

Early Stage Creative Design Collaboration

A Survey of Current Practice

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Background

Much of our current understanding of creativity comes from the study of the different professional practitioners of creativity.

Many of these studies have also attempted to define a model of creativity with-in specific disciplines, industries or environments [Brophy, 2001, Coughlan & Johnson, 2008, Howard et al, 2008, Zhu, 2011]. These models of creativity have ranged from describing creativity in very specific situations and environments, to more general and broad ranging. Other variations of these creativity models have been used to describe the cognitive and organisational aspects of creative process-es.

One approach to modelling creativity that is of particular relevance here has been to focus on the different types of interactions during creative processes. This might be an interaction with a tool (or external “artefact”) or between people. Here, “interactions” are described as the link between mental creativity and physi-cal representation [Coughlan & Johnson, 2009]. This particular research has yield-ed categories of interactions, such as “Productive Interactions”, “Structural Inter-actions” and “Longitudinal Interactions”, which may or may not occur in a linear or chronological way [Coughlan & Johnson, 2009].

“Productive Interactions” could be considered those types of interactions that occur with the purpose of generating a new idea as well as possibly a visual, or physical, representation of that idea [Coughlan & Johnson, 2009]. These types of interactions are frequently dependent on the rapid and spontaneous representation of ideas. Particularly within the visual arts, sketching is frequently used as a mode of idea generation and exploration [Sedivy & Johnson. 1999]. This type of sketch-ing during early stages of idea generation tends to be fast, spontaneous and flexi-ble. These attributes support a process through which early ideas can be identified, explored, and refined, all possibly in a short period of time [Sedivy & Johnson. 1999].

As key elements of this idea generation and exploration are speed and sponta-neity, the tools used must be accessible and easy to use. Research has suggested that immediately accessible, or “ubiquitous” tools are key to the representation of ideas during early stages of creative processes [Coughlan & Johnson, 2008], and recent research has also suggested that analogue tools, such as pen and paper, are generally preferred because of their ease

and immediacy of use [Coughlan & Johnson, 2008]. However, studies have shown that while practitioners prefer the use of analogue tools for the early representation of ideas, they recognise the potential “organizational advantages” of supporting technology [Coughlan & Johnson, 2008].

Whether it is through analogue or digital means, the capture (storage), organisation and reuse of materials and/or creative ideas used or generated in early stages of design can be crucial [Coughlan & Johnson, 2009]. The tendency of creative practitioners to continually save ideas and resources is well documented as a pervasive and constant aspect of their lives [Coughlan & Johnson, 2009]. Research suggests that access to physical artefacts used during idea generation is extremely valuable, even if the ideas have been digitised and are digitally available [Geyer et al, 2011]. However, one benefit of digital tools over analogue that is referred to in the literature is the ability to facilitate the sharing of ideas across distance, with larger numbers of people, and also to do so asynchronously [Geyer et al, 2011, Gumienny et al, 2013].

Exploration and refinement of ideas are aspects of creativity that are supported by another key element of any creative process, reflection. Creative reflection has been described as an internal mental “conversation”, whereby ideas and goals are reviewed and possibly iterated on [Casakin & Kreitler, 2011]. Reflection can also take place in a more physical actionable way. A designer might redraw a sketch multiple times in order to explore variations and subtle changes [Coughlan & Johnson, 2008]. This process frequently includes a degree of internal dialogue whereby the designer compares the resulting changes to previous versions, original goals, or a mental model of a desired outcome.

Acts of creative reflection can also be found within “Structural Interaction.” In the context of a review of current practices of creative collaboration, the category of “Structural Interaction” is particularly relevant. “Structural Interaction” is defined as having a focus on the “self-reflective component” of creativity and is integral to the formation, evaluation, and evolution of creative processes [Coughlan & Johnson, 2009]. Iterating on existing creative process can theoretically lead to new original processes (and tools), which may in turn produce new innovative ideas [Coughlan & Johnson, 2009].

Another common feature of creative processes is the sharing of ideas between peers. Collaboration amongst peers can take many different forms and can involve participants in a variety of ways. Spontaneous informal personal interactions have repeatedly been found to be integral to co-located

collaborative workflow. Re-search has shown that organisational creativity and productivity is often dependent on informal collaboration, and suggested that digital tools developed for creativity in collaborative environments should be designed with this in mind [Bellotti & Bly, 1996]. Other aspects of the environment that facilitate or hinder informal collaboration, such as workspace proximity, noise, available meeting space and social dynamics can also be important [Bellotti & Bly, 1996].

A key area that has been found to be integral to facilitating informal collaboration is the concept of awareness of other participants or potential collaborators [Bellotti & Bly, 1996, Gutwin et al, 2008]. For example, this could be “aware-ness” of availability of a co-worker, or recognition of the status of a project or task. This can be further extended to the awareness of the availability of tools, physical artefacts, or even environments (e.g. an empty meeting room). Greater awareness of these different elements potentially facilitates informal collaboration and communication by making it easier for practitioners to initiate spontaneous and informal collaboration.

In the rest of this chapter, we describe the methods and then the results from our survey, in which we sought to investigate the extent to which issues such as the above were still important in the work of practicing designers.

Research questions & methods

The aim of the study reported here was to understand the current state of practice in collaborative, early stage creative design, in order to determine whether current practice as observed when the study was conducted (in the autumn of 2013) corresponded to what had been reported in the existing literature. The study sought to ascertain whether, as a result of changes in the fast moving world of technology, practice had moved on since the earlier studies, reported above, had been conducted.

The study began with an online survey to which 37 practicing designers responded. Of those 37, 23 were based in the UK, 7 in the US, and 7 in other locations including Canada, France, India, Peru and Malaysia. 7 of the respondents were under 30, 14 were aged 30 - 39, 14 were 40 - 49 and 2 were 50 - 59. In terms of experience, while 7 were relatively new to design with 2 years' experience or less, 11 had between 2 and 5 years, 5 had 6 - 10 years, and the remaining 14 each had over 10 years' experience as a designer. Respondents defined their professions in terms of user experience design, web design, industrial design, marketing, merchandising, video production, motion graphics, graphic design, architecture and hairdressing, with two defining themselves as inventor and artist. All participants took part in some form of creative collaboration, with 97% of respondents described themselves as participating in creative collaboration at work, and 57% describing themselves as collaborating on personal creative projects.

Following the survey, 8 face-to-face interviews, each lasting approximately an hour, were conducted with respondents who had agreed to participate. Of these participants, 4 were male and 4 female. An indication of the type of design these interviewees participated in, as well as their job title and the type of organization in which they were working, is shown in Table 1.

The interviews were conducted as semi-structured conversations. As the self-reflective analysis of process and methods has already been identified as being a common activity (and existing skill) amongst creative practitioners, the study sought to engage them in further analysis of their current processes. The participants were asked to reflect on their creative process and their experience in collaborative situations and environments. The basic outline of the interviews was centered on exploring the specifics of the early stages of each participant's creative process. Key areas of interest

during these interviews were: when, where, how, and even why, collaboration took place. Participants were also queried on the types of tools they used throughout their creative process, as well as which tools they wished they could use. Regarding tools, a key point of interest was to gain insight into why certain tools were being used at certain points, and which re-lated functions they supported (e.g. collaboration). Participants were also asked to elaborate on the process of choosing tools, and the key factors in deciding which tools to use, or not use to use.

The final area of focus for the interviews was on the activity of reflection, with-in the context of a creative process. As the reviewed research literature consistent-ly identified this activity as a key element of creative processes, the interviews were structured in order to gain insight into its relevance to current creative prac-tice. The interviews were intended to explore when, where, and how this reflection occurred and what impact it had on creativity. In addition, participants were que-ried about possible instances of collaborative reflection, or review of ideas. Final-ly, participants were again asked to indicate which tools and technologies were used to support these activities of reflection.

Interviews were transcribed, and a thematic analysis of the transcripts was con-ducted. The remainder of this chapter presents the results obtained from our sur-vey and interviews. Much of this is written using the words of the interview par-ticipants, with the aim of providing a more immediate sense of how work in this area feels to those who are doing it.

Participant	Job title	Design type	Organisation type
P1	Associate Design Director	Product design	Corporate
P2	Researcher	User experience	Corporate
P3	Masters student	Applied creativity	University
P4	Interaction Designer	User experience	Corporate
P5	PhD research student	Research	University
P6	UX practitioner	User experience	Corporate
P7	Interaction Designer	User experience	NGO
P8	Web designer	Web design	Corporate

TABLE 1: Interview participants

In this section, we present our findings in relation to the various forms of col-laboration that take place during early stage creative design, as well as the differ-ent types of activity and processes that designers engage in.

Early stage design activities

Collaboration

As stated earlier, all of the respondents to the survey participated in some form of creative collaboration, either as part of their work or personal projects. The value of collaboration in design was also acknowledged by many of the interview participants. Collaboration was frequently felt to be an integral aspect of the creative process, which potentially generated a greater range of novel ideas, or facilitated more effective problem solving.

Designers in our survey typically worked with teams of different sizes: 13 people said they collaborate on average with just 1 - 2 people; 18 said they worked with 3 - 5 people; 4 with 6 - 10 and 2 with more than 10. Interview participants frequently described collaboration as occurring in many different forms and a variety of environments. Collaborative activities were described as both formal structured events as well as impromptu, unstructured events. The proportion of survey respondents taking part in more structured collaboration processes as well as informal and spontaneous collaboration is shown in Figure 1

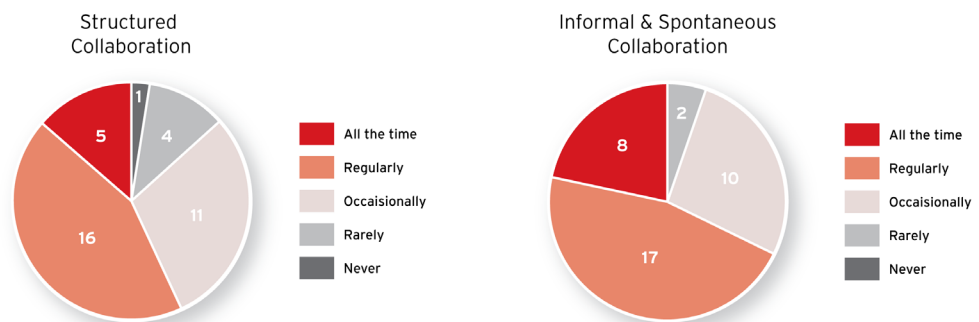


FIGURE 1: Numbers of survey respondents engaged in structured and informal collaboration.

In this section, we first look at how the communication necessary for collaboration takes place, and then at the different ways in which first informal and then more formal or structured collaboration takes place.

DIRECT COMMUNICATION

Participants frequently described their collaboration with others as occurring in the same space, at the same time, talking to each other while sketching things on a shared surface (whiteboard or paper), in an effort to either come up with ideas or to solve a problem. This act of collaboration, with designers working in the same place at the same time, with open and spontaneous communication, was recognised by a number of interviewees as being a key element of their creative collaboration, especially during the early stages of a project.

Many of the participants described this type of collaboration as being integral to the way they worked. Participant P1 went as far as suggesting this was something that his business depended on. A key aspect of this type of collaboration was to allow each individual to contribute by developing their own ideas simultaneously, while also being able to communicate with others directly. This type of simultaneous idea development and communication was described within the context of a wide range of circumstances and environments.

P2 described the differences between remote and co-located synchronous collaboration: 'If they're not in the same room, you don't have all the other things that maybe contribute to that environment. So like you draw something, I draw something, you do something, I do something. Rather than everyone's like, you're in this corner and I'm on the floor, and we're like talking, and you're like 'Oh that's interesting'. It's just lack of a shared space.' The ability to immediately interact and respond to other individuals directly was consistently highlighted as one of the most valuable aspects of co-located collaboration, during the interviews. Further more, interviewees suggested that the lack of immediacy and direct interaction was one of the key weaknesses of remote collaboration, and the technologies that support it.

INFORMAL AND SPONTANEOUS COLLABORATION

Many of the designers interviewed referred to the spontaneous nature of informal collaboration and the regularity with which it occurs. Being able to share ideas and get direct feedback from peers was frequently commented on as being an important part of their creative process. As P6 put it, 'There's lots of spontaneous gatherings and ideation.'

The types of collaboration that could be categorized as 'informal' were instances where there was minimal planning, and the collaborative activities were able to take place in a wide range of environments, and frequently with minimal infrastructure or technological requirements. The main requirement described was the co-located sharing of ideas.

The informal collaboration was frequently described as being triggered by the introduction of a problem, or an initial idea. As one participant described it: 'Whenever we had an idea we'd just go and do it. We'd get the brief ... and figure out what the problem was. And then we'd try to talk through it ourselves. I'd say 'Lets go get some paper and go and do it.' My colleague was sitting right beside me so it was really easy' (P7). This further confirms that this type of collaboration is less dependent on structured events and environments, and can occur in an un-predictable manner.

There were a number of different factors that were indicated to influence the accessibility of informal collaboration. The physical environment was consistently mentioned as a factor in either facilitating or inhibiting this type of collaboration. For example, interviewees frequently commented about how physical proximity to peers can facilitate the sharing of ideas and a variety of collaboration. P7 commented: 'we sit next to each other. It's kind of 'what do you think of this?'; and another participant confirmed, 'I sit in the center of a design team. So we have lots of side conversations all the time.' (P2).

Physical proximity was also important in enabling the visibility or awareness of the availability of co-workers. This again allowed collaboration to happen in a more spontaneous, unplanned manner. For example, P8 described how: 'We sit at one long desk. I just stand up and keep an eye on if they're working, or if they're not 100% busy, and then I'll just ... tap them on the shoulder and say 'Martin, can I have a minute?'

STRUCTURED COLLABORATION

Formal or more structured collaborative events were frequently described as being necessary in order to frame a project and set goals. While the details of this type of collaborative event differed amongst interviewees, some more formal collaboration was often felt to be a necessary part of the early stages of design and problem solving.

Some of the interviewees talked about the transitions between informal and more structured collaboration, and the role that technical tools can play

in facilitat-ing that. In particular, P4 talked about gathering together the whole of a project team for a kick-off meeting, even when some members of the project are in differ-ent locations, by using web conferencing tools: 'That kickoff meeting can be massive. It can even have people in on [web conferencing tool]. ... So typically I'd say between 15 and 20 people. ... It's just so later on people can't go 'I wasn't in-cluded, so I'm not going to contribute'. It's all about bringing people on, ... It's just so everyone knows what's going on.'

This comment also illustrates how these formal collaborative events can poten-tially remove barriers to further collaboration. The inclusion of people at this stage enables further collaboration amongst project participants by giving those includ-ed a common reference point to work from.

Creative activities & process

During the study, as well as with much of the research reviewed, the activities that were seen to be most effective, and return the most creative results, frequently involved the simplest and easiest tools to use, in easily accessible environments with few technical components. Participants continually described early stages of idea generation as being most effective when organizational, environmental, and tool or equipment barriers are removed.

IDEA GENERATION & REPRESENTATION

Idea representation usually consists of the act of putting pen to paper and be-ginning to describe an idea, either visually or with words. The process of repre-senting early ideas is often referred to as an "explorative" activity, where the de-tails of an idea are gradually described and built upon. The activities related to representing an idea are often felt to be the best way to develop and evolve initial ideas, as well as to trigger the generation of new ideas.

The representation of the idea in essence frees the individual (or group) from the cognitive load of remembering, or mentally visualizing the idea, and allows the practitioners to turn their creative energies to investigating other ideas, or de-veloping further details of the initial idea. This in turn can facilitate greater diver-gent thinking, as the practitioners are better able to develop completely unrelated and different paths of thinking.

Additionally, initial representations of ideas are especially important in collaborative environments where developing shared understanding and common mental visualisations is at the very least difficult. In these situations, shared representations of ideas are often used as the building blocks for further idea generation, or idea evolution. In our study, the initial act of representing potential solutions was frequently felt to stimulate creativity and possibly lead to more innovative ideas. As participant P6 explained: 'It's not necessarily ideation, it's just thinking together in a group. "Here's a problem, let's go to the boards, let's go to the wall, let's scribble." Because it's always helpful, to put things down. ... Because it sparks other people's ideas'. As this quote illustrates a key function of these activities at this early stage is not to develop a fully formed solution or design, but to rapidly explore possibilities. A similar approach was outlined by P7, who talked about the use of collaborative sketching to jointly develop an idea: 'Then we'd spend a few days to a week, trying to abstract out the idea of what we were being asked to do. And we'd come up with some sketches. We'd sit down for a couple of hours. One of us would start, just by drawing whatever. And then the other would take that idea and change it.'

The key goal of this act of sketching and representing ideas is to have something tangible result from this exercise that can be used and referred to at later stages. It should also be noted, that while "sketches" are frequently referred to as a desirable outcome of early stage design, other representations of ideas such as lists, or groups of post-its were also often referred to.

The most common attribute of all of these early "sketches" of ideas was that the starting point was more often than not created without digital tools, but with "analogue" tools, such as pen and paper, markers or whiteboards. Analogue tools are a natural fit for this as they produce physical artefacts that are generally easy to interact with. This is particularly important in co-located collaborative environments, where ideas need to be rapidly represented and shared.

IDEA CAPTURE & REUSE

The capture and reuse of previously generated ideas can take many different forms, and can include something as simple as creating and referring to a physical artefact, or generating and reviewing digital documentation of something that emerged from an early ideation activity.

The question of how to capture the outputs from collaborative sketching sessions, such as those described previously, was mentioned by many designers, both in the survey and in the interviews. P1 explained that: 'A lot of the time if we're having a discussion and creating things there's someone who's sort of notetaking or doing diagrams and things that just summarize the areas that we're looking at. And that's often really handy...you're having a conversation and somebody is just writing on a flipchart, writing the key things and drawing sketches, and then puts it up on a wall.'

This sort of "note taking" (or documenting) is a common occurrence. However, a theme that emerged from the interviews was that while analogue tools (such as pen, paper and post-its) are great for capturing ideas in the moment, as they are generated, there is still a necessary digital element. As P6 described: 'How we use post-its is [to] get ideas out, but then you have to still digitise them.'

One issue that came up during the study was that referring to physical artefacts outside of the context of the situation or environment that they were created in is frequently physically problematic, particularly if that initial context was collaborative. Physical artefacts in many cases may not lend themselves to group reviews, depending on size and format (e.g. a sketch in the margins of a sketchbook is not easy to submit to group review). Even in the case of an individual review of physical artefacts, if the object has not been in some way digitized, the individual must have access to the object and be physically present in the same location in order to review it. Even for a portable object, such as a large sheet of paper with ideas written on it, the circumstances in which it can be reviewed may be limited, due to its size and format.

The context in which the ideas were generated was often an important aspect of understanding what was being reviewed. Participants frequently commented on how they wished to capture, not just the ideas, but also some aspects of the context in which they had been conceived. 'For us, for me personally going back into that space, and seeing that work on the wall is a positive thing. Because it takes you back to that thought process.' (P6) P5 also expressed a similar sentiment in relation to attempting to create digital records of ideas generated in workshop settings: '... you try to photograph things, but you're not necessarily seeing the process that was around it at the time.'

The need to digitise the ideas (and in some cases the environment) was a consistent aspect of their creative process. Several of the interviewees

described capturing such outputs simply by photographing them: 'We're using smart phone cameras. That's how we digitise and it works great... We're very low key. Low tech.' (P1); and one explained that although photos are not perfect, they are better than text-based transcriptions of ideas, as they capture at least some of the contextual information: 'When you're capturing these ideas, and you take a picture. You capture so much more when you're doing that, then typing something up and sending someone an email about what happened. You get the context as well a little bit.' (P6).

The use of smart phone cameras was consistent amongst all of the interviewees. Many of them indicated that the simplicity and ubiquitous nature of camera phones was a key factor in their use. It frequently wasn't so much that they were chosen over other methods of digital capture, but rather that they were common devices that most people involved in the collaboration would have immediately at hand and be able to use without any difficulty.

REFLECTION

During the interview phase of the study, participants frequently described activities as part of their own creative process that could be classified as reflection. There was a wide range of activities described, occurring in a variety of circumstances and environments, that all served the purpose of reconsidering previous ideas. This range of activities and environments included planned formal review; spontaneous and informal, collaborative review; and background, low focus thinking which all served as a form of reflection.

One of the most common forms of reflection discussed was a focused review of previous sketches or notes. This was often described as an informal personal re-viewing exercise, primarily dependent on access to notes, via a sketchbook, or digital device (e.g. smart phone) and occurring in a wide range of situations (e.g. commuting on public transport).

A number of the designers interviewed described how reflection could be a background activity that happens as a natural part of their creative process. As P5 explained: 'If you're working on a project it's hard to control when you think about it, when you reflect on it. There'll be times when some random element will trigger something that sits in the back of your mind. And then you'll just sit there and think about it for a while.' In a similar way, P7 explained how: 'you can't just kind of turn it on and turn it off. So you'd come home

and you'd be sort of thinking in your head "Oh what about this, or what about that" and you would still be thinking about it.'

This type of low focus reflection is a common aspect of creativity and can often lead to new ideas being generated. The background processing of information and ideas was continually cited as something that the interviewees were aware of doing, but not necessarily able to control or influence. They also generally placed great value on this background processing of ideas, based on past experiences and the impact it had on generating further creative results.

A common response to the desire to be able to reflect on current work at any time is to carry a physical notebook. Most of the participants mentioned using notebooks, or in some cases for example, P7 described how: 'Since I started working in UX I carry a small notebook always. I always did before, but now I actually scribble in it. Because a lot of times I find myself coming up with a really good idea and then forgetting about it. Which is really annoying. So now you know, if I'm thinking about something in particular, and something comes up out of no-where, or out of somewhere, then I'll go 'Oh that's a good idea', and I'll sketch it down.'

The use of notebooks was seen as an effective way of documenting new ideas and also as tool to support reflection. Browsing through a notebook filled with related ideas can be a valuable form of reflection, where the sequence of ideas and thoughts can also help the practitioner recreate the context within which the ideas were created.

Interviewees described the use of both analogue and digital tools for these types of reflective activities. In describing her preference for reflecting with non-digital tools, P3 also offers some insight as to how reflection helps in the further development of ideas: 'But these days, because I use my computer for so many different things, for research, and making my project happen, for [using a video conferencing product], for email, for everything, I find it a relief to be able to just sit down with nothing digital around me, and to write down ideas. In terms of reflection it helps me clarify some thoughts.' Thus, as well as describing the reasons for choosing an analogue tool over a digital one for reflection, another key point that P3 appears to be making is how reflection can aid the clarity and development of early seeds of ideas.

Finally, one of the interviewees (P1) mentioned a process of collaborative reflection, in the sense of working with a small group on jointly reviewing

and iter-ating on ideas and goals in a physical way when working with physical tools: 'So if you're having a conversation and somebody is just writing on a flipchart, writing the key things and drawing sketches, and then puts it up on a wall. The thing is that as you move along, you might have one wall, you can then refer back to what you've been discussing, and start making links, and you might have a pause half way through ... And we'll kind of look back through and maybe star the things that we think are really valuable and where we don't like to go. And so it's this running dialogue, and it's a way of being able to review what you've already done.' This is a particularly good example of how reflection can occur in a collab-orative environment as a group, and also in a more formal structured setting.

Supporting early stage design

This section covers the various elements that when combined together appear to be particularly effective in supporting the early stages of design, or creative problem solving. These supporting elements range from interaction qualities, or types of interactions with tools, to attributes of the environment, or Press [Rhodes, 1961], in which the designers in our study are working.

Interaction qualities

Two general themes that emerged in relation to the nature of interactions between designers and their tools were as follows.

IMMEDIACY

Immediacy was a commonly occurring theme during the interviews, and was described as having an impact on a range of issues relating to supporting creativity and collaboration in early stage design. The importance of immediacy in early creative stages manifests itself in a number of different ways. Ease of use, familiarity, skill requirements, accessibility, and responsiveness are all qualities that can be linked to immediacy. These qualities were frequently described as key enablers of creativity with the tools used and also to some degree within the environments in which they are used.

'Ease of use' has previously been identified as an important factor here, for example by Sedivy and Johnson [1999], who report how an interview subject commented that an advantage of a multi-modal sketching tool under consideration was that it allowed for performing actions without having to think about how to access them. Participants in our study also commented on how familiarity with tools (i.e. pen and paper) made a tool easier to use in the sense that little thought was required while using it. Tools, which were immediately usable without any thought, were felt to be especially beneficial to creativity and allowed for greater productivity and efficiency.

This ease of use was also connected to the issue of skill requirements. The more a tool requires prior knowledge, expertise, or training, to use, the greater the barrier to immediate use. This was frequently a comment of interviewees that the training requirements of new digital tools could be a major drawback.

Another aspect of immediacy is the need for tools to be available whenever

they are required to record ideas that arise unexpectedly, perhaps during periods of reflection or informal collaboration as described previously. An example of a context in which a designer might have an immediate need for a tool of some kind to record an idea was given by P4: 'Bringing ... a pad of paper feels unnatural some-times because it's like we're at the copy machine and it's like 'ahh no, we've got to quickly sort this out'. So when it's not planned, you know.'

In this case the immediacy is directly tied to availability and accessibility. Having a tool immediately accessible in instances where there is an unplanned need is critical to spontaneous creativity. This is even more important for creative collaboration, where an impromptu gathering might be more difficult to re-create and co-ordinate, if the desired tools were not initially available.

A related issue is that whatever tools are employed should be quick to use and should not interrupt the designers' creative flow. P1 described the disadvantages of the latency inherent in many digital sketching tools: 'If I take it down to the level of being a designer and doing a sketch, think about that kind of thing. There's issues of latency. So the speed between your input and the reaction of the device. You know [tablets] and [smartphones] are great, because that's a media thing. But if you start to do note-taking and stuff, ... there's always a bit of a lag, that just kills it.'

This element of responsiveness is frequently considered a major issue with current technologies. Instances where a tool suffers from any sort of delay in application can bring the user's focus to the device they are using as opposed to the activity they are trying to accomplish.

FLEXIBILITY

A desirable characteristic of creative design tools that is closely related to immediacy, is flexibility. Flexibility, which was proposed by Guilford as one of three key factors (along with fluency and originality) that can characterize divergent thinking abilities [Guilford, 1957], is a key theme in the literature on creativity. It has been suggested that tools developed with a high degree of flexibility of use are less likely to 'disrupt the flow of thinking and action' [Edmonds et al, 2005]. This is very similar to the study's findings regarding immediacy, as described previously.

Recent research has also suggested that creative practitioners frequently work in an improvisational manner and that the tools they use should support

this [Gumienny et al, 2013, Hoeben & Stappers, 2005]. This is supported and explained in a statement from one of our interviewees: 'You've got to be flexible. Because as a designer your brain needs to be really flexible.... because you then start making connections with unexpected things and that's where new and really valuable things come from' (P1).

This concept of flexible thinking allows for practitioners to be more effective in their divergent thinking and to develop ideas without being locked into a linear progression of similar ideas. Flexible thinking raises the potential of having creative jumps from one idea, related to one path of thinking, to another path of thinking that might only tangentially be related to the first idea, thus resulting in a possible novel idea.

Previous work has linked creative design to flexible work environments [Bellotti & Bly, 1996], and this was evident in our study when interviewees talked about moving things around to configure their work spaces. Environments with fixed infrastructure such as interactive tables or wall-mounted devices can be problematic in this respect. Such a lack of flexibility can manifest itself in various negative ways. For example the use of a digital table-top, with an interactive surface, might result in a more rigid environment where people might tend to be stationary in seats around the table. This could potentially inhibit the types of personal interactions and collaboration [Fernaes & Tholander, 2006]. Additionally, the physical dimensions of the tabletop might enable only a very limited number of users [Geyer et al, 2011].

Related to this is a theme that arose a number of times in both the interviews and survey in relation to flexibility: that of portability, or being able to move things around. If a device or tool is not portable and can only be used in a special room, then it is not suitable for supporting the kind of spontaneous and informal collaboration described above, and any use also requires additional administrative work to plan and coordinate its application.

Several of the participants explained how useful it is to be able to move post-it notes around during creative design activity. P5 explained: 'It's kind of the flexibility of just being able to pick something up, move it, stick it down, shift it, that's what makes it work well.'

P1 further elaborated on how the portability or mobile nature of small analogue design artefacts can positively impact informal collaboration: 'So its the real, this is what I mean, they've printed stuff off, often it can be lots

of post it notes, lots of paper, and its about... These things are really mobile, and you can be sitting at your desk where you'll prop these against the wall referring to these as you work and other teams might come over to you and say 'what was that idea that you were talking about?'.

Other issues relating to flexibility that were raised by survey respondents included the restrictiveness of some digital tools due to their form factor (for example providing only small screens), the need for specialized equipment, and compatibility with other tools. These were mainly mentioned as potential disadvantages of digital tools.

Environment

Characteristics of the physical environment that emerged as being important in supporting early stage design were as follows.

INDIVIDUAL SPACES

Within the collaborative context, direct communication, as previously described, is particularly important in the development of ideas. However, even within collaboration the act of representing specific ideas is still very much an individual act, performed by individuals. When designers were asked about where and how they were creative (or generated creative ideas), individual workspace was emphasised as an integral part of their creativity.

This concept of individual workspace seemed for some to include the idea of a personal information space, such as a personal notebook for sketching when alone on the train, for example: 'I really use my notebook and have it with me all the time.' (P3). This personal space allows for designers to be creative and develop ideas without fear of their ideas being evaluated by peers, before they are prepared to share them.

Others talked about how initial creative work might happen within an individual designer's head before being shared and developed with others. For example, P3 explained how: 'When it's a personal project, I think the creativity does happen at the very early stages. But it's happening within myself. ... But then I may need to bring in people to help me figure out what it is that I'm doing.'

This is perhaps the more crucial element of allowing for individual workspace within a collaborative environment. While an individual will usually have the

personal mental creative space to come up with ideas and to develop them, it is also crucial to facilitate a personal space where idea representation and reflection can happen on an individual level. Allowing for this space can remove some of the evaluation apprehension from the situation and provide a safer, risk free space, to explore and be more creative.

COMMUNAL SPACES

As has already been mentioned above in relation to informal collaboration, communal spaces were frequently referred to in our interviews as environments where both informal and facilitated collaborations could take place. The basic requirements for such spaces appeared to be quite minimal, for example P1 described how: 'We go outside and sit on the bench and just talk about it.' P4 explained how: 'if it's a real big problem, ... then we'll go in some room, like a meeting room, or something where we've got loads of whiteboards and loads of marker pens and all that stuff. And we'll just draw things out.'

Three of the interviewees mentioned that spaces for collaboration should ideally be comfortable. P3 described one of her favourite spaces for collaboration as being both flexible and comfortable: 'there's also just couches, and cushions, and you can move them around. And it's a brilliant place to collaborate. And we did use that space quite a lot, and meet there, and it was sort of comfortable, and a great place to discuss ideas.'

Additionally, P2 described the use of both public spaces, such as coffee shops, for collaboration, as well as more dedicated spaces within her own company's offices: 'A lot of people come here [coffee shop] actually. We also have, we have that open space where we all sit. We also have smaller little rooms. Comfy chair, a white wall that we can draw on. So that we can have more of a closed space, that's not distracting.'

There was great variety in the descriptions of the communal spaces that were preferred and used. To some extent this variety also seemed to be a valuable aspect. One participant described comfortable collaborative spaces with the appropriate infrastructure, but also highlighted that busy public spaces were frequently used for collaboration. Where these public spaces might be "distracting", they also appeared to offer variety of environment, which could stimulate creativity.

P2 described her working environment as follows: 'Open plan, we all sit together. Like in small groups. We have whiteboards behind us to sketch.'

We have a glass wall. In some places we draw on the glass. We get post it notes up there. Yeah, its pretty cool.' P1 also described how writing things down in communal spaces is useful for sharing ideas: 'Yeah, you want to be able to see it. You want to be able to get it in front of people and share it. ... We're doing that in an ana-logue way. You know, being able to use this whole wall as a way of mapping out an idea and a thought process is incredible.'

Both of these quotes highlight one of the most important attributes of communal spaces, which is public visibility. This public visibility allows for the results from the creative collaboration to be easily shareable both during and after the collaboration. Persistent visibility of ideas can in turn stimulate further creativity and also facilitate reflection.

PERSISTENT CUES

The study found that one of the possible ways to support creative collaboration, was through awareness of earlier work, and the provision of persistent cues that could enable shared understanding and reflection on ongoing projects. While the issues related to informal collaboration and communal spaces have already been discussed, this section focuses more on the advantages of persistent cues enabling awareness of ideas previously generated during collaborative design.

The informal collaboration and communal spaces are key elements of the potential of persistent cues in that they enable immediate access (sometimes in a passive low focus manner) to the earlier ideas. These earlier ideas can either be shared or reflected on in either a direct manner or in a passive indirect way where indirect sharing, or reflection, could be the result of the persistent display of artefacts (digital or analogue) generated from an earlier creative collaboration.

In a number of cases interviewees expressed the desire to go back and view the scene of informal collaboration, where ideas had been generated. This was thought of as a way to possibly stimulate new creativity. In describing this P1 spoke about how the boards used to capture ideas as analogue drawings and artefacts were very useful to have in plain sight while continuing to work on a project. Talking about outputs from a design meeting, he explained: 'We'll just have them there facing out. That people can sort of glance at them, ... Yeah, ideally you want to have them out all the time. Because there's something, your brain is always working and that's just a reference to go back to. But it's a very ad hoc way of doing things, but it seems to work.'

In this case the physical artefacts “facing out” and displaying the outputs from earlier ideation enable the persistence of the ideas and both focused and passive reflection.

Finally P7 described how he used a persistent display of competing designs to help shape their development and facilitate collaboration: ‘I just draw each thing. So I put it up. So I have 4 designs. Each separated by like a line of white masking tape. ... And I can have people come over and go ‘Uh I don’t like that’ or ‘That’s a good idea.’

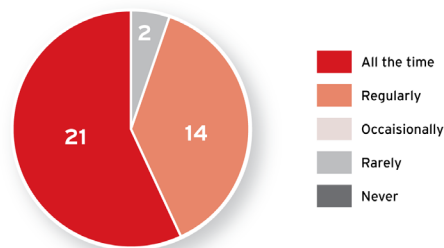
This indicates that the persistence and accessibility of earlier creative results can also further stimulate ongoing collaboration. The facility of co-workers to be able to engage in impromptu conversation (informal collaboration), can be a very valuable quality to a creative enterprise.

Tools for early stage design

Throughout the interviews many of the participants described how they use certain tools to help them in their current creative collaborations. The themes previously identified as being crucial to activities in the early stages of creative collaboration, and the environments in which they take place can also be linked to these tools and the roles they perform. In this section, we provide an overview of the strengths and weaknesses of current digital and non-digital (analogue) tools being used by designers in our study to support those activities in those environments.

In reviewing the benefits and drawbacks of the various tools used, it is clear that analogue tools have a very important role during creative collaboration. For example, the proportion of survey respondents using analogue and digital tools 'when initially coming up with ideas' in early stages of design is shown in Figure 2. From both the reports of interviews above and the figure below, we can see that the use of analogue tools at this stage is currently more prevalent than that of digital tools. However, the limitations of analogue tools such as pen and paper in terms of capturing such outputs for longer-term reuse and sharing were mentioned by around a half of survey respondents.

How often do you use **Analogue** tools when initially coming up with ideas?



How often do you use **Digital** tools when initially coming up with ideas?

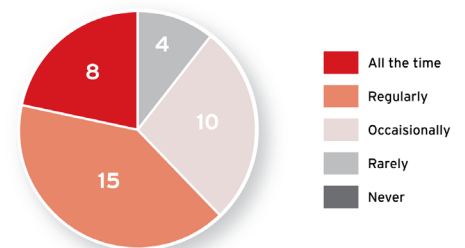


FIGURE 2: Numbers of survey respondents using analogue and digital tools when initially coming up with ideas.

Almost all of the interviewees talked about the importance of writing things down in shared spaces, and it is interesting to note that this is still being done using simple analogue tools such as whiteboards and pens. For example, P4 described how 'we've got a room in the office where it's just whiteboards. And the world's your oyster. You can just scribble over everything' and P6 how 'We've got these big whiteboards. Massive things on wheels. Because it gives us the space to just scribble and try ideas.'

The flexibility offered by analogue tools was cited as an advantage of analogue over digital by around a quarter of survey respondents, and explained by one of the designers we spoke to as follows: 'Paper, or analogue of any kind, is very flexible for [workshop] participants. There are ... many fewer constraints and restrictions on what they can do, and I think fewer pre-conceived ideas. I think asking people to work immediately in a digital format can be a little bit more prescriptive of what they are going to do' (P5).

The comments above offer insight as to how analogue tools support flexibility, and immediacy. The ability to "scribble over everything" for example implies a high degree of both qualities. Due to the freedom inherent in an environment filled with analogue tools, there is a wide range of ways that ideas can be represented (flexibility) and the facility to do so is immediate and accessible. Furthermore, the physical affordances of analogue tools, in combination with the environment, can in turn support direct communication, where communication between multiple people can happen simultaneously, in parallel with sketching.

Additionally, the physical and 'haptic' nature of analogue tools has previously been seen as a key ingredient to enabling both individual expression and collaborative interactions [Geyer et al, 2011]. This was mentioned by around a third of survey respondents as being an advantage of analogue tools. Previous work has suggested that the physical aspect of analogue tools and their corresponding affordances allow for interactions that are not always possible with digital tools. For example the haptic nature of physical tools allows for unsighted inaudible feedback, which is frequently absent from digital tools [Treadaway, 2007], an example being where the sense of pressure exerted on paper using a pencil, or marker, might give the user feedback as to how thick or dark a drawn line is, without actually seeing the line.

Currently one of the key differences between analogue and digital devices relates to the theme previously discussed, 'immediacy.' Almost half the survey respondents referred to speed of use as being an advantage of analogue tools, and slowness as a disadvantage of digital. Survey respondents also cited loss of flow as a disadvantage of some digital tools. This was also reflected during the interviews. P4 reported how the need for everyone on the team to be able to use the same tools without expending additional effort on learning how to do so meant that tools that were perhaps technically less suited to a task were sometimes used anyway, just because everyone was able to use them.

Six of the survey respondents specifically mentioned familiarity and ease of use as advantages of analogue tools, and difficulty of use or an associated learning curve as a disadvantage of digital tools. Additionally, two of the interviewees commented specifically on the learning curve associated with some digital tools being off-putting. In relation to sketching and note-taking on tablets and smart phones, P1 commented: 'And there's a big learning curve to doing all that kind of thing.' and P7 complained that sometimes 'I'm spending more of my time learning tools than actually working.'

Immediacy was also cited as an issue with remote collaboration. While the ability to support remote communication and collaboration through the use of digital technologies was cited by around a third of the survey respondents as an advantage of digital tools, the difficulties of attempting to substitute same time, same place collaboration with distributed collaboration were described as significant drawbacks. As P1 described: '...the video you've got isn't normally of everybody in the room getting this eye-to-eye contact, the resolution isn't that great, and again there's that issue of latency'.

Similarly, P4 commented: 'We've found that it's really difficult to do Agile or all that kind of stuff over [web conferencing product]. Communication is really difficult. Even though you can see everything, people talk over each other, people don't feel like they're a part of it, or there's a bad line, there's always something that just doesn't work.' P4's comment also points to the inherent difficulties associated with attempting to use digital tools to support direct communication.

P2 also described how digital tools restrict this type of activity: 'But also, you're doing one thing at a time when you're using technology to do something, rather than multiple sketches quickly...' While this issue of only being able to do "one thing" relates to how technology can restrict both immediacy and flexibility, it also further illustrates the inherent difficulties with using digital tools in a collaborative environment, where multiple activities between multiple people are crucial to the fluency of creativity.

However, one of the key benefits of digital tools is the capture and digitisation of the results of collaborative activities. The possibilities of capturing ideas in a way that they can be stored, organised, archived, shared, and used for documentation, in which changes to ideas during the course of a project can be tracked, were cited by around a third of the survey respondents as some of the most significant benefits of using digital tools in a creative collaborative process. Conversely this was also described as a drawback of analogue tools, which are not easily shareable, awkward to store and can get lost.

Summary

There can still be difficulties in the digital collection of ideas in that there is also a dependence on the organisational systems. Whereas analogue tools are dependent on the organizational efforts of the users (i.e. filing systems and preferences), digital tools require an added element of system design to enable reuse of the ideas captured.

However, digital tools can, through the effective capture of ideas, facilitate acts of creative reflection. One of the interviewees (P8) adopted a digital approach to her own reflection: 'I've got this note thing on the phone. Yeah it's kind of random thoughts. ... Sometimes when I was in conversation, ... when I get home later I'll be like 'Oh there was something really interesting'. ... and then I would type it down on the notepad. And then once in a while I'll look through it', and described how reflection was facilitated for her by the constant availability of a digital device such as a phone: 'I would take out the phone in a situation like on the train, or after a meeting, where I don't have any paper. I'm just going to jot down whatever I'm thinking. Little thoughts. I actually tried to do audio once. It did not work.'

This also points to one of the potential advantages of digital devices supporting reflection (and other creative activities), in that the ubiquitous nature of a device can allow for a wider range of activities. A device that is already carried for other purposes (e.g. a phone) which supports a variety of activities can also support a greater degree of flexibility and immediacy in relation to creative activities. However, the collaborative, creative work that designers are doing is complex, and as P2 explained: 'The problem with technology and collaboration tools is that there are so many and not one thing does everything you need them to.... usually these tools are designed in isolation for one problem, rather than a whole situation.'

This study has confirmed that current practice is dependent on a number of interconnected elements that potentially increase the effectiveness and efficiency of creative collaboration.

Participants continually identified collaboration, in a variety of forms, as being integral to their current creative process. Additionally, whether it was a quality of the tools they were using (e.g. immediacy) or an element of the environment (e.g. individual spaces), it was clear that there were a number of fundamental attributes of designers' tools and working environments

that were felt to positively influence creative outcomes. Where previous research has identified many of the themes present in this study, the interconnectedness, and possible mutual dependencies between these themes has perhaps not previously been explored to any great extent. An example from our study that illustrates the dependency between some of the themes discussed is the fact that while informal collaboration has been identified as a key element of creative collaboration, in idea representation, capture and reuse, both flexibility and immediacy are required of the tools within the environment for this to occur. This is illustrated by P2 describing how: "... the most creative collaboration that happens with people in my proximity, where you have informal idea generation from a side conversation and you start to talk about it, and if its interesting you start to sketch ideas." In this example the collaboration is dependent on communal space, which supports immediate, flexible, informal collaboration, resulting in idea representation (sketching ideas), which is in turn also dependent on the immediacy of tools (in terms of accessibility, ease of use, and immediacy of output). This example also demonstrates how immediacy and flexibility are underlying themes that support multiple facets of creative collaboration.

In addition, as past research has highlighted, collaboration amongst creative practitioners is 'supported by very simple low-tech tools, such as Post-It notes, color pencils, sketch papers, tapes and so on' [Zhu, 2011]. Our study confirms these findings, but also reveals how designers are increasingly finding a role for digital tools, such as smart phone cameras, video conferencing software and email, to support their work. One of the strengths of some of the more frequently used digital tools, such as smart phones, is their ubiquitousness, which mirrors the availability and accessibility of analogue tools.

The combination of different types of tools in early stage creative collaboration is indicative of the effectiveness of using the distinct strengths of analogue and digital tools to complement each other. For example, analogue tools are well suited to fast, spontaneous idea representation in a collaborative environment. Participants commented on using sketchbooks to develop ideas and then scanning or photographing the pages of the sketchbook in order to share the ideas generated. Digital tools, such as smart phones, are then frequently used to capture the outcomes. In this case the digital tool potentially facilitates sharing, reflecting on, or reusing the original ideas in more flexible environments (e.g. reviewing images on a smart phone in a café).

Sharing of these digital records seems mainly to be done using basic technology solutions such as email. At present, the organization of the resulting information and digital assets remains a challenge and can potentially limit the effective review and reuse of initial representations of ideas. Participants commented on the difficulty of finding and reusing specific digital assets quickly in large and possibly complex storage systems. Existing digital systems (software and digital file storage systems) designed to manage creative outcomes, such as the ideas generated from early stages of creative collaboration, could be greatly improved. The powerful capabilities of digital systems to store and archive information is frequently not matched by the usability of those systems and the accessibility of the stored information.

Another real strength of digital tools is their ability to support remote collaboration, although awareness of the activities of designers on remote sites is still not as good as it would be for same time same place collaborations. However, risks associated with digital tools include their lack of immediacy and flexibility, and associated possibility of breaking the creative flow of both individuals and collaborative teams, as well as the lack of support they currently provide for the kind of informal spontaneous collaboration that is obviously so common. Additionally, the technical overhead (i.e. setup, maintenance, training) involved in digital tool use is a barrier to use in early stage creative collaboration.

'Persistent cues' are an area that currently is minimally supported by digital tools.

Although many of the key themes identified in the existing literature are obviously still very relevant to the work of current designers, it appears that there may also be a subtle but ongoing shift amongst designers towards the increasing adoption of digital tools, especially simple and ubiquitous tools including smart phone cameras, video conferencing software and email, that begin to mirror some of the key interaction qualities, such as immediacy and flexibility, of the analogue tools that have so long been favoured. However, most participants in the study felt that analogue tools are still not currently replaceable by digital tools. The adoption of digital tools has more often been in areas where analogue tools lacked functionality (e.g. capture and reuse of ideas).

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