effectiveness to be measured.

What is needed are **measurable criteria,** to translate the overall aim, such as 'effectiveness' into a criterion that can be used to determine whether the research results have achieved their aim. In our investigation of design research projects, we found quite different criteria being used. Common criteria in research in an industrial context are sales, profit and return on investment. In laboratory research a common measurable criterion is design quality, e.g. in terms of the fulfilment of technical requirements. The link to success criteria in laboratory research is based on a review of literature, e.g. those that indicate the importance of quality for market success.

If the products or processes that are investigated are to be assessed rather than only described, and if methods and tools are to be evaluated with respect to their effects, the formulation of measurable criteria is of crucial importance. Ideally, measurable criteria should 'lie' as close as possible to the success criteria (see Figure 2), that is, the link between the two should be as direct and strong as possible. This link may be very complex, as the few studies into measuring product development performance indicate (Duffy, 1998), and the definition of success may still be disputed, but these should not be reasons for not attempting to make these links explicit, even if they are based on assumptions.

6 Descriptive Study I

The role of Descriptive Study I is to:

– identify the factors that influence the formulated measurable criteria and how they influence these;
– provide a basis for the development of support to improve design;
– provide more details that can be used to evaluate developed design support.

The result of this stage is a reference model.

Descriptive Study I involves studying design in order to increase our understanding, either directly or through reasoning based on a literature review. The focus can be on the product (e.g. product reliability) as well as on the process of designing (e.g. setting up requirements lists). Descriptives studies can be (Yin, 1994):

- exploratory, answering 'what', to provide more research focus when the understanding is still inadequate;
- descriptive, describing 'what, who, where, how many, how much', to find frequencies or incidence;
- explanatory, describing the 'how' "and 'why' - the operational links".

We use the term "descriptive" in a broader sense, to cover all of the three types listed above.

From an experimental point of view, the influencing factors are difficult to analyse because of the uniqueness of each design project, the involvement of human beings, and the strong interconnectivity of influencing factors (see also section 2). Descriptive studies will reveal a chain or, more likely, a network of causes and effects, connecting influencing factors with the criteria (see Figure 2).

Many of the options that can be chosen for the set-up of a descriptive study are interrelated, e.g. the decision to go into industry will reduce the number of options available for data collection techniques, and a particular data collection technique is likely to affect the number of cases that can be investigated. These options have to be made explicit, so that other researchers can determine whether they can use the findings in the context of their own research. We found that knowing the options that were chosen also provides a possible explanation of differences in findings between researchers.

Unfortunately, many publications do not provide details of data collection context and data analysis methods, validation of the results is rare, and there is little reflection on the applied methods and methodology. Often methods seem to be chosen, because they are popular rather than because of their suitability to answer the research questions. In addition, inconsistencies between aim (criteria), data collection method, data analysis method and conclusions can be found. Examples are: conclusions related to the aim that cannot be drawn on the basis of the method used; statistical methods that are unsuitable for analysing the collected data; or data collections methods that are unable to answer the questions. In addition findings, assumptions and interpretations are often mixed, providing an inappropriate starting point for further use. Last but not least, most studies result in correlations between individual pairs of influencing factors, very few link their findings with success criteria. One of the exceptions is (Frankenberger and Badke-Schaub, 1998) who have started to combine these individual results into networks of influencing factors.

Ultimately, design research is about developing methods and tools for improving design. This implies that the new, improved situation (and potential side-effects) have to be envisaged. In our view, a descriptive study has to end with an initial prescriptive study, that is, it has to include a description of the implications of the findings on the aim to improve design.

7 Prescriptive Study

In most publications on design support development, there is little evidence of extensive use of descriptive studies. The development seems to rely on single findings, on assumptions and sometimes on experience. Unfortunately many of these are not articulated.. The publications do not reveal much about the applied methodology (the steps to come to the proposed support) nor on the underlying view on design and design and support. We argue that it is important to take the results of descriptive studies into consideration when developing design methods and tools, irrespective of whether these assist the designer with a task or automate this task, and irrespective of whether or not the method or tool follows the human design process.

The importance of using descriptive studies extensively, rather than relying upon single findings, is illustrated in the following example. Several studies reveal the large amount of time spent on collecting information, e.g. (Beitz, 1979) and (Hales, 1987). A solution to reduce this amount of time, would be a tool that provides easy and quick access to information. Other literature, however, shows that personal contact is the most frequently used source, and that most information is taken from memory, e.g. (Marsh, 1997). As a consequence of this finding, a focus on capturing this information would be a more promising solution. That this solution might be problematic too, is revealed by the finding that in searching for solutions, successful designers restructure and summarise information (Fricke and Pahl, 1991). Storing information as given, is insufficient.

Assuming that the aim is to *improve* the design process, it is necessary to determine what the future, improved, situation would look like. In some cases, the results of a descriptive study (the reference model) can be very close to what is required to develop design support. A typical example is a set of guidelines for good practice. These could have been found directly as a result of the analysis of successful projects and be used with little editing. In general the transformation of the findings of descriptive studies into design support is not so straightforward., because these findings provide the characteristics of *existing* processes, that is, those we aim to improve. The links between these characteristics and the success criteria give some indication of the direction in which to search for improvement measures. But even then, the development of methods and tools remains a creative activity in which experience and assumptions have to be introduced. It is particularly important to make these assumptions explicit, so that the reasoning process can be traced and judged and the results be used. Scientific reasearch has to be open for investigation.

Support developed in the Prescriptive Study address one or more influencing factors in the reference model directly. A so called impact model can be developed that shows how these changes are expected to affect the network. However, interference in the reference model due to the introduction of support, might change the network of causes and effects in a way that has not been predicted, that is, side-effects may occur. One way of reducing the number of potential side-effects is to address the factors that have short paths to the measurable criteria. Nevertheless, even carefully developed support requires testing. As described in section 3.1, several evaluations have to take place. The first evaluations are during the development of design support. The researcher continuously assesses the support for its in-built functionality, consistency, etc.. We call this method or tool evaluation.

One special characteristic of research projects, is that the resulting support is often a demonstrator or prototype to proof the concept. Evaluation criteria such as completeness might not apply. The demonstrator or prototype should be focused on the contribution of the research project to design research. In addition, they will contain what is are absolutely necessary to evaluate the result with respect to the formulated criteria. This has been illustrated in Figure 4. As a consequence, the evaluation stage (Descriptive Study 2) and the development stage (Prescriptive Study) partially run in parallel. An example can be found in (Bracewell *et al*, 2001).

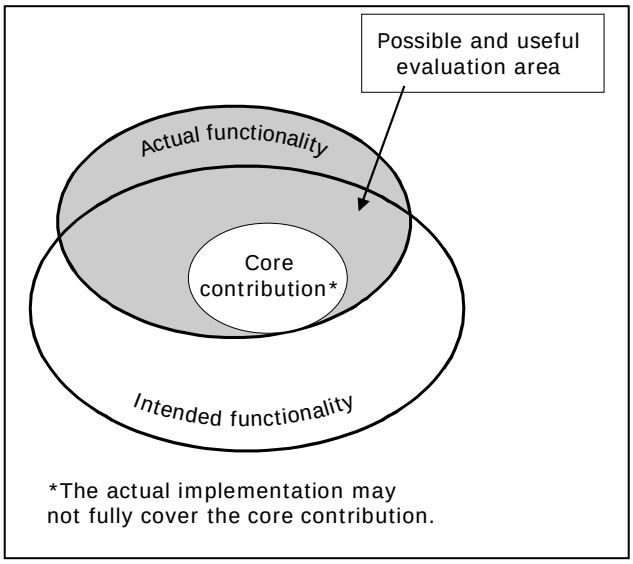

Figure 4 The functionality of a demonstrator or prototype (the actual functionality) compared to that of the intended support (intended functionality). Both should cover the core contribution of the research project

Possible reasons for the lack of using the results of descriptive studies in developing support are: the recency of descriptive studies in the field of engineering design, and the fact that many descriptive studies do not aim at identifying the link between success and the factors they study. We expect that the increasing number of descriptive studies will give a new push into the development and implementation of design support.

8 Descriptive Study II

Once new methods and tools have been developed and first tests suggest that the support should achieve the aims, a formal evaluation has to take place. The evaluation of design support is one of the most difficult research areas. The two main issues are:

- application evaluation to identify whether a method or tool has the expected effect on the influencing factors that are addressed directly;
- success evaluation to identify whether this indeed contributes to success (see the feedback arrows in figure 1). As illustrated earlier, unexpected side-effects may occur.

The first issue aims at investigating whether the method or tool can be used in the situation for which it is intended and that is does address the factors it is supposed to address. Using our earlier example: Does the proposed method indeed improve problem definition quality? The second issue requires a study into the effects on success, thus addressing the network of influencing factors identified in Descriptive Study I and in particular, the link to the formulated measurable criteria. This evaluation can be used to answer questions about usefulness, implications and side-effects of the method or tool. To address the whole network of factors is important in order to be able to identify which of the links caused the net to 'break down', in case the design support did not have the desired overall effect. A descriptive study is the most suitable method for this type of evaluation. A high level of reality in the setting of the study will increase the likelihood of realising a similar effect in industry and helps 'sell' the support to industry.

Formal evaluation should be part of each development process. Unfortunately, many developments are only tested by the developers/researchers themselves using examples of *existing* products. In order to highlight the importance of evaluation and to make explicit the three types of evaluation required, we have separated in our framework the formal evaluation (Descriptive Study 2) from the stage in which the design support is being developed (Prescriptive Study).

Descriptive Study II uses similar methods as Descriptive Study I, but focuses on investigating the effects of introducing design support, that is, a situation in which an intervention has taken place. A variety of approaches is possible. Similar to Descriptive Study I, such as study has to be carefully designed, and the options and underlying assumptions made explicit. Important is that evaluation should not only focus on the measurement of outcomes, that is, on the effects of the support. Many more aspects have to be taken into account. Design support is a proposed solution, addressing a perceived need; based on a theory or set of assumptions linking this solution to expected benefits; is implemented (to a certain degree) as instruction, workbook, software, etc.; is introduced, e.g. by means of training workshops or presentations; is intended to be used in an industrial context which is dynamic and where politics may have a large influence; is used by people with particular backgrounds, preferences, beliefs, interests and motivations; is highly likely to have an impact as it will change the working situation; uses resources such as people, time and equipment; and requires a certain organisational or technical infrastructure.

As a consequence, the aspects that should be considered in planning an evaluation are[2]:

- need;
- conceptualisation and underlying assumptions;
- implementation;
- introduction;

[2]These aspects show an overlap with the five types of conceptual and methodological frameworks for the evaluation of social programmes as identified by (Rossi *et al*, 1999). .

- impact: desired and undesired, indirect and direct, immediate and long-term;
- efficiency;
- users and their behaviour;
- organisational, technical and other contextual prerequisites.

Although the emphasis may vary, all these aspects need to be addressed while setting up the evaluation plan. They affect the success of the support and thus the context of the evaluation – the outcome of an evaluation might be negative because of a poor training, rather than a poor method, or because the wrong type of users has been selected. The aspects also indicate whether additional action has to be undertaken before the evaluation takes place, such as developing a training exercise or creating the appropriate infrastructure.

Evaluation of design support is a complex, challenging task that requires creativity and careful preparation in order to obtain meaningful results. The statement of Rossi (Rossi *et al*, 1999) that, "evaluators must often innovate and improvise as they attempt to find ways to gather credible, defensible evidence about social programs" is also valid for design research. The challenges are "to match the research procedures to the evaluation questions and circumstances as well as possible and to apply them at the highest possible standard feasible in those circumstances".

Application evaluation to identifying the effect of design support on the factors that are directly addressed, e.g. improving problem definition, can be relatively straightforward. Identifying whether this indeed contributes to success is far more difficult and the results are not easy to generalise. True success is difficult to measure other than in a real, industrial situation, and descriptive studies in an industrial situation are notoriously difficult, let alone comparative descriptive studies (comparing those using the developed support with those not using the support). The introduction of 'measurable criteria' is an attempt to address this issue. The success of a method or tool also depends on the context in which it is being used. This context is different for every design process, because every design project is different in some aspect. Whether this aspect is relevant to the subject of study requires an understanding of design. An increased understanding of the effects and interrelationships of the different influencing factors (the focus of Descriptive Study I) can contribute strongly to the interpretation of findings resulting from validation studies.

Very few studies are known that involve such a comparative study. As far as a Descriptive Study involving designers has been undertaken, the common method is the direct observation of one or two projects in which the support is applied. In general, however, systematic testing of design support has not received much attention in design research, despite its importance for the introduction and acceptance of design support in industry. This might very well be one of the reasons why many developments in academia never make it into industry. In our opinion, at least an initial Descriptive Study for evaluation purposes should be part of any design research project in which design support has been developed.

9 Comparison with other methodologies

Only few attempts have been made to develop a research methodology for engineering design, although some authors have addressed some of the issues. In that respect, engineering design does not differ from other disciplines, in many of which research methodology is seldom discussed by researchers (Reich, 1995).

In the area of AI in design, we have found some publications about design research, focusing mainly on the development of expert systems. An example is the Modelling, Analysis and Design Methodology of Cohen (Cohen, 1991), consisting of 7 phases. He combines modelling with predictions derived from the model and empirical tests . Little detail is given to support the researcher.

The most relevant methodology is the one under development by Duffy and Andreasen. Although their model is has similar elements to our framework, their focus is on the development of computer support evident from the translation of the phenomena model, into a knowledge model, into a computer model as three equivalent but distinct stages. In our model, the knowledge model and (if required) the computer model are part of the Prescriptive Study stage.

Our distinction between different types of evaluation has some similarities with the three level model of evaluation described by Smithers (Smithers, 1991): (1) knowledge level: tests models and theories of the design process; (2) symbol level: tests the capability of knowledge representation and of control knowledge and its application; and (3) system engineering level: tests the implementation. Each of these levels corresponds roughly to the evaluations in each of our three main phases. The distinction between application and success-evalation is not made.

An approach, that similar to DRM aims at the combination of research and interference (action) is action research. Through a cycle of action and research a better understanding is obtained, while at the same time gradually changing the organisation or program under investigation. Action research is suitable when the research questions are still fuzzy, and as a consequence the research methodology is fuzzy. The Soft Systems Methodology of Checkland (Checkland, 1981) is an example. SSM is a non-numerical systems approach to introducing and evaluating change. First, reality is analysed and a description of the essence created. Based on this description of reality, a description of the ideal situation is being created. This is compared with reality to generate proposals for improvement of reality. The proposals are put into action, and the 'new' reality is being analysed. This cycle is repeated until the results are satisfactory. The result is not only an improvement of reality, but each cycle also results in a better understanding of reality, and the quality and effects of the proposed actions. Action research requires a close relationship with practice. As a consequence action research often emphasises local relevance (that is responsiveness) at the cost of global relevance (that is, generalisation) (Dick, 1993). In our methodology, we aim to support the generation of design support that is not focused on local solutions, and intend to involve fewer but longer cycles. Nevertheless, action research provides many interesting research methods that can be used.

10 Conclusions

Analysing engineering design literature let us to conclude that research is fragmented, rigour is often lacking, the impact on industrial practice is very limited, no clear subsets of research topis exists and the issue of research methodology is not addressed. Having a research methodology (or methodologies) is important to become an established area of scientific research. In this paper, the outline of a design research methodology (DRM) has been presented, based on the view that the overall aim of design research is to support industry by improving our understanding of engineering design and, using this understanding, developing knowledge, in the form of guidelines, methods and tools that can improve the chances of producing a successful product. Individual research projects can have more specific aims: based on the DRM-framework design research projects have been classified into seven types.

The aim of DRM is to support in particular young researchers by (1) identifying the main stages in design research allowing individual research projects to be placed in the context of other research (as shown in (Blessing *et al*, 1998), and (2) suggesting research methods and pointers to relevant literature for each of the identified stages.

The main issues addressed in DRM relate to the four stages of this methodology: the need for formulating success as well as measurable criteria; the importance of descriptive studies to increase our understanding of design products and processes to inform the development of design support; the systematic development of design support; and the different types of evaluation necessary to assess the developed support in the light of the aims. It is hoped that the proposed methodology contributes to a more rigorous approach to design research, pieces together the various design research areas and encourages collaboration with other disciplines. This is expected to lead to the improvement of design support, which, in turn, is expected to improve the chances of industry of producing a successful product - the overall aim of design research. It is time to start building the picture and not just produce individual pieces.

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