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Abstract

Some recent findings with expert designers relate problem–solution co-evolution and analogy use to framing practices. We wanted to understand if novices also use co-evolution and analogies to frame their thinking. Furthermore we wanted to see if there are any differences across cultures. The paper reports an analysis of data gained from protocol studies with novice interaction designers in the UK and Botswana. Novice interaction designers in the UK and Botswana show some similarities in framing behaviours using co-evolution and opening analogies to develop metaphorical themes in framing. But within these observations we also found differences across the cohorts. The implications are discussed in the light of adopting appropriate design pedagogy for novices in different cultures.

Keywords

Co-evolution, framing, analogy, design novices, culture

Introduction

Two related aspects of expert designer behaviour have attracted increased attention from researchers: framing and co-evolution of problem and solution. During framing, designers create a particular view on the design problem. Cross wrote: "… designers appear to explore the problem space from a particular perspective in order to frame the problem in a way that stimulates and pre-structures the emergence of design concepts." (Cross, 2007 p. 94). The way designers frame a problem implies certain early solutions.

Several design researchers have found that problems and solutions co-evolve over time (e.g. Maher, 1996, Dorst & Cross, 2001), and that there are two types of episode in this behaviour: parallel co-evolution of problem and solution, and bridge building between these two spaces. The first type of episode involves a progression of parallel thought in both solution and problem spaces. In the second, intermediate solutions 'talk back' to the designer to help understand and frame the problem. The 'talk back' situation is understood as a shift in focus between problem and solution spaces (Dorst & Cross,

2001). It can also be understood as a bridge being built between the two spaces. Bridges can be built in both directions. Bridges seem to be built to reconsider the suitability of the current frame and to devise a new solution if the original solution does not satisfy the evolving problem conceptualization. Parallel episodes seem to progress solution and problem criteria without major shifts in either space. Other than this, little is known about the different functions that parallel co-evolution and bridges between these spaces play in the development of a design solution. What we do know is that problem–solution co-evolution as a whole helps experts to frame their design thinking.

Building on this seminal work in problem–solution co-evolution and framing, a new intensification in research around this topic has emerged. Recent studies look at expert designers' use of framing strategies. Dorst (2011) argues that the activity of framing open and complex design problems is at the heart of design thinking. "Experienced designers can be seen to engage with a novel problem situation by searching for the central paradox, asking themselves what it is that makes the problem so hard to solve. They only start working toward a solution once the nature of the core paradox has been established to their satisfaction." (Dorst, 2011, p. 527).

Dorst and Tomkin (2011) then found that 'metaphorical themes' act as bridges between problems and solutions in a co-evolution process. A theme is a central metaphor, which creates a rich mental image and steers the designers' thinking about the situation in a particular direction. They are neither problem nor solution but 'neutral ground' between problem and solution. The neutral ground seems to be the bridge between problems and solutions.

Similar to the idea of a metaphorical theme in framing, Wiltschnig, Christensen and Ball (2013) found independently that analogical reasoning is linked to co-evolution. Analogies occur more frequently in problem–solution co-evolution episode than outside of co-evolution episodes in expert designing. Metaphorical themes and analogies seems to be core drivers for framing experts' design thinking. However, little is known about analogy use in either parallel co-evolution or bridging. Wiltschnig et al's analysis didn't focus on the distinction between parallel and bridging co-evolution episodes.

In previous work we have made this distinction and could demonstrate how interaction design novices in the UK and Botswana use problem–solution co-evolution in the sense Maher (1994), and Dorst & Cross (2001) have observed in experts (Lotz, Sharp, Woodroffe, Rajah & Ranganai, 2013). We have also identified a new type of co-evolution in novices from Botswana, in which co-evolution does not start from a detailed decomposition of the problem. Instead, a solution is used to first co-evolve both spaces in parallel before bridges are built between those spaces. Wiltschnig et al (2013) have observed a similar change in directionality ("solution attempts spark off the analysis of requirements and possible changes to those requirements" (p. 529)) in expert designers' framing.

Dorst and Tomkin (2011) have argued that understanding framing in more detail is desirable in the study of radical innovation. We believe that understanding framing in novices is also desirable to study and improve design education. Almendra and Christianns (2011) found that students had difficulty with framing their designing. Also, Lindner (2011) has shown that helping students to frame problems leads to more diverse solutions. This paper investigates framing behaviour in novice interaction designers. Specifically, we examine how novice interaction designers in the UK and Botswana use analogy and metaphorical themes in co-evolution and framing. Two questions are addressed here:

1. How do novices in the UK and Botswana frame interaction designs?
2. How are analogy, co-evolution and metaphorical theme used in framing designs in novices?

Based on our findings, the paper discuses some implications for design pedagogy in both settings.

Methodology

The Setting and the Module

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

Protocol Study

The protocol study sessions were run just after the students had completed the module's design assignment. Each session lasted about 2 hours, and was structured as follows: introduction, warm-up activity, main study task (lasting about an hour), design presentation to a facilitator. Materials provided were: module books, design method summaries (usability and user experience goals, scenarios, storyboards, card-based prototypes and interface sketches), paper, pencils, refreshments, and a participant booklet each. The participant booklet contained: study background, consent form, warm-up activity (Towers of Hanoi), and design brief. The design brief described the problem and implications around forgetting to take medication and asked students to design an interactive product that will help ensure sick people living at home take the right medication at the right time.

The sessions were recorded using audio and video equipment, and a facilitator was present in the room throughout.

Data Collection

Data collection was adjusted to the way students in each location would usually work. Data collection in Botswana used constructive interaction, i.e. students were paired (O'Malley Draper, & Riley, 1985). Constructive interaction helps overcome problems of concurrent verbalization including silence and inhibition; in addition, students in Botswana usually worked together. We decided against using think-aloud in Botswana because of the possible cultural influence in concurrent protocols reported by Clemmensen, Hertzum, Hornbaek, Shi, & Yammiyavar (2008). Participants were allowed to choose a preferred local language. Eleven sessions were conducted in Setswana and two in Kalanga. The participant booklet was translated, and local staff members facilitated the sessions.

In the UK, participants used the think-aloud technique and worked alone. A facilitator was present throughout the session. To maintain consistency, facilitators in both countries worked from a common guide. In Botswana, 30 participants were chosen from 70 volunteers, making 15 sessions. Two sessions were not usable because the

participants were too quiet. In the UK, 7 participants were recruited. One session was not usable.

Data Analysis

The transcripts were analysed using a modified and extended version of Valkenburg and Dorst (1998)'s notation to identify the processes in Schön (1983)'s design and reflection cycle: naming, framing, moving and reflecting. The extended version includes signature frame matrices to more clearly identify frames (Blyth, Lotz, Sharp, Woodroffe, Rajah & Ranganai, 2012) and a more detailed notation that highlights the distinction between thinking in the problem space and in the solution space (Lotz at al, 2013). The notation allows visualising exactly when problem and solution space co-evolve in parallel and when bridges between the spaces are built. We also coded the use of analogies (Christensen & Schunn, 2007). An analogy helps to transfer elements from the familiar (a source) to use it in constructing a novel idea. Ideas can be transferred from similar problems or solutions to the current situation. The coding was completed by two researchers independently and challenged by two others on a regular basis. This produced 21 annotated transcripts, 6 from the UK and 13 from Botswana.

Based on these detailed annotations we extracted all episodes that showed parallel co-evolution and bridging within and outside of a frame. We split co-evolution into two separate types of episode: parallel co-evolution and bridging between problem and solution spaces. We also tabulated analogies that occur within and outside of frames, and within and outside of co-evolution episodes. In addition to this, and in line with Dorst and Tomkin's (2011) definition of themes, we summarised the main theme for each co-evolution episode and analogy. While the frame column is a representative word, shorthand for talking about the frame, the metaphorical theme column gives a description of both the problem criteria and solution ideas that frame the designers' thinking. An exemplar table for Botswana pair 8 with all the extracted episodes is shown below in Table 1. Each row in the table 1 represents one unit of analysis.

Table 1 Episodes of co-evolution and analogy use in the framing behaviour of pair 8. A blank cell indicates non-occurrence. P = problem, S = solution. Bridges can go from Problem to Solution (P ➔ S) or reverse S ➔ P).

Pair 8: lines	Frame	Metaphorical theme	Analogy S, P	Parallel co-evolution	Bridge
8: 5 - 18	Interactive watch	Patients with AIDS	Anti Retro Viral (P)		P ➔ S S ➔ P P ➔ S
8: 19 – 30	Interactive watch	Caring for patients with AIDS	Bottle Feeding (P) Mobile phone alarm (S)	Mother (P) Caregiver (P) Watch (S) Auto off Alarm (S)	
8: 70 - 97	Interactive watch	Stakeholders using an alarm		All people (P) Disability (P) Alarm (S)	
8: 98 - 113	Interactive watch	Complexity of drug taking			S ➔ P P ➔ S S ➔ P P ➔ S
8: 115 – 130	Phone	Flexibility for a variety of stakeholder	Phone (S)	All stakeholders (P) Phone (S) Text (S) Voice (S)	
8: 224 - 232	Phone	Flexible for various disabilities		Nurse (P) Language setting (S)	

				Deaf (P) Text (S)	
8: 233 - 237	Phone	Flexibility			S ➔ P P ➔ S

Finally the individual tables were compiled into one overview table for each cohort – the UK and Botswana – as shown in Tables 2 and 3. Through this analysis we were looking for novice framing practices in both locations and trying to understand the role of analogies and co-evolution episodes in novices' framing behaviour.

Findings

Our main findings are presented in Tables 2 and 3. Column 1 shows the participant or pair number, column 2 displays the overarching theme that is developed and column 3 shows the frames and their names. Column 4 describes several details about the analogies used. To further investigate relationships between co-evolution and analogy use within framing, we have divided it into 7 sub-columns: the name of the analogy; whether a solution (S) or problem (P) analogy was used; whether the analogy was used within a frame (F); whether the analogy 'opened' the frame (O); whether the analogy occurred during a co-evolution episode (C); and whether it occurred during a bridge building episode (B). 'Opening' a frame means that an analogy was the starting thought around which the thinking was focussed and framed.

Column 5 counts the numbers of parallel co-evolution episodes, and column 6 counts the number of bridge building episodes, and in which direction.

How do novices in the UK and Botswana frame interaction designs?

Columns 2 and 3 in Table 2 give a descriptive summary of the framing practices in the UK. UK novices generate between 1 and 3 frames (2.2 on average) in the 1-hour session. Participants 1, 4 and 7 have frames dedicated to parts of an integrated system, e.g. a PC application used by doctors and a handheld device or tablet used by patients. The ideas of Apps and handheld or portable devices are dominant in UK sessions. However, participant 3 and 7 refrain from specifying exactly what kind of device they envisage. Universal usability and appropriate interaction design for the elderly or less-abled users are important framing thoughts throughout, except for participant 5.

Table 2 UK novices framing practices where S = solution, P = problem, O = opening of frame, F = in frame C = during co-evolution B = during bridge building. X = observed in this category

P#	Metaphorical theme	Frame	Analogy							Parallel co-evolution	Bridge	
				S	P	F	O	C	B		P➔S	S➔P
1	• The elderly needs are satisfied by notepad and doc can connect to it.	• Tablet device • Doc PC	Tablet Picture Prescription Alarm	X X X X		X X X X	X	X	X X X	3	3	2
3	• Appropriate input design for varying user expertise.	• Device	Scanner Camera	X X					X X	7	4	3

4	• Universality of devise for reminding at night and while being out.	• Home alarm at night • Pager • Doc PC	Alarm clock Pager Text message Release system Alarm clock Alarm clock Pager	X X X X X X X		X X X X X		X X X X	X X X X	6	2	1
5	• Complexity of medicine taking requires detailed input and output design.	• App • App input	Dosset box Mobile app iTunes Google search Home button Snooze button	X X X X X X		X X X X	X	X	X	5	1	0
6	• User perception, i.e. intrusiveness of alarm and ease of use guide design.	• Handheld • Watch	Alarm Alarm Phone Drawer Phone alarm	X X X X	X	X X X X	X	X	X X X X	9	3	2
7	• Universal and integrated system of PC app and watch-like device.	• System • Doc App • Device	Alarm clock Wristband Watch	X X X		X X X		X X X		8	2	1
Sum		13	27	26	1	21	3	9	13	38	15	9
Av		2.2	4.5	4.3	0.2	3.5	0.5	1.5	2.2	6.3	2.5	1.5

Columns 2 and 3 in Table 3 show a descriptive summary of the framing practices in Botswana. Botswana novices have between 1 and 4 frames with an average of 2. Similarly to the UK, handheld, worn or portable solutions are dominant frames. However, the frames become much more specific in defining the handheld device, e.g. pairs 1, 2, 4, 5, 6, 7 and 8 have 'watch' as frame. Likewise, mobile phone is a dominant design, which is used as a frame to stimulate the students' design process. Universal usability and reducing complexity is a recurrent theme. A recurring metaphorical theme to address complexity is taking away control from the user, e.g. through preprogramming (pairs 5, 7, 10) and putting it in more literate and educated hands, such as doctors. The needs of illiterate and poor users are brought to the fore. We see service design frames and themes in Botswana, such as education, training of users and volunteering aspects. We observe less integrated systems than in the UK.

Both cohorts frame the interaction design problem in similar ways: they suggest handheld devices. Botswana students become more specific in defining the handheld device, but both cohorts pay attention to user behaviour in their framing.

Table 3 Botswana novices framing practices where S = solution, P = problem, O = opening of frame, F = in frame C = during co-evolution B = during bridge building. X = observed in this category

P#	Metaphorical theme	Frame	Analogy							Parallel co-evolution	Bridge	
				S	P	F	O	C	B		P→S	S→P
1	• A watch for impaired and less abled.	• Watch	Mobile phone Alarm Watch Wall watch Watch Watch	X X X X X X		X X X X	X	X	X X X X	5	3	2
2	• Simplicity of use is reached	• Alarm • Alarm system	Alarm System	X X		X X	X X	X X		7	6	6

	through structured interaction when setting alarm.	• Watch with alarm • Mobile for youth	Mobile phone Computer User manual	X X X		X X X		X	X			
3	• Volunteers remind elderly and the youth is educated to set mobile alarm as reminder.	• Volunteering • Education and mobile phone	Home care Anti Retro Viral Mobile phone Home care Mobile phone	X X X X	 X 	X X X X X	X X 	X X X	 X X 	5	4	4
4	• Wearable object for all environments.	• Watch	Bracelet Watch Watch Mobile phone Cattle Bell Walking Crutches	X X X X X X	 	X X X X X X	 	X X X X X X	 	4	1	1
5	• Free Preprogrammed device given to poor.	• Mobile • Government watch	Mother Watch Watch	 X X	X 	X X X	X X 	 X X	X 	5	1	0
6	• Device needs to be portable to not be forgotten.	• Watch • Pouch for watch	Anti Virus Scan Wallet Mobile phone Answering machine	X X X X	 	X X X X	 X X 	 X X X	X 	5	3	3
7	• Preprogrammed and serviced device by doctor.	• Watch • Call system	Watch Preprogrammed mob Watch Motherboard Mobile	X X X X X	 	X X X X X	X 	X X X X 	 	7	3	2
8	• Flexibility of device for diverse stakeholders.	• Interactive watch • Phone	Anti Retro Viral Bottle feeding Mobile alarm Mobile alarm Mobile alarm Mobile	 X X X X	X X 	X X X X X X	 X	 X X X X	X X 	4	6	5
9	• Designing a trial of a device to specify it further.	• Button device	Mobile phone Mobile phone	X X	 	X X	 	 X	X 	2	4	3
10	• Universal bracelet that is borrowed from and serviced by doctor.	• Bracelet	Mobile phone Bracelet Watch Bracelet Mobile phone Ring Telepole bracelet Mobile phone	X X X X X X X X	 	 X X X X X	 X X 	 X X X X X X	X 	6	4	4
11	• Due to complexity a governmental service provider initiates the house alarm.	• PA • Medics • House alarm • Radiophone	Watch Alarm Alarm	X X X	 	X X X	 X	X X 	 X	4	12	12
12	• There is a need for training instead of reminding, but the first solution suggests timetabling reminders.	• Timetable and phone • Training	Training		X	X	X		X	4	3	3
13	• System housed in a watch like object that could take over family	• System	Trigger Phone	X X	 	 X	 	X 	 X	6	8	7

	member's duty of reminding											
Sum		25	56	51	5	47	15	36	16	64	58	52
Av		1.9	4.3	3.9	0.4	3.6	1.2	2.8	1.2	6.3	2.5	1.5

How are analogy, co-evolution and metaphorical theme used in framing designs in novices?

Co-evolution

Both cohorts use co-evolution to develop frames. Columns 5 and 6 in Tables 2 and 3 show the number of parallel and bridging co-evolution episodes for the UK and Botswana respectively. While UK designers have an average of 6 parallel co-evolution episodes, Botswana designers have 5 parallel co-evolution episodes on average. Botswana novices build on average 4.5 bridges from problem to solution space and 4 from solution to problem space, while UK novices build 2.5 bridges from problem to solution spaces and 1.5 from solution to problem spaces on average.

That means UK designers generally have fewer co-evolution episodes. They co-evolve problems and solutions in parallel more than they bridge between problem and solution spaces. In Botswana, parallel co-evolution and bridging episodes are more balanced.

Analogies

Both cohorts use analogies, on average 4.3 in Botswana and 4.5 in the UK. The tables show a dominance of solution analogy in both settings, as was found in expert designers (Wiltschnig et al, 2013). There was an average of around 4 solution analogies in both cohorts, with a slightly higher average in the UK. We can see only a few problem analogies – 5 in Botswana and only 1 in the UK in total. That means novices in both settings draw on analogies to solve rather than to identify problems.

Our novices use more analogies within a frame than outside of a frame. In fact, only a few analogies occur outside of frames - in the UK one on average and in Botswana less than one. We also observed that analogies occurred more often within co-evolution episodes than outside in both the UK and Botswana. In the UK 22 out of all 27 analogies occurred in co-evolution and in Botswana 52 out of all 56 analogies occurred during the co-evolution episodes. This confirms what Wiltschnig et al (2013) found in expert designers. In novices, the occurrence of analogies can be linked to co-evolution and framing.

Opening analogies and metaphorical themes

In our data, we found that analogies during co-evolution are often used right at the beginning of a co-evolution episode. In this case the function of the analogy was to open a frame, and we called them 'opening analogies'. This means that from the moment the designers used a particular analogy, the design thinking was focused around this analogy. We also observed in our data that all designers who did use an opening analogy developed a metaphorical theme around the opening analogy.

Most of the 13 Botswana pairs use opening analogies (not in 4, 8, 13). For example, in Botswana pair 1, the watch is an opening analogy. The metaphorical theme for the frame was "a watch for impaired and less abled". Likewise in pair 2, the opening analogies alarm and system opened the way for the metaphorical framing theme "Simplicity of use is reached through structured interaction when setting alarm". Pair 3 is interesting, because they use a solution as well as problem analogy to open a frame –

the volunteering frame. The main framing theme to which this leads is “Volunteers remind elderly and the youth is educated to set mobile alarm as reminder”. Although most of the opening analogies occur towards the beginning of the design session, some are towards the end too, for example in pair 12, the designers reframed the problem through an opening analogy that saw the problem as training people. Half of the UK participants also used an opening analogy. For example, participant 1 used ‘tablet’ (notepad) as an opening analogy from which she developed a theme around the elderly use of notepads. Opening analogies are a popular tool to frame novices’ thinking in both settings. They offer a quick route into developing metaphorical themes.

Metaphorical themes as bridges

In Dorst and Tomkin’s argument, metaphorical themes act as bridges between problem and solution spaces. We wanted to see whether this is also the case in our novice designers. Having separated parallel and bridging co-evolution episodes in our analysis, we also wanted to see whether or not analogies in general and opening analogies in particular are associated with bridging episodes.

Previously we have established that opening analogies are linked to metaphorical themes. But are opening analogies are also linked to bridges. In the UK 2 out of 3 opening analogies occur during bridging episodes, while in Botswana only 4 out of 15 do. Our data doesn’t seem to support the argument that opening analogies only act as bridges. It rather seems that opening analogies equally support parallel co-evolution. Since opening analogies were related to the development of metaphorical themes, our data suggest that in novices metaphorical themes are developed not only in bridging but also in parallel co-evolution.

Discussion

What implications do our findings have on design pedagogy?

Both cohorts in the UK and in Botswana use co-evolution. But Botswana and UK novices differed in the number of co-evolution episodes (Botswana had more overall) and the types - bridging or parallel co-evolution.

UK sessions include more parallel episodes while bridges lead to reconsidering the problem frame suitability and devising a new solution. Co-evolution episodes evolve problem and solution spaces but don’t shift them ‘radically’. Having more parallel co-evolution episodes means that UK students progress a small number (often one) of ideas in depth but generate fewer ideas. The frame suitability is not questioned, as it would be during bridge building and so UK students remain in a frame.

Botswana students reconsider problem criteria in the light of a less than satisfactory solution by building bridges. They question the suitability of a frame and generate alternative ideas, but the new solution does not generate a new frame. Botswana students have a similar number of frames on average as UK students.

These differences in co-evolution have implications for design pedagogy in both contexts. To increase reframing and generation of more ideas in the UK, educators would need to increase the number of leaps between problem and solution spaces. This supports Lindner’s (2011) finding that helping students to frame problems leads to more diverse solutions. Conversely, to encourage Botswana students to frame ideas and work them through in depth, educators would need to discourage students from building too

many bridges. This has not been discussed much before in literature. In addition, co-evolution processes are not much discussed in design education either. Research by Almendra and Christiaans (2011) has shown that students are unaware of these co-evolution processes. A visualisation of the students' processes was suggested to support reflection and learning.

Both cohorts in Botswana and the UK use opening analogies to develop metaphorical themes and frames. Both cohorts frame their ideas in terms of handheld devices. Botswana designers are more specific about what kind of handheld device they want to design, often a bracelet, watch or phone. They are specific early on because they use opening analogies. Half of the UK designers also show this behaviour.

One implication this has on pedagogy is to encourage the use of opening analogies to help develop metaphorical themes. On the other hand one could also experiment with prohibiting opening analogies to see what other framing behaviours occur. We think of opening analogies like a jump into water, what if we ask students to wade into water slowly?

Opening analogies start the development of a metaphorical theme for a frame quickly. We could also see that the development of a metaphorical theme is not only related to bridging, but also to parallel co-evolution. In the development of metaphorical themes the consideration of users, user behaviour and contextual constraints allowed solutions to evolve. In line with accepted interaction design pedagogy, our novices pay particular attention to user behaviour and requirements. One implication of this for design pedagogy is that by focusing on user behaviour we also develop students' ability to co-evolve problems and solutions.

Conclusions

To summarise, novices in the UK and Botswana develop similar frames – handheld devices. Novices use co-evolution in framing. Analogies are linked to co-evolution also in novices. Opening analogies help students to develop metaphorical themes in framing, but these themes do not only act as bridges, they also support parallel co-evolution in novices. This is important to note because bridges might support big leaps (i.e. reframing) but parallel co-evolution supports incremental progress. Novices need both to develop metaphorical themes in framing.

The study demonstrated that novices show some expert-like behaviour in co-evolution and analogy use in framing. We also found similarities and some differences across our cohorts in Botswana and the UK. We argue that particularly the differences, such as different numbers of co-evolution episodes or opening analogies, have implications for appropriate pedagogy in both settings. We believe that design pedagogy should support but also challenge the natural behaviours in each setting.

We think it is important for educators to know that an emphasis on understanding user behaviour in designing also supports co-evolution in design education. If educators want to encourage ideation of multiple solutions they need to teach bridge building between problem and solution spaces, but if they want to encourage the working through of ideas they need to emphasise parallel co-evolution. Analogies are clearly important to framing, but educators could teach different ways of using analogy, beyond the opening analogy.

Finally we think that studying design behaviours across cultures gives us some valuable insight into how to challenge students' design learning and design pedagogy in different settings.

Limitations

Our goal was to collect high quality data, which meant adjusting the data collection methods for each country. This might have affected the findings and the level to which we can compare them. However we believe the quality of verbalisation can be considered comparable. Comparing a team and a single designer, Goldschmidt (1995) developed the argument that both, think aloud and concurrent interaction, are an equal window into thinking, because thinking is brought into being through words. In addition, our UK participants frequently used social speech (considered responses) rather than internal speech (stumbling, breaks etc.) when thinking aloud, just as the Botswana pairs did in constructive interaction. The rationale for choosing pairs in Botswana and individuals in UK was based on the learning settings that each cohort experience. In the UK, participants study individually at a distance, while in Botswana participants study in face-to-face groups. By choosing pairs in Botswana and singletons in the UK we replicated their normal learning conditions as closely as possible.

The way we constructed our analysis might have had an influence on the results. For example, in some cases it was difficult to determine exactly when a frame starts. We decided to mark a frame when the conceptual object it pertains to is clearly named. But in several UK samples, the designers do not commit to a conceptual object - and hence a frame - right away. They uncover the beginning of a new frame while moving around the conceptual object. Speaking metaphorically, the designers' waded into water instead of jumping in. We thought that this approach to framing was interesting but it was out of scope to study in-depth here. This would be worthwhile to pick up in a further study.

Acknowledgements

This research as been funded by the Leverhulme Trust. We would like to thank all our participants.

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