Design ideation: the conceptual sketch in the digital age

Ben Jonson, University of London, Goldsmiths College, Department of Design, New Cross, London SE14 6NW, UK

The freehand sketch has traditionally been seen as the primary conceptual tool in the early stages of the design process. But what is the impact of digital technology on conceptual tools and sketching in particular? A multiple case study compared how design students and design practitioners used conceptual tools in everyday design situations. The outcome showed that verbalisation, rather than freehand sketching was the major conceptual tool for getting started. Moreover, the computer emerged as an ideation tool across design domains.

Keywords: conceptual design, design process, design tools, drawing, design ideation

Design ideation can be seen as a matter of generating, developing and communicating ideas, where 'idea' is understood as a basic element of thought that can be either visual, concrete or abstract. As such it is an essential part of the design process, both in education and practice (Broadbent, in Fowles, 1979:15). In this process, freehand sketching has traditionally been considered a core conceptual tool (Schon, 1983; Garner, 1992; Goel, 1995; Suwa and Tversky, 1997; Cross, 1999; Tversky, 1999; Plimmer and Apperley, 2002; Bilda and Demirkan, 2003). But despite the extensive literature on the subject, the role of sketching may not have been sufficiently examined or challenged in the digital age, including the view that computer-aided design, CAD, is an inappropriate means for conceptualisation (Lawson and Loke, 1997; Verstijnen et al., 1998; Purcell, 1998).

1 Case study

1.1 Participants and projects

To illuminate uses of conceptual tools in education and professional practice, five undergraduate design students and five design practitioners in the domains of fashion (FA), architecture (AR), graphic (GR), product (PR), and general design (DE) volunteered to take part in

Corresponding author:
B. Jonson
ben_jonson@hotmail.com

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a comparative case study. The students, who were in their second-year (Y2), and the practitioners, who had been working between one and two years since their graduation, were asked to record uses of conceptual tools as they started on a new design project within their respective domain (*situated research*). Each project, therefore, was part of everyday designing and included in the case study for being accessible at the time of the research.

The project briefs were: (1) to design a collection of six outfits containing a particular print motif (fashion student); (2) to design a luggage range incorporating printed canvas (fashion practitioner); (3) to design an arrival building for visitors on a National Trust site (architecture student); (4) to design a flagship fashion store in London's Oxford street (practising architect); (5) to design an interactive experience that communicates a sense of space (graphic design student); (6) to design an interactive web site for an international retail company introducing a new brand (graphic designer); (7) to design further adaptation and use of electrical plugs and plug sockets (product design student); (8) to design a new retail concept for future record selling business (product designer); (9) to find design solutions for urban cycling (general design student); (10) to design an interactive artefact for an exhibition space (general design practitioner).

1.2 Data collection

The data gathering aimed at capturing uses of conceptual tools as they actually happened in everyday design across a wide spectrum of design domains. The focus on authentic design situations was important because common experience suggests that ideation thrives under opportunistic rather than organisational conditions. Therefore, and unlike laboratory-like research, the participants would need the greatest freedom possible in using their own tools and having unrestricted access to information (Dwarakanath and Blessing, 1996), both in terms of type of information and order of processing it (Plass et al., 1998).

Direct observation, including the think-aloud method, was one possible way of gathering research material. Yet, this method has been criticised for being weak at capturing non-verbal thought processes (Cross et al., 1996), or for affecting the design process itself (Davies, 1995:103). Similarly, participant observation (Robson, 1993:159) raised the issues of confidentiality, reactivity and access and might therefore interfere with the free flow of ideas, particularly as ideation realistically would be situated not only in the studio, but in many 'other places'. Moreover, the observation that design concepts may not appear, 'all at once'

(Goldschmidt, 1994:164), or that the designer cannot always trace the steps of conceptualising (Davies and Talbot, 1987:21), underlined how data collection was a critical research issue.

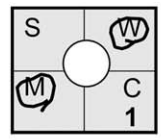
The research instrument, therefore, would have to be both reliable and user-friendly, capable of capturing uses of conceptual tools not after the conceptual events, but during the events. This approach suggested how feedback might be received from participants if they themselves, rather than the researcher, were to identify and record their use of conceptual tools as they went along. Self-reporting, then, resulted in a research instrument that was designed in two parts: the self-report and the interview. In this, the self-report, as a kind of a diary, effectively became a preliminary to interviewing (Burgess, 1981). Therefore, the two protocols complemented each other and, moreover, helped check the authenticity of the outcomes.

1.3 The self-report

The notion of reflective practice (Schon, 1983) together with how designers use sketchbooks, creative journals, diaries and similar devices for keeping track of ideas, informed the designing of the self-report. Thus, the self-report was laid out as a simple grid of numbered squares on paper where each square represented half-a-day of ideation activity. The number of squares was open-ended because the conceptualisation period could not be pre-determined because it would necessarily vary in length according to each individual project. The choice of an ideation period of half-a-day was a pragmatic time management issue reflecting how self-reporting in real design situations could not be a stopwatch activity, as might be the case in a study under controlled conditions, but rather an activity akin to 'reflection-in-action' (Schon, 1983). Moreover, the usability of the self-report was tested in a pilot study prior to the case study.

Each numbered square, therefore, represented a time- and event-based coding unit for four categories of conceptual tools: sketching [S], words [W], modelling [M], and computing [C] (Figure 1b). According to the Guidelines, shown here partially for the purpose of this paper, the participants simply encircled with a pen the symbol(s) for the tool(s) used in each session of the conceptual phase (Figure 1a, b). Thus, any kind of freehand line drawing, including annotation, was marked as sketching [S]. Words [W] meant both spoken and written words, including Internet searches. Any activity involving direct manipulation of materials, say card, wood, or fabric, was denoted modelling [M]. Any

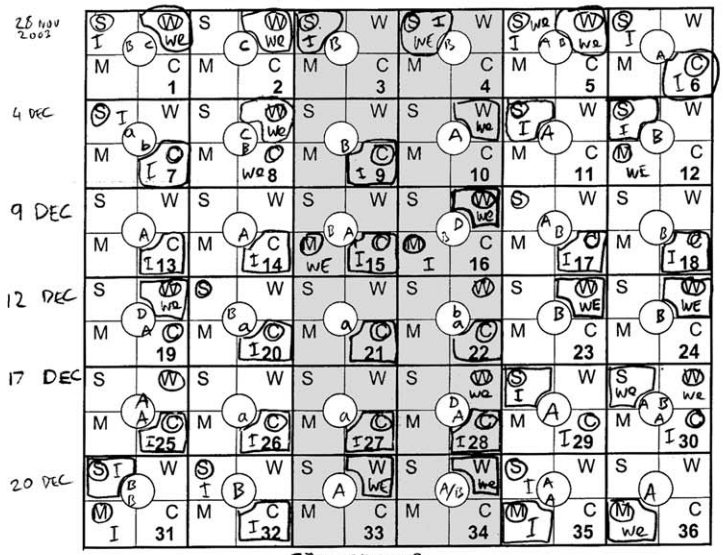
(a)



S = Freehand SKETCH
W = Spoken & Written WORDS
M = Sketch MODELLING
C = COMPUTING (CAG/CAD/Multimedia)
1 (etc.) = Other tools in numbered footnote.

(b)

Each numbered square (1-36) represents one half-Day session worked.



Footnotes: Using the square numbers as reference (1-36), add other tools, special circumstances or "landmark events" ("Aha!") you experienced during the sessions worked.

(2) OFFICE VISIT TO TATE BRITAIN TO SEE BAR DESIGNED BY FS.
(5) TEAM MEETING - — QUICK DECISION MAKING IN ADVANCE OF MEETING W/CLIENT (8) CLIENT meeting - V. good discussion (10) FIRST SITE VISIT — VERY INSPIRATIONAL! (18) DESIGN BREAKTHROUGH! RESULT OF TESTING NEW 3D-MODELLING SOFTWARE "ARGON"
(23)+(24) MEETING W/ "CONVEYOR" PEOPLE, CENTRAL ELEMENT OF SCHEME...
(34) 1ST DAY BACK FROM HOLIDAYS — TEAM "BRAINSTORMING" + ORGANISATION.

Figure 1 (a) Guidelines: For each session worked, circle the tool(s) (S,W,M,C) you used in that session. If other than S, W, M, C, describe in numbered footnote (1, etc.). (b) An example of how the self-report was filled in. It shows the architect's first sheet of the self-report, or 36 sessions (of a total of 85 recorded sessions). N.B. More data were recorded in and extracted from the self-report than presented in this paper

digital work, from CAD to hypermedia, was described as computing [C].

The word 'tool' might invoke the mechanical, rather than the digital age. Yet 'tool' was used for representing both action and thinking, as in 'thinking tool', and therefore the notion of conceptual tools covered both physical and cognitive activities. However, the chosen tool categories, which were tested in the pilot study, were not exclusive. The self-report, therefore, provided additional space to record conceptual tools other than [S], [W], [M], and [C] (Figure 1b). In the event, however, none of the participants reported using any other tool. But just 'having ideas in one's head' did not constitute a tool option because the term conceptual tool implied the need for ideas to be externalised, or nobody else would know about them. Yet this was not to dismiss 'non-productive thoughts', say, daydreaming, which, if externalised, for instance as doodling, would be regarded as sketching [S].

1.4 The interview

The participants' thoughts on ideation after the events, or 'reflection-on-action' (Schon, 1983), were important not only as a source of research material, but also as a data check because self-reporting can be faulty, particularly through forgetfulness. At the end of the conceptualising period, therefore, individual interviews were conducted with the participants. Each interview, which was audio-taped and transcribed, included the following scripted questions: What conceptual tools did you use? Where in the design process did you use them? Did you experience any sudden insights ('Aha!'), and if so, what conceptual tools were then used? What were the strengths and weaknesses of the respective conceptual tools? The interviews, however, went beyond the scripted questions confirming how case study interviews 'appear to be guided conversations rather than structural queries' (Yin, 2003:89).

1.5 Analytical approach

The research material, as recorded in the self-reports and the interviews, was not treated as sample data, but rather as rich descriptions in which the authority of the research was shared between the researcher and the participants, as co-researchers. Therefore, protocol reliability and validity was built on trustworthiness from a practical and pragmatic perspective (Silverman, 2001). Moreover, using purposive sampling (Denzin and Lincoln, 1994), the case study did not amount to a survey and therefore any generalisation would be of an analytical rather than statistical nature (Yin, 2003).

The length of the conceptualisation period varied greatly in the 10 cases reflecting the unique character of each project as well as individual approaches to ideation. Thus, the fashion student recorded 29 conceptual sessions; the fashion practitioner 7; the architecture student 17; the architect 85; the graphic design student 19; the graphic designer 45; the product design student 16; the product designer 10; the general design student 23; and the general design practitioner 6. To enable comparison between the distribution of conceptual tools according to the four tool categories, and between students and practitioners, and between domains, single tool usage was calculated case-by-case as a fraction of all tools used in each project (tool distribution).

In this, the analysis was concerned with tool usage by designer status (student or practitioner) and by design domain, not with the evaluation of ideas per se. This was because at the time of the interview, the ideas represented propositions, or work in progress, rather than final plans, artefacts or systems. The focusing on ideation as process, rather than outcome, therefore recognised the gap between the ideas and their realisation, which can be considerable. Moreover, as ideation is concerned with both thinking and feeling, assessment of ideas can be biased because they evoke personal reactions to the idea itself (Lawson, 1990).

2 Findings

2.1 Most used single tools

Table 1 shows the most used single conceptual tool, as a fraction of 1.0 of all tools used, in each of the 10 cases. For instance, the most used single tool by the second-year fashion student (Y2 FA) was modelling [M], at the ratio 0.7 (for easy reading, any other tools, and whether used or not are marked zero in the table. For a full set of figures, see Tables 2 and 3). Overall, then, what emerged was the range of 'primary tools' used by the participants with the exception of sketching [S], which was not recorded as the most used single tool in any of the cases.

Table 1 Most used single tool (ratio of all tools used)

	Y2 FA	Pr FA	Y2 AR	Pr AR	Y2 GR	Pr GR	Y2 PR	Pr PR	Y2 DE	Pr DE
Sketch	0	0	0	0	0	0	0	0	0	0
Word	0	0.4	0	0	0	0	0	0.5	0.4	0.5
Model	0.7	0	0.5	0	0	0	0.4	0	0	0
Comp	0	0	0	0.4	0.5	0.5	0	0.5	0.4	0

Table 2 Y2 students relative tool usage

	Y2 FA	Y2 AR	Y2 GR	Y2 PR	Y2 DE
Sketch	0.1	0.1	0.2	0.2	0.2
Word	0.0	0.2	0.3	0.3	0.4
Model	0.7	0.5	0.0	0.4	0.0
Comp	0.2	0.2	0.5	0.1	0.4

The findings, therefore, challenged two dominant views in the literature. First, that sketching [S] is the primary conceptual tool, and, second, that computing [C] is unsuitable for conceptualisation.

2.2 Getting started: Square One

The first ideation session in each case was particularly illuminating (Square One in the self-report). Thus, Figure 2 shows what single or mixed conceptual tool(s) the participants used, as recorded in the first session of each project. That is, single use of sketching [S], words [W], or computing [C] as well as the combination of sketching and words [S + W], and computing and words [C + W], as proportions of all the tools used in all the projects for getting started.

Again, the role of sketching was less prominent than that often assumed in the literature. That is, sketching on its own [S] initiated the design process in only one case, or 10 % of all the cases, whereas sketching in combination with another tool [S + W] was used in two cases (20%). In contrast, verbalisation on its own [W] was used in four cases (40%), and with another tool [S + W] or [C + W], in four more cases. That is, verbalisation, either on its own or together with another tool, was used in a total of eight out of 10 cases (80%). One participant went straight to the computer [C]. None began with the modelling tool [M].

2.3 Relative tool usage

The relative use of conceptual tools, as a decimal fraction of 1.0, is shown in Table 2 (Y2 students) and in Table 3 (Practitioners). For example, in Table 2, under Y2 AR, the ratio 0.1 means that the

Table 3 Practitioners relative tool usage

	Pr FA	Pr AR	Pr GR	Pr PR	Pr DE
Sketch	0.3	0.2	0.1	0.0	0.2
Word	0.4	0.3	0.4	0.5	0.5
Model	0.0	0.1	0.0	0.0	0.0
Comp	0.3	0.4	0.5	0.5	0.3

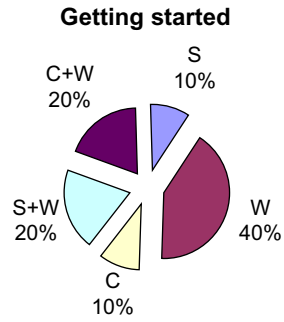


Figure 2 Tools used for getting started

second-year architecture student used sketching [S] in about 10% of the recorded sessions, whereas the corresponding figures for spoken and written words [W] were 0.2, or around 20%. Or put differently, the architecture student used words [W] roughly twice as often as sketching [S] when conceptualising. The corresponding decimal figures for the practising architect (Pr AR) were 0.2 and 0.3 (Table 3).

The findings highlighted how all the Y2 students and the practitioners, except the product designer (Pr PR), used sketching [S] as a conceptual tool. Significantly, however, in no case was sketching recorded as the most used conceptual tool.

All the Y2 students, with the exception of the fashion student (Y2 FA), and all the practitioners used words [W] in conceptualisation. Noticeable was the relative strength of verbalisation as a conceptual tool among the practitioners.

Three of the five Y2 students used the sketch modelling tool [M], which was the single most used conceptual tool, whereas among the practitioners only the architect (Pr AR) used it, which was the least used tool.

All the Y2 students and all the practitioners recorded computing [C] as a conceptual tool, and the practitioners relatively more so than the students. The software used by the participants included painting packages (bitmap), such as Adobe Photoshop™, as well as drawing packages (vector), for example, Adobe Illustrator™, Macromedia Director™, and Rhinoceros™.

2.4 'Aha!' moments

The participants were asked to capture any 'sudden breakthroughs', or so-called 'Aha!' moments, and then record the corresponding conceptual

tool(s) (Figure 1b). Figure 3 shows that all participants except the architecture student (Y2 AR) recorded at least one 'Aha!' moment. Thus, of a total of 13 such moments (aggregated from left-hand scale), a total of 15 conceptual tools were used (as coded), of which eight were words [W], three were sketching [S], another three computing [C], and one modelling [M]. The graphic design practitioner (Pr GR) was alone experiencing a 'Aha!' moment while engaged with more than one conceptual tool. And only the fashion student (Y2 FA) and the general design student (Y2 DE) recorded more than one 'Aha!' moment (three each).

The findings show how over half of the 'Aha!' moments occurred in the verbalisation mode [W]. Sketching and computing equally captured three 'Aha!' moments, in contrast to one for modelling.

3 *Discussion*

The study challenged the primacy of freehand sketching for conceptualising (Table 1). Instead, verbalisation, on its own or in combination with other conceptual tools, emerged as the prime mover for getting started (Figure 2), and was the most used tool for externalising 'Aha!' moments (Figure 3). Moreover, the combination of tools suggests that design ideation was an interaction, or a dialogue between visualisation (non-verbal) and language (verbal), similar to what has been described elsewhere as 'the language of design' (Schon, 1983), 'the translation problem' (Tomes et al., 1998), or the 'picture-word-cycle' (Dorner, 1999).

The relative strength of verbalisation, however, made sense in that words are the most common means of human communication, both in face-to-face and computer-mediated environments, as experienced by many designers in conceptualising designs (Lawson and Loke, 1997). But words are fundamental not just to communication but to the process of thought itself, although this observation may be overlooked or underestimated, as the case study findings suggest. Furthermore, verbalisation emphasised the social and collaborative aspects of

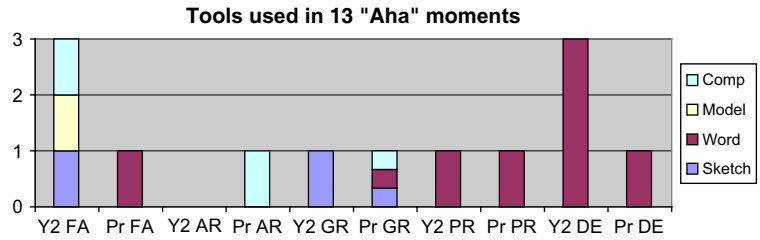


Figure 3 Tools used for capturing 'Aha!' moments

designing (Cross and Clayburn Cross, 1995). Interestingly, the fashion student was the only case where verbalisation was not used as a conceptual tool and explained by a preference for working solo, in a non-verbal mode away from other people in the early stage of the design process (Table 2).

Verbal–visual interaction, moreover, may reflect how all forms of human expressions are 'just the surface structure created by the deep structure of the human language instinct' (Nolte, 2001:106). Arguably, then, representation of ideas is the *surface* structure of ideas whereas the meaning of ideas is embedded in the *deep* structure of language. Therefore, as deep structure, 'sketching about for ideas' suggests a *sense-making* activity that is not tied to any particular conceptual tool.

In broadening the concept of sketching, then, CAD is not just a narrowly defined technical drawing tool but a conceptual tool capable of developing new ways of perceiving and conceiving design. That is, CAD may foster new patterns, relationships, or aesthetics expanding, rather than reducing designers' creative options, as suggested by the participants in their use of computing for conceptualising (Tables 2 and 3). Arguably, then, the view that CAD is inappropriate for conceptualising seems to be based on a preconception of conceptual tools as surface, rather than deep structures.

3.1 Computer-aided ideation

What seems to complicate the discussion on CAD for ideation is that commercial CAD systems tend to be driven by production needs (efficiency and accuracy), rather than creativity, focusing on automating routine tasks and on increasing drawing productivity, and therefore reducing product development costs. Limiting CAD to changes or improvements of existing products or systems, which constitute the bulk of designing, may, however, overlook advances in digital technology in which the computer can introduce new practices and promote different ways of working towards experimentation and discovery (Coyne et al., 2002). Moreover, designers who focus on innovation through analogue tools alone might effectively censor CAD during conceptual and schematic design phases (Gibson, 2000). Such narrow focusing also highlights knowledge and skills of computing technologies. For instance, a research study into design devices found that inexperience with computing seemed to limit design possibilities (Coyne et al., 2002, pp. 270–271). The lack of experience may also help explain why in the case study most of the students used less computing relative to the practitioners (Tables 2 and 3).

3.2 Why sketching?

The strength of verbalisation in the ideation process, and the use of the computer for conceptualising, did not, however, sideline the drawing issue. That is, although sketching was not recorded as the primary conceptual tool, all the participant students said that they would have liked to do more sketching, which they considered a skill. In general, the students felt they lacked opportunities for sketching in set projects, and that studio teachers were not always seen as role models for sketching. The practitioners considered sketching a skill too and backed the teaching of drawing despite the fact that they themselves did relatively little sketching in their everyday practice. The reasons given for this was mainly commercial, for example, time and cost pressures, but also client expectation of photo-realistic images at the ideation stage.

This suggests that the relatively small amount of traditional sketching among the participants had more to do with constraints in the design environment than any personal rejection of freehand drawing as such. To illuminate uses of conceptual tools through self-reporting, therefore, seemed worthwhile because the participants, by looking critically at their own ideation process (reflection-on-action), gained greater awareness of conceptual tools and therefore better understanding of *why sketching?*

References

Bilda, Z and Demirkan, H (2003) An insight on designers' sketching activities in traditional versus digital media *Design Studies* Vol 24 No 1 pp 27–49

Burgess, R G (1981) Keeping a research diary *Cambridge Journal of Education* Vol 11 Part 1 pp 75–83

Coyne, R, Hoon, P and Wiszniewski, D (2002) Design devices: digital drawing and the pursuit of difference *Design Studies* Vol 23 No 3 pp 263–286

Cross, N (1999) Natural intelligence in design *Design Studies* Vol 20 No 1 pp 25–39

Cross, N, Christiaans, H and Dorst, K (1996) Introduction: the Delft protocols workshop,, in **N Cross**, **H Christiaans and K Dorst** (eds) *Analysing design activity*, John Wiley, Chichester, UK pp 1–16

Cross, N and Clayburn Cross, A (1995) Observations of teamwork and social processes in design *Design Studies* Vol 16 No 2 pp 143–170

Davies, S (1995) Effects of concurrent verbalisation on design problem solving *Design Studies* Vol 16 No 1 pp 102–116

Davies, R and Talbot, R J (1987) Experiencing ideas: identity, insight and the imago *Design Studies* Vol 8 No 1 pp 17–25

Denzin, N and Lincoln, Y (eds) (1994) *Handbook of qualitative research*, Sage, Thousand Oaks, CA

Dorner, D (1999) Approaching design thinking research *Design Studies* Vol 20 No 5 pp 407–415
Dwarakanath, S and Blessing, L (1996) Ingredients of the design process: a comparison between group and individual work,, in **N Cross, H Christiaans and K Dorst** (eds) *Analysing design activity*, John Wiley, Chichester, UK pp 93–116
Fowles, R A (1979) Design methods in UK Schools of Architecture *Design Studies* Vol 1 No 1 pp 15–16
Garner, S (1992) The undervalued role of drawing in design,, in **D Thistlewood** (ed) *Drawing research and development*, Longman, London pp 98–109
Gibson, K (2000) Divergent and convergent thinking with CAD *Journal of Design Communication* Vol 2
Goel, V (1995) *Sketches of thought* The MIT Press, Cambridge, MA
Goldschmidt, G (1994) On visual design thinking: the vis kids of architecture *Design Studies* Vol 15 No 2 pp 158–174
Lawson, B (1990) *How designers think: the design process demystified* (2nd edn) Butterworth Architecture, London
Lawson, B and Loke, S M (1997) Computers, words and pictures *Design Studies* Vol 18 No 2 pp 171–183
Nolte, D (2001) *Mind at light speed – a new kind of intelligence* The Free Press, New York, NY
Plass, J, Chuan, D, Mayer, R and Leutner, D (1998) Supporting visual and verbal learning preferences in a second-language multimedia environment *Journal of Educational Psychology* Vol 90 No 1 pp 25–36
Plimmer, B and Apperley, M (2002) Computer-aided sketching to capture preliminary design Paper at Third Australasian User Interfaces Conference, Melbourne, Australia, in **J Grundy and P Calder** (eds) *Conferences in Research and Practice in Information Technology* Vol 7, Australian Computer Society, Inc., Darlinghurst, Australia pp 9–12
Purcell, T (1998) Editorial. Special issue: sketching and drawing in design *Design Studies* Vol 19 No 4 pp 385–387
Robson, C (1993) *Real world research* Blackwell, Oxford
Schon, D (1983) *The reflective practitioner* Temple-Smith, London
Silverman, D (2001) *Interpreting qualitative data* (2nd edn) Sage, London
Suwa, M and Tversky, B (1997) What do architects and students perceive in their design sketches? A protocol analysis *Design Studies* Vol 18 No 4 pp 385–403
Tomes, A, Oates, C and Armstrong, P (1998) Talking design: negotiating the verbal–visual translation *Design Studies* Vol 19 No 2 pp 127–142
Tversky, B (1999) What does drawing reveal about thinking,, in **J S Gero and B Tversky** (eds) *Visual and spatial reasoning in design*, University of Sydney, Australia
Verstijnen, I M, Hennessey, J M, van Leeuwen, C , Hamel, R and Goldschmidt, G (1998) Sketching and creative discovery *Design Studies* Vol 19 pp 519–546
Yin, R (2003) *Case study research, design and methods* Sage, Thousand Oaks, CA