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http://dx.doi.org/10.1386/adch.10.2.127_1

PUBLISHER

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VERSION

AM (Accepted Manuscript)

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Self, James, Hilary Dalke, and Mark A. Evans. 2019. “Innovation in Knowledge Exchange: An Approach to the Dissemination of Research Findings in Support of Design Practice”. figshare. https://hdl.handle.net/2134/22148.

Innovation in knowledge exchange: An approach to the dissemination of research findings in support of design practice

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Abstract

The ability to embody design intentions is critical to an industrial designer's studio practice. From the design sketch to 3D computer-aided design, an increasing variety of design tools are employed in the embodiment of design proposals. A literature review identified the implicit characteristics of tool use during design activity. These characteristics were employed in surveys of design practitioners and design students. Findings indicated a tendency for student design activity to be characterized by convergence and less exploration, early fixation and attachment to concept, in contrast to the practitioners' more divergent and iterative approach. A concern for conventional research dissemination, articulated through conference papers and academic journals, to engage a practice-orientated audience lead to the development of a digital resource (IDsite). The paper describes an interim pilot of the resource. Findings suggest, although IDsite requires further development, the approach has relevance in terms of the communication of design knowledge.

Keywords

design expertise

design research communication

industrial design

design activity

design tools

Introduction

Industrial design, as part of a process of new product development, is characterized by a responsibility for the form and aesthetics of the final design solution (Dormer 1993). Industrial designers must also be aware of and sensitive to the processes of engineering and manufacture through which the final design solution is realized (Cross 2000). In this way industrial design may be described as located between the creative stylist, sensitive to the expectations of end users, their needs and requirements; and the pragmatic constraints of the materials and engineering processes employed in the realisation of the designed artefact. Sitting between these two principles, the industrial designer must address an often ill-defined design problem, generating and reflecting upon solution ideas in an attempt to better define these problems (Cross 2007). To support the generation of proposals, the practitioner employs a variety of analogue, digital and hybrid tools that embody design intentions through drawings, sketches, digital models, prototypes and handmade concept models (Goldschmidt 1997; Purcell and Gero 1998). It is through this process of embodiment and reflection-in-action (Schön 1983; Schön and Wiggins 1992)

that the industrial designer continually works design solution ideas towards the final specification of design intent prior to manufacture.

Industrial design process

Figure 1 illustrates a model of the industrial design process based upon Cross' (Cross 2000) description of convergent and divergent design activity. Although the model is a simplification of what is in reality a complex activity influenced by many factors (stakeholder requirements, working practices within individual consultancies, the designer's own idiosyncratic working methods) it is useful as a means of making explicit some of the universal characteristics of industrial design activity.

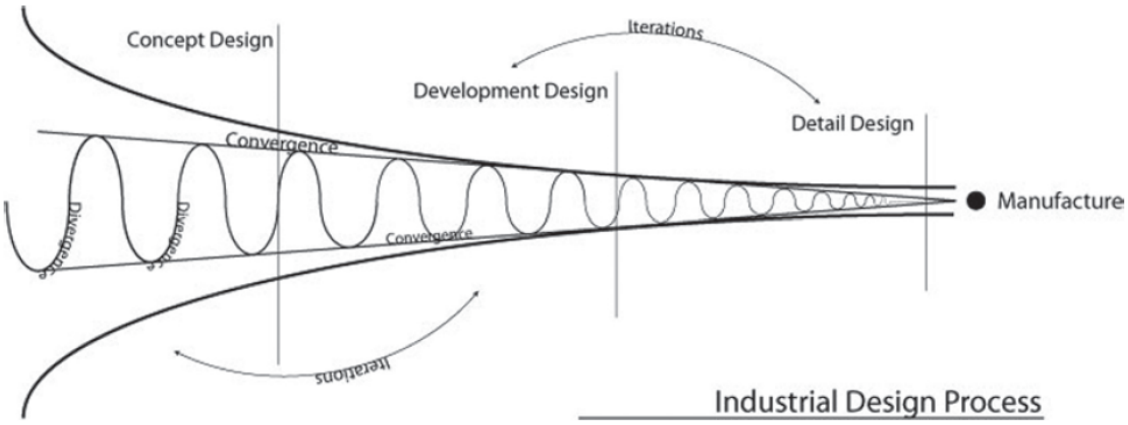


Figure 1: Generic model of industrial design process.

The model (Figure 1) describes design activity as converging towards the final specification of design intent prior to manufacture. This convergence is the culmination of activity, the end specification of intent, and the outcome of the design process. All design activity during studio practice is influenced by a requirement for the specification of a final design solution prior to manufacture (Powell 2007). In order to achieve this, the

industrial designer will move through stages in the design process, evolving solution ideas through increasing levels of detail (Pipes 2007). These stages are illustrated in the model as concept, development and detail design. Concept design is an initial phase of design activity involving the generation of a variety of design solutions to be reduced and refined as design moves from concept to development design. During development design, solution proposals are considered in greater detail before a single design direction is agreed and activity progresses towards detail design and specification for manufacture.

The industrial design process is both convergent and divergent in that, although it is concerned with the final specification of intent (Cross 2000), design activity is characterized by both periods of divergent iteration (returning arrows and looping vertical lines, Figure 1) and convergent specification (converging horizontal lines, Figure 1). The weighting of divergent/convergent design activity will differ from project to project dependent upon the requirements of individual design problems and the ways in which the designer or design team work in their exploration of solution ideas. However, a constant in this is the need to evolve the solution towards a final specification of intent.

Throughout this process the industrial designer will use design tools to embody design intentions as sketches, drawings, digital models, visual renderings and prototypes of various kinds and degrees of fidelity (Goldschmidt 1997; Pipes 2007; Badke-Schaub and Frankenberger 2004; Dahl et al. 2001; Jonson 2005; Stolterman 2008; Visser 2006). These embodiments are critical to design activity. They are used to explore the design problem and generate solution proposals that may then be employed to both communicate

design intent to others and as a way for the designer to reflect-in-action (Schön 1983) upon the physical embodiment of design ideas. In this way, there exists a relationship between the designer, the particular design tool used during activity and the kinds of embodiments made in support of the various requirements of practice. The character of an individual tool will influence the kinds of embodiments made (Tovey and Owen 2000). The skills and experience of the designer have implications for the ways in which the design tool is used during design activity, which in turn influences the character of the design embodiment (Lawson and Dorst 2009). Finally, all design activity is tied to and influenced by the various requirements of the design process (simplified model, Figure 1), within which activity locates as solutions are progressed towards final specification (Cross 2007).

Universal characteristics of design activity

A literature review was conducted to identify existing work relating to design tool use for the embodiment of design intent during design activity. The outcome of this review was the identification and synthesis of a number of universal characteristics of design activity. These characteristics served as a means to investigate relationships between tool use, the character of activity and the various requirements of practice as activity progresses from conceptual design through development and into detailed specification (Figure 1). Table 1 illustrates the identified universal characteristics of design activity. The table shows five characteristics of activity, a brief descriptor outlines each of the five characteristics, source literature and terms of reference used within the literature to describe the five characteristics.

Characteristics	Description	Terms of Reference	
1. Modes of Communication	Design activity as communication to stakeholders and/or as reflection-on-action	(Dorta, Pérez and Lesage, 2008)	self-reflective mode
		(Schon, 1983)	representation, analysis, emergence
		(Goldschmidt, 1997)	dialogue with self
		(Jonson, 2005)	I-representations
2. Levels of Ambiguity	The extent to which the embodiment of design intent may be described as ambiguous (leaving room for interpretation and revision)	(Fish, 2004)	vagueness
		(Goldschmidt, 2004)	Unstructured nature
		(Goel, 1995)	Ambiguity/ Density
		(Visser, 2006)	unspecific
3.Transformational Ability	To what extent design activity is characterized by the movement from one design direction to another (lateral), or the evolution of a single design direction (vertical)	(Goel, 1995)	Transformation
		(Visser, 2006)	duplicate, add, detail, concretize, modify, revolutionize
4. Levels of Detail	The depth of detail considered during design activity and externalised through the embodiment of design intent	(Brereton, 2004)	kinds of information available
		(Visser, 2006)	precision
		(Goldschmidt, 1997)	Less/more specific
5. Levels of Commitment	The extent to which design embodiments appear to communicate commitment to design proposals	(Goel, 1995)	Early Crystallisation/ completeness
		(Pipes, 1990)	More Committed
		(Powell, 2007)	less committed
		(Tovey, Porter and Newman, 2003)	uncommitted/ more committed

Table 1: Universal characteristics of design activity.

The first characteristic, modes of communication, refers to the nature of design activity as it is used to support communication of solution ideas to others and/or the designers themselves as the embodiment of design intentions are reflected upon. All design

embodiments, be they sketches or high fidelity prototypes, may be used to a greater or lesser extent in both models of communication. However, it is the weighting of one over the other, and how the use of different tools influences this weighting, that was of interest to the study of design tools.

Levels of ambiguity refer to the extent to which design tools are used to embody intentions during design activity that appear to be more or less ambiguous. For example, a key characteristic of design sketching is often described as its ability to support ambiguous embodiment of design intent. This ambiguity is described as aiding conceptual design activity and helping the designer to avoid early fixation or attachment to initial concept ideas.

Transformational ability is referred to within the literature as the movement from one design idea to another new idea (lateral transformations), or the evolution of a single design direction (vertical transformations). Again design activity is often described by these two characteristics working together within a given design project. However, it was the weighting of one over the other that was repeatedly discussed in the literature, with, for example, the activity of sketching being characterized by an ability to laterally move between concept proposals in contrast to computer-aided design, tending towards vertical transformations.

Levels of detail refer to design activity as being marked by a concern for the specification of more or less design detail. As design activity progresses through development and on

towards detail design, levels of detail are often described as increasing in response to a requirement for final specification prior to manufacture.

Finally, levels of commitment refer to design activity as it is characterized by the degree to which design embodiments may communicate weaker or stronger level of commitment to the design proposal.

Instead of representing a prescriptive or definitive description of design activity, the five characteristics were used as a means to engage designers on their attitudes towards design activity, tool use and design embodiment. These five universal markers where therefore used as a framework for analysing designer attitudes towards design tools and their support of various design activities. The aim of this investigation was to attempt to explore relationships between the practitioners' influence upon tool use, the character of individual design tools and the ways they may be used to embody design intent to support the various requirements of practice. The aim of the study was to provide a more holistic understanding of tool use during design activity, and in so doing, support designers in their approach to and critical engagement with design tools.

Research methods

To consider relationships between the design practitioner, the design tool and the character of design embodiments made during design activity, a survey of industrial designers was conducted. A total of 244 designers comprised of 138 practitioners and 106 students were surveyed. The practitioners had been active in the professional field for three years or more. The students were all graduating designers and third year

undergraduates. All participants were drawn from the discipline of industrial design, including product and transportation design.

The survey questions were designed to analyse designer attitudes towards the character of design activity when using different tools to embody design intent. Designers were asked about their attitudes towards a given design tool in terms of its ability to support the five universal characteristics of design activity described in Table 1. Survey questions are presented in Table 2 below along with the characteristics of design activity each question was designed to measure.

Questions to measure 5 Universal Characteristics of Design Activity	Characteristics Measured
Q1.The design tools listed below are useful for: Representing the engineering detail of design ideas: Do you agree or disagree?	**Levels of Detail** To what extent the design tool affords a high or low level of specific detail.
Q2. The design tools listed below are useful for: Representing the artistic/creative form of design ideas: Do you agree or disagree?	**Levels of Detail** To what extent the design tool affords an overall or artistic impression of detail.
Q3. The design tools listed below are useful for: Representing design ideas in a more constrained, unambiguous way: Do you agree or disagree?	**Levels of Ambiguity** To what extent the design tool affords design ideas to be represented unambiguously
Q4 The design tools below are most useful for: Design work that can move easily between design ideas (Lateral Transformations): Do you agree or disagree?	**Transformational Ability** To what extent the design tool affords movement from one design idea to a new idea – horizontal transformations.
Q5 The design tools below are most useful for: Design work on variations of one or the same design idea (Vertical Transformations): Do you agree or disagree?	**Transformational Ability** To what extent the design tool affords movement from one idea to a variation of the same idea – vertical transformations
Q6 The design tools below: Communicate a high level of commitment to design ideas: Do you agree or disagree?	**Levels of Commitment** How the design tool communicates a high or low level of commitment to design ideas.
Q7 The design tools below are more useful for: Communicating design intentions to others: Do you agree or disagree?	**Modes of Communication** How the design tool affords communication of design ideas to others.
Q8 The design tools below: Aid self reflection and the dynamic generation and evolution of design ideas: Do you agree or disagree?	**Modes of Communication** How the design tool affords self-reflection and the emergence of design ideas

Table 2: Survey questions and the characteristics of design activity measured.

Responses to survey questions were registered using a five-point Likert scale (Bryman 2008), whereby the following response values were given: strongly agree (+2) agree (+1) neutral (0) disagree (-1) strongly disagree (-2).

Research results

In addition to presenting empirical research outcomes, this article also describes the ongoing translation of research findings into an interactive digital resource to support

industrial design practice. As such, the presentation of research findings is restricted to an overview. A more detailed account of the results can be found in Self et al. (2009).

A survey study of designers sampled two distinct groups: practicing industrial designers and design students. The Dreyfus model of skills acquisition was used as a means to identify differences within the skills and levels of expertise present within the two samples (Dreyfus and Dreyfus 1986). Dreyfus (Dreyfus and Dreyfus 1986) proposes a generic model of expertise consisting of six stages: 'novice', 'advanced beginner', 'competent', 'expert', 'master' and 'visionary'. Applying the Dreyfus model (Dreyfus and Dreyfus 1986) to the skilled embodiment of design intentions through drawing and sketching, Lawson and Dorst (Lawson and Dorst 2009: page 106 suggest the critical importance of the designer's level of expertise, describing the designer who is less able to represent ideas effectively as, 'severely handicapped and unlikely to be able to reach an advanced level of expertise' (Lawson and Dorst 2009). In terms of the survey's two sample groups, student participants were classified as 'advanced beginners' (Dreyfus and Dreyfus 1986), practitioners falling within the levels of 'expert' to 'master'.

Figure 2 illustrates the responses for students and practitioners to a survey question asking of attitudes towards the ability of hand sketching to support unambiguous design embodiment during design activity. The horizontal axis lists the five items of a Likert scale question.

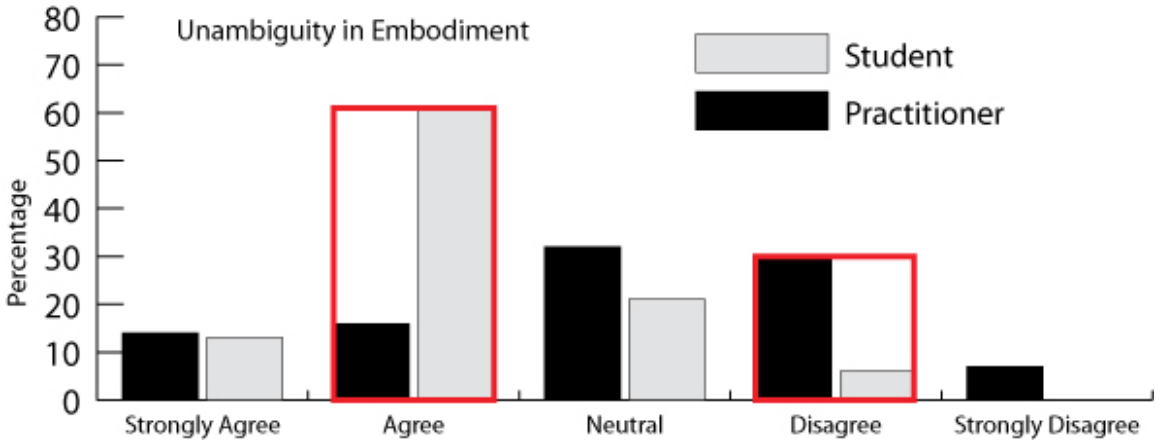


Figure 2: Hand sketching is useful for representing design ideas in a more constrained, unambiguous way. Do you agree or disagree?

In terms of ambiguity and sketching, responses suggested different attitudes towards the ability of design activity, through sketching, to be characterized by the unambiguous embodiment of design intent. This may suggest different approaches to design activity when using hand sketching to embody design proposals. The students tending towards unambiguous embodiment (indicated in a larger percentage of students registering agreement, Figure 2, 61%). The practitioners, on the other hand, may tend to be more inclined to use sketching in an activity that supports more ambiguous embodiments (indicated by a greater number of neutral or negative responses, neutral: 32%, disagree: 30%, strongly disagree: 7%).

Difference in response between sample groups was also seen in findings relating to the use of other design tools. Figure 3 illustrates results relating to sketch modelling (the use of foam, card and paper to quickly embody design intentions as physical models) and its ability to support the ambiguous embodiment of design intentions during design activity.

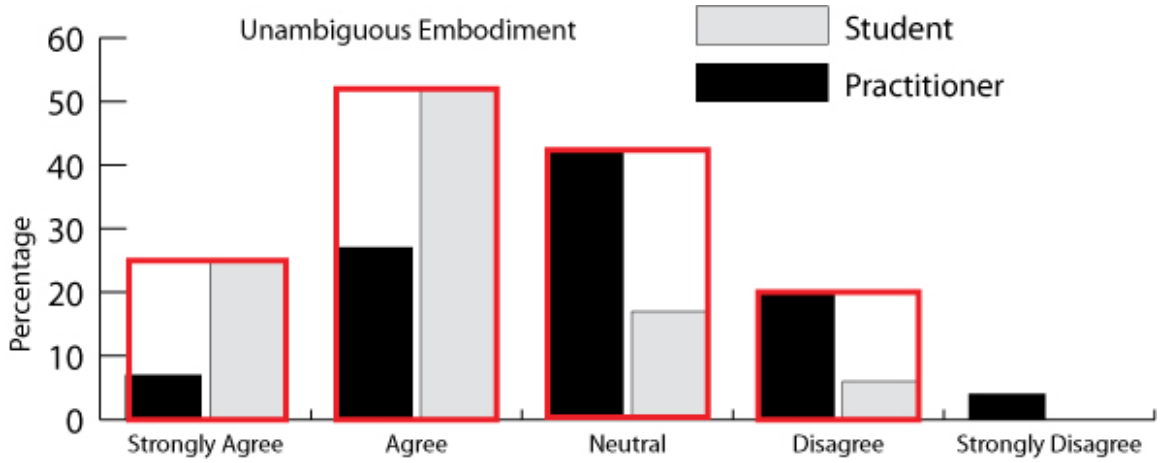


Figure 3: Sketch modelling is useful for representing design ideas in a more constrained, unambiguous way. Do you agree or disagree?

As was the case with results relating to hand sketching (Figure 2), findings suggested different attitudes towards the capacity of sketch modelling to support design activity that may be described as unambiguous in its embodiment of design intent. The more positive response from the student sample may suggest an approach to design activity when using sketch modelling that tends towards unambiguity and fixation of concept compared to the practitioners (seen in greater number of positive student response, Figure 3).

Figure 4 illustrates survey findings relating to a question asking of sketch modelling's ability to support reflection-in-action during design activity.

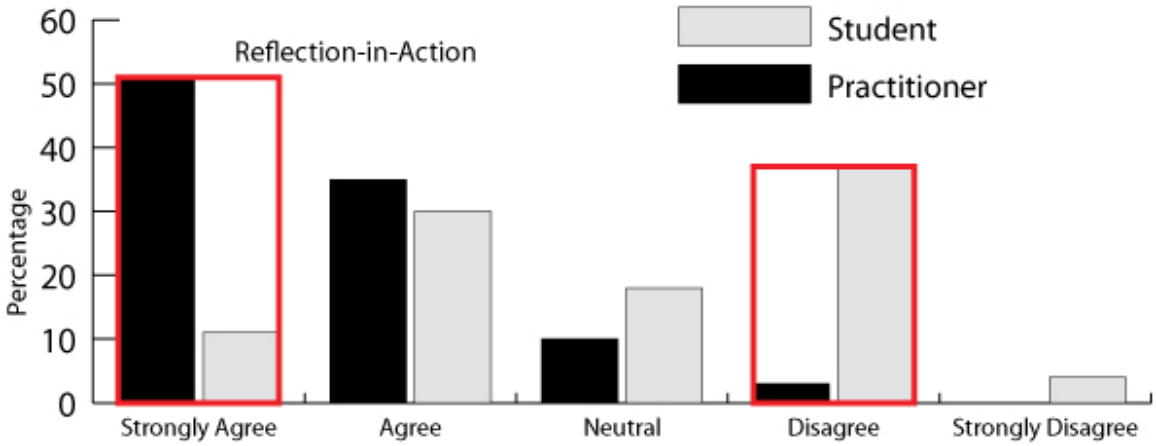


Figure 4: Sketch modelling aids self reflection and the dynamic generation and evolution of design ideas. Do you agree or disagree?

Again, the survey results suggested a contrast in attitudes towards design activity when using sketch modelling tools. The practitioners were more inclined to strongly agree (51%) or agree (36%) sketch modelling aids reflection-in-action (black bars, Figure 4). Student findings were mixed across the five items of the Likert scale, some in agreement (30%) others in disagreement (37%). This may indicate different attitudes towards and approaches to design activity when engaged in design embodiment through sketch modelling, with practitioners employing greater reflection and students tending to reflect less and move design towards specification more quickly.

Responses towards the ability of sketch modelling to support design activity characterized by the lateral movement between design proposals, and so support divergent design activity, also indicated contrasting attitudes between the two sample groups (Figure 5).

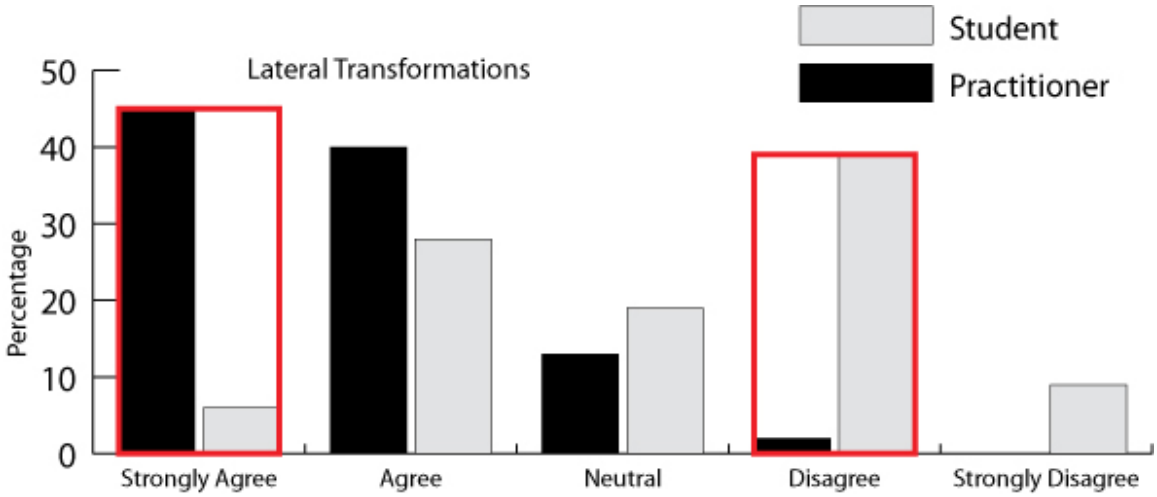


Figure 5: Sketch modelling is useful for design work that can move easily between design ideas (lateral transformations). Do you agree or disagree?

The design practitioners tended to register responses of strong agreement (45%) or agreement (40%) in contrast to the students' more mixed response across the five items of the Likert scale (grey bars, Figure 5). This again suggested different approaches to design activity during design embodiment through sketch modelling tools practitioners being more inclined to lateral transformations, divergence and iterations. Students erring towards earlier fixation and attachment to a concept.

Emergent in survey findings was a tendency, across a variety of design tools, for less-experienced designers (design students) to respond more negatively to questions relating to those characteristics associated with divergent design activity; ambiguity in embodiment; the lateral transformation between various design proposals; and reflection-in-action during design embodiment. This may suggest a significant difference in the students' approach to design activity and the ways tools are used to support studio practice. It may be that less-experienced designers err towards design convergence during

design activity. The ways in which they approach design embodiment, through the use of design tools, is a reflection of this. In contrast, and with experience of practice, design practitioners tend to remain more open to iterative divergence, and it is this open approach that influences more positive attitudes towards the characteristics of design activity associated with exploitive conceptual design, lateral transformations, ambiguity of embodiment and reflection-in-action.

It seems that the experiential knowledge and understanding displayed in the work of the more experienced designers differs from that seen in the practice of students. Because this is the case, it is important that students are made aware of the ways in which expert designers approach design activity and tool use. Opportunities to do this will help students to reflect upon their own design practice and its ability to support a process of design. The following section describes an attempt to support the communication of knowledge on the use of design tools within design activity.

Research dissemination as digital resource (IDsite)

The following section discusses the ongoing development of a digital resource, branded IDsite. The aim of IDsite is to present research findings in a way that is both relevant to and accessible by an intended audience of industrial design students and practitioners. A pilot proposed as an initial test study at an interim stage of the site's development is presented.

The challenge of engaging practicing designers in design research is identified by Dorst:

> We [design research] need to re-engage with practitioners, and get involved in experiments within the rapidly changing design arena. Design researchers should join design practitioners in co-creating the design expertise and design practices of the future. (2007: 11)

The aim of the resource was to engage practitioners and design students through dissemination of research outcomes in a format and style that might be more relevant and accessible compared to more conventional forms of research dissemination (publication of findings through journal papers for example). The objective was to provide a platform to promote awareness of the role tools play within the wider contexts of studio practice, supporting a more critical engagement with tools during design embodiment during design activity.

The following objectives informed the design and realization of the digital resource:

1. to illustrate and describe the industrial design process as a staged model, progressing towards the specification of deign intent prior to manufacture

2. to describe the iterative nature of design activity between periods of convergent evolution and divergent exploration

3. illustrate where, typically, tools of various kinds are used to support practice

4. articulate tool effectiveness in support of the various requirements of practice through relating the character of tools to the requirements of practice

and to:

5. engage an audience of practicing and student designers through the presentation of knowledge in a way that is immediately accessible and clearly relevant to studio practice.

A review of existing attempts to engage practice through systems and tools for supporting design activity identified a card-based approach as a popular option (Methods Cards for IDEO. 2010; Lockton et al. 2010; Pei 2009). However, it was decided that a Web-based, interactive resource would be advantageous when compared to an approach based upon the use of physical cards. The logistical and financial cost of Web-based publication through hosting was seen as more economic in terms of time and cost compared to a printed publication. Importantly, for a study wishing to disseminate findings to the widest possible audience, Web publication affords the opportunity to reach larger audiences. Given a requirement to include visual images as reference points to aid explanation and engage the audience, a Web-based approach would provide an opportunity for the use of multimedia through the layering of information in the form of images and graphic animation. A Web-based approach would also provide opportunity for continually revision and evolution of the resource in light of testing and validation studies.

Design and realisation of digital resource

Figure 6 illustrates a screenshot of the resource's home page. The page presents a simplified model of industrial design practice as illustrated in Figure 1 above. Interactive buttons were embedded within the model. As the curser hovers over each of these buttons, information relating to the stage in practice is displayed.

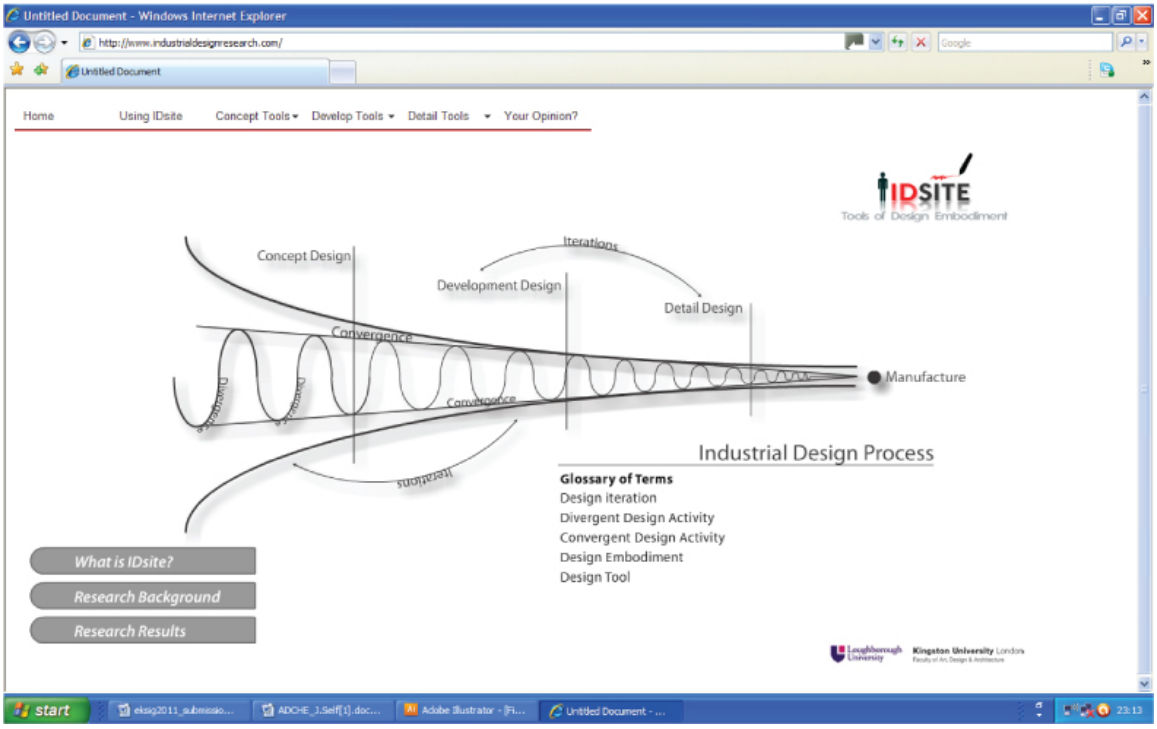


Figure 6: Home page of IDsite with curser hovering over Detail Design button.

Navigation of the site is achieved via a horizontal navigation bar consisting of four buttons: 'Home', 'Concept Design Tools', 'Development Design Tools' and 'Detail Design Tools' (Figure 6). Hovering over any of these brings down a panel of tool options. Clicking on these tool options navigates to the corresponding tool. Figure 7 illustrates the Web page relating to the design tool sketch modelling. On the left, two variants of sketch modelling, 'Explorative Sketch Models' and 'Explorative "Ad hoc"

Sketch Models', are shown. Hovering over either one of these variants brings up a descriptor of the tool and its place of use during studio practice (red oval, Figure 7).

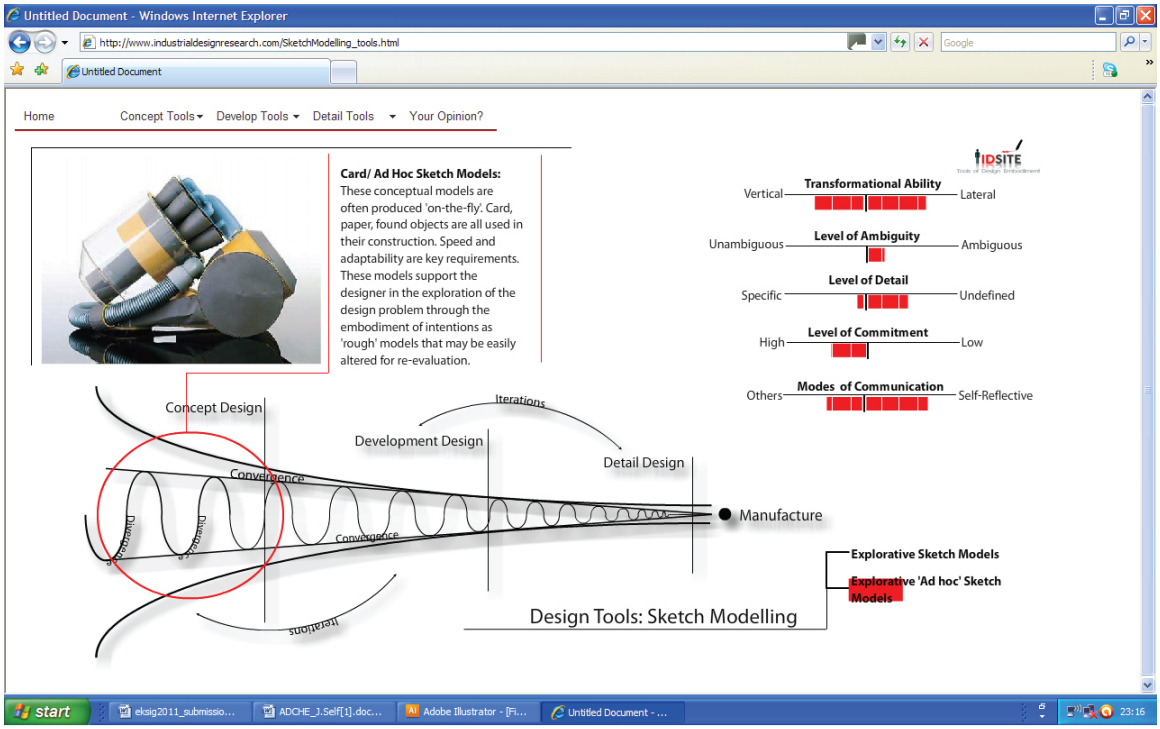


Figure 7: Page relating to the design tool sketch modelling.

In addition to communicate information relating to the various design tools investigated during a period of empirical research, IDsite attempts to describe relationships between the character of various tools, the requirements of practice and the practitioner's own idiosyncratic use of tools during design activity. To achieve this, a second 'characteristics' menu, to the right, is included on each of the tool pages. This menu comprises of five buttons: 'Transformational Ability', 'Levels of Ambiguity', 'Levels of Detail', 'Levels of Commitment' and 'Modes of Communication' (Figure 8). Hovering over any of these five provides a description of the characteristic and explains how it may relate to the tool's ability to support design activity during concept, development and detail design. Figure 8 illustrates the curser hovering over 'Transformational Ability'.

Information relating to the relationship between sketch modelling and design activity as it is characterized by lateral and vertical transformations is displayed.

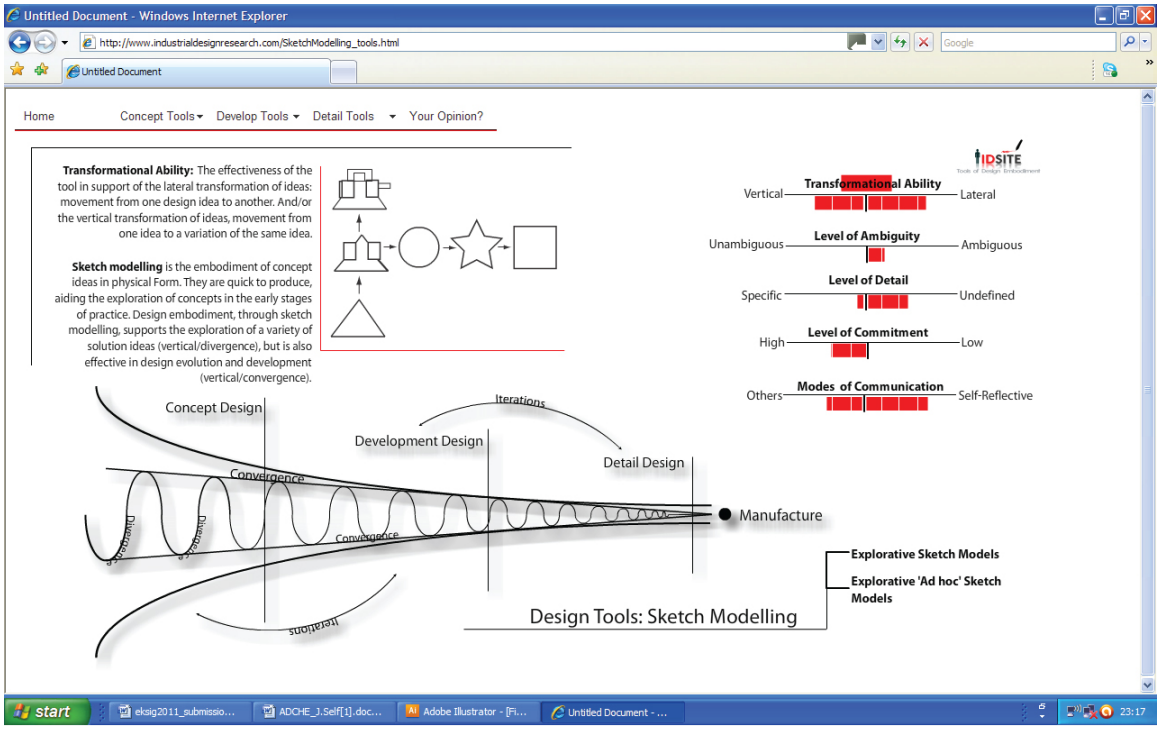


Figure 8: Sketch modelling page showing relationship between design tool and its ability to support transformative design activity.

Pilot survey of site

An alpha version of IDsite was piloted as a means to initially test the resource at an interim point in its development. A sample of 50 design practitioners were contacted via e-mail and invited to take part in a survey asking their opinion of the resource and its ability to support understanding of design tool use during design activity. Attribute questions were first used to gather information on the designers' employment, education and experience. These consisted of four questions regarding the practitioners' place of work, job title, the discipline within which the designer worked, and the length of time worked within the design industry. A further six questions invited the practitioners'

response to the digital resource. Rating scales were used to gather qualitative data on designer attitudes, with practitioners registering responses using a five-item Likert scale consisting of the following response values: excellent; very good; average; below average; and poor. A final survey question provided the respondents with an opportunity to add comments and suggestions. Of the 50 designers contacted, sixteen completed the online survey which represented a response rate of 32 per cent.

Pilot results

Figure 10 illustrates results relating to the attribute question asking respondents about their job title. As the figure suggests, the majority of practitioners described themselves as company directors. This may be related to findings from Question 1, indicating a majority of respondents worked in smaller-sized consultancies. Together with findings from other attribute questions (length of time within industry), the findings suggest that a majority of respondents had four or more years experience of practice and held senior positions within the companies in which they worked.

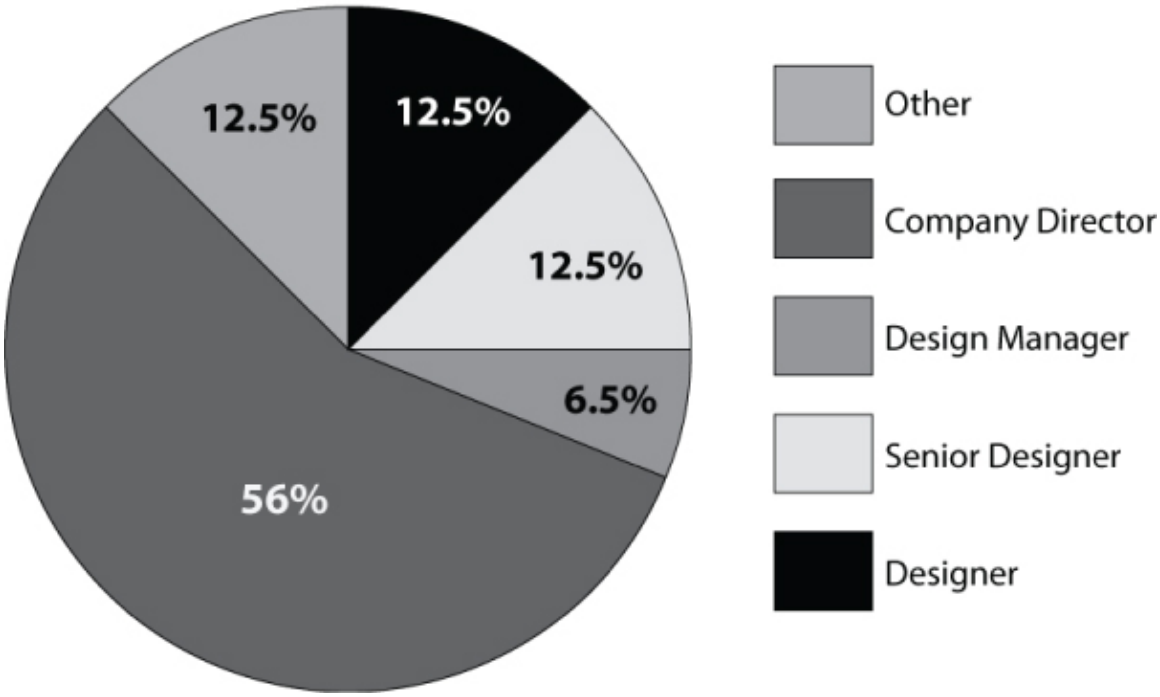


Figure 9: Q2: What is your job title?

Figure 10 illustrates findings for Pilot Survey Question 5, which explored the ability of practitioners to navigate the site.

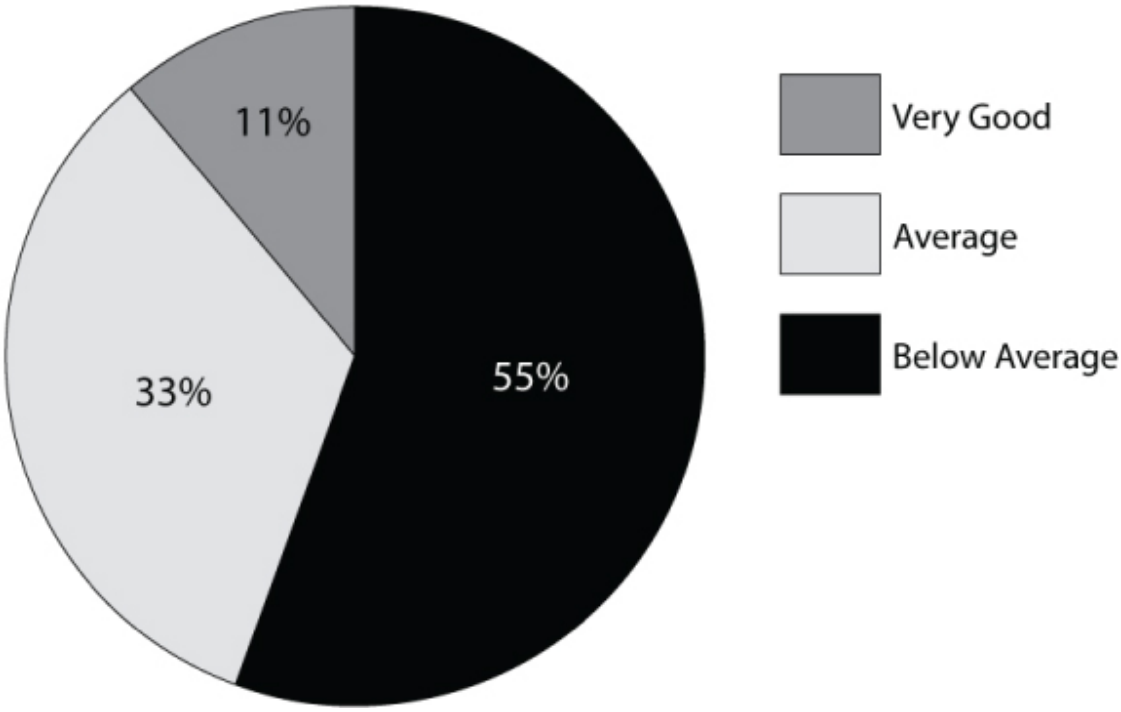


Figure 10: Q5: How do you fell about your ability to navigate the site?

The majority of practitioners registered a below average response to this question (black segment), suggesting respondents found the resource difficult to navigate. Problems with the speed and response of the drop-down menus and hover panels were identified as a possible reason for the more negative responses. Moreover, some of the qualitative feedback suggested the navigation menu, and the overall presentation of information seemed difficult to understand. As one respondent indicates: ‘The degree of complexity is off-putting’.

Figure 11 illustrates results for Question 11 that explored the capacity of the resource to clearly communicate information relating to design tool use during design activity. Although a majority of respondents rated the site as average in its clarity of information,

others registered below average or poor responses. Again, qualitative responses indicated concerns over clarity in terms of the complexity of the resource, as on respondent suggested: ‘In fact I find the general graphics a bit “unfinished”’.

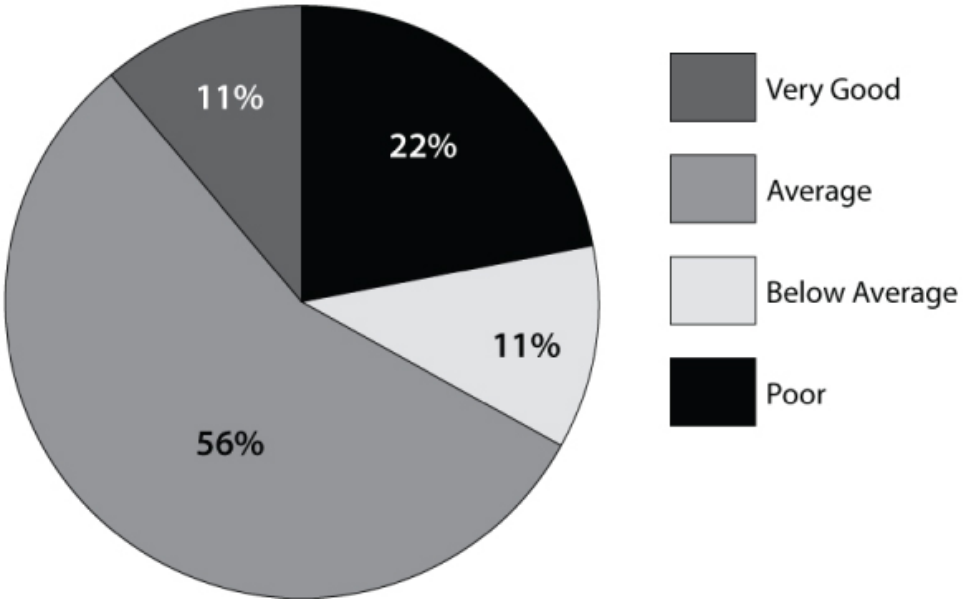


Figure 11: Q6: How would you rate the clarity and understandability of textual and pictorial content?

When asked about the ability of the digital resource to describe the design process (Figure 12), 45 per cent registered an average response, with others rating the site as very good and, fewer, as below average. Responses suggested that designers generally reacted positively to the description of the design process presented in the digital resource.

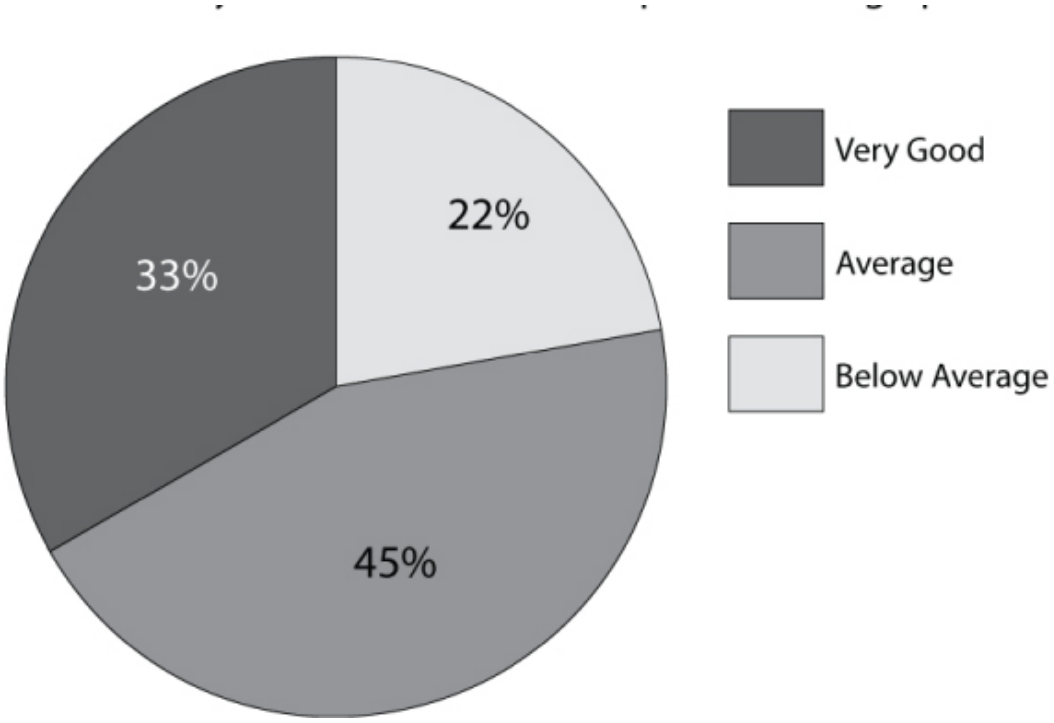


Figure 12: Q7: How would you rate the site's description of the design process?

Figure 13 illustrates results relating to practitioners' responses to the ability of the resource to foster understanding of tool use within design activity. A majority of the pilot sample registered an average response, with the remainder indicating a negative attitude towards IDsite's ability to support improved understanding. Of the sixteen respondents, only half completed Question 8, with all responses falling within two of the five items of the Likert scale: poor and average, Figure 13).

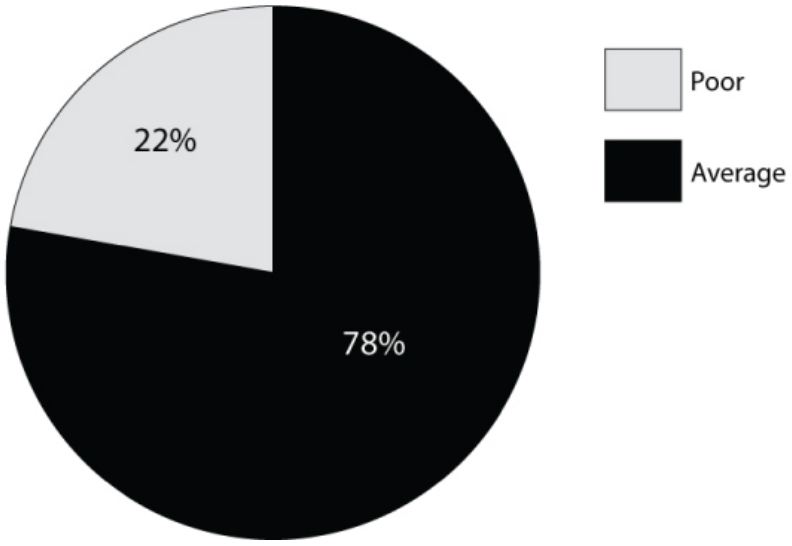


Figure 13: Q8. How would you rate the ability of the site to foster enhanced understanding of various design tools and their support of practice?

Findings from this initial pilot study, as part of the ongoing development of IDsite, highlighted problems in terms of the site's ability to communicate research outcomes clearly. However, as a pilot study, these findings were successful in indicating how IDsite might be revised and further developed before additional validation is undertaken. Encouragingly, although concern was voiced over the design and execution of the digital resource, practitioners considered the idea of a new approach to research dissemination interesting and relevant: 'A great idea for students […]. It seemed like a good idea but it misses the target in execution'.

The pilot was required to identify problems which could be addressed at an interim stage of the site's development. At the time of writing, IDsite continues to be developed in

light of the pilot's findings. Further testing and validation using larger samples of industrial design students, educators and practitioners are planned.

Conclusion

This article has presented empirical findings from a survey study of two distinct groups of industrial designers: design students and design practitioners. The survey explored approaches to design activity through analysis of relationships between a designer's level of expertise and attitudes towards the use of design tools during studio practice. Findings were then considered in terms of the practioners' approach to design activity during studio practice.

Existing work relating to the character of design activity was identified and synthesized in the design of the survey study (see Table 1). Instead of constituting a prescriptive or definitive set of principles through which design activity may be described, five characteristics acted as a framework for investigating designer attitudes towards design activity when using various design tools. The survey questions facilitated feedback on designer attitudes towards the ability of various design tools to support the five characteristics of design activity.

Empirical findings have suggested differences in attitudes between samples towards the ways various tools support the five characteristics. Significantly, findings may indicate student designers err towards an early fixation and attachment to concept. Evidence of this was seen in attitudes towards the ability of design tools to support those

characteristics of activity often associated with divergent concept design: reflection-in-action, lateral transformations and ambiguity in the embodiment of design intent. Practitioner findings indicated a more positive response to questions on the tools' ability to support the same conceptual, explorative characteristics. This may be evidence of a tendency for experienced practitioners to take a more open, divergent and iterative approach to design activity during their studio practice. It is also evidence of how the designer's experiential knowledge is developed through experience of practice. In making this knowledge and understanding explicit, design educators will be better able to underpin their students' studio work through providing opportunities for them to consider the concepts and principles that underpin the expert designer's approach to design activity and use of design tools.

A survey study identified a relationship between designer expertise and approaches to practice that relates to the divergent/convergent model of the design. In response to this IDsite attempts to provide a platform for understanding the rich and complex activity of industrial design, how the use of tools and the designer's own idiosyncratic approach has influence upon design activity during studio practice and the final specification of design intent. IDsite is one example of how experiential knowledge may be communicated in a way that employs the visual language of design to engage the audience and communicate research findings.

A pilot of the site has suggested, although the approach to research dissemination was seen as significant and relevant, challenges remain in the design of the resource and its

ability to communicate research clearly. In the ongoing development of IDsite, the authors are working to address these concerns through a second iteration of the resource in response to the pilot study. A beta version of IDsite will undergo a period of further validation, helping to continue the evolution of the resource. Although the digital resource is clearly a work in progress, it represents an example of how innovation in research knowledge dissemination can be used to engage an audience of design practitioners.

This approach to research dissemination has the potential to facilitate improved engagement with a practice-orientated audience. Whilst acknowledging the role of more conventional methods of dissemination, more relevant approaches to the articulation and exchange of design research knowledge are required. These approaches call for innovation in knowledge dissemination that exploits the highly visual language of design in order to best engage practice.

References

Badke-Schaub, P. and Frankenberger, E (2004), 'Design representations in critical situations of product development', in G. Goldschmidt and W. Porter (eds), *Design Representation*, pp. 105–26. Springer. London.

Brereton, M. (2004), 'Distributed cognition in engineering design: Negotiating between abstract and material representations', in G. Goldschmidt and W. Porter (eds), *Design Representation*, London: Springer, pp. 83–103.

Bryman, A. (2008), *Social Research Methods*, 3rd ed., Oxford: Oxford University Press.

Cross, N. (2000), *Engineering Design Methods: Strategies for Product Design*, 3rd ed., Chichester: John Wiley & Sons.

Cross, N. (2007), *Designerly Ways of Knowin*, Basel: Birkhauser.

Dahl, D. W., Chattopadhyay, A. and Gorn, G. J. (2001), 'The importance of visualisation in concept design', *Design Studies*, 22:1, pp. 5–26.

Dormer, P. (1993), *Design Since 1945*, London: Thames & Hudson.

Dorst, K. (2007), 'Design research: A revolution-waiting-to-happen', *Design Studies*, 29:1, pp. 4–11.

Dorta, T., Pérez, E. and Lesage, A. (2008), 'The ideation gap: Hybrid tools, design flow and practice', *Design Studies*, 29:2, pp. 121–41.

Dreyfus, H. L. and Dreyfus, S. E. (1986), *Mind Over Machine: The Power of Human Intuition and Expertise in the Age of the Computer*, Oxford: Basil Blackwell.

Fish, J. (2004), 'Cognitive catalysis: Sketches for a time-lagged brain', in G. Goldschmidt and W. Porter (eds), *Design Representation*, London: Springer, pp. 151–84.

Goel, V. (1995), *Sketches of Thought*, London: The MIT Press.

Goldschmidt, G. (1997), 'Capturing indeterminism: Representation in the design problem space', *Design Studies*, 18:4, pp. 441–55.

Goldschmidt, G. (2004), 'Design representation: Private process, public image', in G. Goldschmidt and W. Porter (eds), *Design Representation*, London: Springer, pp. 203–17.

Methods Cards for IDEO (2010), Methods Cards for IDEO http://www.ideo.com/work/method-cards/. Accessed: 23 August 2010.

Jonson, B. (2005), 'Design ideation: The conceptual sketch in the digital age', *Design Studies*, 26:6, pp. 613–24.

Lawson, B. and Dorst, K. (2009), *Design Expertise*, Oxford: Architectural Press.

Lockton, D., Harrison, D. and stanton, N. (2010), 'The design with intent method: A design tool for influencing user behaviour', *Applied Ergonomics*, 41:3, pp. 382–92.

Pei, E. (2009), 'Building a common language of design representation for industrial designers & engineering designers', Ph.D. thesis, UK: Department of design and technology, Loughborough University.

Pipes, A. (2007), *Drawing for Designers*, London: Laurance King Publishing.

Pipes, A. (1990), *Drawing for 3-Dimensional Design*, London: Thames & Hudson.

Powell, D. (2007), 'Product design: The essentials of product design', http://www.designcouncil.org.uk/en/About-Design/Design-Disciplines/Product-design/ Design Research Council. Accessed 4 March 2007.

Purcell, A. T. and Gero, J. S. (1998). 'Drawings and the design process: A review of protocol studies in design and other disciplines and related research in cognitive psychology', *Design Studies*, 19:4, pp. 389–430.

Schön, D. (1983), *The Reflective Practitoner*, London: Ashgate.

Schön, D. and Wiggins, G. (1992), 'Kinds of seeing and their functions in designing', *Design Studies*, 13:2, pp. 135–56.

Self, J., Dalke, H. and Evans, M. (2009), 'Industrial design tools and design practice: An approach for understanding relationships between design tools and practice', *IASDR 2009 Proceedings, Design Rigor and Relevance*, 18th – 22nd October, 2009. Seoul. Korea Society of Design Science.

Stolterman, E. (2008), 'Designerly tools', *DRS2008 Conference*, Sheffield University, Sheffield, UK, 16–19 July.

Tovey, M. and Owen, J. (2000), 'Sketching and direct CAD modelling in automotive design', *Design Studies*, 21:6, pp. 569–88.

Tovey, M., Porter, S. and Newman, R. (2003), 'Sketching, concept development and automotive design', *Design Studies*, 24:2, pp. 135–53.

Visser, W. (2006), *The Cognitive Artifacts of Designing*, New York: Routledge.