

# PEELING APPLES: PROTOTYPING DESIGN EXPERIMENTS AS RESEARCH

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Design research often includes design experiments. But the discourse generated by the idea of 'research through design' has not always been a helpful starting point for novice design researchers who intend to incorporate design as a component of their research inquiries. In this paper we make two contributions. Firstly, we present a short analysis of six design research exemplars that involve design as a constituent part of the research. We do this in an effort to demonstrate that there is a multitude of ways that design can, and has, formed the basis for research contributions. Following from that observation, we introduce an experimental workshop involving apple peeling that we have developed and trialled. We put this workshop forward as a pedagogical instrument to help design research students

clarify the many connections that can exist between design experiments and research contributions.

## INTRODUCTION

Design research is a rapidly growing discipline, although it is comparatively new in the wider academic context. Partly on account of its relative immaturity, the nature of design research is still contested ground. A number of scholars have tried to clarify the meaning of design research, the way it should be conducted, and the questions it should explore. Typically, these discussions have tried to clarify descriptions of the disciplines of design and design research by making comparisons between traditional scientific disciplines and design. Some of the more influential discussions merit consideration. In the following we aim to highlight some of the key points in the discussion. Frayling (1993) famously introduced a set of three distinctions with respect to the relationship between art & design on the one hand, and research on the other: research *into* art & design (as e.g. art history, or sociological studies of design), research *through* art & design (e.g. where new technology is developed to

address a problem and the results communicated), and research *for* art & design (e.g. where research was done within a design process and is now “embodied in the artefact”, p.5). For Frayling, the first two categories, *into* and *through* were relatively unproblematic; but he was uncertain about the idea of research *for* design. In his conclusion, he simply calls for more research into the notion. Biggs (2002) has suggested that ‘research for design’ is a non-sequitur. Without the explicit communication of knowledge and understanding, the artefact is not necessarily an example of research, but simply a “work of” art or design.

Ironically, debate in the design research field about the design/research relationship has centred on the notion of “research *through* design”, a form of design research that Frayling considered essentially unproblematic, if not straightforward. This may be due, in part, to Archer’s (1995) roughly contemporary (and more lucid) discussion of the research/practice relationship. Archer also introduces a tripartite distinction: research *about* practice, research *for the purposes of* practice, and research *through* practice. Like Frayling, Archer finds the first two categories uncontroversial, but the third potentially problematic (see Donovan’s valuable discussion). Archer’s treatment clarifies these issues by holding fast to a determinate set of criteria for what can and should count as research. That is, for work to qualify as research, it must be aimed at producing knowledge, systematically pursued, unambiguously described, transparent with respect to evidence and method, and its knowledge outcome must be communicable (p.12). A practitioner’s action (in any field) can therefore qualify as research, but only to the extent it conforms to these criteria. Much of what is ordinarily termed ‘practice’ thus falls outside of the domain of ‘research’ so defined. It becomes clear, when comparing Archer (1995) to Frayling (1993), that for Archer there is no possibility of research simply being “embodied in the artefact” in isolation of the intent of the practitioner, the process of its production, and the transmissibility of its contribution to knowledge.

For us, there remain several issues in the research/design relationship to be clarified. For many students pursuing advanced (research) degrees in our field, design (in an as-yet-unspecified role) is expected to be a substantial component of the research conducted. In this respect, Frayling’s discussion is not particularly helpful. Although he introduces the notion of research *through* design and associates it with action research, he does not discuss the concept in sufficient depth for it to serve as a guide for the conduct of research. In this respect, Archer’s discussion is more valuable, but still

remains at such a high a level of generality that it offers little practical assistance. For example, the design research community has not reached anything like a consensus on the criteria Archer identifies.

‘Systematicity’ and ‘transparency’ are as much Archer’s proposals for criteria (adopted from other research traditions) by which design research should be assessed as research; they are not established standards that the field has already determined and to which it has subscribed.

Doctoral training in design does not typically follow a specific research tradition but is still searching out ways that benefit of the nature of design competence and the making of artefacts. This creates challenges for doctoral students (and perhaps also for their supervisors and examiners) to construct a clear picture of the connections between design work and the research contribution that can (and must) be made.

To pursue this challenge, we will leave the more programmatic discussions of figures like Frayling and Archer, and instead examine a few of the different ways that design work (experiments, artefacts, processes) has figured in research, and some of the discussions that have revolved less around programmatic and more around concrete examples of design-and-research. Although we are interested in clarifying these matters for their own sake, our principal motivation is pedagogical. As supervisors of doctoral thesis projects in design, our pressing concern is to develop a tool or set of tools that provide novice research students in design a way in to the relationships between design and research (c.f. Matthews and Buur 2005). To this end we have developed a practical apple-peeling exercise, based on our examination of the research/design relationship, that exposes some of the connections between design experiments and research. We first trialled the exercise at the Nordes summerschool 2008 with doctoral students in design. The experimental apple peeling workshop, in a rather tangible way, prototypes some of the challenges many doctoral students in design research face: how to make the turn from designing to a research contribution?

## DESIGN IN DESIGN RESEARCH

One challenge in design research seems to be the centrality of relevance to practice. In some cases, the academic ‘it’s nice to know’ is simply not enough—research is expected to be directly applicable to the real world of design practice. Design research is inherently an ‘applied’ field; any ‘basic’ or ‘fundamental’ research that is relevant to design research and practice seems to belong to *other* fields, e.g. experimental psychology,

sociology, materials science, computer science, etc. Thus, there is often an expectation that design researchers should be contributing to an academic discussion (to a design research audience) but also to the design world of design practice. This dual requirement necessitates the accessibility of research to a community of practitioners who are work within a rather different discourse than academic argumentation. This is a tall order for many experienced researchers, let alone novice doctoral students.

Recent discussions in design research have preceded us in clarifying some of the connections between design (that involves research) and research (that involves design). Binder and Redström (2006) and Brandt and Binder (2007) have been developing an understanding of the role of design experiments in research. Rather than starting with a set of abstract definitions or criteria drawn from other fields' discussions of research practice, Binder and his colleagues have considered exemplary design research cases, constructing two 'sensitising' notions from their examinations: they contrast design *experiments* with the idea of *programs* of research. Programs provide a research objective and lens through which design experiments can be conducted and analysed. A program, for instance, could be about understanding the theoretical perspective and properties of tactile interaction, while an individual experiment might explore material qualities, interaction functions or generative methods to study those in different settings. The experiments feed into the program's larger frame of interests and vice versa. Design experiments, and the programs of design research they elaborate, serve as examples of how design and research can be complementary, and explore the possibilities of how 'design research' can be done. Such exemplary design research has addressed theoretical aspects, informed particular challenges in design thinking and created suggestions for a (critical) design practice.

A related (but different) perspective on the design-research relationship, born of consideration of different design research exemplars, is Koskinen et al. (2008). They introduce three general approaches that have emerged over the past decade or so, in which design has played a central role in research endeavours. The three approaches are *lab*, *field* and *gallery*. The 'lab' is an approach that has been developed out of a natural science research tradition (experimental psychology), where (typically) designed products are evaluated with users in controlled experiments. The 'field' is the label they give to the family of approaches that have adopted naturalistic studies of contexts of use from the social

sciences (sociology and anthropology). The detailed (typically qualitative) understanding of the actual use of designed products, and activities and meanings attached to them in context, has in turn informed the development of those products. This approach has formed an important component of work in user-centred design, CSCW and the Scandinavian tradition of work-oriented design. 'Gallery' describes an emergent form of design research that is inspired by a tradition of inquiry in the fine arts. In this approach, new designs or art work, *through their constitution as artefacts*, explore theoretically relevant conceptualisations and themes. The artefacts are deployed, exhibited and discussed as research. 'Gallery' gives precedence to design practice, and especially its outcomes, with respect to the research contributions that it argues on behalf of.

Lab, field and gallery are a useful set of distinctions for glossing some of the ways that design has formed a component of design research. But although they are intended to succeed the programmatic and general discussions of important precursors such as Frayling, they also inherit some of the same patterns of argumentation. For instance, the division of the three approaches along natural scientific, social scientific and fine arts traditions is useful insofar as one is interested in genealogy, but is less valuable when one wishes to see how those differences play out (and indeed, if they actually obtain) in the conduct of the research and the interpretation of the findings.

We do not make this point merely as an idle critique of their distinctions or their discussion—on the contrary, it is one we have found most helpful to date—but only to suggest that there remains some work to be done with respect to our practical concern of creating pedagogical tools for novice researchers to enter the design research fray. Towards this end, we (like Binder, Brandt, Redström, and Koskinen et al.) also want to inspect specific examples of how design has formed a component of research, but we are less interested in creating *general* categories or grouping together families of approaches. Rather, we wish to unpack, through consideration of a set of specific instances, some features of the design/research relationship that to our minds are yet to be emphasised.

Perhaps the central point that we want stress relates to the variety of ways that design projects have formed a basis for research contributions. In spite of the popularity of the label 'research through design', there is nothing like a 'research through design' method (in the way that the scientific method has been idealised in popular culture). Rather, there are many ways that design methods, processes and products have been

fundamental to (but not sufficient for) making a research contribution. Furthermore, the contributions to knowledge depend on the intersection between any design project and another set of concerns that are not entirely dictated by, e.g. the *program* of the design experiments or *paradigm* of the research tradition. Such additional concerns include the audience of the research, the research question, the evidence presented, and the argument being constructed that contextualises the work as a contribution. By considering a bounded set of examples of design research, we want to paint something of the diversity of the ways in which design has been used to generate a research contribution.

## EXEMPLARS OF DESIGN EXPERIMENTS

In what follows, we consider six different examples of design research, drawn from different research domains (interaction design, fine arts, engineering design, participatory design). We want to suggest these examples serve as different models of some of the ways that design and research can intersect. In each case, design was a fundamental component of the research in the sense that the contribution could not have been made in the absence of the design project, process or artefact. Thus, they exemplify the connections between design and a research contribution. Our discussion is not exhaustive—we do not mean to suggest in any way that these are the only ways that design and research can be put together. We are, however, specifically interested in the diversity of ways that design has formed the basis of a research contribution.

### **Example 1: Engagements with design practice**

Buur et al. (2001) conducted a set of design engagements with use context. The point of the research was to find ways of better addressing the gap between what designers imagine use and use context to be like, and what users know about their own work practice. In so doing, they first brought users into a simulated site of use in the design studio (a boiler room, in this particular case); they later brought camping chairs and sketchpads out to an actual site of use (a power plant) and designed in-situ. The two experiments with design practice formed the basis of their reflections on the material and conceptual possibilities afforded by the context of *design*; these were the contributions of the paper.

### **Example 2: Reflective learning**

Binder (2002) revisits three design projects in which he was involved that ran over the course of a decade. This retrospective analysis gradually presents the emergence of a perspective, case by case, that attempts to re-orient

design discourse. Notions of intent, design material, and the form-qualities of interaction technology are scrutinised. Binder's thoughtful analysis suggests that design practice cannot be adequately served by research programs that are grounded in the idea that design (practice and product) is accountable in terms of designers' intent. Furthermore, he argues that the material embodiment of systems in the ebb and flow of users' daily work practice is the materiality of information technology and constitutes the 'form' that designers of IT systems must shape. These conceptual shifts are articulated against a backdrop of the design project cases through which these insights emerged as a part of design practice itself.

### **Example 3: Collective experiments**

Mattelmäki (2006) presents a research case from consideration of a number of facets of Design Probes. The study was conducted as a collective process that included several cases. It was not a thoroughly premeditated project but instead a path in which one experiment followed another in a fortuitous way, that ultimately resulted in a rather coherent structure. The role of designing in the cases appeared in the customising of the probes experiments, in designing the probes kits and "communicational" artefacts as design objects. Design skills were also applied in seeking of design opportunities and elaborating alternative solutions in several cases (however these results were not well described in the research). The research contribution included placing and characterising the probes as a method into the bigger picture of methods for UCD. The research was done by creating new experiments that successively built on what was learned from the old ones, comparing and developing with various foci and questions, and finally presenting reasons for using probes and instructions for their application.

### **Example 4: Analysing products in use**

Matthews et al. (2008) examined a deployed functional prototype in use. The 'Body Games' project they discuss was about designing interactive play devices for children to make interaction with technology more physically active. The project produced a set of interactive tiles that were built and deployed. The research contribution is constituted in a critical discussion of the design-use relationship on account of how many unanticipated 'games' the children had created with the tiles. In this sense, there were no explicit prior research questions or hypotheses; rather, there was a set of observations of a designed product in

use that enabled the authors to rethink issues such as the role of the interaction designer in creating new forms of interaction, and methodological reflections on how researchers should best seek to understand the novel appropriation of interactive technologies by users.

**Example 5: Testing a theory or hypothesis**

Stienstra (2003) is an interaction designer interested in gender and technology. She designed and built three contrasting tangible interfaces for a simple screen-based game that children could play. The three interfaces were designed so that the types of motor-skills they demanded were contrasting. This was in order to be able to test a prevailing theory, that boys preferred gross motor-skills in play, and that girls preferred fine motor-skills. She set up a controlled experiment in which pairs of boys and girls played the game with the different interaction interfaces, and they answered a questionnaire afterwards. Design came into play here as a means of testing a hypothesis drawn from theory. The contribution of the work, however, consisted not merely in confirming or refuting the hypothesis (in this case, both genders preferred the gross motor-skills interface), but in developing a better appreciation of what aspects of interaction that are under the control of designers are actually consequential to users' enjoyment of a system.

**Example 6: Artistic exploration**

This example depicts an artistic, practice led PhD work. Maarit Mäkelä's (2003) work consisted of two ways of

**Table 1.** The different roles of design, and types of contributions, in six examples of design research.

Example	Role of design	Type of contribution
Buur et al. (2001)	Design events as objects of analysis	Suggests how design can be organised
Binder (2002)	Design projects as objects of reflection	Reconceptualises topics
Mattelmäki (2006)	Iterative design experiments as case material	Contextualises the value of a method
Matthews et al. (2008)	Products-in-use as objects of analysis	Identifies methodological issues for research
Stienstra (2003)	Products-in-use as components of experiment	Tests a theory's validity for design
Mäkelä (2006)	Products as theoretical explorations	Challenges conventions of representation

doing inquiries: On one hand she explored through a personal and creative process the possibilities of gender-aware ceramic art to express and change the conventions of representing femininity. On the other hand, in the written study, she looked at the cultural representation of gender and the female body and their meanings through different themes. Women's studies were utilised as the wider theoretical framework and the research themes were discussed with several written sources and in close understanding of art practice (see also Mäkelä 2006). In addition to, and in dialogue with, the written dissertation, the research work included three exhibitions of her own art work on femininity. The academic evaluation system reviewed the exhibitions as part of the research work. The challenge for the artist

became to tightly couple the artwork with the written discussion. Thus, the artistic reflection and practical making of art were conducted simultaneously, and in close dialogue with more theoretical explorations that were exhibited, or validated, in the work itself.

**Discussion of examples**

The first three examples make iterative use of design processes; the latter three, generally speaking, are about the products of art and design. But among the six, there are remarkable differences with respect to the particular role that design (artefact or process) played in the contribution, and the type of contribution made. For example, in Buur et al. (2000), specific design events were the object of analysis in order to speculate on how design events can be more fruitfully organised to take advantage of context; in Binder (2002), whole projects formed material for different aspects of the argument for a reconceptualisation of topics in design research; in Mattelmäki (2006), a sequence of iterative design experiments were assembled to articulate the value and limitations of design probes in commercial/industrial settings. In Matthews et al. (2008), the process of the design of the tiles is entirely absent to the account (and inconsequential to the argument), since products-in-use are all that is required to make the points they argue about methodological matters for interaction design research; in Stienstra (2003) it is also the products-in-use that are important, but in a different role here as the embodiment of a theory in a hypothesis-testing

experiment; in Mäkelä (2006) we also have artefacts produced as theoretical embodiments, but not in order to validate theory as much as to explore and extend academic discourse. In the six examples we have, we have six ways that design has been essential to the research contribution, and six different kinds of contributions to design research.

Table 1 depicts the different roles of design in the research contributions of the example cases, and the different kinds of contributions they have made to design research. It is important to note that we are not claiming, nor do we believe, that the type of contribution is tied in any necessary or essential way to the particular role of design in each case. For instance, the reconceptualisation of topics is a type of research

contribution that is not necessarily dependent on a reflective examination of design cases; in the same way, theories can be tested for their validity to design in more ways than through controlled experiments with designed prototypes that embody theoretical principles. Once more, we are emphasising the contingency and plurality of research that involves design.

### **Moving to application**

From these examples, and from other general discussions, we can see that design research that involves designing as a component of it has taken many different forms, with a variety of research questions motivating inquiry. But again, our central motivation is pedagogical, towards creating a designerly exercise to make these issues tangible. From Table 1, it is clear that any exercise or demonstration developed to prototype design experiments as research needs to incorporate something of the diversity of the different roles that design might play: design events, projects, successive iterations, resultant products and/or their appropriation in use. It would also need to be able to deal with the variety of topics that are of potential interest to design research.

In an influential piece, Cross (1999) delineated three focus areas in design research: studying people i.e. design thinking and knowing; studying the practices and processes of design; and studying the products i.e. the form and configuration of artefacts and systems. Along similar lines, Dorst (2007) has suggested that historically, design research has primarily concerned itself with studying design methods and the design process, neglecting designed artefacts and the person of the designer as equally important objects of research interest. Beyond just the designer, there is an increasing interest in actors in the design process such as users and other stakeholders in decision making (Findeli and Bousbaki 2005). From such discussions we might loosely delineate three broad lines of design inquiry:

- a) *methods*, what are the elements that influence the application of methods, how to improve, customise and develop them, what are the influences and outcomes of the applications (see e.g. Sleeswijk Visser et al 2005).
- b) *artefacts* dealing with issues such as functionalities, material, interaction, ergonomic, and aesthetic qualities of designed products (see e.g. Frens 2006)
- c) *actors*, looking at how interaction between different participants unfolds, what their role in the design process is, the process of participation, who the stakeholders are, how and when to engage them, (see e.g. Brandt 2004).

These are three general concerns alive in design

research, which do not overly delimit the research questions that might be posed towards them. We used these three categories in our planning of the pedagogical exercise.

### **THE APPLE PEELING EXERCISE**

So, based on our investigation of the relationships between design and research and these three overarching concerns of design research, we developed a pedagogical experiment that attempted to prototype (through peeling apples) a learning-through-exploring approach to the roles of design in research. Of course, prototyping and iterations belong fundamentally to the practices of design making. S ade (2001) mention several reasons for prototyping such as idea generation, communication and testing. Low-fidelity design representations can be used to address specific questions, support collaboration and to provide a hands-on feeling of the future product that is easy to communicate and understand. Prototyping for idea generation is a way to make sense of the topic, design brief, material and form. Thus, prototyping is an activity to concretise thoughts and make them visible. What happens in this reflective practice of idea generation is typically rather difficult to rationalise verbally. Instead of abstract or theoretical questioning, prototyping allows personal and collaborative learning.

To create prototype, in a practical exercise, the models and experiments presented above and how their application influences the researching and experimenting process, we planned a workshop for design research students. The workshop aimed at making sense of the connections of experiments and design contributions through a tangible prototyping activity. Since we had identified three foci that design research has typically explored, we created three different tasks that especially tried to concretise those interests: methods, artefacts and actors. Among the aims of the prototyping exercise was to give PhD students a simplified hands-on experience of some of the possibilities of research-through-design that many of them were conducting, but may not have been able to clearly see these connecting points, or to reflect on the process of turning complex fieldwork or design experiments into research contributions.

#### **The procedure**

The Peeling Apples exercise was conducted as follows: there were six groups of four to five PhD students, and each group was given three apples and two short-blade peeling knives. The apples as design material were meant to provide a tangible, low-fidelity (and seasonal)

prototyping material to work with.

The groups were given a design brief that they were instructed to follow. Three members acted as ‘designers’ whose responsibility it would be to fulfil the design brief. The remaining (one or) two members of the team were pre-selected by the organisers to adopt a ‘researcher’ role: each ‘researcher’ was given a special research question through which she had to observe the ‘designers’ action and/or outcome. The questions for the researchers were formulated by us (the authors), and were made directly relevant to the student’s own research projects, to the extent we were aware of them. We had three kinds of design briefs with the following instructions:

1) *Focus on the activity: Method to the madness.*

The brief is about peeling the apple. You have 3 iterations (e.g. 3 apples) to develop a peeling method that uses the least effort. ‘Effort’ here will be determined by the sum of the time taken to peel the apple (in seconds) plus the number of pieces of peel produced, with the lowest total winning. (See Figure 1).



Figure 1. These students were after developing the most effective method, measuring their process in seconds.

2) *Focus on the design artefact: Beauty is everything.*

The brief is *about the peel*. You have 3 iterations to produce an apple peel of immense artistic worth. The apple peel must not merely be beautiful; it must stand as an aesthetic statement—something that redefines the meaning of ‘apple peel’. You have to decide what you want the apple peel to be, and iterate to refine the concept. Independent, unbiased judges will determine which apple peel is the most aesthetically sophisticated (i.e. beauty in combination with the expressed design intent). (See Figure 2).



Figure 2. The groups that were after the most aesthetic artefacts focused on the potential of apples as design material.

3) *Focus on design collaboration: What’s gonna work? Teamwork!*

The brief is *about the people and their process*. You have 3 iterations to teach yourself how to make the longest single apple peel from one apple. But there’s a catch—no single member of your team can be holding both the peeler and the apple at the same time. The length of the longest peel will be determined by holding the peel out and letting it hang down until it just touches the floor; the tallest peel wins. (See Figure 3).



Figure 3. These students are experimenting and observing teamwork. One is holding the apple and the other operating with the knife. The result is dependent on the interaction and coordination between the two.

The teams were given about 30 minutes to respond to the brief, i.e. to peel their three apples, during which time the ‘researchers’ on each team observed the team’s activity in order to address the research question they were assigned. After the action phase the groups were asked to reflect on what happened in their group and discuss what they had accomplished. We asked each group to list three distinct contributions that the process/product lent itself to; to determine the audience that would be interested in each contribution; and finally to invent a CHI-type paper title for their favourite contribution (e.g. ApplePeel: Collaborative design methods for multidisciplinary dialogue). This ensured that the discussion would focus on the relationship between the design exercise (apple peeling) and possible research contributions.



As mentioned, the research questions given to the ‘researchers’ were created by the organisers but were based on the individual students’ research interests. To give two examples, a student whose design experiments in his/her project considered Design Games (Brandt 2006) was given a question “How do the properties of the materials influence the playful co-design of the team?” Another student who experimented with the relationship of tactile senses and textiles was given a question “How do the team’s tactile senses figure in their process?” Thus, the questions aimed at giving them a somewhat familiar frame through which they analysed the apple peeling activity, but also served as a simple tool to critically reflect on their own questioning, and their practices of observation and description.

## DISCUSSION

Design tasks include ill-defined problems, skilled practice, hands-on making and reflection. Design experiments as part of research programmes contain these complex characteristics, too. Academic work requires critical and analytical thinking; design is typically generative in nature. It has proven rather challenging to combine these two. The exercise we have constructed is intended to prototype, in a very short duration, some of the combinations of research and design. For the students, it became a way to experience some of the different ways that design might feature in a research project. Peeling an apple can become a complex issue, if one starts looking at it through academic eyes. ‘Researchers’ had the chance to try to identify their research topics, or concepts in their research question, in the witnessable details of (apple peeling) practice. This proved to be a challenge to many of them. But if it was difficult to observe e.g. the ‘playful co-design’ of the team in *this* simulated exercise, it is likely to be much more difficult to identify it in the richness of actual design practice. Similarly, ‘researchers’ also encountered difficulties in having something to say in response to their research questions given the empirical material of three designers trying to peel three apples. Even if they could identify the concepts in their research question, it remained to be seen if they could actually begin to formulate an answer to the question from the apple peeling design cases: what actions the team took, how they organised their process, or what apples/apple peels they produced. The students’ reflections indicated that the given research question affected very much how they saw the process, and what they looked at.

In spite of the fact that all of the groups were given the same design material and tools, the tasks were different.

Interestingly, with respect to the ‘researchers’ findings and the reflections of the teams on their achievements, the apples as design material all but disappeared. That is, findings tended to focus on design-relevant topics, e.g. the team’s collaboration strategies or the effective iteration process and its relationship to the evaluation criteria. The fact that it was apples being peeled as content for analysis did not limit the kinds of things the students were able to claim or reflect on about design. In these respects the apple peeling exercise of prototyping design experiments as research had certain value.

However, it also had some important limitations. Although most teams were able to think of three possible contributions, a paper title and a potential audience, that is hardly the same as actually *making* a research contribution. Specifically, making a contribution includes, among other things, contextualising the work *as a contribution* in relation to prior work (as in a literature survey), and having to argue it as a contribution to an audience or community of research practice. To the extent the exercise falls short of prototyping these aspects of *research contributions*, it must also fall short of prototyping the relationship of design (projects, processes and artefacts) to research contributions. Furthermore, in comparison to the ways in which design has figured in design research (summarised earlier in Table 1), there are some aspects that are not prototyped here. For example, although designed products (in the form of aesthetic apple peels) feature in the exercise, we have not been able to prototype designed products-in-use as objects of analysis. The design, subsequent deployment of a product/system, and the study of its use, is a kind of design research that appears to require a longer time-horizon to model than achievable within the typical 2-3 hour workshop format.

Nevertheless, the exercise has the distinct advantage of explicitly addressing many of these issues in a designerly way, and in a very compressed format that permits of hands on experience with design, addressing research questions through empirical (design-based) data.

## CONCLUSION

We have tried to make two principal contributions in this paper. The first is to contribute to the ongoing discussion of the design-research relationship by examining a set of cases that highlighted the very different ways that design has formed a component of research contributions. We are well aware that the examples given in this paper for connecting design



experiments and research are not complete. However, to the extent that each of these cases might be considered efforts at research-through-design, we have suggested that research-through-design should not be seen as a method, but rather a family of heterogeneous approaches to design research that only occasionally resemble each other. This is not a failing or something to be remedied; it is simply an important realisation that will (hopefully) enable the field to move beyond highly generalising programmatic discussions of e.g. 'the' research-design relationship and into more fruitful considerations of the multiple ways that design research can profitably, practically speaking in form of contributions, be pursued, and the variety in the kinds of contributions acceptable to our field.

Secondly, in spite of the increasing prevalence of references to 'research-through-design', we are unaware of the existence of other practical exercises that are geared towards helping design research students appreciate the intricacies of making research contributions that incorporate design as an element of the process. The apple peeling exercise is itself a prototype of how the design-research relationship can be explored in a compressed period of time.

The pedagogical exercise is a design-oriented way of prototyping experiments as research, and developing understandings of the possible turn(s) from designing to making research contributions. Finally, we acknowledge that achieving our aim, i.e. teaching students about making research contributions through designing, can only be illustrated (not actually practised) by peeling apples. Research contributions of this kind are only made in concert with the exercise of traditional academic skills such as reading, critical reflection and argumentation, in combination with doing design work. Nevertheless, the exercise gives us, and our students, a starting point for discussing a number of the issues inherent to the role of design as an indispensable component of design research.

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