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Contract research in design

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Abstract

The present paper reconsiders some of the activities that properly constitute design research, by focusing on case studies of contract research carried out by the Design Contract Research Unit at Nottingham Trent University. A review of recent UK papers seeking to define the nature of design research suggests that a consensus is still some way off. Contract research, which is a professional research service undertaken for commissioning clients, poses further questions again, since a commercial service may amount to little more than jobbing work. The aims of this paper are to identify the characteristics of contract research in design through particular examples and to consider how far such particulars assist the search for general consensus.

Contract research in design

In the UK, there is political pressure on academic communities to reach consensus about the nature and value of research in their chosen disciplines, most obviously evidenced in the introduction of Research Assessment Exercises. Politicians and civil servants seem increasingly drawn to the idea of fixing an apparently tangible value on the quality of public activity by creating new funding equations. An academic Oscar ceremony like the RAE is a useful means of demonstrating their diligence and the accountability of their fund management. However, success in such an exercise is not the beginning or end of funding support for design research. To the contrary, the most impressive research campuses I have seen recently are those belonging to the giant corporations Microsoft and Nestlé (Alcon Laboratories in Dallas). Armies of researchers also inhabit those campuses and it would be a serious misunderstanding in those of us less well accommodated on university campuses to believe that somehow, our industrial colleagues are working one level below us, tied as they are to the directions of greedy masters. Such masters may provide academics with patronage additional to that given by politicians and bureaucrats, whose motives are not obviously purer, appearing driven as much by self-maintenance as the public interest.

To get a picture of the value of the outcomes of corporate research, try to imagine operating a computer or taking care of your health without using the software and medical devices developed by researchers in such companies. Colleagues to whom I have made such a case have told me that such outcomes evidence “applied” research, which seems by implication to be a rung down the ladder from “pure” research. The distinction I think they are making is between research with a pre-determined goal, and research without the same, which is often called “fundamental” research in the sciences. An example of the former would be to find a way of preventing a carbon filament that becomes incandescent when an electrical current passes through it, from burning up after a few seconds. This was a major research project that led to the invention of the first durable electric light bulb by Edison.

An example of fundamental research would be to investigate what happens when electrical currents are passed through strands of different materials. In hindsight, this may seem a necessary precursor for inventing a light bulb, but in foresight, it does not appear to be a research programme guaranteed to add even to theoretical understanding of electromagnetic behaviour. It is invidious to value one approach more highly than another. Both exist in design research, yet goal led research is evidently the more dominant form because research programmes can be very expensive and so market forces in both public and private sectors favour the goal led form in design. Indeed, it is hard to imagine that design researchers could learn much of value from practice based activity unless there were commercial manufacturers and developers available to collaborate in essential realisation processes, such as tooling, fabrication and distribution. It is largely due to this consideration that my own unit has been led into accepting goals set by clients, rather than ourselves, and why the term “contract” prefixes our research activity.

Concerning the notion of practice in relation to research, Nigel Cross (1999) is persuasive in insisting that practice itself does not constitute a significant research activity, because in a community, others may feel that if they cannot gain access through public reports to the methods behind the outcome, they cannot easily assess their value or further applicability. In the case of craft production, many craftspeople would probably go to considerable lengths not to disclose their methods to others. The success of such an approach both in defending innovation as well as adding value or mystique to the products is well evidenced by the successful transition of famous Renaissance figures, such as Leonardo, from the status of craftsman to artist. Parallels are still to be found in contemporary design, where the status of designers such as Armani and Starck, indicates

that even in an industrial culture, mystique still plays an important role in the value systems of consumers and profit margins of manufacturers.

More commonly in industrial cultures, we have mechanisms for protecting personal innovation by actually disclosing outcomes in formal public ways. Patent and copyright are the most obvious examples and both are recognised as satisfactory research outcomes by UK research assessment exercises. Patents must by definition be: 1) new ideas, not previously disclosed in public, 2) involve an inventive step, such that 'when compared with what is already known, it would not be obvious to someone with a good knowledge and experience of the subject', 3) 'be capable of industrial application' (UK Patent Office 2001). In this respect, 'industry is meant in its broadest sense as anything distinct from purely intellectual or aesthetic activity'. Under such definition, natural discoveries, scientific theories, mathematical methods and aesthetic creations are excluded from patent protection. On the other hand, the specific form of an aesthetic creation, such as the exact words of a text, or the patterns and shapes of a designed object can be protected under copyright or design patent.

Patent definitions are then most instructive in telling us about the forms of knowledge which are pertinent to the definition of design research. Design practice primarily concerns the creation of apparatus, devices, processes or methods of operation that are capable of industrial application. Whilst it is by no means necessary that the outcomes of design practice are in any way inventive, many of them may be claimed to take a specific form that is novel and can be disclosed and protected. As the broad parameters of the UK RAE category "Art and Design", witness, design practice encompasses activities that add to public knowledge in two different forms. The ordinary patent, involves creating products, methods or processes, which can be described in such a way as to enable others to reproduce and apply the inventive steps. The design patent involves creating a specific arrangement of symbols, shapes, lines or patterns, which so differs to precursors, that just describing it in patent form prevents others from trying to reproduce the arrangement without permission. Of the two kinds of disclosure, the ordinary patent makes it far easier for others to gain insight into the particular research and creative processes giving rise to the outcome. Designers, like other professionals, may then wish to comment publicly through formal means such as publication, on the kinds of approaches and insights underlying particular design outcomes. This constitutes a third form of contribution to public knowledge, which is not patentable, but is recognised as a vital part of the research culture of any discipline.

As to the relationship between research and knowledge, the dictionary definitions of research include 'collecting information about a subject', in a way that is 'careful or diligent'. This diligent way may also involve a more complex 'investigation and experimentation aimed at the discovery and interpretation of new facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws' (Britannica Webster's 2002).

An attribute of research in general that is embedded in the official guidelines of organisations like the UK RAE is that it 'contributes to knowledge'. In this sort of description, knowledge seems to be principally the public kind, and accordingly, a contribution may be seen as something that is new, or different enough, to add to a public 'bank' of knowledge. For patents there is a highly developed and complex method that allows professional examiners to determine the extent to which knowledge claims may be deemed new additions. Unfortunately, for forms of knowledge 'excluded' from patenting, such as intellectual discoveries and theories, it is far less clear cut how they come to be accepted as additions. The primary mechanism is that of peer review by academics, publishers and media editors.

As a relatively young and emergent discipline, design introduces problematic issues of its own. There seems to be consensus that design is very much an interdisciplinary activity, attracting inward a variety of research paradigms from longer established academic disciplines (Margolin 1999; Cross 1999). There also seems to be some agreement even between those with differing views of design research, that it is right and proper for all those different specialists gathered under the design umbrella to develop new research paradigms (Owen 1994; Manzini 1994).

Among the new paradigms entering design, is post-structuralism, or 'the new criticism' (e.g. Seago & Dunne 1999) which challenges traditional knowledge hierarchies. Although most evidenced in what used to be called literary criticism, the new approach is derived from the work of cross disciplinary mentors like the psychoanalyst Jacques Lacan and the philosopher Jacques Derrida. Derrida (1982) argues that no form of knowledge is "centred", there is no unique "logos" or knowledge structure that is truer than any other. In fact, Derrida's main point here has already been expressed by other philosophers, as different as Karl Popper and Richard Rorty. Popper (1972: 71-81) has argued that knowledge comprises a network of theories, in which even the firmest beliefs appear to be provisional, subject to the discovery of a better theory. Rorty (1980: 313-22) attacks the "foundational" view of knowledge, where philosophers have traditionally assumed a privileged view of knowledge in general, which portrays different forms of knowledge building up from a hard base layer of the cognitive kind to progressively softer layers of the hermeneutic kind. Popper seems to be one of these traditional philosophers, arguing (1972: 73-4) that objective knowledge, such as "it is true that 2 add 2 makes 4", holds a special place because the veracity of such propositions does not appear to be open to subjective inclination. Objectivity is clearly an important feature of the way knowledge is viewed in the hard sciences and may help to explain why even great creations such as relativity theory are more usually described as "discoveries". As recognised in the earlier discussion of patenting, design activity may involve some form of new discovery which can be tested in a way that provides reproducible results. However, design also encompasses forms of creative output which can be recognised, described and evaluated, but only in the form of a critical activity that appeals to a sharing of personal experiences and aesthetic codes.

It is unlikely that many in design would want to claim that critical arguments impose the same sense of necessity on the understanding as do objective findings about, say, the physical performance of designed objects. Accordingly, design by its very nature seems divided between views of knowledge that differ according to the kind of activity undertaken and questions posed. Designers are frequently called upon to tackle different problems, which involve different forms of knowledge and thus, methodology. For instance, the writing of this paper involves critical discourse, which appeals to subjective experience, leaving the arguments open to a spectrum of personal interpretations. Whereas, some of the product design work we are about to show is not open to the same level of subjective interpretation, it either performs to an International Standard, makes valid patent claims, or it does not - and these issues can be resolved by reproducible testing and examination. Such work is not even typical of much product design, which concerns re-styling familiar objects, an activity that could be the subject of a design patent, but not an ordinary one. Differing research methodologies are bound to underlie such different tasks, and anyone working on three such projects is bound to adjust their goals, knowledge claims and research methods, without ceasing to be engaged in some form of worthwhile design research.

Whilst the new criticism has sought to introduce a plurality of discourses by dismantling traditional knowledge hierarchies, it has also introduced some unfortunate syntheses of methodologies. Consider the "Theory of the Gaze", originated by Laura Mulvey's article "Visual Pleasure and Narrative Cinema" (1975). This has been an influential critical stance on film narrative, based on an entirely uncritical acceptance of Freud's theory of scopophilia, which although probably new to most in visual studies at the time, was already regarded as outmoded and unreliable by many in

psychology (Eysenck & Wilson 1973, pp1-13). Caution is required when introducing ideas and methods from contingent disciplines. It is better advised to select from them the methodologies that seem most appropriate to particular tasks. Through informed adaptation to specific requirements in design, existing methodologies may even be revised or expanded to become generally useful in design research. For instance, asking if a design is patentable is a useful way of assessing the sense in which workers from all disciplines may see it to be innovative, but not of regarding it critically.

Returning to the value of patents as indicators of worthwhile research activity, if numbers demonstrate anything, our colleagues in the corporate sector are making a far more prolific contribution in the field of product innovation than ourselves. However, to recognise this is not to exclude academic researchers from the field. In addition to the 'live' student/company projects, to which many departments such as the one at Brunel are already committed, there are many small to medium enterprises (SMEs) interested in what we have to offer, who cannot afford to maintain their own research and development units. To such organisations, we can offer what in today's parlance is called a 'transfer of knowledge'. Teaching Company Schemes are one well known method in the UK, less well known are a number of university design research units, such as those at UCE, Brunel and my own university, Nottingham Trent, who offer their services to companies of all sizes.

In university nomenclature, such activities are classed as 'external consultancy', but this is a label my own unit has struggled to resist, as witnessed by the words "contract research" in our title. The resistance is explained by three important factors. The first is that we are supported by European Regional Development Funding, with a remit to provide a subsidised knowledge transfer service to SMEs. The second is the corollary condition that we should not therefore be competing for work with local design agencies. The third is that we have followed a vocation in choosing academic, rather than commercial life. Our commercial counterparts like to tease us that we teach because we can't do, and they may be right. In our defence, we would argue that we each do different things, which the other cannot, or will not. The most important of these is we academics have the benefit of being part of a much larger expert community whose presence greatly increases the range of methods, techniques and resources we can bring to bear in planning a goal led research programme. Few agencies either could or would want to compete with these resources and so that makes it easier for us to identify the kind of projects in which we want to get involved. Our rule of thumb is that we say "sorry" to any company asking us to "Design one of those", but welcome collaboration with anyone asking us "Do you think it would be possible to design something that...?", or "Are we going the right way about designing this?" A good demonstration of this principle is provided by our case study, a collaboration with a small, but successful plastics company in our catchment area.

Europalite Ltd. mould plastic products like road cones and grit bins by rotational methods. Essentially a rotationally moulded form is a single plastic surface bounding a closed volume - a hollow sphere is a typical primitive. On the other hand, an open form like a bowl is not typical, but could be made by sawing a rotationally moulded sphere in half. The process also allows more complex primitives, such as a form pierced through by a hole - "genus 1" in mathematical language - as well as genus 2, 3, and so on, provided the walls of the holes are all orientated on the same axis and do not "return" into the body of the basic form. Whilst the method is less flexible than other moulding processes in allowing a variety of geometries, plastic affords more opportunities for constructing complex forms than kindred processes such as clay slip casting. The vast majority of moulds are split into two parts, which are filled with finely ground plastic, sealed and then rotated bi-axially in a large oven that causes the polymer to melt and attach to the wall surfaces inside the mould, which may later be split open to release the finished product. The two great advantages of rotational moulding are that it can produce large products, and the mould tools are cheap to fabricate or cast, typically costing between 10-25% the price of much smaller injection tools. It is

then, a relatively simple process, often associated with large utilitarian products of relatively low production quality, and large tolerances of accuracy.

The managing director contacted us because he thought the process was capable of far more than his industry has demonstrated thus far. You may imagine our wonder when early in our association, he suggested to that we investigate the possibility of designing an adjustable builder's trestle to compete with the tubular steel variety that are fabricated to meet stringent British Standards in safely supporting a working load of 650kg. His cheerful justification of why he should want to attempt such a thing was: "Because I make things in plastic". Whilst this had scared away more sane design agencies, it proved irresistible bait to people who enjoy getting their students to build improbably strong bridges out of drinking straws. It was a project through which we felt we could learn, which made it seem an ideal form of knowledge transfer (Figure 1).

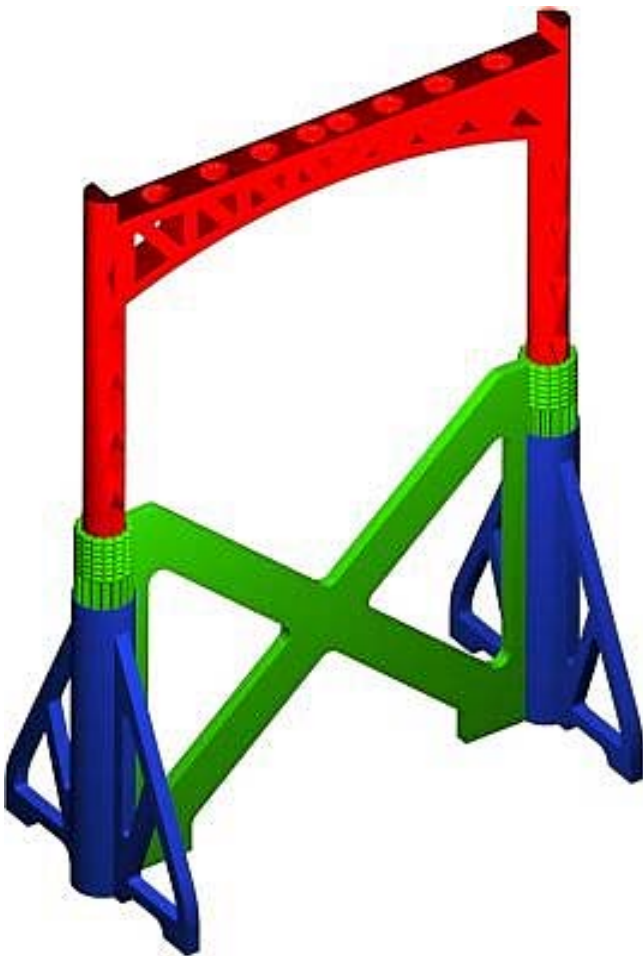


Figure 1: Adjustable builder's trestle to BS 1139 650kg SWL

As in our student bridge projects, we were astonished by what we found and greatly edified by what it taught us, not just about rotational moulding, but much else besides. Neither of us working on the project were trained engineers and so we felt a duty of care to buy in some more books on engineering design and against all advice, a basic Finite Element Analysis (FEA) package, *Design Space*. After driving us nearly mad, *Design Space* grudgingly started to give answers to some of our questions (Figure 2). It was not until we finished the project that we discovered we were actually asking the program to do more than it was designed to, by analysing hollow forms, rather than solids. Part of the benefit of this, was that it taught us how to fool *Design Space* into making calculations it was not supposed to.

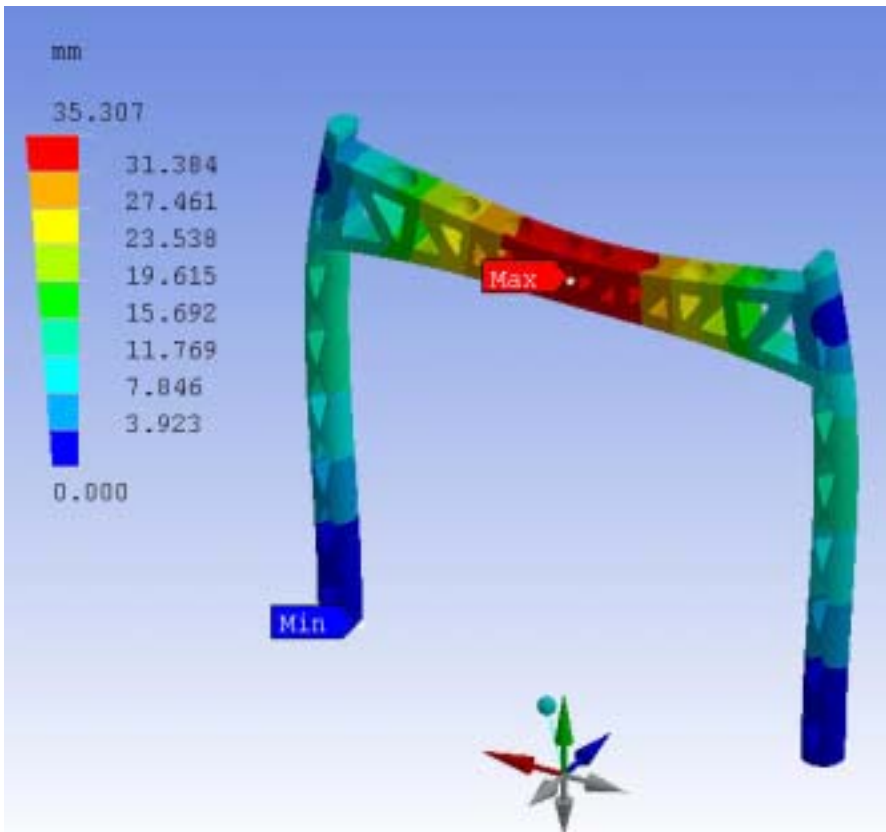


Figure 2: Finite element analysis of trestle beam under 650kg point load

Mindful of the warnings we had received, we cross checked the solutions by taking small segments of a given part and calculating the answers manually. By such means, our confidence grew to the point where within a few weeks, we could not understand why such programs were not a standard component of the product design studio and indeed, our student computer resources. In the event, the loading simulations were within 12% of the real values found in the final design. Despite our reservations about the eventual commercial viability of the design, we sought throughout our programme to play to the strengths of a moulded trestle, by limiting the components to four forms that could be inexpensively moulded with few fabrication steps thereafter, and assembled from a flat pack by the user. The standards testing we were able to contract in house from our engineering laboratories and the dissemination of what we had learnt was in part publicised through the filing of a patent.

Another vital part of our mutual learning was an investigation into whether it was possible to increase the strength of the polyethylene polymer we were using, perhaps by glass fibre reinforcement. This investigation demonstrates the value of patent literature to design researchers, since we found two patents from the 1980s which showed the polymer suppliers to be wrong in their assertion that rotationally moulded plastics could not be successfully glass reinforced. Nevertheless, when we tried to replicate the methods disclosed in the patents, we were disappointed with the results, which showed the fibre tended to migrate into the inside of the product walls and was poorly packed, which made the strength of the compound less than the values that were to be expected by comparison to other moulding methods. Proceeding in a way more reminiscent of Edison's empirical approach to the light bulb than of contemporary polymer engineers, we picked the brains of a major glass strand manufacturer, acquiring free information that seems to flow easily when the word "university" is introduced. We got free samples of a variety of glass strand types,

which we compounded in a variety of different test batches. We were perhaps unjustly fortunate in achieving the desired result within a few hours of moulding.

The next task was to further improve the strength of the glass to polymer bond by finding a more appropriate chemical coupling agent than those described in the patents. Despite superb support and advice from Akzo Nobel and Hoechst, we had far greater difficulty in these tests. The eventual solution was again derived from a leap of designer's intuition, rather than good research method. We felt an instinctive discomfort in suggesting that the workforce introduced a rather unpleasant chemical into the moulding compound in liquid form. This led to a search for a powder based form, which we could not find, but we did come across an analogue product used in rheology, rather than coupling, that was based in a fine chalk powder of similar grain size to the polymer. Having empirically found the correct concentration to use after blackening the mould tools with incorrect quantities, the strengthening effect was so tangible we scarcely needed laboratory testing to tell us which measure and mixing method gave us the best coupling. Again, the results of this work are to be disclosed in a patent file.

The final example concerns a rather more disciplined project, more within our range of expertise, which arose from the company's success in persuading us that there was untapped potential in rotational moulding. The problems to be overcome had more to do with the standards of toolmaking, than of product design. The tolerances of steel fabricated mould tools are at least 2mm and wall thickness can vary up to 20%. In theory, an aluminium tool cast from a wooden model, or pattern, can be made accurate to fractions of a millimetre, but then the patterns are hand built from the design drawings and therefore prone to larger error. In the trestle, we had to connect opposing walls in the hollow form to create a true structure, rather than a void enclosed by unconnected walls. This we did by dimpling key areas of the walls to create "kiss points" inside the form as the product moulded. The unconventional dimple forms we created did not endear us to the toolmakers, whose notions of tolerance did not endear them to us. If we could find a more accurate way of generating the patterns, we felt we could overcome the limitations of the process to liberate its potentials.

These are that the ovens can be as large as 4 metres in diameter, which means smaller products can be tooled as "parasites" that are just fixed into any space not filled by a larger product being moulded. Given tooling costs of as little as £3-5000 for a product the size of a torch, the parasites can act as prototype generators, which if successful, can be duplicated and arrays of these small products can be moulded 20 or 30 at a time, for half the cost of an injection moulding tool manufacturing them at a comparable rate. So here, rather than trying to apply rotational moulding to products never made before in plastic, we were seeking to advance rotational moulding into a more competitive form of making plastic products. A good vehicle for this idea turned out to be a hard hat, a product always injection moulded. Since the hard hat is essentially a shell supported by an adjustable webbing cradle, we set out to see if it were possible to turn the underside of a rotationally moulded hat into a webbing and find an alternative method of adjusting the headband to fit all sizes of head (Figure 3).



Figure 3: Desktop model of rotationally moulded hard hat

The design solutions seemed relatively simple. You need only to look at the adjustable back of a baseball cap to see how size adjustment could be made. Whilst the webbing could be created by making a template that could be put inside the inner skin of the helmet to provide guides for a small dentist-type drill that could cut out the unwanted material. The real problem was how to ensure the accuracy of tooling that was essential from a structural point of view and indeed an aesthetic one, because this was an apparel item. Contrary to what might be thought, construction workers seem to have a greater consciousness of their appearance than may popularly be believed. Evidence comes in the form of the Stetson hard hat, which is apparently a major seller in the US heartlands. The fact that our hat has ribs that form a Union Jack is completely fortuitous, a result of our mainly structural approach to the task. We would argue that it is no more an option to remove these than it would be to remove the ribs from the dome of Florence cathedral! However, that has not inhibited us from suggesting this hat be marketed as the “Jack Hat”, and we can imagine Prince Charles modelling it on industrial visits. On the other hand, if the best structural solution had been ribs that formed a swastika, then our awareness of the appropriate methodologies for the design of apparel would have led us to seek a different solution.

As to making an acceptably accurate model, we turned to colleagues in Nottingham University to help us with rapid prototyping, either by laminating or CNC cutting. Both methods involve generating an extremely accurate solid model direct from our original CAD files (Figure 4). For this relatively small product it was economically acceptable to use LOM, laminated object manufacture, which produces the “wood” model by scanning the CAD model in paper thin horizontal slices and then laser cutting the slice from a sheet of paper, running a glue impregnated roller over the slice and then repeating to generate the complete model. The casting from this model is taking place at the time of writing, so the results are not yet fully known. However, we are confident that our approach is the way forward to realising the larger objective of introducing accurate toolmaking into this industry in order to facilitate a new generation of products that conform both to consumer expectation and to necessary regulatory standards for public health and safety.



Figure 4: Rapid prototype pattern of hard hat in laminated paper

As to the lessons that can be learnt from the practice of contract research in design, the following seem instructive: The responsibility of working for an external client on real commercial projects need not be daunting, it can be enjoyable, indeed entertaining. We have found that the effect of working with academics seems to liberate the playfulness in our clients, which is a vital ingredient for both creativity and formulating interesting research questions. It may be surmised that clients have a perhaps unwarranted trust in our abilities, just because of our job titles, when all the time we are telling them that we too are trying to learn. Learning is another key ingredient for successful research and interdisciplinary collaboration. I believe part of the reason we have had considerable fortune in resolving challenging projects, is because we are shameless about wanting to learn about anything that might lead us closer to the goal that always looms over a contract research project. The goal is something that has to be achieved by practice, but such practice is unrealisable without a programmatic approach in which the designers endeavour to identify as best they can, the methods and techniques that best suit the various demands of the project.

We have tried to be candid about what our more expert colleagues would see as the shortcomings of some of our research approaches. We are not ashamed by these, we defend them on the grounds that ends justify means in the market driven world of design practice. With due qualification, these reflections may be used to recommend that elements of a shared understanding of design research be allowed to emerge retrospectively from practice, not just prospectively from theoretical debate.

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