Discovery and Creation: Explaining Collaboration between Designers and Scientists in Scientific Research

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Abstract

This paper examines the role of product/industrial design in scientific research. It reports the results of three case studies in which designers and scientist collaborated. The paper presents the initial findings of these cases, and reflects on the designers' contribution to research, and on those aspects that can act as a barrier or as a facilitator in designers and scientists' collaborative endeavour.

Keywords

Product design; industrial design; science; scientific research; interdisciplinary; collaboration; participatory approaches.

Design has the potential to play an important role in scientific research by linking it to people's day to day lives, but also to steer research in new and unexpected directions. Attempts have been made to discuss the commonalities and differences between design and science (Cross, 2001; Willem, 1990; Bonsiepe, 2007) and to compare design research and scientific research (Krippendorff, 2007; Glanville, 1999) and to reflect on how design can be complementary to research practices (Rust, 2004). There have also been attempts to study the impact that designers collaborating with scientists can have on public perception of science (Beaver, et al., 2009) and there is extensive literature about the interaction between art and science that occasionally mentions design[1]. However, there is little empirical evidence of product/industrial designers[2] having an active participative role in scientific research, and few studies of the role that product/industrial design could have in the practice of scientific research.

This paper illustrates the initial findings from three case studies undertaken to explore the impact that product/industrial designers might have in scientific research addressing the questions:

- Can designers meaningfully contribute to scientific research, and if so, what would be the nature of such contribution?
- What would be the main aspects that can act either as a barrier or as a facilitator for collaboration between designers and scientists, in the context of scientific research?

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[1] *The cited authors seem to use the word design as an overarching concept that covers different design disciplines. In this paper, it is assumed that the discipline of product/industrial design is included in that design overarching concept.*

[2] *In this paper, the term Product/Industrial design refers to the Industrial design definition of the ICSID (International Council of Societies of Industrial Design): "Design concerns products, services and systems conceived with tools, organisations and logic introduced by industrialisation - not just when produced by serial processes. The adjective "industrial" put to design must be related to the term industry or in its meaning of sector of production or in its ancient meaning of "industrious activity". Thus, design is an activity involving a wide spectrum of professions in which products, services, graphics, interiors and architecture all take part. Together, these activities should further enhance - in a choral way with other related professions - the value of life. Therefore, the term designer refers to an individual who practices an intellectual profession, and not simply a trade or a service for enterprises." (ICSID, 2010)*

Background

Although there are known examples of collaborative interaction between designers and scientists in commercial, academic and institutional contexts[3], access to useful information about these initiatives is limited.

Interaction between social scientists and designers in the context of product development has been well documented in Squires and Byrne, (2002). Although the book covers several aspects of collaboration between social scientists and designers, it does not focus on collaboration in the context of scientific research, remaining instead in the realm of product development.

A meaningful contribution to the subject of collaboration between designers and scientists has been made by Rust, (2004 and 2007). In the first paper, Rust claims that although scientific pursuit is different from that of design, it may be possible to initiate collaboration between both "traditions" that serves both of their aims. The author proposes that designers' abilities to "image new scenarios", and to create a "practical environment" and "experimental artefacts" may be of use to scientists to select or even generate routes of scientific enquiry. Rust sustains that there is a "creative dimension" in scientific research and that designers can contribute to it. Rust presents examples of collaboration between scientists and designers, and concludes that designers can contribute to scientific research.

Even though Rust offers an interesting perspective on interdisciplinary collaboration, identifying both opportunities and barriers for designers in collaborative research, he does not present firsthand empirical evidence to sustain his claims. Although some of the papers cited in support of his argument show a reflection on research outputs and research methods, they do not look at the specifics of interdisciplinary collaboration, or reflect on the experiences of the researchers in the context of interdisciplinary work. This opens up opportunities for further empirical exploration of collaborative work between designers and scientists.

In his 2007 paper Rust reflects on how creative disciplines (art and design) can contribute to scientific research. He argues that designers may be better suited to undertaking research activates than artists. Rust points out that participant in design and science research projects may experience difficulties because of the absence of a "shared formal language". Rust also formulates "tentative principles" for interdisciplinary research between creative people and scientists.

Although Rust develops interesting ideas, most of the evidence that supports his claims (personal conversations with artist and designers), is not presented or accessible. It is apparent that further study on collaboration between designers and scientists that presents "first hand" evidence may help to find new insight on the subject.

Approach

In order to fill the existing literature gap in collaboration between product/industrial designers and scientists, and with the purpose of obtaining empirical evidence to support claims on this theme, initial case studies, involving designers collaborating with scientists on their research work, were carried out, observed and analysed. Three case studies were selected from a range offered by a university technology transfer office. These studio cases were selected so that a) the design team (composed of the two main project researchers) could provide a meaningful design intervention, and b) the nature of the research needs, and subsequently of the design intervention, would be different in each case.

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[3] *A few good examples of commercial and academic design and science collaboration that can be found on the web are: Simbiotica (University of Western Australia http://www.symbiotica.uwa.edu.au/welcome), Material Belief (Goldsmith Univ. http://www.materialbeliefs.com/), Biomimicry Guild (http://www.biomimicryguild.com/)*

Case 1 (Mask project) entailed the development of a device for the testing of a medical scientific hypothesis; *case 2* (Immuno project) included the design of systems and devices to reduce the time taken to perform a laboratory analysis technique. *Case 3* (Multistable project) involved developing a new technique of forming multistable structures from a variety of materials.

Different activities were carried out in each case study, and the project stakeholders' participation changed for each activity. Stakeholders can be divided in two different groups: Project Team (Scientist(s) + University technology transfer officer(s) + design team) and Design team (2 main project researchers + project director).

In each of the three case studies, the main activities were:

- *Preliminary meeting:* to understand the nature of the scientific project, to understand the perceived design need and to determine whether the project matches the research team expectations. (Project team)

- *Briefing meetings:* To discuss and agree on the design brief for the project (Project team)

- *Visits to labs/field:* To understand scientist/user requirements (Project team, or Design team + scientist(s))

- *Desk work:* To prepare presentations, reports, papers, briefs, computer drawings/plans, etc. (Design team)

- *Brainstorm/design focus sessions:* To generate/discuss ideas (Design team, or Project team, or design team + invited designers)

- *Workshop/lab work:* To make sketch models, to produce prototypes and to test ideas. (Design team, or Project team, or Design team + Scientist(s))

- *Interim meetings:* To report, discuss project developments. (Project team or scientist + Design team)

- *Presentations:* Formal communication of design work/ideas (Project team)

Notes, tape and video recordings were taken during meetings and work sessions. Initial and follow up semi structured interviews with the participant scientists were recorded and physical collection of cognitive artefacts and design outputs was undertaken. Design team follow up discussions were systematically carried out immediately after each meeting, presentation and work session. Written case reports were produced and the project team was invited to comment, and check for any errors in perception or interpretation.

The mixed data sources were analysed by the research team, to determine patterns, common issues and differences among the case studies. Analysis was carried out mainly through the narrative reconstruction of the study cases, using recordings, documents and design outputs as to trigger memories and reflections.

Case 1 Mask Project

Project Background

The scientist was conducting research in gas delivery for patients with respiratory problems. In order to perform experiments with patients, a mask was needed that would provide a perfect seal against the patient's face. However, the scientist found that the masks available on the market do not provide effective sealing or are not sufficiently comfortable for the patients over lengthy periods of study.

To address this problem, the scientist, using materials readily available at home, created a first prototype to solve the problem.

However, the mask was manufactured with materials not suitable for a clinical environment and medical trials, was not designed in a way that production of a standardized small batch (for clinical trials) was possible, and it was not comfortable enough to try on patients.

Scientist Requirements

The scientist required his concept be developed into a mask that could be tested on users. He was interested in finding materials that would make the mask comfortable to wear, and that allowed the manufacture of a batch of 30 masks for use in:

- Clinical trials and experimentation leading to the development and improvement of oxygen therapy techniques

- Accurate gas measurement for early detection of respiratory problems.

He was also seeking to use them as the basis for the development of a mass produced mask, to target the medical research market in the first instance, and then the clinical and therapeutic market.

The Design Team Approach

In a preliminary meeting, the design team agreed on producing a working design brief so all project stakeholders could discuss and agree on the project programme, its tasks, objectives and deliverables. The brief also helped to ensure that the designers had a clear understanding of the project design parameters and the mask's potential primary and secondary users (patients and clinicians) and context (labs and hospital wards) characteristics. At this stage while a collaboration agreement was in principle tacitly accepted by all participants, internally the design team further discussed the suitability of the project as a case study, because of doubts on two aspects. Firstly, the main concept of the mask seemed to be quite developed as an idea, so the design task appeared to be limited to finding materials and ergonomic adaptation. The design team was concerned that these were minor tasks that didn't offer enough opportunities for a meaningful contribution to scientific research. Secondly the project seemed to be too similar to those that would frame a normal product design consultancy commission. Rather than being involved in the scientific research process, addressing research questions, the designers felt that they might be solving a standard product design problem in which the customer happens to be a scientist.

However on further consideration, the project appeared to provide an opportunity to understand what the impact of a "normal product design project" would have in scientific research. In addition, the project would provide a good opportunity to demonstrate to the gatekeepers (university technology transfer officers) the design team's capabilities. Finally as the design team had been recently formed, this project would be "safe" enough to allow team members to develop working and collaborative practices.

The designers felt it necessary to directly observe patients in their environment, and to be able to revisit the information received, in the field. For this reason, the design team also conducted a guided visit to the hospital in order to observe patients with different levels of respiratory problems.

The Design Process

A first draft of the brief was presented including a detailed work programme and product specification, a description of who would be using the device and the context in which the product would be used. The brief was approved and it was agreed that the design team would focus on developing a mask for clinical trials and experimentation (leaving the potential development of a mask for commercial purposes aside). The focus on trials and experimentation meant that the project was no longer primarily concerned with exploitation.

After a brainstorm session involving other design researchers, the design team decided to follow the main principles of the scientist's idea, but to explore new materials options. This resulted in a mask that looked substantially different to the one developed by the scientist, but promised to meet all the criteria of the design brief.

Although the scientist's reaction towards the new design was positive and he eventually gave his approval to proceed with the construction of a prototype, he brought up for discussion some discarded features from his original design. He seemed not completely convinced by the design team's arguments, although samples of materials and drawings were presented to him alongside the explanations of the new design.

The designers proceeded to build a prototype of the mask. Once finished, the design team presented it to the project team. The prototype was tested by the scientist during the presentation and it become evident that it met the design parameters. It was agreed that the scientist would carry out formal tests with a sample of healthy people with different face shapes. After the tests the scientist reported that the new mask satisfied his technical requirements.

Nevertheless when further testing was carried out on cadavers some minor problems of sealing were observed. On this occasion, the scientist's response was to modify the mask to overcome these newly detected problems. This new feature implied a departure from the design team's ideas. Furthermore, in a later meeting, the scientist suggested incorporating some of the features of his original prototype. At this point the design team chose to incorporate ideas from both the scientist's and the design team's prototypes.

Case 2 Immuno Project

Project Background

A team of scientists built a fluid handling device based on a commercially available plastic component. They believed that their device could form the basis for a safer, cheaper and faster method of performing an immuno assay (a common laboratory test) compared with existing techniques. However, the device was not easy to handle, it did not allow multiple tests to be performed on different samples simultaneously, and it did not fit other standard components for carrying out immuno assays (microtiter plates, multiple channel pipettors, etc). These problems made it difficult for the scientists to prove their idea by making a reliable and credible comparison with other existing immuno assay techniques.

Scientists' Requirements

The scientists were looking for the development and fabrication of an improved version of their handling device so they could:

- Develop the new Immuno Assay procedure.
- Measure its levels of safety and reliability, its cost and its speed, so a comparison could be made with other existing competing procedures.
- Have the main underlining design principles ready for the development of a commercial version in the near future and for a fully automated version in the long term.

The Design Team Approach

In the first meeting of the project team, the designers were given an explanation of the fluid handling device and were introduced to the general principles of immuno assays. However, conducting an immuno assay in practice is a lengthy process that involves several steps. Also, a number of key aspects of the process had a scientific basis and were not directly observable, requiring an explanation in scientific terms. The designers asked for an observation day so they could have a real sense of the immuno assay process, and be able to associate the theoretical aspects of the process to the actual stages of it. The observation day was carried out and helped the designers to fully understand all the steps and the main scientific principles of the process. A diagram prepared by the scientists with scientific symbols was used during the day to explain those aspects of the process that were not directly observable. Some days later, the designers created their own diagram of the process, assigning a pictogram to each stage of the immuno assay, identifying its name and its corresponding scientific symbol. This diagram was shown to the scientists and it confirmed that the designers had achieved a good understanding of the process and its associated scientific concepts. Although at the beginning of the project, the design team was not familiar with the scientific concepts and vocabulary related to immuno assays, this mix of observation, scientific explanation and visualization of the process through diagrams, helped to establish effective communication between scientists and designers.

The Design Process

The design team started their design process by borrowing some standard equipment used to carry out immuno assays. They intended to use these in combination with sketch models to test some initial design concepts. The design team soon realized that any idea they might develop should be proved beforehand as being as efficient at handling liquids as the model developed by the scientists. However, the reduced scale of the components and parts they were designing did not permit them to use the sketch modelling techniques they were used to. So the designers had to resort to computerised rapid prototyping techniques to create the models. Since these techniques are considerably more expensive than normal sketch modelling techniques, the processes of consultation with the scientists was more thorough and intensive than usual. Interestingly, the presentations of the prototypes, carried out in the scientific labs, became almost “design sessions” were the scientists and designers considered different ideas and took key design decisions. Of equal importance was that the designers developed competing ideas, and subjected them to group scrutiny.

After a few prototype iterations and a number of discussions with the project team, the design team proposed a more radical version in which a set of objects formed a fluid handling system. A prototype was made, the scientist carried out some tests and they found that the system successfully met the design parameters. The scientists decided to take this idea forward, by applying for additional funding for the further development and production of 100 test devices.

Case 3 Multistable Project

Project Background

A scientist has patented a process for producing structures that can be configured into a variety of stable shapes without plastically deforming the material (e.g. a metal sheet that can be rolled into a tube). These structures are named multistable structures. The scientist has developed a number of samples and sketch models that have been used to show the potential of multistable materials to different potential industrial partners. In particular, he has built a sketch model of an accessory using bistable hinges (Bistable is a form of multistable material that changes from one shape to other as a consequence of a mechanical effort). However the size of the hinge seems too large and not easily adaptable to the accessory body. An accessories manufacturer has taken interest in this product and the scientist and the university technology transfer officer believe that manufacturing a more sophisticated and “designed” model of the accessory will help to cement the interest of the accessories manufacturer. They also believe that this material will allow the production of low cost accessories for people with limited purchasing power.

Scientists’ Requirements

The scientist was looking for the development of a bistable hinge of an appropriate size to be used in an accessory. He also wanted to build a new model of this accessory made out of metal with an integral bistable hinge, in order to use it as an example of the potential use of multistable technology in industry. Lastly they wanted to expand the range of possible applications for multistable structures.

The Design Team Approach

In the first meeting with the project team, the scientist explained the principles of the process that he developed to bring multistable properties to metallic sheets, and he showed some samples of multistable and bistable materials. He also brought the accessory's hinge sketch model. After this first meeting, there were discussions amongst the design team about the suitability of this case, since it seemed that the scientist's need (and the university technology transfer officers' needs) for design input, was more focussed on attracting commercial interest in his patented process than progressing his research activities. However, the designers thought that during the process of developing the hinge, questions would arise that may foster new thinking and encourage new directions in the scientific research. On this ground, the designers engaged in collaboration.

The Design Process

Soon after starting the development of some initial concepts the designers realised that it was necessary to have access to the multistable materials and to learn the multistable forming process in practice. For this reason, the scientist granted the designers access to the workshop in which the multistable samples had been made, so the designers could learn and practice the multistable forming process, and use multistable material for sketch modelling.

During this period of experimentation it became clear to the designers that although the nature of multistable materials was well understood by the scientist, the process of formation of multistable material was not standardized, and the tools used for it did not allow a precise control of the process. Furthermore, knowledge about the process of achieving multistability has been developed only for one type of material, and any idea that implied the use of a new material would first require the development of a new material-specific process. The project team met to discuss these issues. Through the discussion it became evident that any development of applications for the multistable process would need further development of its theoretical base, and would need the intervention of engineers with the expertise to perfect the process and make it more precise, and to develop more adequate tools for the experimental production of multistable material.

Regarding the development of the hinge, the designers also pointed out at that the rationale of using multistable material to produce accessories for people with limited purchase power may have not been appropriate. Producing accessories with multistable material would probably be more expensive than doing it with other competing materials, for example injected moulded plastic. Furthermore, developing accessories using bistable material would not necessarily be the right strategy to raise interest from the accessories manufacturer. A working model of a bistable hinge should be enough to show the potential of the process.

At the end of this meeting, the project team realized that on one hand it was too early for the type of collaboration that has been set up, and on the other hand, the planned project outputs were not adequate for its aims. At this point it was agreed that the collaboration should be postponed.

Initial Findings

The case studies have offered insight related to the questions into the initial research questions:

- Can designers meaningfully contribute to scientific research, and if so, what would be the nature of such contribution?
- What would be the main aspects that can act either as a barrier or as a facilitator for collaboration between designers and scientists, in the context of scientific research?

1. Design Contribution

Although the designers contributed to scientific research, the nature of this contribution was different in each of the studies.

Case 1: Mask Project

By developing the mask, the design team contributed to the scientist's research by delivering a suitable design proposal for experiments to be conducted. Also, the designers contributed to the scientist's understanding of the differences between developing a mask for experimentation and a mask for commercialisation. Additionally, the design input affected the scientist's understanding of his mask original idea and opened his mind to new possible solutions.

In addition the designers enhanced the commercial potential of the research, by providing a model that can help the scientist to attract partners or investors. In this way, the designers set the foundations for a viable product, potentially useful for other researchers, and for clinical applications.

Case 2: Immuno Project

By delivering a new system for Immuno Assay tests, the design team developed a tool that will potentially make the scientist's research procedures faster, safer and less expensive. If commercially exploited, these benefits can extend to other research and clinical laboratories around the world.

The designers also helped to bring the scientists' idea to a level of development advanced enough to make it easier to apply for a grant for funding further development. Finally, the designers' intervention brought the project closer towards commercialisation.

Case 3: Multistable Project

Even though the collaboration did not have any specific design output, the designers made a contribution to the scientist understanding of his own research. By specifying to the project team what was needed before designers could make a meaningful intervention in the project, the scientist was able to reassess his research priorities in regards to the development of the multistable production process. Thus, the designer's intervention triggered the project team's reassessment of their strategy towards the commercialisation of the multistable application in the accessories industry.

2. Barriers and Facilitators

Some common issues arose from the case studies that can be identified as barriers or facilitators for collaboration between designers and scientists in scientific research.

Communication

Some issues regarding communication acted as a barrier in the projects. For example, the designers' understanding of some important aspects and features of the projects was slowed down at the beginning by the scientists' use of specialised vocabulary and acronyms. However, this was quickly solved by the designers using different resources including direct questions to the scientists, internet searches, and elaboration of written summaries and graphic diagrams. An example of this was seen in the Immuno project, in which the designers created a diagram of the immuno assay process, associating scientific nomenclature, pictograms and text. The scientist also helped to overcome this problem by making an effort to filter out some technical expressions from their vocabulary while talking to the designers, but sometimes this resulted in key pieces of information being partly communicated. These omissions were later found to be critical to the design task. But on the whole, the combination of the efforts of designers and scientists allowed the creation of a basic vocabulary kit that permitted a fluent exchange of ideas.

Standard design communication tools such as drawings, sketches and models were useful to facilitate communication during the collaboration. Also, the design brief became instrumental in ensuring that all project stakeholders had a mutual understanding of the project main features and the nature of the collaboration. It helped to make explicit any misunderstanding that problems of communication may have produced.

Roles

Understanding of roles by all members of the project team became a fundamental aspect of collaboration between designers and scientists. Lack of clarity on the roles that scientist and designers play in regards to the design activity, can become a barrier for collaboration. In the Mask Project for example, the scientist independently made design changes to prototypes that compromised some of the basic principles of the designers' concept. Although well meant, these changes sometimes created tensions between the scientist and the designers. However, they proved to be useful in the long term, since a final solution was reached by combining both the designers' and the scientist's ideas.

The Immuno Project was different in this aspect. Even though the scientists had produced some design ideas before the beginning of the collaboration, they kept them aside during the project. Interestingly, during presentations and interim meetings while testing the prototypes produced by the designers, both designers and scientists agreed on design direction by consensus. This was a form of co-design with scientist and designers sharing the design role. However, it was the design team who pushed the ideas forward and when necessary, changed the project direction.

Another issue that can become a barrier in designers and scientists collaboration was the preconception that scientists had about a designer's abilities. At the beginning of the Mask Project for example, the scientist said that he was looking for design input since he did not "know anything about materials and (he was) not good with (his) hands". This view did not change: He stated at the end of it that the designers' main contribution to the project was related to the new materials they found and to their professional standard of prototype.

On the other hand, designers failing to be explicit about their role and capabilities can also become a barrier for collaboration. In the case of the Multistable project, the scientist expected that the designers would be able to do a job that should be actually done by a manufacturing engineer (develop multistable elements from new materials). An early conversation about the designers' capabilities and limitations would have been useful and would have saved time.

Preparedness and relevance

Another aspect that potentially can hinder collaboration between designers and scientist is the project's readiness for design intervention. Design development input can be limited if certain preconditions are not met. For example in the multistable project, the requirement of developing a new product (hinge for accessories) was not timely since the process to produce multistability was not fully developed and multistable materials were not standardised. On the other hand, the immediate need of that project was related to the further development of a production process, which made the product design input irrelevant at that stage. This highlights another aspect that can become a barrier for collaboration; there may be certain stages in projects for which Product/Industrial Design input is not relevant.

Conclusions

This paper has examined three case studies of collaboration between designers and scientist in the context of scientific research. It described their background, the scientists' design requirements and the design team approach. It also offered details about their design briefs and design processes.

This document has also summarised the initial findings of the research, specifying the design contribution to research in each of the projects, and the possible barriers and facilitators in collaborative effort between designers and scientists.

This work provides an initial step towards understanding the ways in which designers might contribute to scientific research and to its related activities. By developing this understanding further, it is expected that strategies that facilitate collaboration between product/industrial designers can be developed. In the long run this might also influence the way in which scientific research proposals and funding applications are made and the way in which scientific research teams are configured. Most importantly, the results may change scientist and designers' perception of each other, potentially fostering collaboration.

While this paper has attempted to outline aspects such as communication, roles, preparedness and relevance to highlight possible barriers and facilitators in collaborative work between designers and scientists, other equally important aspects such as personal characteristics and personal attitudes have been left aside. Questions like: How do personal characteristics such as age, interests, personal views or working habits affect the success of collaboration, or what is the importance of designers' and scientists' attitudes towards other disciplines and ways of working when they engage in collaborative endeavour.

Although this paper has provided some initial examples of the potential role of designers in supporting scientific research, they are based only in a type of collaboration in which designers engage with scientist in a form similar to that of the client and the design consultant. The nature of these case studies, in which the scientists identify a design issue and seek design professional intervention, implicitly excludes the designers from a direct intervention in the core of their research.

Future case studies may team up designers and scientists to meet the needs of a mutually agreed research project based on a scientific question, so that in this way, the role of designers may switch from that of a design provider to that of a researcher with a design background. In this manner, new and unexpected ways of design contribution to scientific research may be revealed.

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