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COMPARISON OF THREE METHODOLOGICAL APPROACHES OF DESIGN RESEARCH

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ABSTRACT
This paper compares three framing methodologies of design research from: (a) ontological (what the framing methodologies actually are and why they exist), (b) epistemological (what the sources, structures, and contents of knowledge are), (c) methodological (what processes the framing methodologies imply, and what methods they involve), and (d) praxiological (to which problems the framing methodologies have been applied, and how they are working in the practice) aspects. The three framing methodologies are: (i) research in design context, (ii) design inclusive research, and (iii) practice-based design research. The first methodology supports analytical disciplinary research aiming at insights, understanding, and predictions, relies mainly on the knowledge of background disciplines, uses the research methods of these disciplines, lends itself to mono-disciplinary approaches, and concentrates on building and proving theories, which add to the disciplinary knowledge of design. The second methodology supports analytic disciplinary and constructive operative design research by the involvement of various manifestations of design in research processes as research means, integrates knowledge of multiple source domains, and lends itself to multi-disciplinary insights, explanations and predictions, but can also generate knowledge, know how, and tools for problem solving. The third methodology extracts knowledge from concrete practical design processes, environments, and artefacts, and it supports the improvement of design problem solving intelligence by exploring and constructing common principles, rules, and standards in a reflexive manner. In general, the three research methodological approaches are characterized by a growing level of contextualization, and by an increasing level of knowledge synthesis. They together offer a genuine methodological platform for doing design research.

Keywords: Design research, methodological frameworks, research in design context, design inclusive research, practice-based design research

1 INTRODUCTION
As a consequence of the on-going design research movement (DRM), the methodologies of design research have become the object of both philosophical speculations and academic research [1]. In its widest meaning, design research means both *an evolving human agency* reflected by all design disciplines, and *a way of thinking and acting* undertaken within a set of philosophies and a framework of methodologies, respectively. Design research enables us to build a testable body of knowledge by systematic investigations through observation and reasoning. A distinguishing feature of design research is that it is done with a dual goal in mind. On the one hand, design research seeks to provide insights in, and theoretical explanations of, all phenomena related to design. In other words, design research contributes to a universal understanding of the issues and problems belonging to, and addressed by, various design disciplines. On the other hand, it is done in order to increase the problem solving intelligence, and to provide tools and methods for practical design activities. This duality raises many ontological, epistemological, and methodological issues, which have lead to debates about the nature, contents, and structure of design knowledge, as well as about the proper methodological frameworks and research methods.
In the design and development of new artefacts, scientific knowledge, together with common sense knowledge, is an indispensable problem solving capacity. Hence design is inextricably bound up with sciences, and needs streaming of the scientific knowledge to the practice of design [17]. At large, the disciplinary knowledge explored by fundamental research in the basic sciences is transferred to

application oriented knowledge by applied sciences. Then, this application orientated knowledge is exploited in technology innovation, and finally, after having been extended with know how and technical information, it forms the basis of development of products.

Many experts have been arguing that design research can be explained by the conventional fundamental, applied, and operational categories of scientific research, because it has no specialties except its subject matter. This argumentation however raises several issues. On the one hand, *design research is specific*, because it: (i) focuses on both the discipline of design and the practice of design concurrently, (ii) synthesizes knowledge from many sources, but it also generates knowledge on its own, (iii) constructs its own understanding of the world by interpreting phenomena in design context [12], and (iv) creates mental models that correspond to both scientific inquiry and subjective experiences. On the other hand, the assumption that (part of) design research is fundamental contradicts with both the objective and the nature of fundamental research. It is widely accepted that the only *objective of fundamental research* is advancement of knowledge. It is driven by the researcher's curiosity, interest or hunch, and is conducted without having any practical end in mind. Fundamental research operates with both systematic empirical and rational investigations. It goes with high risks, and requests high investments, but offers no guarantee of short-term practical gains. It is typically of mono-disciplinary nature, and enhances disciplinary understanding. Fundamentalism assumes that design research should be fundamental likewise research in mathematics, physics, informatics, and psychology, in order to be able to generate sufficiently deep and sound knowledge about the phenomena and principles of design. Considering these objectives, many design researchers reject fundamentalism and believe that there is no sense to use the term 'fundamental research' in the context of design.

Other experts have been reasoning that the goals and approaches of design research are *closer to applied research* than to fundamental research. This is due to the fact that the industry considers design as part of engineering, which is in turn known to be a specific manifestation of applied research. The other arguments are that the research activities related to engineering design resemble those of applied research, and that the features of applied research better characterize design research than those of fundamental research. Applied research is indeed closely related to engineering and technology, and is usually governed by the requirements of the funding agencies. Applied research aggregates and constructs knowledge with the goal to solve specific practical problems of the society, and to achieve short-term practical gains. The boundaries of applied research are somewhat vague, and are often blended with those of original technology and know how development. A problem is that these general features of applied research do not explain the methodological approaches of design research. Furthermore, we must not forget that design is a much wider category than that is indicated by engineering design. In its wider meaning design ranges from creative arts to planning of systems and, in this context, even the relevance of applied research can be questioned.

In our modern age, product and production technologies have a special position, and play a different role than ever before. The major professional and societal issue is not the development of technologies anymore, but the *proper selection and use of technologies.* This reasoning is rather strong in the field of industrial design engineering, which intends to achieve an optimum utilization of the available and emerging technologies with a view to customer experiences, social well-being, sustainability, and competitiveness. The currently dominating and intertwining strategies of human centred design and global product realization imply the need for a socially sensitive technology development. Combined with the need for shortening the time of transferring and utilization of scientific knowledge for solving societal and economic issues, this entails a different thinking about the classical unidirectional knowledge transfer, as well as about the *nature of design research.* This has given the basis for my thinking about design research approaches, and, more specifically, for the investigation of how industrial design engineering research is methodologically framed.

In the rest part of the paper, first I try explaining this new thinking about research methodologies, which is supported by the relatively large number of papers published in various science philosophy and design study journals, conference proceedings, and on web-sites. Actually, I am going to consider and compare three framing methodologies of design research. The comparison will be made from: (i) ontological (what the framing methodologies are, and why they exist), (ii) epistemological (what the sources, structures, and contents of the knowledge are), (iii) methodological (what research processes the framing methodologies imply, and what methods they involve), and (iv) praxiological (to which problems the framing methodologies have been applied, and how they are working in the practice)

aspects. The goal of the comparison is to make these framing methodologies transparent, to cast light on their features, and to show how they complement one another in industrial design engineering (IDE) research. My main findings will be generalized in the Conclusions.

2 DESIGN RESEARCH AS A LINK BETWEEN BASIC SCIENTIFIC RESEARCH AND INDUSTRIAL DESIGN ENGINEERING

Assuming the changed role of technologies, design research can be interpreted as a (socially requested) bridge between basic sciences (such as mathematics, physics, chemistry, biology, physiology, and psychology), and industrial product development. Knowledge of basic sciences, as produced by fundamental research is general (not contextualized) and disjointed (not integrated). On the other hand, knowledge used in design is specific (context dependent) and is supposed to be coherent (amalgamated). As mentioned above, this knowledge transfer has traditionally been explained and realized, respectively, by the involvement of the categories 'fundamental research', 'applied research' and 'technology development'. As it is shown in the upper part of Figure 1, this flow of knowledge is unidirectional, technology-oriented, and results in a technology-driven industrial product design. In our modern age, technology has been considered to be an enabler, rather than the eventual result of applied research and development. In this role, technology facilitates human, culture, environment sensitive, as well as business oriented development of products. Assuming the existence and the feasibility of enabling technologies, we can talk about a socially-inspired deployment of techno-scientific knowledge, instead of a technology-driven utilization of scientific knowledge. This *socially-inspired knowledge deployment* is in fact a two-way relationship, enabling short innovation cycles. This two-way relationship, which is shown graphically as a knowledge loop in the lower part of Figure 1, concerns not only the necessities and the affordances, but also the requirements and the opportunities. In my view, design research plays and will even be playing a stronger role as the engine of a socially-sensitive knowledge transfer between fundamental sciences and industrial product realization, and a mediator of translating research findings to design actions.

Based on the above reasoning, we can argue that scientific research produces knowledge and means for industrial product design, and the latter formulates the purpose and context of research. In this loop, fundamental research remains the only source of basic knowledge associated with formal, natural, human, social, and engineering sciences, but design research synthesizes and contextualizes even the otherwise disjoint bodies of knowledge of applied sciences for the design practice. This knowledge synthesis concerns both horizontal and vertical integration of knowledge, that is, both the reduction of thematic fragmentation and specialization, and the elimination of semantic disconnections of terminological knowledge. In addition, design research extends scientific knowledge with genuine design knowledge. In this process knowledge becomes more and more contextualized and integrated,

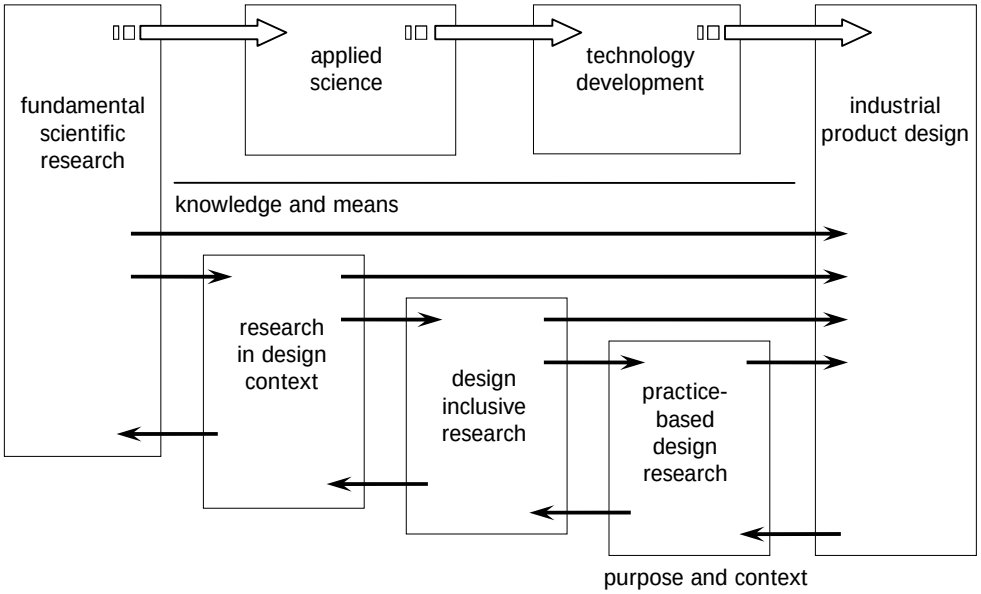

Figure 1 Placing design research in the context of socially sensitive knowledge transfer

which are considered to be important to arrive at legitimate *designerly inquiries* [24].
On the basis of the growing level of contextualization and integration, various framing methodologies have been identified. The goal of defining these framing methodologies and interpreting/formalizing design research accordingly is to make the research activities more systematic, structured, consistent, reproducible, and assessable. At this point it may be helpful to further elaborate on the concept of *framing methodology*. By definition, research methodology is a theoretically underpinned system of principles, methods, procedures, and practices of research applied to a specific design discipline (branch of knowledge). In our regard, framing means the process of selectively using mental structures to facilitate a thinking process, or invoke a particular image or idea. Consequently, application of a framing methodology is a process, where the activities are primarily intellectual and controlling concrete actions. In general, a framing methodology: (i) introduces a strategy of reasoning, (ii) indicates a possible research design (a structure and set-up of research actions), and (iii) the way research actions are to be done. However, it does not explain explicitly: (i) what concrete methods are to be applied, and in which order, (ii) how to solve a particular research task, and (iii) how new

Table 1 Levels of contextualization and amalgamation of design knowledge

	low	medium	high
contextualization	research in design context	design inclusive research	practice-based design research
integration			

information is to be found, collected, and analyzed.
Table 1 presents the three investigated framing methodologies: (i) research in design context, (ii) design inclusive research, and (iii) practice-based design research, in the order of growing contextualization/integration. *Research in design context* is a term proposed to refer to the disciplinary (foundational) inquiry in design, which shares a number of commodities with fundamental scientific research. In terms of design knowledge, usually a higher level of contextualization and a more extensive integration of knowledge are targeted. One strategy of achieving this is the inclusion of various manifestations of design in the research process. This methodological approach has been called *design inclusive research*. It is supposed that the strongest contextualization and the ultimate synthesis of scientific and design knowledge happen in design processes, and eventually in artefacts. The research approach, which intends to generalize and extend design knowledge based on strongly contextualized practical knowledge, has been called *practice-based design research*.
This kind of conceptualization of the framing research methodologies is believed to offer not only a different, but also a structured view on what purposes design research approaches can serve. In the next sections, I will systematically analyze and compare the above mentioned framing methodologies of design research from various aspects, which can be sorted as ontological, epistemological, methodological, and praxiological. Since my research has been conducted in the context of industrial design engineering, I will compare the framing methodologies with a view to this specific field of application.

2 RESEARCH IN DESIGN CONTEXT

The statement that research in design context shares a number of commodities with fundamental scientific research first of all refers to the fact that all kinds of observational, descriptive, and explorative (both qualitative and quantitative) research methods of sciences can in principle be applied in design research. Afterwards, this also points at the fact that the knowledge of the concerned background disciplines, such as psychology, marketing, form theory, and information theory is considered as the basis of research [8]. Actually, these can be observed in the recent design research literature too. However, what makes the differences in comparison with the other disciplinary research approaches is that the observations, studies, or experiments in design research do not happen with disinterest, which is typical for other fundamental sciences [6]. The studies conducted according to the framework of research in design context (RiDC) are mono-disciplinary, their set-up corresponds to that of the ‘classical’ empirical approaches, but they are, in the overwhelming majority of cases, not decontextualized inquiries. However this latter ‘bias’ does not necessarily have influence on the objectivity and independence of the conducted research. As a matter of fact, empirical and

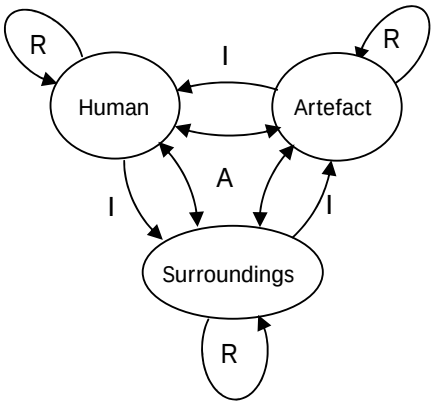

Figure 2 Concerns of design and the types of contextual relationships

experimental inquiries are conducted purposefully to get insights, or to achieve enhancement in various contexts, such as human behaviours and reflections, artefact qualities, and interactions and impacts on natural/artificial surroundings. This is eventually a consequence of the duality of design (and design research) discussed earlier.

The context of inquiry comes from the consideration of the various concerns of design, such as: (i) the people who are involved in design, or who are influenced by design, (ii) the artefacts that are brought to a conceptual existence by design processes, and (iii) the surroundings in which humans and products exist and interact [11]. Here, 'people' means individuals, teams, and communities of designers and customers, 'artefact' include concepts, designs, products, and 'surroundings' refer to natural, social, economic, ecological, technological, and cultural environment. In the practice, contextualization of design research influences: (i) the definition of the purpose (goals) of research, (ii) the creation of circumstances and conditions in which the studied phenomenon can be investigated in the context, (iii) identifying the relationships that must be studied in a given context, and (iv) interpretation of data in the given context.

Contextualized research seeks to understand the semantic relationships (interplay) between the investigated phenomena, the related research variables, the concerns of design, and the reflections on the concerns of design [15]. The contextual relationships to be taken into consideration can be reflexive (R), implicative (I), and aggregative (A) (Figure 2). A reflexive relationship exists when humans, products, or surroundings are investigated in the context of themselves (e.g. when the relationship between the creativity of a designer and his practical experiences is investigated). An implicative contextual relationship exists when directed semantic dependences are investigated between humans and products, humans, and surroundings, and products and surroundings (e.g. when the effects of lighting in a home interior are investigated from the point of view of designing visual electronics, or when the improvement of designers' efficiency due to virtual presence in a collaborative virtual design environment is studied). Finally, an aggregative contextual relationship is to be taken into account when multiple semantic dependences are simultaneously investigated related

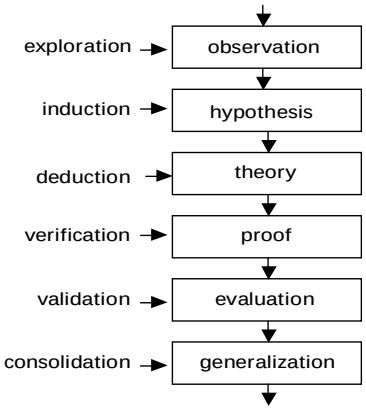

Figure 3 Major phases of research in design context

to all concerns of design (e.g. when alternative solutions for personal mobility in urban regions with low environmental impacts are investigated).
As indicated above, RiDC can deal with a wide variety of research problems and questions ranging from human through social to engineering interests. It indicates that this type of research does not depend on particular disciplines or application domains. The knowledge explored by RiDC processes manifests as better insights and enables theory building. The learning process involved in RiDC follows the six-stage scheme of scientific research (Figure 3). This pattern of activities may occur recurrently in complex research projects. The style of research is analytical, rather than constructive. The goal is to explore, describe, understand, and explain design related phenomena, which occur naturally related to, or are partly or entirely created by design. Operationalization of RiDC happens through alternative observational and experimental research, and it may require adaptation and tailoring of research methods and procedures according to the needs of the research task at hand. Though RiDC dedicated to contextualized studies, it does not have strong capacities for integration of knowledge from multiple-disciplinary sources due to its mono-disciplinary nature.

3 DESIGN INCLUSIVE RESEARCH

The objective of design inclusive research (DIR) is to provide a sound theoretical foundation and a robust methodological approach for designerly inquiry to meet scientific rigor [23]. The principal assumption of DIR is that a designerly inquiry should provide knowledge of higher level of contextualization and integration than that can be achieved by foundational (disciplinary) research, and that this can be facilitated or even intensified through the involvement of design, because design is a controlled knowledge synthesis process. Thus, DIR opens up the prospect to blend systematically two domains of learning: research and design [22]. As a framing methodology, DIR offers the possibility to embed design as a research means, and allows combining scientific study and designerly inquiry in a scrupulous way. The embedding of design creates new opportunities for exploring and constructing contextualized knowledge that can not be produced otherwise by other research approaches [20]. Design as a research means can be artefacts, process, entities, phenomena, and knowledge. In this context, artefacts include various manifestations, such as hardware, software, firmware, knowledgeware, and service products. Likewise RiDC, design inclusive research also requires that the research procedures and methods are tailored according to the context.
The general process of DIR is shown graphically in Figure 4. Ignoring the technical details we can claim that embedding design divides the research process into three phases: (i) phase of explorative research actions, (ii) phase of creative design actions, and (iii) phase of confirmative research actions. The arrangement of these phases gives a specific pattern to design inclusive research. Phases (i) and (iii) are called pre-study and post-study, respectively. The pre-study involves: (i) exploration, (ii) induction, and (iii) deduction activities of a systematic research process. The goals of the pre-study are: (i) aggregation of knowledge and constructing new knowledge related to the research problem and its surroundings, (ii) formulation of a critique of the current understanding and existing approaches, (iii) defining the research questions and development of hypotheses, (iv) setting the goals of the design activities, and (v) development of comprehensive theories to solve the research/design problem. The paper of Chang W.-C. and Van, Y.-T. illustrates how proper pre-design research can contribute to a

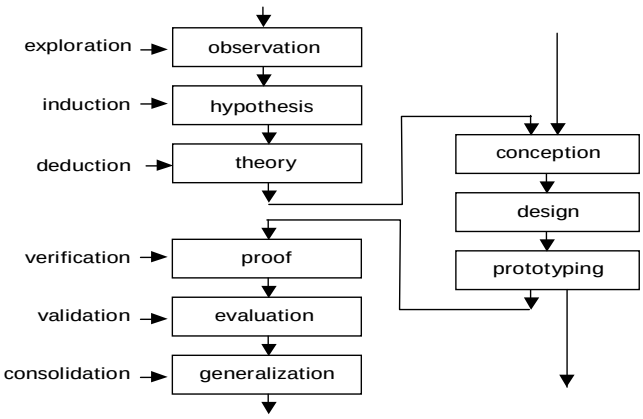

Figure 4 Major phases of design inclusive research

successful redesigning the form of printers in order to increase the success rate of a redesigned product in the market [7].
The goal of the embedded design process or other experimentations with artefacts can be set as: (i) to invent concepts, models, and methodologies, (ii) to prove the validity and feasibility of the ideas by creating a testable instantiations, and (iii) to experience towards a better understanding and enhancement. From an epistemological point of view, the recurring design processes contributes to a theory building in context in an evolving manner [21]. The control of this process is ensured by the confirmative phase of research. It means that both internal and external views can be present concurrently in design inclusive research.
The confirmative post-study typically comprises the actions orientated to: (i) the verification of the hypotheses, the constructed theory and the outcome of the design processes, (ii) the internal validation of the research methods and the design methods, (iii) the external validation of the findings of the research, and the results of the artefact development, and (vi) the consolidation of the results by matching them against the existing body of knowledge, and by generalizing them towards other applications.
Two major issues associated with DIR are: (i) in which concrete forms and through which procedures can design activities be included in practical research processes, and (ii) how the information coupling can, or should, be implemented between the research activities and the design activities. As for now, we can find many more open questions than robust answers in these regards. DIR intends to study the object of research holistically (synthetically), and to combine the analytical research methods with constructive design methods in producing new non-idiosyncratic knowledge [5]. In addition to exploration, description, and explanation, which are also targeted by research in design context, DIR may pursue prediction and manipulation. The research activities may have multiple objectives originating from the goal of the study, and may concentrate on many phases of the product life cycle, many forms of product manifestation, human behaviours, and environmental relationships, and alternative aspects of use and experiencing with evolving products. These together form one source of complexity in DIR.
Informational coupling between research and design within one embracing inquiry process requires the amalgamation of three bodies of knowledge, namely, (i) object- and context-related design knowledge, (ii) design methodological/process knowledge, and (iii) research methodological/process knowledge. Nevertheless, design inclusive research interweaves information flows not only from inside, but also from outside the research process. From an information processing point of view, the theory derived from the research hypotheses provides one set of information for the design activities in the research process, and the market needs, technological opportunities and customer preferences concerning the conceived product form another set of information for it. These two sets of information need to be integrated in the head of the researches, as well as in the research methods. They can complement each other, but may also be inconsistent or even conflicting. Further studies seem to be necessary in order to resolve these issues. It has to be also noted that this framework allows the design researchers: (i) to complete the designing exercises by themselves, and (ii) to involve experienced designers to develop artefacts and perform as subjects, but also for the designers (iii) to operate as researchers, as well as designers. The combination of rigorous research and creative design integrates knowledge of multiple domains, and lends itself to multi-disciplinary approaches.
The difference between using the conventional observational/experimental research means (such as a linear accelerator in experimental particle physics) and using designs/designing as a research means (such as a product, which is developed to fulfil a societal need) should also be pointed at here. In the first case: (i) the research means is practically unchanged during the research process, (ii) its nature and functions are for the most part predefined by the goals of research, and (iii) it is realized (produced) under high-end technological and economic constraints. In the second case, the research means: (i) may appear in altered (even completely different) forms, (ii) may be dynamically evolving, and (iii) interacts with the research project by providing a direct feedback for the researchers. In addition, (iv) the nature and functions of the research means are defined, on the one hand, by the specific (internal) goals of research and, on the other hand, by the (typically vague) requirements imposed by the target user group, application, and/or environment. In other words, the internal goals should be harmonized with the external goals, i.e., with the societal context of designing and the assumptions concerning the nature, function, and utility of the conceived product. This is also a source of complexity, as well as of under-determination, which can be interpreted both positively (on the

basis of the opportunities left for alternative knowledge synthesis) and negatively (because of weakening the rigor of the knowledge generation process).

4 PRACTICE-BASED DESIGN RESEARCH

The roots of *practice-based research* (PBR) are in the fields of fine arts and social work services, where it deals not only with inferable, but also with doable research questions [1]. PBR positions the practitioner as an observer, or a researcher [2]. Researchers in art are pursuing new knowledge through practical activity and interventions in the production of artefacts (images, objects, performances, or events). Since artists are not required to account for their activities, there is no strong requirement for rigour in the art practice. PBR is a new conceptualization of research leading to different interpretation and operationalization in practical fields [14]. On the other hand, much of what is currently claimed to be research within fine arts would not be recognized as such by other academic disciplines. There seems to be a convergence on the position that each creative practice is not necessarily research, but some of them have the potential to create generalizable knowledge, and to meet certain criteria of scientific inquiry. For instance, the Royal College of Art has defined some criteria for practice-based research, such as: (i) purposive - based on identification of an issue or problem worthy and capable of investigation, (ii) inquisitive - seeking to acquire new knowledge, (iii) informed - conducted from an awareness of previous related research, (iv) methodical - planned and carried out in a disciplined manner, and (v) communicable - generating and reporting results, which are testable and accessible by others.

Douglas, A. et al. used four *crucial influencing factors* of practice-based research, namely, (i) context of research, (ii) motives for doing the research, (iii) who the research addresses, and (iv) funding of research, to characterize research situations in fine arts. They identified three different research routes: (a) personal research, (b) research as critical practice, and (c) formal research [9]. They also argue that the three approaches impact in different ways and to different degrees on the discipline. For instance, the goal of personal research is to study interpretations, reflections, and influences of the individual art work through public exhibitions, critiques in recognized art journals and networked interviews. Within critical practice review and appraisal sessions, such as discussion platforms, workshops, and symposia have been inaugurated as means of (forerunning or follow-up) inquiry. These methodological approaches cast light upon the fact that the practical actions and the research actions in PBR may be separated in time.

The concept of *practice-based design research* (PBDR) has recently appeared in some disciplines of design, such as industrial design engineering, architecture, and media design. The reason is that designers recognized the need to extend the knowledge base of design as part of their professional responsibility. PBDR has been defined as “the use of research-inspired principles, designs, and information-gathering techniques within the existing forms of practice to answer questions that emerge from practice in ways that inform practice” [16]. It involves the application of qualitative, quantitative, and mixed methodologies to mine information by practitioners. Some PBDR is close to design analysis, but it is separated from that based on three criteria: (i) formulation of explicit research questions, (ii) use of some operative research methods (such as, e.g. action research and case study), and (iii) outcomes of the research are disseminated to others. It is conducted as a reflexive interrogation, pursuing abstractions and generalizations from the practice of designing. Other researchers used the notion of *research by design* to describe a combination of research and design in which an evolving artefact is employed as a research means in the process. Several papers intended to show how researchers actually work within practice-based design research.

The basic assumption of practice-based design research is that there is a need for and there exist a designerly knowledge production and this is *done in the process of designing* [10]. PBDR is conceived as a form of qualitative research operating with information concerning design processes and designed artefacts. However, as Overbeeke, C. J. and Forlizzi, J. illuminated this very clearly: (i) physical hypotheses are actually generated through design, and/or (ii) a context-related body of knowledge is constructed from pieces borrowed from other disciplines and sciences [19]. This implies that we should pay attention to the fact that the concept of PBDR introduces at least as many problems as it is able to resolve. It is believed that, when this framing methodology is applied, *objective and testable knowledge* is generated through cycles of building and evaluating structurally varied, experiential, and product relevant prototypes. For the scientific value of the work an *appreciable element of novelty* was assumed in addition to the resolution of uncertainty, and providing a solution to a problem, which is

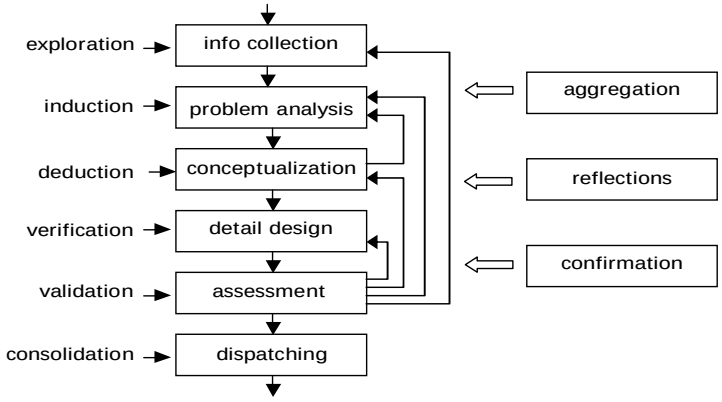

Figure 5 Process flow of practice-based design research

not readily apparent to someone familiar with the basic stock of common knowledge and techniques for the area concerned.

As far as the process of doing practice-based design research is concerned, it significantly differs from the other two approaches [3]. Its main process is *typically a design process.* In the generic model of design processes cognitive elements similar to those of research processes can be identified, but the mechanisms of information processing and the applied methods are different. Usually, the whole process of design or the outcome of design is put into the focus of observational and explorative investigations. Alternatively, discrete research actions can be made at certain phases of the design process with the goal of: (i) systematically aggregating testable knowledge, (ii) investigating the reflections invoked by the design process and/or the designed artefact, and (iii) confirming the outcome of design by validation (Figure 5). In the former case, the investigations are driven through the *logic of a design process*. In the second case, an *inherent methodological fuzziness* is to be taken into account, because there are no clear rules on how to append ordinary design processes with research actions. Some argue, consequently, that the only goal, which can be set for practice-based design research is to extract knowledge about how artefacts and design processes can be done better.

Breen, J. proposed to differentiate design activity and design artefact driven research, and introduced a classification of various design driven research methodologies typical for architectural design [4]:

- Design activity driven research
  - Design process driven research
    - Individual process based research (descriptive/explorative)
    - Thematic process based research (descriptive/explorative)
  - Design(erly) workshop driven research
    - Design workshop based research (descriptive/explorative)
    - Designerly workshop based research (explorative > empirical)
- Design artefact driven research
- Design result driven research
  - Individual result based research (descriptive/explorative)
  - Comparative result based research (descriptive/explorative)
- Design(erly) enquiry driven research
  - Design data comparison based research (descriptive/explorative)
  - Designerly interpretation based research (explorative > empirical)

The concrete research methods of PBDR are such as: (i) participatory observation, (ii) action research, (iii) case study, (iv) protocol analysis, (v) expert interviews, (vi) grounded theory construction, and (vii) assessment forums. Jonas, W. pointed at the fact that involving the means of research in designerly inquiries increases the *academic respect of design*, but does not substantially contribute to tackling practical issues of social/economic innovation and human well being [18].

As an integral part of professional design practice PBDR has been accelerating rapidly in recent years. Typical features of PBDR are: (i) real-time intervention, (ii) short timescales, (iii) evaluation in real-life context, and (iv) reduction of complexity. It is done to gain intelligence rather than insight for design science. Notwithstanding, it is claimed to be an advantage that the research is done

(collaborated) by design practitioners themselves, and the research results reflect their understandings better than the work of external professional researchers alone could. However, PBDR does not really support obtaining deep theoretical insights and understanding due to the lack of a comprehensive external view, and the derived theories and models will be partial [13]. The conversation, reflection, and action that occur in response to the generation of sketches, models, and prototypes have the potential to form the basis for an understanding of the *perspectives and practices* relevant only to a specific design domain. Also, more substantial critiques have been formulated about practice-based design research, for instance, that it: (i) insufficiently supports disciplinary (theoretical) underpinning of design research, (ii) offers only a limited possibility for a rigorous verification and validation of the findings, (iii) suffers from an insider view because it is headed by designers through design, but not about design, and (iv) when the findings are taken out from the studied situation or context, they may loose their relevance, significance, or feasibility. For these reasons, practice-based design research is considered a *weak form of inquiry*, and there is a strong debate concerning the value of practice-based output as a scientific research output. On the other hand, it is also a debated issue how much research is a mode of construction of artefacts.

CONCLUSIONS

Like many other professions, design is seeking to establish itself as a discipline, and eventually as a science. It implies a need for a continual growth of knowledge that distinguishes designers from other professionals. On the other hand, the lack of genuine design research paradigms and methods are often mentioned as an obstacle in the development of design science. In these contexts scholarly design research plays a key role. It is supposed not only to explore and aggregate knowledge with sufficient rigor, but also to construct its own research methodologies and methods. In the last years three specific faming methodologies were outlined for design research. This paper compared these with the goal to make their characteristics visible. It was shown that the three framing methodologies lend themselves not only to contextualization of design knowledge but also to integration of domain knowledge. The other main findings can be summarized as follows.

- Research in design context: (i) supports analytical disciplinary research aiming at insights, understanding and predictions, (ii) relies mainly on the knowledge of background disciplines, (iii) uses practically all research methods of these disciplines, (iv) lends itself to mono-disciplinary approaches, and (v) concentrates on building and proving theories, which add to the disciplinary knowledge of design.
- Design inclusive research: (i) supports constructive disciplinary and operative design research by involving various manifestations of design in research as research means, (ii) integrates knowledge of multiple source domains, (iii) lends itself to multi-disciplinary insights, explanations, and predictions, and (iv) generates knowledge, know how, and tools for problem solving too.
- Practice-based design research: (i) extracts knowledge from concrete practical design processes, environments, and artefacts, (ii) supports the improvement of the design problem solving intelligence reflexively, and offers generally valid principles, rules, and standards. However, the epistemological and methodological adequacy of design processes to explore genuine and general knowledge is heavily questioned. The philosophical consideration of the problem has lead to the debate on the creative endeavour as a form of research. A different, but not less significant issue is that design-based research does not fit easily within the assessment parameters/judgment criteria of science funding agencies.

This paper tried to show that there is an *alternative way of thinking* about the role and manifestation of design research, and that the three studied framing methodologies together offer a genuine and widely-based methodological platform for doing design research. The presented work was based upon the premise that design practice wants solid disciplinary research and theory-based knowledge, while design science also wants the knowledge in a form that speaks to practice.

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