Integration of Design Projects within a Ph.D.
Owain Pedgley and Paul Wormald

1.   Introduction

In recent years, there's been an ongoing debate over the legitimacy and efficacy of incorporating one's own design activity, in the form of a design project or several interconnected projects undertaken, within a Ph.D. One continual disappointment within this debate has been a lack of practical examples of completed work or work-in-progress. This, in turn, has made it difficult to ascertain what "good practice" might entail, and has left students and supervisors with scant advice on how to integrate design projects within a doctoral program leading to a Ph.D. Conceptually, the idea that a student should engage in the practices of his or her specialized subject in the pursuit of a Ph.D. can be easily grasped. Physics Ph.D. students, for example, would very likely be involved in undertaking physics experiments. Thus, logically, it is quite reasonable to propose that Ph.D. design students should be expected to design something relevant to their training and expertise, for example, in industrial design, graphic design, or some other design specialty. Thus far, however, in failing to clarify essential differences between designing and researching, and the particular research activities in pursuing a Ph.D., the present debate has reached an impasse. Practical advice on integrating design projects within a Ph.D. remains largely unresolved and deserving of greater academic effort, which is the main thrust of this paper.

In the UK, deliberation over the legitimacy of integrating design projects within Ph.D. research is most prominent among art and design institutions, where research historically has had a low profile or priority compared to teaching and design output. Such institutions have the most to gain from the identification of successful routes for integrating design and research activities, and in so doing being able to respond to government pressures to deliver internationally acclaimed research. In contrast, within the mechanical and manufacturing engineering faculties of the older UK universities, Ph.D.s reporting the evidence base and rationale for designing or redesigning artifacts and systems have a long history. Some of the current debate, therefore, arises because of a lack of transfer of ideas and approaches between disciplines and faculties. Other points of dispute arise through misconceptions of the anatomy of research,

through an absence of disseminated approaches to structuring design Ph.D.s; and through a lack of confidence that a designer can be trained to be a researcher.

The Ph.D. is recognized worldwide as the pinnacle qualification for scholarly endeavor. It follows, then, that a design Ph.D., whether or not it includes a design project undertaken by the doctoral candidate, should be equivalent to a Ph.D. in other subject areas and disciplines. But at the center of current concerns are the academic credibility of one's own designing,[1] its position in relation to a written thesis; and its ultimate function given that a Ph.D. is awarded on the basis of good practice in research, not in design.[2] Very recently, in one of his final public speeches, Bruce Archer issued a warning based on his personal experiences that design and research can sit uncomfortably together.[3]

> There is a real difference […] between the mind-set which you have to have to be a successful researcher and the mind-set you have to have in order to be a successful designer. You can come to a nil result in research. You cannot come to a nil result in design. You have to get a result. I think it is quite a demand on an individual to move from the practice of research to the practice of design, and vice versa. In fact […] I used to discourage practitioners from going into research whilst they were still engaged in practice. I think it spoils their ability to make decisions, and so if you become a researcher you should do so full-time, full bloodedly, for a certain period of time, and then go back into practice.

It should be made clear from the outset of this paper that it is not a prerequisite for a design Ph.D. to involve personal design activity. Studies of other people's designing, of artifacts, or of people who use artifacts, are among many other possible routes to a design Ph.D. However, given that a designer's essential function, satisfaction, and inspiration is in the processes and outcomes of designing and making,[4] how can a Ph.D. be devised to suit? This paper is intended to directly answer this question, and to achieve a new level of transparency of thought for the key issues involved. While the emphasis is on the practicalities of structuring Ph.D. programs that fuse designing and researching, implicit within the paper is a discussion of the mind-set required to do so. Therefore, this paper is aimed especially at prospective Ph.D. students; providing a theoretical framework and timely practical examples capable of informing the development of their own Ph.D. proposals.

1   B. Martinson, "The Graduate Program in Design at the University of Minnesota: An Overview" in *Doctoral Education in Design 1998: Proceedings of the Ohio Conference,* Pittsburgh (1999): 159–168. R. Buchanan, D. Doordan, L. Justice, and V. Margolin, eds.

2   C. Rust, "Context—Many Flowers, Small Leaps Forward: Debating Doctoral Education in Design" in *Art, Design and Communication in Higher Education* 1:3 (2002): 141–148.

3   B. Archer, transcript of DRS lifetime achievement award acceptance speech available at: http://nelly.dmu.ac.uk/4dd/DDR4/DDR4-frame2.html (2004) (accessed January 1, 2006).

4   R. Buchanan, "The Study of Design: Doctoral Education and Research in a New Field of Inquiry" in *Doctoral Education in Design 1998: Proceedings of the Ohio Conference,* R. Buchanan et al., eds., 1–29.

5   B. Archer, personal facsimile via P.
     Roberts at Loughborough University
     (1999).

6   C. Frayling, *Practice-Based Doctorates
     in the Creative and Performing Arts and
     Design* (Warwick, UK: UK Council for
     Graduate Education/CEDAR University of
     Warwick, 1997).

7   O. Pedgley, "Doing One's Own Design
     Work in a Ph.D." posting to www.drs

8   D. Durling, "Discourses on Research and
     the Ph.D. in Design," *Quality Assurance
     in Education* 10:2 (2002): 79–85.

9   D. Durling, "Fostering a Research
     Culture" in *Doctoral Education in
     Design 1998: Proceedings of the Ohio
     Conference,* R. Buchanan, et al., eds.,
     169–181.

10   Research Training Initiative,
     "Case Studies" available at:
     www.biad.uce.ac.uk/research/rti/
     case_studies (2006) (accessed January 1,
     2006).

11   "The Role of the Artefact in Art and
     Design Research: Peer Reviewed
     Papers from the Research into Practice
     Conference 2004" in *Working Papers
     in Art and Design Vol.3,* M. Biggs, ed.,
     available at: www.herts.ac.uk/artdes1/
     research/papers/wpades/vol3 (2004)
     (accessed January 1, 2006).

12   "The Concept of Knowledge in Art and
     Design: Peer Reviewed Papers from
     the Research into Practice Conference
     2002" in *Working Papers in Art and
     Design Vol.2,* M. Biggs, ed., available
     at: www.herts.ac.uk/artdes1/research/
     papers/wpades/vol2 (2002) (accessed
     January 1, 2006).

13   "The Foundations of Practice Based
     Research: Peer Reviewed Papers from
     the Research into Practice Conference
     2000" in *Working Papers in Art and
     Design Vol. 1,* M. Biggs, ed., available
     at: www.herts.ac.uk/artdes1/research/
     papers/wpades/vol1 (2000) (accessed
     January 1, 2006).

14   E. Norman, R. Heath, and O. Pedgley,
     "The Framing of a Practice-Based Ph.D. in
     Design," available at: www.core77.com/
     research/thesisresearch.html (2000)
     (accessed January 1, 2006).

15   Ph.D. Design Mailing List, available at:
     www.jiscmail.ac.uk (2006) (accessed
     January 1, 2006).

2.   Research through Designing

The idea that design research can be framed in one of three ways is attributable to Bruce Archer who, during his post at the Royal College of Art from the 1960s, coined the phrase: "Research about design, research through design, and research for the purposes of design."[5] This phrase shows that, more than forty years ago, in the era of the "design methods" group, serious thought already had been given to how personal design activity could be interconnected with research. "Research through design," though perhaps more appropriately termed: "research through designing," explicitly referred to research in which one engaged in one's own designing.

A resurgence of interest in "research through designing" can be traced to 1997, when a group of senior researchers, under the auspices of the UK Council for Graduate Education, published a study of "practice-based" doctorates in art and design.[6] That same year also saw numerous postings to the newly formed Design Research Society Internet mailing list, including one inviting opinion and examples on the question: "In what ways can one successfully make one's own designing an integral component of a research program?"[7] At the time, completed design Ph.D.s were not common, and answers were sparse. It has taken the efforts of many researchers in the intervening time to lay firmer foundations[8,9] and start to disseminate case studies.[10, 11, 12, 13, 14]

Since 1999, academic attention to doctoral education in design has grown significantly, most notably through the Ph.D. Design Internet mailing list[15] and a series of specialist conferences organized in Ohio, La Clusaz, Tsukuba, and Tempe. Related conferences and seminars have been established, including the "Designing Design Research" series at De Montfort University, Leicester, the "Research into Practice" series at the University of Hertfordshire and the "Design Plus Research" conference at the Politecnico di Milano.

In reviewing the prior art, it is apparent that much of the current debate and controversy concerning research through designing is attributable to unsuitable or clumsy use of terminology, such as "research by doing."[16] Particularly contentious is the widespread use of the term "practice-based" research,[17] which is really a misnomer. Consider for a moment that all Ph.D.s are based and assessed on the practice of research.[18] What design researchers mean by "practice-based" research is rarely stated very clearly, so it is helpful at this juncture to provide a suggestion. "Practice-based" could be a forewarning that design activity (i.e., the practice of designing) is present within the research. But the key issue is the extent to which designing is present, and this can vary widely. One rather bold position is for the investigative and creative processes of designing to be equated, or at least promoted as being close, to processes involved in the practice of research. Thus, with this view, designing comprises the mechanism through which research is undertaken. A more modest position is for selected periods of a research study to be

occupied by a design project carried out by the researcher. However, these periods are unlikely to feature so heavily that the research can be reasonably described as "based" on design activity. Terms such as "research with a practical design element," "research incorporating a design project," "design-oriented research," [19] or simply "research through designing" are suggested as better alternatives to the awkward term "practice-based" research.

3. Motivations for a Ph.D. in Design

Motivation is a strong factor in the decision to integrate a design project into a Ph.D. Contrary to views held by some research students,[20] the primary goal of a Ph.D. in design is not an extension of the creative self or personal expression. Nor is it about engaging theory to extend one's own design expertise. All of these may, however, be planned consequences. Instead, the primary goal, as with all Ph.D.s, is the improvement and gains to be had by the communities targeted by the research. Thus, a key message here is that the integration of design activity within a Ph.D. must be as a means to an end, and not an end in itself.[21] So if a Ph.D. candidate is motivated chiefly by the prospect of becoming a better designer, or a "guild master,"[22] then his or her motivations are somewhat misdirected. Other more direct and supportive higher degrees are available for these candidates (e.g., M.A., M.Des., D.Des., Eng.D.), focusing specifically on developing and complementing personal design expertise. Such distinctions between Ph.D.s and other higher degrees in design have been contemplated at least since the 1960s,[23] and are a thread that continues to run in contemporary discussions on doctoral design education.

4. Distinctions between Designing and Researching

No apologies can be made for including this section within the paper, even if it does cover recurring topics. It is vitally important that Ph.D. candidates grasp distinctions between designing and researching; especially when they propose, as advocated in this paper, to form a union between the two. The intention is for the arguments presented here to dispel misconceptions, such as the rather unhelpful polarization of "researching as academia" and "designing as commerce" that sometimes surface.[24] On first inspection, designing and researching appear to have much in common. Designers and researchers are both concerned with improving current situations and circumstances. Both also share a common goal to generate, communicate, and extend human ideas and experiences. Furthermore, designing and researching both draw heavily upon investigative techniques, and both are forms of educative enquiry. However, design activity ordinarily does not constitute or resemble research because a variety of criteria characteristic to research are not normally met. In other words, the operational rules for the practice of design are different to those for the practice of research.

16 B. Sevaldson, "The Integrated Conglomerate Approach: A Suggestion for a Generic Model of Design Research" in *Doctoral Education in Design: Foundations for The Future,* D. Durling and K. Friedman, eds. (Stoke-on-Trent, UK: Staffordshire University Press, 2000), 163–170.

17 M. Thomas, "Editorial: Practice-Based Research" in *Digital Creativity* 15:1 (2004): 1.

18 J. Langrish, "Not Everything Made of Steel Is a Battleship" in *Doctoral Education in Design: Foundations for The Future,* D. Durling and K. Friedman, eds., 297–305.

19 D. Fallman, "Why Research-Oriented Design Isn't Design-Oriented Research" in *Nordes* (Nordic Design Research Conference, Copenhagen, 2005).

20 J. Hockey, "Writing and Making: Problems Encountered by Practice-Based Research Degree Students," *Point* 7 (1999): 38–43. More information at: www.point.ac.uk.

21 A. Findelli, "A Quest for Credibility: Doctoral Education and Research in Design at the University of Montreal" in *Doctoral Education in Design 1998: Proceedings of the Ohio Conference,* R. Buchanan, et al., eds.: 99–116.

22 K. Friedman, "Doing One's Own Design Work in a Ph.D." posting to drs@jismeil.ac.uk (October 2, 1997) (not archived on the Web).

23 "Doctoral Programs in Design" in *Proceedings of the American Society for Engineering Education Annual Meeting,* J. Meriam, ed. (University of California, Los Angeles, 1968).

24 O. Pedgley, "DDR4 (Designing Design Research 4) Event Review and Reflections," *Design Issues* 21:3 (2005): 82–85.

4.1 Designing

Designing things and devising proposals is what designers from all backgrounds do, irrespective of their roles as, for example, commercial consultants, university lecturers, or students. Good design leads to excellent products, design registrations, patents, sales, global recognition, and so on. Critically, while the broad goal of research practice is new knowledge, the broad goal of design practice is new artifacts and designed outcomes, as explained by Archer and Roberts.[25]

The legitimacy and efficacy of a design result resides in the demonstrability and appreciation of its appropriateness to purposes rather than in the clarity of understanding of the principles governing the production of the result.

4.2 Researching

At a very straightforward level, the activity of researching is about finding out something new. But at the heart of the matter is the question "New to who?" Hunts for information to satisfy personal curiosity is a tenuous example of research, while a Ph.D. aiming to consolidate and expand a body of knowledge associated with a discipline, beyond any single person's or institution's claim to know, is far more significant. Bruce Archer[26] has provided a robust and widely adopted definition of design research.

> Design research is systematic enquiry whose goal is knowledge of, or in, the embodiment of configuration, composition, structure, purpose, value, and meaning in man-made things and systems.

From Archer's quotation, it can be seen that research has several conditions attached that need not be met through, nor even relevant to, designing. The emphasis on knowledge—and only then in a communicable form—is a crucial matter to researchers, and no less so to Ph.D. candidates wishing to integrate a design project into their studies. So what does this mean in practice? In recent years, senior design researchers have demonstrated agreement on basic demarcations between what is admissible and not admissible as research through designing. The presence of reflection, analysis and theorizing on one's own design activity is paramount,[6, 22, 27] as is transparency in the adopted methodologies.[28] But these alone are not sufficient. Adherence to general criteria for good practice in research also must be striven for. These criteria are listed in Table 1, adapted from Cross,[29, 30] and augmented by standard research methodology texts. When combined, the criteria provide a set of benchmarks for distinguishing research from the activities of both information-gathering and designing.

25 B. Archer and P. Roberts, "Design and Technological Awareness in Education," *Studies in Design Education, Craft, and Technology* 12:1 (1979): 55–56.

26 B. Archer, "A View of the Nature of Design Research" in *Design: Science: Method,* R. Jacques and J. Powell, eds. (Guildford, UK: Westbury House, 1981): 30–40.

27 N. Cross, editorial in *Design Studies* 19:1 (1998): 2.

28 B. Allison, A. Owen, A. Rothwell, T. O'Sullivan, C. Saunders, and J. Rice, *Research Skills For Students* (London: Kogan Page, 1996): 21.

29 N. Cross, "Design as a Discipline" in *Doctoral Education in Design: Foundations for The Future,* D. Durling and K. Friedman, eds., 93–100.

30 N. Cross, "Key Points—The Refereed Journal" in *Designing Design Research 2—The Research Publication,* A. Robertson, ed., available at: http://nelly.dmu.ac.uk/4dd//drs5.html (1998) (accessed January 1, 2006).

Table 1
A–Z criteria for design research

Criterion	Explanation
Analytical	Building of explanation, theory or models through reasoned argument
Clear	Communicated unambiguously and readily comprehended by peers
Disseminated	Appropriately communicated to target audiences
Effective	Data, methods, and end results are useful and suited to meeting aims and objectives
Evidence-Based	Involves something demonstrated or found out in contrast to speculation or opinion
Focused	Each element combines to form a coherent whole related to a common theme
Generalizable	Tackles the applicability of results, from a single point in time to a fundamental principle
Informed	Conducted from an awareness of previous work
Intentional	Purposefully seeking to generate new knowledge
Original	Delivery of new outcomes relating to a subject area or methods
Questioning	Driven by an aim and set of objectives
Reliable	If repeated, the research would yield the same results
Risky	Involves a level of uncertainty, trepidation and operation outside of routine
Systematic	Planned and carried out in a disciplined manner
Transparent	Research methods are sufficiently documented to be capable of replication
Truthful	Honest and complete accounts of work done
Valid	Sources and data are authentic, trustable and can be corroborated
Worthwhile	Carried out in response to an identified need capable of investigation

Contrast the criteria in Table 1 with characteristics typical of design practice. Usually, there is no obligation for designers to document the information, resources, and methods they use. Ad hoc approaches can be as effective as systematic approaches; just as serendipity can replace intent. And while some aspects of design rationale may be expected in a final design report, other aspects may be incapable of being articulated in words, being reliant on tacit knowing[31, 32] and the exercising of skills and intuitive decision-making. Clearly, on close inspection, designing and researching have much that separate them.

31   M. Polanyi, *Personal Knowledge* (London: Routledge, 1983).
32   M. Polanyi, *The Tacit Dimension* (London: Routledge & Kegan Paul, 1967).

Readers could be forgiven for thinking that research, as presented here, is the preserve of academic institutions. This, of course, is far from reality. "Commercial research"—synonymous with the term "R&D" (research and development)—is deployed worldwide to resolve problems and develop ideas at the technological boundaries of a company's products or operations. Commercial research is directed at practical action and results, and for Ph.D. candidates wishing to deploy their own design activity, much can be learned from commercial research strategies. Some important differences exist though compared to academic research. Prior art reviews typically are conducted only to solve the most immediate and pressing problems; and, overall, less rigor, time, and fewer resources are committed to contextualizing the work. The results of commercial research, therefore, can prove difficult to publish in academic journals, occasionally being viewed with some disdain as little more than information hunts or activities to keep practitioners abreast of developments in their field.[9] There is, however, no reason why the majority of the criteria in Table 1 cannot be satisfied by commercial research, with the caveat that the contribution to knowledge is retained within the business to maintain confidentiality, and that the contribution need only be new to the business.

5.   Example Ph.D.s Incorporating Design Projects

Three successfully awarded Ph.D.s in the field of industrial design[33, 34, 35] now are presented to illustrate different strategies for integrating design projects within a Ph.D. Table 2 provides a summary of the key aspects of each Ph.D. Of course, in addition to the students' personal design activities, extensive prior art reviews were undertaken in all cases to properly ground the work, and to lend credence to claims of originality and knowledge contributions.

5.1   Owain Pedgley Ph.D. (1999)

Pedgley's Ph.D. was built on the principle that, in order to understand the rationale for industrial designers' materials and processes decisions, it was essential to uncover in a documentary manner how different resources (e.g., kinds of knowledge and sources of information) are put to use by those designers. This also was the emerging position of a body of researchers at the time, concerned with analyzing various aspects of design activity.[36, 37] Pedgley's research also was built upon the theoretical position and agenda of Eddie Norman, as supervisor, in which the interaction of knowledge, skills, and values comprises the technology required to practice design.[38] Materials and processes were selected as the focus because little prior art existed pinpointing the precise roles and responsibilities industrial designers have for decisions on these crucial matters.

33 O. Pedgley, *Industrial Designers' Attention to Materials and Manufacturing Processes: Analyses at Macroscopic and Microscopic Levels* (Ph.D. thesis, Loughborough University, 1999).

34 J. Allen, *Some Problems of Designing for Augmentative and Alternative Communication Users: An Enquiry through Practical Design Activity* (Ph.D. thesis, Loughborough University, 2002).

35 B. Sener, *Enhancing the Form Creation Capabilities of Digital Industrial Design Tools* (Ph.D. thesis, Loughborough University, 2004).

36 *Analysing Design Activity,* N. Cross, H. Christiaans, and T. K. Dorst, eds. (Chichester, UK: John Wiley, 1996).

37 N. Bayazit, "Designing: Design Knowledge: Design Research: Related Sciences" in *Design Methodology and Relationships with Science,* M. deVries, N. Cross, and D. Grant, eds. (Dordrecht, The Netherlands: Kluwer Academic, 1993), 120–136.

38 E. Norman, "The Nature of Technology for Design," *International Journal of Technology and Design Education* 8:1 (1998): 67–87.

Table 2
Three example Ph.D.s incorporating design projects

	Owain Pedgley	Jonathon Allen	Bahar Sener
Year awarded	1999	2002	2004
Supervisor	Eddie Norman	Paul Wormald	Paul Wormald
Research aim	To advance understanding of the information, knowledge, skills and values deployed by industrial designers when making decisions on product materials and manufacturing routes	To advance the design of, and champion new approaches to designing, products for people with severe communication disabilities and physical impairment	To investigate the phenomenon of modelling in industrial design, to evaluate the efficacy of current digital design tools for modelling, and to develop rationale for advanced next-generation digital modelling systems
Key audiences	Information providers Design educators Design researchers	Product designers Design educators Design researchers	Hardware/software developers Design educators Design researchers
Purposes of design project(s)	To generate case study data comprising documentary evidence of design activity, for subsequent analysis at macroscopic (strategic/ resource) and microscopic (trains of thought/rationale) levels To provide a vehicle for the development of data collection instruments and research methods suited to documenting design activity	To directly engage in investigating, understanding, and responding to the research area and research questions, thereby adopting designing as a mode of enquiry	To enable evaluation of state-of-the-art digital modelling technology (the FreeForm® haptic system) in commercial and academic contexts To translate research data into coherent proposals for next-generation digital modelling systems, serving as a catalyst and pointer to future R&D
Contribution to design portfolio	Fully working prototype polymer acoustic guitar	Fully working prototype communication device	Fast moving consumer goods concepts and rapid prototypes Presentation quality concept illustrations of next-generation digital modelling systems
Additional sources of primary data	Interviews with practising industrial designers, design engineers and applied artists Diary studies and interviews with industrial design undergraduates		Designing and modelling experiments with professional and student designers using three modelling media

Personal design activity was adopted as a vehicle for generating case study data on materials and processes decision-making (Figure 1). Pedgley's design skills (first-class industrial design graduate) were considered suitable for exposition and scrutiny within such a study. Data were collected primarily through daily entries into a diary of designing, the development and evaluation of which was a supplementary objective of the Ph.D.[39] The case study in question was the design of a new generation of polymer acoustic guitar, a concept with much potential that had been commercialized in the 1950s by Mario Maccaferri, but which failed in the marketplace. Technology and markets had moved on significantly in the intervening decades, and it was very reasonable to be optimistic about achieving innova-

39 O. Pedgley, "Towards a Method for Documenting Industrial Design Activity from the Designer's Perspective" in *IDATER97,* J. Smith, ed. (Leicestershire, UK: Loughborough University, 1997): 217–222.

tion and creating a successful product. Aside from the project personnel being keen musicians, good methodological reasons existed for choosing the guitar. It was well known that guitar-making traditionally draws upon know-how, intuition, and tacit knowledge. In parallel, it also had been established that technologists and engineers were not in a position to advise on the selection of "musical polymers" or on polymer instrument design. However, a successful guitar undoubtedly would hinge upon effective materials and processes choices, and because of this made for a particularly engaging study on design decision-making in the face of limited technical and documented advice.

Pedgley's Ph.D. succeeded in bringing the subject of materials and process selection in industrial design up to date. Eclipsing this achievement though was the success of the guitar project. A fully working prototype was completed, and patent and design registrations were filed. A collaboration with master guitar-maker Rob Armstrong was vital to the success of the instrument. The project has since evolved into an R&D and business venture,[40] a source of employment for Pedgley, and has resulted in new artifacts, exhibitions, an audio CD, a DVD, technical papers, a concert, and a booklet.

5.2   Jonathon Allen Ph.D. (2002)

Allen's Ph.D. was, in many ways, an impassioned call for the power of industrial design to improve the lives of people with disabilities. The product area under scrutiny was Augmentative and Alternative Communication (AAC) devices, used by people with severe communication difficulties, who often have pronounced physical disabilities. AAC devices had been identified as suffering from a drought of good design input, resulting in products of low esteem

40   Cool Acoustics, available at:
www.coolacoustics.com (2006) (accessed
January 1, 2006).

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and few innovations. Allen's Ph.D. had personal design activity at its core. The user-centered design and prototyping of a technologically advanced product provided evidence of the gains to be had by engaging industrial design expertise in the development of AAC devices and, by implication, for disability products in general. An easily comprehended framework was adopted: the success and impact of a newly created product hinged on both the specification of that product (i.e., matters of design) and the path to its conception (i.e., matters of designing).

Allen's thesis argued that the investigative-creative act that is designing can be adopted as one method, among others, for carrying out research. That is to say that research questions can be clarified and modified through designing (i.e., through the investigative techniques characteristic of industrial design, including studies of users and product interactions), and can be addressed through designing (i.e., through the engagement of industrial design decision-making). Designing was deployed as a form of educative enquiry, essentially a case of "learning by doing." Such use often is referred to as a "designerly mode of enquiry" and, in a research context, has similarities to the established humanities enquiry of "action research." The investigator is a participant within the situation under study. He or she intervenes and takes planned action to make some desired or anticipated events happen or to improve circumstances.[41, 42] While there are methodological aspects of action research that conspire to distance it from design practice, Allen contributed much to addressing their equivalence and to empirically define the emergence of what may be termed a formal "designerly mode of research."

Although design practice was adopted as the primary mode of enquiry, it was regularly interspersed with additional activities including reading, writing, and theorizing. The design project accounted for approximately half of the total time spent on the Ph.D. The research succeeded in devising, justifying, and road-testing new approaches to designing AAC devices. It resulted in a fully-working prototype AAC device, termed the Portland Communication Aid (PCA), which embodied, demonstrated, and vindicated the new approaches to designing, and which was specified with state-of-the art technologies (Figure 2).

41   B. Archer, *Designerly Activity and Higher Degrees: Seminar Papers from a Staff Development Short Course* (Wellesbourne, UK: DATA, 2004).

42   E. Stringer, *Action Research: A Handbook for Practitioners* (London: Sage, 1996).

Figure 2
"Book" component of the PCA, photo by Media Services, Loughborough University.

5.3   Bahar Sener Ph.D. (2004)

Sener's Ph.D. had the advancement of one of the primary tools of modern professional industrial design practice at its core. Three-dimensional, computer-aided design (3D CAD) is now ubiquitous among industrial designers, particularly for the modeling and communication of design ideas, and their subsequent use in new product development (NPD). However, it was known that the use of 3D CAD in the early phases of industrial design had yet to be developed to a satisfactory level. Sener's research explored relationships between designers and their modeling tools, with the specific aim of establishing an evidence base for enhancing 3D CAD for idea generation and the conceptual phases of industrial design.

The work plan for the research required Sener to become fully conversant with a range of non-digital and digital design tools, and included a four- month industrial design placement at the Procter and Gamble Technical Center. One significant technology evaluated for its effectiveness was 3D CAD driven by haptic interfaces.[43] During the placement, Sener was employed to design, model, and prototype new consumer goods concepts using the FreeForm(r) virtual clay haptic modeling system (Figure 3). As a practicing designer in the company, Sener had significant professional authority for her investigations of how 3D CAD was perceived and used by other designers. Sener's involvement in the day-to-day business of the company's NPD Department provided her with evidence of the uses of 3D CAD that otherwise would have been impossible to obtain. It also led to useful and unanticipated avenues of investigation, such as the use of FreeForm(r) as a co-design tool.[44]

Sener also completed a second design project during her Ph.D. This was featured in the latter stages, and involved translating her research results (as tabulated text and numerical data) into coherent proposals for enhanced 3D CAD systems. The designing resulted in presentation-quality concept illustrations of next-generation 3D CAD systems, with the specific intention of serving as a catalyst and pointer for future R&D by hardware and software developers.

6.   Quality of Design Projects

The Ph.D. examples give rise to further practical considerations, which will now be considered in detail. At doctoral level, design excellence represented by originality, innovation, or new technology is likely to be aspired to in any incorporated design project. Ph.D. candidates would be well advised to consider two specific indicators of excellence: "completeness" and "esteem." When combined, these indicators act as a useful test of the adequacy of the technology, principles, ideas, and methods employed in the designing.

Completeness refers to the delivery of high-quality design outcomes that lend integrity to the preceding design activity and, thus, to the wider research study. For industrial design, typical outcomes can be preproduction artifacts, working prototypes, or

43   SensAble Technologies, available at: www.sensable.com (2006) (accessed January 1, 2006).

44   B. Sener and T. Van Rompuy, "'In Touch with Consumers: FreeForm(r) as a Co-design Tool for Real-time Concept Modification," *The Design Journal* 8:1 (2005): 14–28.

appearance models. Contrast this to embryonic, incomplete, or poor-quality outputs, which can cast doubt over the preceding design activity. Of course, some leniency must be exercised where product innovation is a stated goal within the Ph.D., since this brings inherent risks of noncompletion and only partial success. Esteem refers to the significance of the design outcomes, and their reception outside of the host academic institution. The following criteria have been used in the quality assessment of design research from UK universities, and directly indicate esteem:[45, 46]

   A. Granting of patent or registered design rights
   B. Availability of products for purchase
   C. Signed agreements with third parties to produce products under license
   D. Publicity and media attention following exhibitions, competitions, awards, reviews, etc.
   E. Standing and reputation of commissioning, sponsoring, or collaborating organizations.

Design projects not subject to confidentiality are preferred, since these have little or no restriction on dissemination. This is especially important if a body of examples of research through designing is to be created and promoted.

7.   Documenting Design Activity
A common thread to each of the three Ph.D. examples was a need to document design activity for subsequent reporting and analysis. This need should be expected of all Ph.D.s involving a design project, with the associated selection of appropriate data collection

45   Research Assessment Exercise, available at: www.rae.ac.uk (2006) (accessed January 1, 2006).
46   M. Woolley, "Design Publications and the UK University RAE" in *Designing Design Research 2—The Research Publication,* available at: http://nelly.dmu.ac.uk/4dd/ /drs6.html (1998) (accessed January 1, 2006).

instruments and methods. These can range from the effortless and unobtrusive (e.g., archiving of all sketch sheets and log books) to the relatively laborious and intrusive (e.g., diaries of designing, audio-visual recordings, and concurrent verbalization).

8.   Design Outcomes versus Scholarly Writing

Any discussion on the integration of design projects within a Ph.D. is intricately linked to the role of the outcomes of those design projects within the final submission. The three Ph.D. examples provide a good starting point, but much more can be said. A rather complex recurring argument is how design outcomes can replace or augment the scholarly writing that is the universal currency of academic research.[47] Part of this argument is that designers, as a general population, are not skilled writers,[20] and that the anatomy of a design Ph.D. submission should take this into account.

At the heart of the matter is a quandary over the extent to which design outcomes can adequately convey or embody research thinking and results. On the one hand is the position that words of description and explanation cannot satisfactorily replace firsthand experience, and therefore understanding, of a design outcome. On the other hand, some believe that a design outcome alone rarely expresses either its specification or the rationale behind its creation. The quandary can be distilled to a central issue of effective and unambiguous communication of the key messages required for a Ph.D. Thus, the choice of medium through which the communication is best accomplished can be largely pragmatic. Text, numbers, notation, diagrams, tables, and figures are all well established in this regard, but there seems no logical reason why a design Ph.D. submission should not use design outcomes as an equally valid medium. Indeed, design outcomes can offer an alternative and direct route to understanding in situations in which the written word is found to be inadequate; for example: where underlying technology is ineffable (i.e., reliant on tacit knowing); where masses of text would be needed to substitute direct sensory experiences; and where intended audiences are designers, who are known to be more stimulated and receptive to visual communications.[48] At least four general situations have been proposed in which knowledge and ideas may be found in or through artifacts:[49]

A. Simple forms—artifacts demonstrate or describe principles or techniques.
B. Communication of process—artifacts arising from a process make the process explicit.
C. Artifacts within research—artifacts are instrumental in advancing the research by communicating ideas or information.
D. Knowledge elicited by artifacts—artifacts provide a stimulus or context which enables information to be uncovered.

47   S. Hanrahan, "The Possibility of Dialogue: The Relationship Between 'Words' and 'Art-Making' in Fine Art Research,' *Drawing Fire* 2:2 (1998): 29–31.
48   J. Woudhuysen, "About Design: The Design Process: Trends," available at: www.designcouncil.org (2006) (accessed January 1, 2006).
49   C. Rust, S. Hawkins, G. Whiteley, A. Wilson, and J. Roddis, "Knowledge and the Artefact" in *Doctoral Education in Design: Foundations for The Future,* D. Durling and K. Friedman, eds., 395–404.

There are logistical constraints, of course, to the inclusion of artifacts within a Ph.D. submission. Models and prototypes usually are not easily duplicated or transported, thereby having implications for dissemination, archiving, and global access to research. But the role and potential gains of design outcomes, particularly in Ph.D. studies where personal design activity is prevalent, are too important and significant for logistical constraints to take precedence. The whole area of the relationship between design outcomes and scholarly writing is still somewhat in flux, and so Ph.D. candidates would be well advised to keep an eye on new thinking and new sources of examples.

9. Degree Rules and Regulations

All of the preceding discussion counts for nothing if the host institution's Ph.D. regulations do not accept the activity or outcomes of designing as admissible for examination. A conventional Ph.D. submission in the UK takes the form of a bound, eighty-thousand word thesis. Accounts of personal design activity certainly are not precluded from this format. Indeed, each of the three Ph.D. examples in this paper was submitted by conventional thesis, since no alternative format was admissible at the time. This obviously placed severe restrictions on how the designed outcomes (i.e., the polymer guitar, PCA, and conceptual consumer goods) could be communicated, with images being the only viable route. In Allen's case, moving images were included on a CD-ROM annex that fitted unobtrusively into the thesis.

Clearly, there is a case to be made for institutions' regulations to allow design Ph.D. candidates to submit their work partially "by design outcome," for example, through expositions and critiques of the physical or virtual objects arising from the research. Note the careful use of the word "partially": it tempers such a submission with the arguments presented throughout this paper. Furthermore, the acquisition of skills in academic discourse and writing are considered integral to the shared experiences incumbent on receiving a Ph.D. and graduating as a competent researcher irrespective of specialist subject or discipline.[50, 51, 52] Looking back to the 1980s and 1990s, degree regulations for UK polytechnics and art and design colleges were administered by the Council for National Academic Awards. Their regulations were relatively progressive compared to those of universities, and provided scope for the inclusion of candidates' own creative work in a thesis accompanied by "material other than a written form."[53] Moves to widen Ph.D. rules and regulations can be detected across the UK higher education sector, and issues relating specifically to "practice-led" research in art, design, and architecture[54] are presently being reviewed through a commission from the UK's major funding body of art and design research.

50 F. Candlin, "Practice-Based Doctorates and Questions of Academic Legitimacy," *International Journal of Art and Design Education* 19:1 (2000): 96–101.

51 J. Hockey and J. Allen-Collinson, "The Supervision of Practice-Based Research Degrees in Art and Design," *International Journal of Art and Design Education* 19:3 (2000): 345–355.

52 J. Wood, "The Culture of Academic Rigour: Does Design Research Really Need It?" *The Design Journal* 3:1 (2000): 44–57.

53 *Council for National Academic Awards Handbook* (London: CNAA, 1992).

54 Arts and Humanities Research Council-Research Review, available at: available at: www.ahrcreview.aces.shu.ac.uk (2006) (accessed June 8, 2006).

Loughborough University has been responsive to the need for more flexible formats for Ph.D. submissions, and now offers six distinct routes:[55, 56] "by conventional thesis"; "by new route," using the U.S. model of taught modules prior to self-directed study;[57] "by nonconventional media" such as DVDs and Websites, adopting best practices of graphic and interaction design to access and navigate research processes and results as multimedia content;[58] "by published work," typically involving the collation and connection of a series of separately published journal articles; "by practice," typically involving the collation and connection of a series of separate public domain presentations of design practice embodying original research; and "by creative writing," targeted at English and drama researchers, and typically involving the collation and connection of a series of original literary works in response to a research agenda. The available routes now provide Ph.D. candidates at Loughborough with a great variety of admissible formats for communicating their research, and especially so for design candidates who have integrated their own design projects into their Ph.D. programs.

10. Conclusions

For design Ph.D. candidates not to consider engaging in designing while undertaking research because of a lack of example or a lack of confidence in the legitimacy of the approach would be a travesty. This paper has argued that designing indeed can be successfully integrated into a Ph.D., and that candidates need not abandon their hard-won design skills and design portfolio in the process. Nor should their decision to enroll in a Ph.D. program necessarily dictate a future career researching and teaching in academia. The position that designing and researching are mutually incompatible no longer carries weight, so long as a carefully conceived research methodology is adopted. Confidence should be shown in the purpose of the integral design project(s), while serious thought must be exercised over how the project(s) should sit within the overall research agenda. What would be lost without the designing? What is the essential research function of the design project(s)?

Design activity alone is absent of essential criteria for it to be legitimately equivalent to research practice. A design Ph.D., as with all Ph.D.s, must center around scholarly endeavors. The inclusion of own design activity within a Ph.D. essentially must be for making advances to an identified body of knowledge. The paper has shown how design projects integrated into a Ph.D. program can vary widely in scope and nature, from a single element within a larger study to a methodologically central role, in which designing is adopted as a primary mode of enquiry. Three models can be drawn from the paper for design research in which it is contingent on the researcher to carry out a design project:

55 Loughborough University, "Regulations for Higher Degrees by Research," available at: www.lboro.ac.uk/admin/ar/calendar/regulations/rhdr/index.htm (2006) (accessed January 1, 2006).

56 Loughborough University, "Notes for the Guidance of Research Students, Directors of Research, Supervisors, and Examiners," available at: www.lboro.ac.uk/admin/ar/rso/guidance.htm (2006) (accessed January 1, 2006).

57 B. Tellefsen and T. Love, "Doctoral Research in Design: The Future of the Practice-Based Doctorate," *International Journal of Design Science and Technology* 10:2 (2002): 45–59.

58 J. Malins and C. Gray, "The Digital Thesis: Recent Developments in Practice-Based Ph.D. Research in Art and Design," *Digital Creativity* 10:1 (1999): 18–28.

A. Finding out about current design practices (e.g., pursuing a design project to help uncover decision-making processes)
B. Devising improvements in design methods (e.g., pursuing a design project to help conceive and develop new design procedures, information, priorities, and tools)
C. Making improvements to designed artifacts (e.g., pursuing a design project to help contribute to what is known about how a type of product can or ought to be designed, how it can be improved, and to demonstrate the benefits to be gained).

By bringing clarity to the decisions involved, it is hoped that a new cohort of researchers will be inspired and empowered to undertake research through designing. With a supportive institutional framework in place, the challenges and opportunities open to students and supervisors are immensely exciting and stimulating.