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The influence of cognitive style, design setting and cultural background on sketch-based ideation by novice interaction designers

Nicole Lotz, The Open University, Engineering and Innovation, Walton Hall, Milton Keynes,
MK76AA, UK +447595345064 nicole.lotz@open.ac.uk

Helen Sharp, The Open University, Computing, Walton Hall, Milton Keynes, MK76AA, UK
helen.sharp@open.ac.uk

Dr Nicole Lotz specialises in design research across cultures. She designs materials for, and teaches design thinking in virtual environments. Her research interests include design processes and design collaboration, both in online design studios and across cultures.

Professor Helen Sharp is joint author of the Interaction Design textbook (id-book.com) underpinning the module referred to in this paper. Her research focuses on professional software practice, particularly on human and social aspects of software development.

Abstract

Protocol studies to compare interaction designers' sketch-based ideation were conducted in two countries. Participants' cognitive style was assessed and the two cohorts differed significantly. UK participants (UKP) used graphical sketching more than Botswana participants (BP), and UKP used interaction-focused techniques while BP used context-focused techniques. Eleven sketch function patterns were identified. Some were observed in both UKP and BP while others were observed in only one cohort. The findings have implications for ideation techniques, professional development and support tools. They highlight a complex relationship between cultural background, cognitive style and design setting, and their combined influence on sketch-based ideation.

Keywords – Design ideation; Sketch function; Cognitive style; Interaction design

Introduction

The value of sketching in design ideation is well understood and has been recognized for many years (Gross, 1988, Purcell and Gero, 2006). A sketch is a preliminary and not very detailed representation of a design idea. Interaction design is a younger field than product or engineering design, and is particularly concerned with how the user will interact with a design. Evaluation of the design with users is a central concern of interaction design. Ideation in interaction design therefore focuses on sketches as prototypes that can be explored with users (Snyder, 2003). Several

techniques for ideation and the creation of prototypes are known in interaction design, for example scenarios (Carroll, 2000), storyboards (Landay and Myers, 1996), and card-based prototypes (Preece et al, 2015). Studies in interaction design have considered how professionals use ideation techniques during collaborative designing (Tholander et al, 2008; Mangano et al, 2015), but none have compared interaction designers' sketch-based ideation in different countries.

The paper presents an analysis of ideation techniques and sketch functions from two comparable protocol studies of interaction designers who had recently completed the same interaction design course but in different countries. In UK, designers worked predominantly individually, and in Botswana, designers worked predominantly in groups. Having been taught the same techniques and approach, the question arose whether there would be any observable differences in their sketch-based ideation. Analysis of the video-recorded protocols revealed different uses of ideation techniques and 11 sketch function patterns. The paper argues that the intertwined factors of cultural background, cognitive style of the cohort and preferred design setting in each country encourage different interaction design ideation techniques and sketch patterns.

Sketch-based ideation

Empirically grounded theories explain why sketching is a preferred technique in design ideation (Goldschmidt, 1991, Purcel and Gero, 1998, Goel, 1995). Sketching activity utilises a variety of approaches, such as writing, drawing and modelling to create and communicate ideas (Sener, 2014). Gross et al (1988) found that sketches contain high-level ideas. Sketching develops detail gradually, because it moves ideas from the general description to the specific depiction (Fish and Scrivener, 1990). Goel (1995) also found lateral sketches where one idea is transformed to a different idea. McKoy et al (2001) summarised research on the cognitive benefits of sketching: sketching accelerates reasoning and image capture; a sketch represents an idea concisely and extends the designers' memory; sketching helps understanding, provides insights, and allows unexpected connections to be made; and sketching aids feedback.

Schön and Wiggins (1992) described sketching as an interactive conversation that can take different forms or functions. Ferguson (1992) also argued that the same sketch could take on several functions. He described the *thinking* sketch, the *talking* sketch and the *prescriptive* sketch. While the *thinking* sketch is employed by individuals, the *talking* sketch involves more people talking about one idea. The *prescriptive* sketch is for communication and presentation to others. Bar-eli (2013) renamed this function *communication* sketch. Looking at group sketching, Van de Lugt (2005) proposed an additional sketch function (the *storing* sketch) that stores ideas for the designers' or team's later use.

Despite extensive research into variations and similarities in creative problem solving (Brophy, 2006), only some of these studies target sketch-based *ideation in different settings*. McKoy et al's (2001) experiment with novice engineering designers compared textual and graphical ideation between groups and individuals who were free to choose their ideation techniques. They confirmed

that graphical ideation produces higher quality and novel ideas compared to textual ideation, and that individual ideation scored the lowest for quality overall. Comparing individually working novice and expert textile designers, Saitamaa-Hakkarainen and Hakkarainen (2000) found further differences between textual and graphical ideation. Advanced novices used more graphical ideation than experts. Heiser and Tversky (2005) compared individual and paired participants and found that individuals used combinations of text and diagrammatic representations while pairs used fewer visual and more textual representations of ideas. Individuals do better than groups in some settings and vice versa (e.g. depending on task complexity and group size) (Brophy, 2006).

Researchers agree that sketching is used differently for ideation in different design domains (Goel, 1995; Healey et al, 2002; Eckert et al, 2012). Razagghi et al (2009) identified cultural patterns by comparing Iranian and Australian students' sketches. These patterns give insights into the culturally varying values that influence ideas, but not about the ideation process or behaviour. In software engineering, research has been conducted to understand how computer users ideate using sketches and to develop software that recognises sketches and sketching electronically (e.g. Healey et al, 2002).

Interaction design research focuses on how sketches and other prototypes engage a range of stakeholders in design discussions, such as users or programmers. Comparing scenarios, software prototypes and sketches, Johansson et al (2007) found that sketches supported broader discussion in design team meetings than other prototypes. Tholander et al (2008) concentrate on the role of jointly created sketches in meaning creation. They highlight the importance of talk during sketching activity. Mangano et al (2015) analysed eight pairs of professional software designers' sketching and reasoning. Their work emphasises the role of sketches to support conversation with other designers through repurposing and grouping of sketches. These findings are insightful for interaction design collaboration, but cannot be transferred to different settings or countries. This paper asks:

How does sketch-based interaction design ideation vary in different countries?

Methodology

The interaction design module

The research built on a five-year teaching partnership between the Open University, UK, and Botho University, Botswana. The two cohorts of participants studied the same self-contained module, called "Fundamentals of Interaction Design", consisting of a main textbook (Sharp et al, 2007) and wrap-around materials. Both cohorts used exactly the same materials, the same study path, and the same assessment.

The module emphasizes sketch-based prototyping and teaches three key techniques: *storyboard*, *card-based prototype* and *interface sketch*. Storyboards are a series of sketches showing how a user might accomplish a task using the product (Figure 4). Card-based prototypes consist of several index cards, each of which represents one interface element (Figure 5). Interface sketches

show the product's detailed interface design (Figure 6). The module teaches a structured and iterative approach to interaction design which builds from a scenario (a text-based description of one use of the product (Figure 3)), to storyboards, from storyboards to card-based prototypes and from cards to interface sketches.

The protocol study

Protocol studies that ask designers to verbalise thoughts while designing (concurrent verbalisation) have been used extensively in design research (Cross et al, 1997). Study sessions took place just after the participants had completed the module's design assignment. Each session lasted 2 hours, with about one hour devoted to the main design task. No time limit was set but participants were told that they could stop at the end of this hour. After the main task, participants presented their designs to the facilitator. Sessions were audio- and video-recorded.

Participants had access to all module materials, paper, pencils, refreshments, and a participant booklet that was available in three languages (Setswana, Kalanga or English). The participant booklet contained: study background, consent form, warm-up activity (Towers of Hanoi), and design brief: a medication system for home-based patients. Participants were given no direction regarding the techniques to use or how to address the design problem. Local staff members facilitated the sessions, and a facilitator was present throughout. For consistency, facilitators all worked from a common guide.

Participants

Seven UK participants (UKP) were recruited; one session was not usable. In Botswana, 30 participants were chosen from 70 volunteers, making 15 pairs (BP); two sessions were too quiet to be usable. All participants were educated in their country of residence.

Data collection

The protocol studies were designed together and data collection was adjusted for each country. In the UK, students study individually, at a distance, and only occasionally work in groups. UK participants therefore worked individually and were asked to think-aloud throughout. In Botswana, students usually work together on campus. To reflect this and to help overcome problems of concurrent verbalization including silence and inhibition, students were paired using constructive interaction (O'Malley et al, 1985). Think-aloud was not used in Botswana because of possible cultural influences in concurrent protocols (Clemmensen et al, 2008). In addition, post-task interviews were replaced with a debrief role-play in which participants presented their design(s) to a facilitator. This was advised by local Botswana colleagues to overcome participants' inhibitions.

Previous research points to evidence that cognitive processes (including ideation and creativity) are not universal (Nisbett, 2003), so participants completed a Group Embedded Figures Test (GEFT). GEFT is a measure of field-independence, which indicates how much participants are influenced by context. Field-independence assesses the "ability to break up an organized visual field in order to keep a part of it separate from that field" (Witkin et al, 1971, pp2). Field-independent thinking encourages focus on one object and goals with respect to it. Field-dependent thinking

fosters attention to relationships and context. In GEFT, participants need to locate a familiar figure within a more complex figure. The better participants can locate the figures, the higher their field-independence. Higher field-independence enables minimal cognitive load and maximal working memory efficiency and is correlated positively with visual perceptiveness.

The reliability and validity of GEFT scores is generally supported (Panek, Funk & Nelson, 1980), but others question their interpretation in measuring field-dependence. Evans et al (2013) argues that GEFT can only be used reliably to measure field-independence.

Data analysis

Analysis focused on the main design task. Both audio transcripts and video data were analysed. Local interpreters translated the Botswana data into English and superimposed the spoken translation on the video. All analysis was conducted in English.

Two analyses were undertaken: one focused on the ideation techniques used and one to extract sketch function patterns. Which ideation techniques were used and for how long they were used were extracted from the video data. Videos were watched repeatedly and the beginning and end of ideation technique use was marked in a spreadsheet aligned with the transcribed data. The significance of any differences found was investigated using the Mann-Whitney U-test.

The coding scheme for sketch functions we used was developed from Ferguson (1992), Van de Lugt (2005), Bar-eli, (2013):

- Thinking sketch: to focus and guide the designer's individual process of thinking (usually non-verbal)
- Talking sketch: to produce ideas together with other designers while talking
- Storing sketch: to capture ideas for later use by the designer(s)
- Communicating sketch: to communicate ideas to others including non-designers

Figure 1 illustrates this coding. In snapshot 1, one participant is sketching individually, - coded *thinking* sketch. A previously produced sketch is placed on top of the new sketch, and is coded *storing* sketch. Both sketches are represented as ellipses in the spreadsheet (line 352); the dotted line indicates the time a function is active. In snapshot 2 the second participant starts sketching, and the first participant points and talks over the pair's activity. This is coded *talking* sketch. Snapshot 3 shows a short episode of *thinking* sketch when the second participant sketches in silence and the first sits back and watches.

Patterns both within one sketch function and across functions were sought.

348	A&B. We are now designing for the youth.				
349	A. Setswana is hard, it's tricky				
350	B. I can't write in Setswana...be when I speak through.				
351	A. Which product now?				
352	B. The youth use cell -phones	thinking		storing	
353	A. That is very true, that is our design, a cell-phone has to be on.				
354	B. What should I sketch?				
355	A. Just sketch a patient and a cell-phone.		talking		
356	A. Where you sketch. A patient should have a cellphone as a first requirement, isn't it? I can't sketch				
357	B. Just they				
358	We are sketching not real sketches.				
359	A. It doesn't need to be very accurate.				
359	I should state that a youthful patient should have a cell-phone. Isn't it?

snapshot 1

snapshot 2

snapshot 3

Figure 1. Excerpt of BP2 coded transcript with video snapshots

Reliability

A test-retest reliability measure was performed. One entire protocol from each data set was tested, which represents 10% of the data. Under the same conditions, the coder repeated the coding 1.5 years after the first test. The retest reliability for techniques used was very good with Kohen Cappa 0.89 (Kippendorf Alpha 0.90). The retest reliability for *thinking* sketch was very good with Kohen Cappa 0.87 (Kippendorf Alpha 0.85). *Talking* sketch retest reliability was good at 0.62 (Kohen Cappa and Kippendorf Alpha). *Storing* sketch reliability was 0.61 (Kohen Cappa) and 0.66 (Kippendorf Alpha).

Findings

GEFT scores

Tables 1 and 2 show participants' GEFT scores. According to the Mann-Whitney U-test ($p < 0.05$) UKP GEFT scores and BP GEFT scores were significantly different, even when those who did not understand the test are excluded. Lower GEFT scores indicate a field-dependent cognitive style while high GEFT scores indicate a field-independent style.

Table 1 Individual GEFT scores and Mean for BP. Participants 6, 32, 46 and 48 indicated they did not fully understand the GEFT instructions, Participant 21 could not attend.

BP	1		2		3		4		5		6		7	
Participant	1	44	2	11	3	6	13	33	14	22	15	48	19	46
Gender	F	F	F	F	F	F	F	M	F	F	F	F	M	M
GEFT Score	3	3	7	7	4	0	4	4	4	1	11	3	9	0

<i>BP</i>	8		9		10		11		12		13		<i>Mean</i>
Participants	21	65	25	70	29	34	32	38	37	50	39	63	
Gender	F	F	F	F	F	M	F	F	F	F	F	M	
GEFT score	x	0	0	3	3	5	0	5	0	7	2	7	3.6

Table 2 Individual GEFT scores and Mean for UKP.

<i>UKP</i>	1	2	3	4	5	6	7	<i>Mean</i>
Gender	F	F	M	M	F	F	M	
GEFT Score	4	9	18	18	16	15	15	13.6

Overall use of techniques

Tables 3 and 4 show the time spent using sketch-based ideation techniques. Unstructured notes and scenarios are textual ideation techniques; storyboard, card-based prototype and interface sketch are graphical ideation techniques (marked **). Free talk was not categorized.

Table 3 Techniques used by BP in % of time (sums vary due to rounding). *BP8 worked individually, in parallel so total technique time > 100%.

<i>Pairs / Technique</i>	1	2	3	4	5	6	7	8	9	10	11	12	13	<i>Av %</i>	<i>SD %</i>
Notes %	0	8	10	0	5	0	23	0	36	18	0	32	35	13	14
Scenario %	30	0	29	57	22	56	43	44	0	6	20	0	5	24	20
Storyboard** %	25	83	22	0	31	0	0	31	38	35	36	15	18	26	21
Card-based Prototype** %	0	0	0	0	9	0	0	0	0	0	0	0	23	2	6
Interface Sketch** %	0	0	0	26	9	22	20	27	22	25	0	22	0	13	11
Total for any Graphical Sketching %	25	83	22	26	48	22	20	58	60	60	36	37	40	41	19
Total for any Technique %	54	92	61	83	76	78	86	102*	97	85	55	68	81	78	14
Total Time (min)	57	60	59	53	58	55	56	45	58	65	56	41	62	56	

In BP, the time spent using any technique (row 8) varies from half the time to nearly the entire time, with an average of 78% (excluding BP8). In UKP, the average time spent using techniques is 88%.

Table 4 Techniques used by UKP in % of time (sums vary due to rounding). UKP2 was excluded from our analysis.

<i>Participant / Technique</i>	<i>1</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>Av</i> %	<i>SD</i> %
Notes %	20	43	23	10	0	45	24	16
Scenario %	0	0	7	0	13	0	3	5
Storyboard** %	25	8	23	0	11	11	13	9
Card-based Prototype** %	40	47	8	87	38	32	42	23
Interface Sketch** %	3	0	28	0	0	4	6	10
Total for any Graphical Sketching %	68	55	60	87	49	48	61	25
Total for any Technique %	88	98	90	97	62	93	88	12
Total Time (min)	60	60	60	60	55	71	61	

Textual ideation

Participants took notes of requirements, user experience goals or system specifications (Figure 2). On average, BP spent less time taking notes than UKP, with many BP (e.g. 1, 4, 6, 8, and 11) taking no notes. In UK, only UKP6 took no notes; participants 3 and 7 spent nearly half the time taking notes.

On average, BP spent 24% of their time writing scenarios and some spent much longer, e.g. BP4 (57%) and BP6 (56%) (Figure 3). This contrasts with UKP, where only participants 4 and 6 used scenarios at all with an average of 3% for all participants. According to the Mann-Whitney U-test this difference is significant at $p \leq 0.05$.

Figure 2. UKP3 Unstructured notes

②a Scenario

Patient is prescribed medication
 Doctor enters information on the device
 Patient takes it home
 Device alerts patient when and what drugs need to be taken at what time.
 When medication is finished, information can be removed.
 Any required further information can be added.

Figure 3. UK6 Scenario: a text-based description of one use of the product

Graphical ideation

UKP used graphical ideation more than textual ideation. BP used graphical and textual ideation equally. UKP spent more time sketching graphically (61%) than BP (41%) which is significant at $p \leq 0.05$ (Mann-Whitney U-test).

The two cohorts sketched differently. BP employed storyboards for 26% of their time, and UKP for only 13% (see examples in Figure 4). BP data showed a large variation with BP2 spending 83% of their time and BP12 only spending 15%, while BP4, 6 and 7 didn't use storyboards at all. UKP1 and UKP4 used storyboards for 25% and 23%, while others only used it 8-11% of their time and UKP5 not at all. According to the Mann-Whitney U-test this difference is not significant.

Figure 4. BP5 storyboard describing a watch-like solution

Only 2% BP used card-based prototypes. For UKP card-based prototype (see Figure 5) was the most-used technique (42%). All UKP developed card-based prototypes, but with varying intensity. UKP5 used this technique 87% of the time, while UKP4 only used it for 8%. Only two BP used this method: BP5 for 9% and BP13 for 23% of their time. According to the Mann-Whitney U-test this difference is significant at $p \leq 0.01$.

Figure 5. UKP7 Card-based prototype

The interface sketch technique (see Figure 6) was used for longer by BP (13%) than UKP (6%). Time spent on interface sketches by UKP varies: UKP4 spent nearly one third of the time, UKP1 and UKP7 spent very little time. Seven out of 8 BP used interface sketches and dedicated about 25% of their time. According to the Mann-Whitney U-test this difference is not significant.

Figure 6. Interface sketch of a wristband device by BP10, with translated sketch annotation .

Sketch function patterns

Eleven patterns were identified (Table 5). Subsequent sections detail the patterns by sketch-function and combinations of functions.

Table 5 Patterns of Sketches and Sketching

Function	Pattern	BP	UKP
Talking	Confidence	x	
	Relay partner	x	
	Teamwork	x	
	Apprentice	x	
Thinking	Flow		x
Talking and thinking combined	Breaking the silence	x	
Storing	All time open	x	x
	Quick look back	x	x
Communication	Pin board	x	
	Selective	x	x
	Sequential		x

Talking sketch patterns

The *talking* sketch was common in BP data because constructive interaction requires pairs to talk to each other. Four talking sketch patterns were observed: *confidence*, *relay partner*, *teamwork* and *apprentice*. No talking sketches were observed in UKP data as participants worked alone.

Confidence. One participant sketches while the other comments on the emerging design; the one who is sketching implements the changes. This appears when one designer is more confident in sketching, and ideation occurs during talk.

Relay partner. One participant sketches initially, but if they meet a problem they stop and let their partner continue sketching on the same paper while talking. This appears when the designer is not confident in sketching.

Teamwork. Both designers sketch on the same paper at the same time, even in the same sketch (Figure 7a). This might involve clarifying the discussion, or one colouring while the other finishes the outline.

Apprentice. Both designers talk and sketch on separate papers at the same time (Figure 7b). One designer sketches on paper and the other copies to another paper.

Figure 7. (a) Teamwork and (b) Apprentice patterns

Thinking sketch pattern

One *thinking* pattern was predominant in UKP:

Flow. When designer has started with a technique, they follow a flow of ideation and sketching keeps the ideas going.

Talking and thinking sketch combination pattern

In BP, one combination of thinking and talking sketch was observed:

Breaking the silence. Quick and repeated iteration between *thinking* and *talking* sketches. This pattern occurred during short breaks in discussion. The *thinking* sketch is produced in silence, and used as a catalyst to restart a halting discussion. This pattern often occurs with *apprentice*.

Storing sketch combination patterns

In both cohorts there were two *storing* sketch combination patterns - *quick look back* (Figure 8b) and *all time open* (Figure 8a). In both patterns, the designers take inspiration from the information stored in the sketches while working on a new sketch or idea. The focus and the function of the sketch can shift rapidly. The *storing* sketch quickly turns into *thinking* or *talking* sketch again and

the *storing* sketch itself is amended in this process. Both patterns were observed within a technique and across techniques.

All time open. Several sketches are laid out. This facilitates working on all sketches in parallel, although one sketch is in focus at a time.

Quick look back. The most important sketch (e.g. the one holding a key idea) or most recent sketch becomes *storing* sketch during the production of another new sketch.

Figure 8. (a) All time open (UKP5) (b) Quick look back (UKP7)

Communication sketch patterns

Only one occurrence of *communication* sketch was observed during ideation: in BP8. Both participants sketched alone and then told each other what they had done.

When participant(s) presented their design to the facilitator, all the sketches presented became *communication* sketches. We found three communication sketch patterns – the *pin board* (BP only), the *sequential pattern* (both cohorts), and the *selective pattern* (UKP only).

Pin board. All pages are laid out to review, giving an overview of all the designs produced.

Sequential pattern. One page after another is shown and explained. In BP this sometimes occurred after reviewing the designs. This pattern was more common in UKP.

Selective pattern. All sketches are piled up. During presentation a few are selected as *communication* sketches.

Discussion

This study compared design ideation by interaction designers in two countries. The participants were chosen to be resident and educated in the respective countries and worked in their preferred design settings. These choices led to two significant differences that may influence the findings: participants' cognitive styles (more or less field independent); design setting (individual or paired). This section discusses the results in the context of other literature and considers how cognitive style, design setting and cultural background may explain the observed variations in each country.

Cognitive style and sketch-based ideation in different countries

According to the Mann-Whitney U-test ($p < 0.05$) the GEFT scores for BP and for UKP were significantly different, indicating that the Botswana cohort were more likely to emphasise relationships and context (field-dependent), and the UK cohort were more likely to focus on one object and goals with respect to it (field-independent). This difference in field-independence might explain the observed preference for different ideation techniques and the development of design detail. There is support for this from previous research that suggests a relationship between cognitive style and sketch-based ideation. Witkin (1964) observed that field-independent individuals drew figures with more detail and differentiation than field-dependent subjects. Pei-Shan et al (2009) found that analytic individuals (akin to field independent) prefer ideation with words and intuitive individuals prefer images. So the differences in behaviour and technique choice may be due to differing cognitive styles but might this variation be attributed to cultural background or setting?

Miyamoto and Wilken (2013) suggests that Collectivism is a prime indicator of cognitive style and low Collectivism is linked to field-independence. The GLOBE project (House et al., 2002), identified Botswana as high on the family Collectivism scale while England is relatively low. This implies that BP were less field-independent because they were from Botswana. Countering this, Sealetsa and Moalosi (2012) used GEFT with freshman engineering students in Botswana and found the majority of them ranked higher on field-independence than our cohort. They argue that engineering students generally score higher on field-independence regardless of national culture. They also argue that male participants score generally higher than female subjects. This indicates that our difference may be due to more female BP participants (16/21) and a balanced UKP cohort (4/7). And that discipline and gender might have influenced Sealetsa and Moalosi's results more than cultural context.

Miyamoto and Wilken (2013) summarised the literature on cognitive styles and concluded that several factors, including age, gender, professional discipline and cultural context affect cognitive style. Socialisation and education strengthen a particular cognitive style, and the development of a preferred design setting. Therefore, our participants' cultural background will have influenced their cognitive style and hence their sketch-based ideation, but not as the sole factor. Cognitive style, cultural background and preferred design setting are related factors and all impact on the similarities and variations we found.

Similarities and variations in ideation techniques

Similarities

Since the cohorts studied the same interaction design course, similarity was expected. Both cohorts used sketch-based ideation and only used techniques taught in the course. This is consistent with Saitamaa-Hakkarainen and Hakkarainen (2000) who studied textile designers who had just completed the same educational programme and reported a large overlap in ideation techniques.

Variations

We expected variations due to the different design settings, but our data also indicates variations due to cognitive style.

UKP spent more time sketching graphically than BP, and the difference is significant. They also used different techniques to ideate and develop the detail, and the techniques chosen highlight and enforce a context focus (BP) or task focus (UKP). This difference is consistent with the cohorts' variations in cognitive style.

BP used ideation techniques to describe contextual features of a new design (scenarios and storyboards), while UKP spent more time detailing specific interface elements and user interaction (card-based prototypes). Storyboard and scenario are appropriate techniques to detail context, such as how a phone could be used by illiterate users. The low use of card-based prototypes in Botswana suggests that detailed user interaction is not considered an important ideation task. BP used the interface sketch technique more often than UKP, but this is a static view of the interface.

BP scenarios and storyboards described the design in detail. UKP left much more uncertainty in storyboards, and drew them more quickly, being just one step in a series of ideation moves. UKP gradually reduced this uncertainty and developed detail in their design ideas through card-based prototypes that describe detailed user interaction through a series of steps. BP focused on using known devices in a new problem context. For example the interaction involved when setting a phone alarm is well-known and doesn't need to be re-designed.

UKP followed the module's structured approach that starts with a storyboard, moves to detailed card-based prototypes and then an interface sketch. The use of several ideation techniques, each with a different focus, gradually solidifies ideas and reduces uncertainty with each step. BP ideate differently. They seldom follow the module's approach nor go through a sequence of techniques, and often use a storyboard. Individuals with higher field-independent scores prefer sequential approaches, while those with lower scores approach problems more holistically (Witkin, 1971). Low field independence also favours peer interaction which might influence the preferred design setting in Botswana.

Preferred design setting may account for the significant difference of time spent sketching between cohorts. Neumann et al (2009) found that teams elaborated ideas more if working on a common sketch compared to sketching individually and discussing their sketch afterwards. Working on a common sketch means that fewer sketches are produced, and the number of ideas and diversity of ideas decreases in team sketching. Less time spent sketching in BP supports Neumann et al's observations and confirms Heiser and Twersky's (2005) observation on the dominance of textual representations in designer pairs.

Previous research has also found that some techniques are better suited to individual or team ideation. Mangano et al (2015:p151) found that teams prefer sketches that support the discussion of alternative scenarios, as BP did using storyboards and interface sketch. It is easier for teams to refer

to ideas stored in storyboards and interface sketches than in card-based prototypes, because the idea is contained on one sheet rather than several separate cards. This suggests that BP might have neglected card-based prototypes because they are less useful for discussion, and hence better suited to individual ideation.

Variations in sketch-based design ideation may be explained by a combination of cognitive style and preferred design setting.

Similarities and variations in sketch function patterns

Similarities

Sketch patterns are not taught in the course, so we expected less similarity, but we found some. Both cohorts used the *storing* sketch function in similar ways to support consistency in ideation and revision to previous ideas. For example, UKP5 had all the card-based prototypes open at the same time and said:

“So, I’m looking at these and some of my screens are looking very crowded. It’s quite busy at this side and they’re going to need an iPad at least, not a little thing they can slip in their pocket. So, I might end up having to break these down across more screens to enable it to be used on a smaller device.”

Quick look back progressed ideation better than *all time open* when it was used within one technique. For example, using *quick look back*, BP1 considered the stored ideas in a previous storyboard, but stayed focused on the new storyboard. In contrast, BP who used *all time open* in constructing storyboards risked the designs becoming too similar despite intending to account for varying contextual factors.

Although *quick look back* progressed ideation within a technique, both *storing* sketch patterns were appropriate between techniques, i.e. taking ideas from a storyboard to sketch an interface or card-based prototype. Tholander et al (2008) point to the central role of *storing* sketches in professional interaction design ideation. Zannier and Maurer (2007) found that software designers are more critical of their ideas when looking at them simultaneously (*all time open*) than when evaluating ideas sequentially (*quick look back*). Mangano et al (2015) found professional software designers used stored ideas to generate new ideas from a sketch, but did not necessarily do a new sketch. They simply changed the original sketch or discussed ideas based on the sketch. In their experimental set-up *all time open* was encouraged overall. But *quick look back* was also found when comparing one sketch to another in ‘short bursts’ (p152). Storing sketch patterns seem less influenced by the design setting or designers’ country.

Variations

Most sketch pattern variations derive from the design setting. For example, UKP could not have used *talking* sketch patterns because they ideated individually and had no-one to talk with.

Our findings that pairs use a variety of *talking*, and *talking* and *thinking* sketch combination

patterns contrast with Van de Lugt's (2005) finding that *talking* sketch was used surprisingly little in collaborative design. However they used the brainsketching technique in which participants sketch individually and only afterwards discuss their sketched ideas. Working on sketches together forces the team to create common ground dynamically during conversation (Badke-Straub, 2009; Casakin and Badke-Schaub, 2013). This dynamism is rooted in the tentative nature of collaborative design conversations (McDonnell, 2009). Pairs assign various roles to individuals to deal with tentativeness and dynamism in sketch-based ideation. Tholander et al (2008) also identified dynamism in paired interaction designers' conversations. During ideation, designers took varying communication roles such as negotiator or expert. *Apprentice* and *relay partner* illustrate specific roles being taken in a paired setting. This emphasis on roles and relationships links to the field-dependent cognitive style, which again highlights an influence of cognitive style on preferred design setting.

In contrast to BP's dynamic sketch-based ideation, the *flow* sketch pattern supports UKP's more linear ideation. The occurrence of *flow* in UKP can also be explained by the field-independent cognitive style, as field-independent individuals perform well when they can effectively structure a task. The contrasting use of *communication* sketch patterns is also related to varying cognitive styles. While *pin board* presents sketches in context and highlights relationships, favoured by field-dependent cognitive style, the *sequential* pattern allows a focus on one object and goals with respect to it, exemplified by field-independent individuals.

Although the use of sketch patterns seems initially more related to individual or collaborative design settings, there is also support for the influence of cognitive style on *talking*, *thinking* and *communication* sketch patterns.

Limitations

Participants were novice interaction designers and inferences cannot be made about expert interaction design ideation. Moreover, there were only 6 UKP and 12 BP and the interpretation of these findings is limited; further research is required.

Coding the sketch functions was challenging and could be improved. *Thinking* was difficult to clearly separate from *talking* in BP because the iteration between *thinking* and *talking* was very rapid. *Storing* was also difficult to identify. Van de Lugt (2005) coded only explicit references i.e. when an utterance explicitly pointed to a previous sketch or idea. We found this limiting and used a wider definition including naming, pointing and looking at a previous sketch. However, the video recording focused on hands and sketching activity rather than the face, for data protection and ethical reasons. We relied on pointing or lifting of the paper to code *storing*, but glances of the eyes would have indicated *storing* more accurately. Similarly, *thinking* was difficult to identify reliably. Finally, some misalignment of the spoken translation superimposed on the BP videos made it harder to choose the exact lines where *thinking* started and ended, which caused some variation when the coding was repeated.

Conclusions

In this study we observed two cohorts of novice interaction designers and their use of ideation techniques and sketch function behaviour. The two cohorts were similar in terms of their interaction design knowledge and experience and differed in terms of background: one cohort lived and had been educated in Botswana, and one lived and had been educated in UK. The study design was similar in terms of materials provided, structure, data collection, and given problem and differed in terms of the participants' preferred design setting: UKP designed individually and BP designed in pairs.

As part of the study, participants' level of field independence was assessed and we found that BP cohort scored lower on field independence and UKP scored higher; the difference is statistically significant. Findings show similarities and variations in the use of ideation techniques and sketch function behaviour between these two cohorts.

These findings add to our understanding of design ideation strategies in different countries and settings, and inform the adoption of appropriate interaction design approaches in industry and education.

Three of these results have particular implications for interaction design. Firstly, BP focused on ideation techniques that emphasise the product's context and a holistic but static view of it, and did not use ideation techniques that support the development of detailed, dynamic interaction. But a key characteristic of interaction design is the need to design *interaction*. For a simple design task, a combination of storyboard and interface sketch may be sufficient, but for complex interaction design problems, techniques that support the design of interaction are paramount. This indicates a need for ideation techniques that support field-dependent designers in carrying out *interaction* design.

Secondly, low field-independent designers prefer a less structured design approach. Even though BP were taught a structured approach, they chose not to follow it. This calls for flexibility in education and professional development for interaction designers with lower field-independent styles.

Thirdly, storing sketch function behaviour has implications for electronic and physical interaction design support environments. While *quick look back* encourages divergence in design, *all time open* reinforces consistency. Both divergence of ideas and consistency across ideas are valuable in different circumstances, so each should be encouraged at appropriate times. For example providing a facility that encourages *quick look back* is appropriate when generating alternative designs but supporting *all time open* is better when developing one design that needs to be internally consistent.

The observed variations cannot be explained simply, nor by one factor alone. Some of the variations in ideation technique use and sketch functions can be explained by the preferred design setting (individually or paired) in each country. For example, less use of graphical ideation and the use of *talking* sketch are influenced by the paired setting. Other variations can be explained by the different cognitive styles in each country. For example, the use of card-based prototypes and the

flow thinking pattern is in line with the field-independent cognitive style of UKP, while the neglect of card-based prototyping, a focus on scenarios and storyboards, and the variety of *talking* sketch patterns in BP can be explained by their more field-dependent cognitive style. But both preferred design setting and cognitive style are intertwined, and depend on other factors too.

Several influences lead to a preference of working individually or collaboratively, and age, gender, class background, and discipline all influence cognitive style. Cultural background, e.g. level of collectivism, influences cognitive style, which in turn influences a preference to work individually or in a pair. Moreover, education and socialisation reinforce these factors over time.

This study has shed light on an important but complex relationship between cultural background, cognitive style and preferred design setting, and their combined influence on sketch-based ideation in different countries. Only in combination can these factors explain the findings of this study.

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