**Maria João Félix[1]**

**Gilberto Santos**

**Ricardo Simoes**

**Jorge Rui Silva**

# PRACTICE-BASED DESIGN RESEARCH KNOWLEDGE PRODUCTION FOR QUALITY ASSURANCE IN DESIGN

*Abstract: The main goal of this work is to demonstrate that the concerns about the qualification of research in the field of design have had in the last years of this decade an extraordinary development due to the recognition of its importance for quality innovation and competitiveness of business, but also due to its importance as a strategic partner in a system-oriented approach.*
*The methodology of this research will focus on a literature review that shows that Design Research itself is a very complex area of knowledge production, thus it requires an equally rich repertoire of methods and positions.*
*The main findings point to the need to position individual researchers approaches in this complex scenario that ensures quality in design and development processes.*
*In conclusion it is necessary to continue defining its particularities and also to develop a scenario proposal for Design Research through practice.*

*Keywords: Research design; Practice-based research; knowledge production; Quality; Design and development processes*

## 1. Introduction

We should look to design research as an opportunity to create a vision and a direction of design system, or even better, the capacity that design research has to foresee new subjects and new answers, concerning the main subjects of contemporary life and the economic, social, cultural and environmental challenges of our society.

Thus, one of the objectives of this analysis is to propose a way of describing and differentiating the emerging models, through the description of the relations between practice and research, between doing and reflecting and between implicit and explicit knowledge.

These two areas include different research systems, including universities, institutions and companies, that aim a transference of technologies, the cross fertilization between sectors, the dissemination and exchange of the best practices, in order to promote quality

(Santos et al., 2017) innovation (Doiro et al., 2017) and competitiveness (Bravi et al., 2017) in companies, through the use of design research.

Design research means mainly the promotion of a series of actions that enable to bring the university closer to the industry, promoting the dialogue. Thus, it is important to invest in education/training processes and scientific and technological research trough practice-based design research, where the reflection process is stimulated through a methodological, instrumental and operational approach applied to teaching and research processes, ensures knowledge production and

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[1] Corresponding author: Maria João Félix
Email: mfelix@ipca.pt

the quality in design and development processes, where are necessary good ideas (Santos et al., 2018; Sá et al., 2019).

We need a global vision of design research, Richard Buchanan (Buchanan, 1992) has always said that there is not a unique definition that is totally appropriate to design. All the same approaches and methods of design research are varied and complex, an aspect that is often neglected when it comes to debate the concepts of rigor and traditional scientific methods and when simplistic methods are proposed.

A perspective of systems in design research offers a holistic and dynamic vision, where it is seen as a complex and changing area, where new ideas and positions are created, where there are ideological contradictions and where new research practice patterns are created (Sevaldson, 1999)

The design history, as a subject for study and mainly as research object in universities, is recent, but the tendency to transform real-life settings and produce objects has been a part of human activity since the most ancient times.

During the transition from a world of craft skills to an industrial society, the process of making design continued to be an implicit process, learn through experience. It did not develop as other knowledge areas, in a coded subject that was transmitted through a formal learning process. Its particular history results from the inner nature of design that is situated between the artistic and craft ability, producing cultural products and contents, and also results from scientific practice that produces technical products and contents.

During the first experience of training at university level, it was possible to find the first attempts to code the subject and formalize a method for learning design.

Simon's approach, (Simon, 1969) has placed design subject in a new perspective, and facilitated its introduction at universities as a study and research object. Conversely it proved to be contradictory and its application proved to be limited to the real context of professional practice. Thus, recent debates have tried to establish a balance between the two extremes of design, which is seen as an artistic talent of the person and design as a science. Donald Schön (Schön, 1983) was one of the first persons to question Simon's positivist doctrine, supporting theories of design as a science. From the point of view of Schön, design is the interaction field between theory and practice, where scientific reflection does not fit in the reflection about design and its impact in the context.

This more balanced view of design further enhances its capacity to produce knowledge, but on its own way, which does not necessarily reproduce scientific means in the positivist sense. Therefore, design research is starting to be interpreted in the phenomenological point of view, and design reality is taking into consideration for the creation of rules and general principles that are, however, in permanent development according to the point of view and context changes.

It is not just the academic community that explicitly interprets this approach, the elements of professional world increasingly make design and also acquire and develop knowledge about and for design. In these companies, multidisciplinary professional groups have, over time, created not only codified technologies, but authentic design, enhancing innovation theories.

There is also research in a more transversal and multidisciplinary way, particularly at doctorate level, that has been trying to explore the true potential of design as a research tool about the present situation, and with much more operation possibilities than those traditionally consolidated. These are transversal research project that connect design questions to emerging contemporary phenomena, revealing in real time the impact that the changes that are taking place can have over theoretical and practical aspects of the subject.

The objective of this work is to contribute to the understanding that the knowledge

production in practice has a much greater potential than a mere curiosity of academic research.

It is claiming a stronger focus in the production of general knowledge within the different domains and in society.

This work also aims to build the basis for future studies realizing that the construction of tacit knowledge, has great potential to generate the knowledge that we need for a sustainable future.

In conclusion it is necessary to continue defining its particularities and also to develop a scenario proposal for practice-based design research, guaranteeing the different approaches of individual researchers in this complex scenario, that ensures quality innovation (Santos et al., 2018) in the design and development processes and stimulates the knowledge production.

## 2. Literature review

In the early 1960s, the notion of design research arose, which until now had been based on personal and partial concepts. The Design Methods Movement emerged from a series of conferences. The movement was developed through a series of conferences in the 1960s and 1970s: in London, 1962, "*The Conference on Design Methods*" (Jones & Thornley, 1962); in Birmingham, 1965, Sidney Gregory's paper, included in "*The Design Method*" proceedings of the conference he organized (Gregory, 1966); in Portsmouth, 1967, "*Design Methods in Architecture Symposium*" (Broadbent & Ward, 1969); in Cambridge, Massachusetts, 1969, (Eastman, 1970); again in London, 1973, "*The Design Activity*" (Bayazit, 2004); again in Portsmouth, 1976, "*Changing Design*" (Evans, Powell, & Talbot, 1982) and, in 1980, "*Design: Science: Method*" (Jacques, R., & Powell, 1981).

These events were useful for design research. Design came to be understood as a process and a systematic view, from these discussions. In some of his articles, Bruce

Archer highlighted design as an activity common to many disciplines (Archer, 1965).

Systematic approaches to problem solving through computer technology and management theory have been developed. One of the objectives, of the first researchers, was to launch design as a science. This period began with "*The design science decade*", by Buckminster Fuller (Fuller & McHale, 1963), and ended with "*The science of the artificial*", written by Herbert Simon (Simon, 1969) at the end of the decade.

Design was considered worthy of study, intellectually difficult, partly formalized and partly teachable and not an intuitive and artistic approach.

A typical design research includes prescribed models, the design process, how to use and how to disable the design done, that is, standard management models that consider using information and specifications. Develop systematic methods to rationalize decision making

Since 1970, there has been a greater interest in systematic design methods and design science (Bayazit, 2004)

On the engineering side, Morris Asimow (Asimow, 1962), Thomas T. Woodson (Woodson, 1966) and Vladimir Hubka (Hubka, 1974a), (Hubka, 1982) introduced a new generation of systematic design methods. According to Hubka and Ernst Eder (Hubka & Eder, 2012) the period after 1967 and especially in the seventies can be labeled as the starting point for the development of design science. Hubka continued the work that had begun in 1960 in Czechoslovakia. His book "*Theorie der maschinensysteme*" (Hubka, 1974b) theory of machine systems expands the horizon of design knowledge to generalization and recognition of the object.

The problem of the project, understood as process, was thoroughly discussed in "*Theorie der konstruktionsprozesse*" (Hubka, 1976) theory of the design process and later transformed into a generalized process model (1980). Hubka (1978) addressed the topic of education in design in

"*Konstruktionsunterricht an technischen hochschulen"* (Hubka, 1978) and in the article *"Design education and design science"*, published *in The place of design in the engineering school: Proceedings of the S. Neaman international workshop* (Hubka, V., and Eder, 1989) and began to consider design science in the essay "Konstruktionswissenschaft"

(Hubka, 1974a).Vladimir Hubka organized the first *"International Conference on Engineering Design"* (ICED) in 1967.

Hubka and Eder spent several years in the industry, working and leading design teams and defining design science as follows: "*The term Design Science should be understood as a logically related knowledge system, which should contain and organize the complete knowledge production about and to design"* (Hubka & Eder, 2012, p.73)

In the 1970s, the so-called intermediate years (Luck, 2006), there was a reaction against previous prescriptive design models. The Design Methods Group, on the one hand, and Christopher Alexander's article *"Notes on the synthesis of form"* (Alexander, 1964)*, on the other, had a great influence in the USA in this decade, as did Chris Jones Design Methods book (Jones, 1970), based on his earlier work and published in 1977 (Jones, 1977).

The evolution of design research includes the work of Horst Rittel and Bruce Archer in 1973 at the University of Ulm. This second generation of design methods recognised the participants and their arguments as part of the process. Rittel (Rittel, 1972) understood planning problems as "wicked problems", and while science deals with tame problems, most problems in life are inexorable.

Bruce Archer recognized the importance of design education in general education, in schools, for children and for everyone. Design has its own tools that are not only to imitate science. *"Design has its own distinct things to know, ways of knowing them, and ways of finding out about them"* (Cross, 1982 p.221). Progressively, it was recognized that design should be understood with its own

terms. Typical research included theoretical analysis of what design was, descriptive design studies and participatory methods.(Cross, 2006)

Meanwhile, the Design Research Society (DRS) was founded in London in April 1966. The Design Methods Group (DMG) and DRS began publishing the DMG-DRS newspaper instead of the DMG newsletter, until 1979, while DRS started the Design Studies newspaper, edited by Nigel Cross until then.

In 1980, in the so-called consolidation period (Luck, 2006) several magazines appeared: in 1979, Design studies; in 1983, Design issues; in 1988, Research in engineering Design. The theme of the book *"Developments in design methodology"*(Cross, 1984) by Nigel Cross, dealing with the design process Project. Specific influential texts: How designers think (Lawson, 1983) Design thinking (Rowe, 1987) Engineering design (Pahl & Beitz, 1984), Practical studies in systematic design (Hubka, 1988) and The reflective practitioner (Schön, 1983).

Donald Schön (1983) started a new paradigm in design research with his book Reflective Pracitiner (Bayazit, 2004), addressed the way designers work and recognized the contribution of designers professionals in this area. Schön made a significant contribution, focusing his analysis on professional practice and the daily challenge of dealing with *"messy, problematic situations"* (Guerrini, 2001, p.61), confused and problematic situations. Schön criticized Simon's "science of design", based on the idea that the design process served to solve well-formulated problems (well-formed).

Instead of an abstract methodology for practice, Schön proposed putting trust in the skills of competent professionals (put trust in the abilities displayed by competent practitioners), describing and interpreting the phenomenology of the design process as a *"reflective practice"* (Cross, 2000 p. 45).

Also in 1980, the conference, *"Design: Science: Method Conference"* (Jacques, R., & Powell, 1981), organized by the Design

Research Society; also L. Bruce Archer, in the paper presented at the conference with the title *"A view of the nature of design research"* (Archer, 1981, p. 30) asks the same question.

Archer limited the scope of design research by identifying the following ten areas across the design domain as a science, design history, design taxonomy, design technology, design praxeology, design modeling, design metrology, design axiology, design philosophy, design epistemology and design pedagogy.

At the same conference Ranulph Glanville, asks *"Why design research?"* and considers that design research should provide a paradigm for science. *"This paper considers the nature of scientific knowledge and of scientific research NOT as a paradigm for design but, conversely, as a design activity in which particular (although not necessarily articulate) restrictions are allowed to operate. [...] And research into design should be considered as providing a paradigm for science"* (Glanville, 1981 p. 86)

One of the most important conferences in this period was the Design Policy Conference, which brought together a large number of design researchers at the Royal College of Art in 1982 (Bayazit, 2004). The influence of philosophers such as Karl Popper, Imre Lakatos, Thomas Khun, Paul Feyerhaben (Guerrini, 2001, p.60), was reflected in the construction of design theory and the first scientific formulations of design research.

And Charles Owen, between 1986 and 1993, began issuing the journal on design processes, edited by the Illinois Institute of Design (ID). These publications addressed design research, management and design policy issues and a variety of topics of interest to the design community.

In Europe, research has focused on prefabricated building design, coordinated construction elements and optimization of construction layouts. These research topics were well accepted in universities as well as in research centres as prefabricated buildings (Bayazit, 2004, p. 25) were indispensable due

to the great housing shortage in Europe after the Second World War.

In the 1990s, during the so-called expansion period (Luck, 2006), more journals on design were published, such as the Design journal and Codesign, and more conferences were promoted, such as "*Design Thinking Research Symposia*", "*AI in Design*", "*European Academy of Design*", "*ICED*" and "*Design Theory and Method* (USA), *"Theory and Methods, in engineering"*.

Comparing the numbers of official studies, outstanding events and activities in specific disciplines over time, there has been a visible change in the attention of design research activity.

During the 1960s and 1970s, many activities were carried out in the fields of architecture and engineering. Mechanical engineering design studies were more productive in the 1980s and, more recently, electronic and software design studies were developed.

A new era of design research began in the 1980s and 1990s.

Design research incentives have been created through government funds to be applied in American industry. Many design departments have emerged at this time, driving academic research. The "*Ohio Conference on Doctoral Education in Design*" in 1998 (Buchanan, R., Doordan, D., Justice, L., & Margolini, 1998), is one of the first calls for design education, particularly industrial design and graphic design.

According to (Buchanan, 1998), the aim of this conference was to deepen the nature and status of the doctorates in design held to date and in the world. The conference proceedings highlight the various fields of research in design and new training models at PhD level and their relationship with professional practice. This includes discussions on ongoing and planned doctoral programs around the world.

*"The Proceedings of the Ohio Conference on Doctoral Education in Design focus on the nature and current state of doctoral*

*education in design around the world. This volume explores the foundations of design as a field of inquiry, the role of research in alternate models of doctoral education, the relationship between doctoral education and professional practice, and other issues that are central to the development of design as an emerging field of investigation. Included are discussions of many existing and planned doctoral programs around the world"* (Buchanan, 1998).

There was a significant growth in research in all areas of design during the 90's and 2010 verified mainly in new professional and educational challenges. This restructuring of knowledge changed the context of design.

Ph.D. design models began to be rethought in Design philosophies and theories are popular topics for discussion, where the first conferences in the field were held in La Clusaz, France (2000), Tsukuba in Japan (2003) and Tempe in Arizona (2005).

The relationship between practice and research in design has become an important issue among academics as well as in professional communities.

Interest in design doctorates has increased considerably. New programs have been implemented, in large numbers, and many more are emerging, although the question remains about what a PhD in design is. New programs are being developed locally, without any reference to others that are already in operation.

Design practice should not be totally excluded from design research, but in order for it to be recognized as research, there must be a reflection by all those involved in the process, and subsequently the results obtained from this reflection must be communicated. In this way we can approach the practice of research whose main mission is to extract reliable knowledge, both of the natural and artificial world, and make this knowledge available to others in a reusable way.

One of the great problems of research, in design, is the inability to develop a theory based on practice (Friedman, 2003).

Designers in many situations confuse practice with research, and do not develop a theory in practice through the dissemination of the results of their work. There is the argument that practice is research and that research based on practice is in itself a way of building theory. Tacit knowledge of design practice is not identical to design theory, we cannot confuse tacit knowledge with general design knowledge,

According to Polanyi, who makes the distinction between tacit knowledge and theory construction, we can consider theoretical knowledge to be more objective than immediate experience (Polanyi, 1974).

According to (Findeli, A., Brouillet, D., Martin, S., Moineau, C., & Tarrago, 2008) the construction of a consistent and coherent methodology of design research has been a constant concern. This phenomenon is not unrelated to the trends and oscillations that methodologies have suffered in recent years and that have affected the scientific community. This excessive focus on finding the right or ideal method(s) tends to be fruitless if not supported by a necessary epistemological, preliminary and insurmountable investigation. Unless we know exactly what the purpose of our investigation is, there is no point in discussing, debating and arguing about the correct or ideal method.

Currently, the epistemological issue of design research is far from being resolved. We think so because there is still doubt between the objectives of the research and the design project. Strange as it may seem, the central question of what could or should be the objective of the research in design is still on the agenda and can be divided into the following set of questions:

*"What exactly are the objects of design considered as a scientific, academic discipline? What are the phenomena of the world we are interested in observing and understanding, that are not already the "property" of other disciplines? What do we intend to say about these phenomena that is*

*not known yet and that other disciplines cannot know or at least that design claims to now better?"* (Findeli, A., Brouillet, D., Martin, S., Moineau, C., & Tarrago, 2008)

We believe that these clarifications are useful in identifying what we consider to be the main conditions for an investigation that corresponds to the specifics of the area or design discipline.

All the concerns in developing a greater knowledge of the best procedures in design research through practice, also aims to consider the quality of life (Félix & Duarte, 2018) in all its forms, defined as a result of the combination of social, scientific, technological and environmental control conditions. The concern with the future is imposed by the haunted reality of the planet (Félix et al., 2018), which can see in design a contribution to the development of new products that appeal to equity in the distribution of resources (Chiaradia & Pazmino, 2015).

## 3. Some types of representation of knowledge of design research

According to Fällman, (Fallman, 2008) the process of design research can be seen as a triangular model (Figure 1) defined by the areas of activity of design practice, design studies and design exploration, aiming what is, respectively, real, genuine and possible. The sides of this leadership model represent the three external interfaces: Industry, academia and society in general.
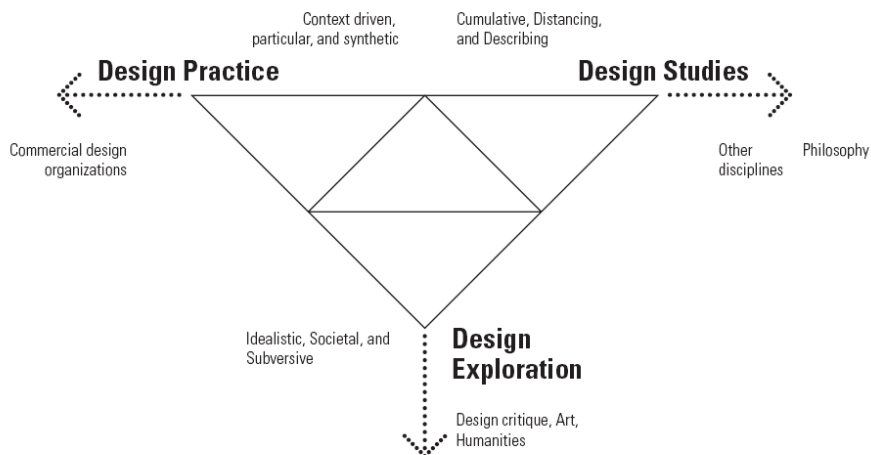


**Figure 1**. Triangular model of Design Research (Fallman, 2008)

During the course of the design research project, the researcher can move and toggle between the different sectors of activity in loops and paths – changing the point of view of the researched matter – which differs in terms of design research perspective and its tradition of motivation and research methods.

Design research is different from traditional sciences since it enhances the close link between theory and practice. According to the concept of research through the design by Wolfgang Jonas (Jonas, 2008) and Alain Findeli (Findeli, 2012), also called research oriented project, the hierarchical distinction of design knowledge in basic and applied knowledge and practical competences in natural sciences is not useful for design research (Jonas, 2006); (Findeli, 2012). Instead, we are referring to the idea of Schön, reflective practice as a close link between acting and reflecting (Schön, 1983) Knowledge of design is inherent to

professional practice, within specific problems.

As a multidisciplinary field, design inherits traditions from other disciplines, implementing also the high standards of the dissemination of scientific knowledge.

Design research generates knowledge production that aims to inform and enable the present and future practice of design. The Knowledge in design provides reference information to develop future scenarios. In this regard, it goes beyond the present to active projective actions. The knowledge in Design is not just descriptive; it is also projective and instructive.

## 4. Materials and method

In order to carry out the present research it was necessary to proceed with the theoretical foundation, which was based on the collection and bibliographical analysis, through which the thought produced internationally, on the outlines, challenges, methods and most relevant results of the research, in the Design area, was studied and systematised in depth. An analysis of the nature of Design research was also systematised and organised.

The analysis of contents was carried out from primary information gathering tools which consisted in the analysis of official decrees, photographs, letters, articles, etc. And as secondary sources were consulted books, theses, monographs.

The analysis of documents was carried out in libraries, official bodies, institutions, as well as in some reference works acquired for this purpose and relevant to the study in question.

The whole process of preparation and design of the instruments, previously mentioned, resulted from the research, analysis and treatment of the information collected during the bibliographical review.

Thus, we presented our data collection methods and their interpretation criteria, putting into action the concepts and methods analyzed, at the theoretical level, in order to perceive its topicality and relevance, in an institutional context, allowing the development of valid ideas in the scientific universe. Our objective was to be able to perceive the problem treated with the as close as possible in order to describe experiences and theories that could serve as a study basis for other future situations.

## 5. Results

It is necessary to continue to define the particularities, to design and to develop the design research landscape. According to (Sevaldson, 2010) the creation of models and the construction of methodology are two important areas for future research.

For the creation of models, it is important describe global models of some examples of practice, build a library of perspectives and specific approaches in the design research, discuss the theoretical and methodological implications of these perspectives, develop more models of theory construction, placing the research design in a wider context, including the philosophy of practice and the design science, relate design research with other science concepts natural, technological research, social sciences, humanities, etc., and transcribe these relationships to create authentic and relevant perspectives.

It is necessary to transcribe existing methods and theories in the most relevant areas, such as technology, natural sciences, grounded theories, ethnography, social studies, research in practice in other areas, in order to build a methodology.

Develop specific domain methodologies, train the ability to develop specific project methods, build thinking and visual analysis, develop ostensible writing practices, develop the relationship between text and visual material and develop interdisciplinary ways of working between disciplines and academic fields.

The main challenge now is to move from describing and understanding what design

research is to a position where you begin to actively apply that research.

The production of knowledge, in practice, has a much greater potential than a mere deviation from academic research and claims an increasing prominence in the production of general knowledge between the fields of knowledge and society. This construction of tacit knowledge has great potential to produce the knowledge needed for a more sustainable future. There are several examples of projects that illustrate this type of knowledge ((Sevaldson, 2008), ranging from generalizable experiences of media creative processes to specific answers to the initial question of research.

The knowledge generated not in the traditional sense of scientific knowledge, is explicit and generalizable and basic research is evolving into applied research, outside the design offices. The project presents a specific approach to the relationship between practice and reflection.

It is now necessary to understand the area of design research in general and design research in particular, realizing its complexities in terms of knowledge production.

It is a very challenging task for the individual researcher to look at design research from a systemic perspective.

The main issue is not to sketch a perfect image, but to redefine the way we design our field. It is not in the unity and conformity of an area that its "maturity" shows itself, but in its "multiplicity", diversity and discourse. It seems, in fact, that design research is growing rapidly.

The rapid expansion of doctoral programs in design has created the need to form research units or groups that can publish and disseminate an increasing volume of work in the area. So far, some of these works have contributed to the development of new design practices, such as interaction design, sustainable design, service design, organizational design, universal design, and design for and development.

This is its positive side, but it is also true that design research is not always directed at shared issues or problems. Consequently, the interest is moderate and the impact on the area of design is irrelevant.

The problem of disconnection between research groups is that the design developed today is very technical and, as it is configured in large systems, has a significant impact on our lives. More research is needed to understand these systems and new links need to be established between researchers who study design and those who are doing research, which generates new and unprecedented products.

Bruce Archer was prescient in recognizing the relationship between two types of research: one, directly related to doing things, and the other, more concerned with understanding not only things themselves, but also the environment in which they are conceived, made and used.

The comprehensive taxonomy of design research that Archer (Archer, 1981) outlined in his article *"A view of the nature of design research"* in 1981 may not be the one he would adopt today, but the sense of wholeness it represented is something we need to recover. Archer was concerned with practice (praxeology, modeling, technology and metrics), understanding (taxonomy, history, axiology, philosophy and epistemology), and teaching. We would do well to recover Archer's broad view of design research and develop it with contemporary methods, themes and purposes.

## 6. Discussion and Conclusions

The above observations provide us with two important criteria that research must be rigorous, conform to the usual scientific standards, must be relevant, and contribute to improving design practice. Research through design must be understood as having the properties of both design research and design research.

The idea of research, through design, also called practice-based research, still strives for

methodological solidity and scientific recognition.

Many developments have been noted since the beginning of research through design but no real consensus has yet been reached, the main obstacle is of an epistemological nature. Research through design should have its place within the research project but should not be confused. Some researchers disagree about the epistemic function to be assigned to the design project within the research, because they consider that the result must be rigorous and relevant in the process of producing design knowledge. This is one of the crucial issues in design disciplines.

The relationship between theory and practice is important and necessary. The great challenge will be to explain how this contribution of practice to theory should be planned and operationalized.

Knowledge, experience and questions move in both directions, practice tends to incorporate knowledge, research tends to articulate knowledge. As mentioned above, design knowledge is related to epistemology. Taking up the question of the purpose of design research, the criteria that any project of design research should follow targeting three of the end users of design research who are interested in its production: the design research community, the design practice community and the design teaching community.

The type of knowledge and the part of the information considered relevant and valued by each of these communities differ. Hence the need for design researchers to consider these aspects when building their protocols and writing their final conclusions or reports.

Expressed in conventional terminology, the research community is interested in fundamental (fundamental) or theoretical (theoretical) knowledge, while the community of practitioners focuses on applied and useful knowledge and the community of educators, teachable and applicable knowledge. This means that there is no point in conducting design research if it is not to improve the act of design and, consequently, the lives of the people involved, that is, presumably all of humanity.

Consequently, the purpose of design research is directly linked to that of design, which means improving or maintaining the inhabitable world in all its dimensions, physical, psychic and spiritual.

In other words, in project-based research, one must look beyond the immediate production of the design project, without, however, neglecting the latter. The challenge for researchers and research teams is to "understand" the two potentialities mentioned above and the appropriate and accessible research issues.

In such a framework, there are naturally numerous potential and available research objects and projects. Contextual circumstances will help to determine which are the most appropriate for the planned research.

According to Findeli (2008), this is indeed a vast research programme, but is such an ambitious statement acceptable? Not if design scholars pretend that this is their private territory. But yes, if they believe they have a say in this very serious matter about describing and understanding how we inhabit the world and how some want to improve it.

One possible entry into the puzzle is to realize that the two potential issues, indicated above, are not really private property of design.

It is certain that almost no scientific discipline is completely foreign to our human condition and to the way the human being, individually and collectively, relates to the world. If we adopt a broad definition of the objects of design knowledge, then we definitely share these issues with several other disciplines. Trying to isolate a specific part of the world's phenomena and adapt it in the name of scientific design statements may not be the only possible way to ensure a specific domain of knowledge. We believe that, instead, it is the kind of questions design asks about these phenomena that constitute the originality of this discipline.

The search for new and different ideas on the part of the industry will be the evidence of a split, difficult to overcome between academia and the market, about what constitutes the discipline. This split should not be resolved by the unilateral granting by the academy, otherwise design will not be able to assert itself as an object and field of investigation in the near future. This issue is particularly relevant in the current context of the reorganization of higher education and the consequent need for fundraising by laboratories and research units, as the only way to guarantee survival.

We are still building the right paradigm for design research. Building such a paradigm can be useful in the long term for design practice and education. We still know relatively little about design skills and that limits our proper study to mankind. This is the goal of design research.

The main challenge is to come forward with the description and with the understanding of what is design research, to achieve a position where we can start to actively outline this specific area.

The production of knowledge in practice has a much greater potential than a mere curiosity of academic research. It is claiming a stronger focus in the production of general knowledge within the different domains and in society.

It is also more than just a construction of tacit knowledge; it has great potential to generate the knowledge that we need for a sustainable future. The development of a project is an example of these activities in the knowledge production.

It is, obviously, a challenging task to illustrate the area of design research in a systemic perspective, but it is necessary to continue defining the details, drawing and developing research scenarios, describing the global models, creating libraries of specific perspectives and approaches, debating the theoretical and methodological implications, developing more theoretical construction models, establishing the link between Design and other concepts from natural and social sciences, etc.

## References:

Alexander, C. (1964). *Notes on the Synthesis of form.* (Harvard University., Ed.). Cambridge.

Archer, L. B. (1965). *Systematic Method for Designers*. London: Council of Industrial Design.

Archer, L. B. (1981). A View of the Nature of the Design Research. In R. Jacques, & J. A. Powell: *Design:Science:Method.* (pp. 30-47). Guilford, Surrey: IPC Bussiness Press Ltd.

Asimow, M. (1962). *Introduction to design.* Englewood Cliffs, N.J.: Prentice-Hall.

Bayazit, N. (2004). Investigating Design: A Review of Forty Years of Design Research. *Design Issues*, *20*, 16-29. https://doi.org/https://doi.org/10.1162/074793604772933739

Bravi, L., Murmura, F., & Santos, G. (2017). Attitudes and behaviours of Italian 3D prosumer in the Era of Additive Manufacturing. *Procedia Manufacturing*. https://doi.org/10.1016/j.promfg.2017.09.095

Broadbent, G., & Ward, A. (1969). *Design Methods in Architecture* (Lund Humph). London.

Buchanan, R., Doordan, D., Justice, L., & Margolini, V. (1998). Doctoral education in design. *Proceedings of the Ohio Conference.* October 8-11 October, 1998. The School of Design, Carnegie Mellon University.

Buchanan, R. (1992). Wicked Problems in Design Thinking. *Design Issues*. https://doi.org/10.2307/1511637

Buchanan, R. (1998). The Study of Design: Doctoral Education and Research in a New Field of Inquiry. *Doctoral Education in Design 1998: Proceedings of the Ohio Conference,* October 8-11, 6-7.

Chiaradia, L. D., & Pazmino, A. V. (2015). Save the Bio: O design como ferramenta contra a perda da biodiversidade. *MIX Sustentável*, *1*(2).

Cross, N. (1982). Designerly ways of knowing. *Design Studies*, *3*(4), 221-227. https://doi.org/https://doi.org/10.1016/0142-694X(82)90040-0

Cross, N. (1984). *Developments in design methodology*. John Wiley & Sons Ltd, Ed. Chichester.

Cross, N. (2000). Designerly Ways of Knowing: Design Discipline Versus Design Science. Design Plus Research. In S. Picazzaro, A. Arruda, & D. De Morales (Eds.), *Proceedings of the Politenico di Milano Conference.* (pp. 43-48). Politenico di Milano.

Cross, N. (2006). *Designerly Ways of Knowing*. (N. Cross, Ed.). London: Springer London. https://doi.org/10.1007/1-84628-301-9_1

Doiro, M., Fernández, F. J., Félix, M., & Santos, G. (2017). ERP-machining centre integration: a modular kitchen production case study. *Procedia Manufacturing*, *13*, 1159-1166. https://doi.org/10.1016/j.promfg.2017.09.178

Eastman, C. (1970). *On the Analysis of Intuitive Design Process*. Cambridge, MA: MIT Press.

Evans, B., Powell, J. A., & Talbot, R. J. (1982). *Changing design*. UK: Wiley, Chichester.

Fallman, D. (2008). The interaction design research triangle of design practice, design studies, and design exploration. *Design Issues*, *24*(3), 4-18. https://doi.org/10.1162/desi.2008.24.3.4

Félix, M. J., & Duarte, V. (2018). Design and development of a sustainable lunch box, Which aims to contribute to a better quality of life. *International Journal for Quality Research*, *12*(4), 869-884. https://doi.org/10.18421/IJQR12.04-06

Félix, M. J., Santos, G., Barroso, A., & Silva, P. (2018). The transformation of wasted space in urban vertical gardens with the contribution of design to improving the quality of life. *International Journal for Quality Research*, *12*(4), 803-822. https://doi.org/10.18421/IJQR12.04-02

Findeli, A., Brouillet, D., Martin, S., Moineau, C., & Tarrago, R. (2008). Research Thrugh Design and Transdiciplinarity: A tentative contribution to the methodology of Design Research. In *Swiss Design Network Symposium* (pp. 67-91). Berne Switzerland.

Findeli, A. (2012). Searching for Design Research Questions: Some conceptual Clarifications. In S. Grand & W. Jonas (Eds.) *Mapping Design Research* (pp. 123-134). Barcelona/Basel: Birkhauser Architecture ©.

Friedman, K. (2003). Theory construction in design research: criteria: approaches, and methods. *Design Studies*, *24*(6), 507-522.

Fuller, R. B., & McHale, J. (1963). *World Design Science Decade, 1965-1975: Five Two-year Phases of a World Retooling Design Proposed to the International Union of Architects for Adoption by World Architectural Schools*. World Resources Inventory, Southern Illinois University.

Glanville, R. (1981). Why design Research. In R. Jacques, & J. A. Powell (Eds.), *Design:Science:Method* (pp. 86-94). Portsmouth, Uk: Westbury House.

Gregory, S. A. (1966). The Design Method. In Springer Science (Ed.), *The Design Method*. New York. https://doi.org/10.1007/978-1-4899-6331-4

Guerrini, L. (2001). Cultural shift: The role of Italian Design in the doctoral programme approach. In *Guerrini, Notes on Doctoral Research in Design, Contribuitions from the Politecnico di Milano*. Milano, Italy: Serie di Architettura e design, FrancoAngeli.

Hubka, V., & Eder, W. E. (1989). Design Education and Design Science. In S. Neaman *International Workshop. The Place of Design in the Engineering School* (pp. 31-55). Haifa, Israel: S. Neaman Press.

Hubka, V. (1978). *Konstruktionsunterricht an Technischen Hochschulen (Design Education at Technical Universities)* (Konstanz).

Hubka, V. (1974a). Konstruktionswissenschaft (Design Science). *VDI-Zeitschrift*, *116*(*11*), 899-905, & (13), 1087-1094.

Hubka, V. (1974b). *Theorie der Maschinensysteme (Theory of Machine Systems)*. Berlin/Heidelberg: Springer-Verlag.

Hubka, V. (1976). *Theorie der Konstruktionsprozesse (Theory of Design Processes)*. Springer-Verlag.

Hubka, V. (1982). *Principles of Engineering Design*. Guilford, UK: Butterw orth Scientific Press.

Hubka, V. (1988). *Practical studies in systematic design.* Butterworths.

Hubka, V., & Eder, W. E. (2012). *Design Science: Introduction to the Needs, Scope and Organization of Engineering Design Knowledge*. Springer London.

Jacques, R., & Powell, J. A. (1981). Design Research Society, Portsmouth Polytechnic, Design, science, method. In *Proceedings of the 1980 Design Research Society conference. Portsmouth:* Westbury House.

Jonas, W. (2006). Research through DESIGN through research - a problem statement and a conceptual sketch. *Kybernetes*. https://doi.org/10.1108/03684920710827355

Jonas, W. (2008). Design Research and its Meaning to the Methodological Development of the Discipline. In *Design Research Now* (pp. 187–206). https://doi.org/10.1007/978-3-7643-8472-2_11

Jones, J. C. (1970). *Design Methods.* Chichester, UK: Wiley.

Jones, J. C. (1977). How My Thoughts About Design Methods Have Changed During the Years. *Design Methods and Theories*, *11*(1), 50-62.

Jones, J. C., & Thornley, D. G. (1962). Conference on design methods. Paper presented at the *Conference on Systematic and Intuitive Methods in Engineering, Industrial design, Architecture and Communications*, London, September 1962 / edited by J.C. Jones and C.G. Thornley. Oxford : Pergamon Press, 1963.

Lawson, B. (1983). *How Designers Think, The Design Process Semystified*. New York, USA: John Wiley & Sons,.

Luck, R. (2006). Design Research: Past, Present and Future a national symposium to celebrate 40 years. *Design Research,Past,Present and Future. Design Research Quarterly*, *1*(1), 19-20.

Pahl, G., & Beitz, W. (1984). *Engineering Design.* London: Design Council.

Polanyi, M. (1974). *Personal Knowledge.* Chicago: University of Chicago Press.

Rittel, H. W. (1972). Second-generation Design Methods. In *Developments in Design Methodology* (pp. 317-327). Chichester, UK: John Wiley.

Rowe, P. (1987). *Design Thinking.* MIT press Cambridge.

Sá, J. C., Amaral, A., Barreto, L., Carvalho, F., & Santos, G. (2019). Perception of the importance to implement ISO 9001 in organizations related to people linked to quality- An empirical study. *International Journal for Quality Research*, *13*(4), 1055-1070. https://doi.org/10.24874/IJQR13.04-20

Santos, D., Ferreira Rebelo, M., Doiro, M., & Santos, G. (2017). The integration of certified Management Systems. Case study - organizations located at the district of Braga, Portugal. *Procedia Manufacturing*, *13*(pp. 964-971). https://doi.org/10.1016/j.promfg.2017.09.168

Santos, G., Afonseca, J., Lopes, N., Félix, M. J., & Murmura, F. (2018). Critical success factors in the management of ideas as an essential component of innovation and business excellence. *International Journal of Quality and Service Sciences*, *10*(3), 214-232. https://doi.org/10.1108/IJQSS-05-2017-0051

Santos, Gilberto, Murmura, F., & Bravi, L. (2018). Fabrication laboratories: The development of new business models with new digital technologies. *Journal of Manufacturing Technology Management*, *29*(8), 1332–1357. https://doi.org/10.1108/JMTM-03-2018-0072

Schön, D. A. (1983). *The Reflective Practitioner: How professionals think in action. Basic Books*. Universidade de Michigan.

Sevaldson, B. (1999). Research design in design research. In *Cumulus Conference,* 12-16 April, Rome: (pp. 1-14). Rome, Italy.

Sevaldson, B. (2008). No Rich Design Research Space. *FormAkademisk - Forskningstidsskrift for Design Og Designdidaktikk*, *1*. https://doi.org/https://doi.org/10.7577/formakademisk.119

Sevaldson, B. (2010). Discussions & Movements in Design Research A systems approach to practice research in design. *Form Akademisk*, *3*(1), 8-35. https://doi.org/10.7577/formakademisk.137

Simon, H. A. (1969). *The Sciences of the Artificial* (MIT Massac). M.I.T. Press.

Woodson, T. T. (1966). *Introduction to engineering design*. New York: Mcgraw-Hill.

**Maria João Félix**
Design School -
Polytechnic Institute
Cávado Ave
Campus do IPCA,
Barcelos,
Portugal
mfelix@ipca.pt

**Gilberto Santos**
Design School -
Polytechnic Institute
Cávado Ave
Campus do IPCA,
Barcelos,
Portugal
gsantos@ipca.pt

**Ricardo Simoes**
Design School -
Polytechnic Institute
Cávado Ave
Campus do IPCA,
Barcelos,
Portugal
rsimoes@ipca.pt

**Jorge Rui Silva**
Design School -
Polytechnic Institute
Cávado Ave
Campus do IPCA,
Barcelos,
Portugal
jrsilva@ipca.pt