Strategies in Creative Professionals' Use of Digital Tools Across Domains

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ABSTRACT

On the basis of a qualitative study of five domains of creative work, this paper analyzes two recurring strategies in the use of digital tools, 'margins' and 'view-shifts'. These strategies are commonly employed by creative professionals across five different domains. Based on video from observational studies of music producers, video production, industrial design, graphic design, and service design, we conduct a thematic analysis to arrive at the two strategies. We furthermore examine the two strategies in relation to existing research into creativity and cognition, and discuss how this can inform future studies of the use of digital tools in creative work.

CCS Concepts

•**Human-centered computing** → **Empirical studies in HCI;** *HCI theory, concepts and models;*

Author Keywords

Creativity Support Tools (CSTs); Creativity; Observational Study; Creative Professionals; Strategies

INTRODUCTION

Digital tools are closely integrated in many professions today, with the creative industries being no exception. As these tools continue to evolve and make use of new technologies and interaction techniques over time, it is necessary to revisit our understanding of current tools used by creative professionals, particularly in how they shape practice and work processes. As evidenced by recent literature surveys [10], research into this domain took off with the first Creativity & Cognition conference 20 years ago [10]. Shneiderman subsequently emphasized that the development of creativity support tools is one of the grand challenges of Human-Computer Interaction (HCI) [29]. Given the prevalent use of digital tools in many forms of creative work today, the need for understanding the role and nature of digital tools in creative work has only grown stronger. For researchers and developers with an interest in designing creativity support tools (CSTs), this understanding is necessary if we wish to make informed choices about how creative processes are inevitably shaped by our digital tools.

While some studies focus on the use of one tool in one professional domain of practice [10], there are very few studies into how digital tools are used across domains. We fully support the need for in-depth insights into domain-specific practices, however, we also find it worthwhile to examine the patterns, commonalities, and differences in how digital tools are employed across different domains of creative practice. This forms the motivation for our study in this paper, in which we examine the use of digital tools across five different domains, namely music production, video production, industrial design, graphic design, and service design. Our study is informed by prior work in HCI and creativity research.

Creativity-related contributions from HCI provide a strong focus on the tool, with a inclination towards building new, one-off tools which are usually tested in lab settings [9, 10]. In contrast, there are fewer studies on how digital tools are used in the complex settings of in-situ creative work. Alongside creativity-related research in HCI, psychology has been tackling the topic of human creativity for almost 70 years, resulting in extensive amounts of both empirical and theoretical knowledge. The study of creativity has undergone its own evolution, from a focus on the exceptional individual, to underlying cognitive processes, and eventually to socio-cultural and distributed approaches; but contributions in this field do not directly provide an understanding of the role of the digital tool [27, 8]. These characteristics of the two adjacent fields highlight a lack of studies of creative professionals that are in-situ, focused on digital tool-use and informed by existing creativity theories. Our study is thus also motivated by the

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need for observational studies of digital tool-use in creative practices. Over the last 1.5 years, we conducted an exploratory study of digital tool use across these creative domains, guided by the research question: *What characterizes the use of digital tools for creative professionals across domains?*

In this paper, we first ground our study in related literature. We then introduce the setup and condition for the study conducted. In our analysis, we arrive at two central strategies employed by creative professionals in their use of digital tools across the domains, namely, *margins* as ideas buffers and *view-shifts*. We then examine these strategies in relation to existing creativity and cognition research. Finally, we initiate a discussion on how to move forward in formulating hypotheses based on these strategies, and on how they can inform future studies on the use of digital tools in creative work.

BACKGROUND

Creativity Studies

Due to its ontological complexity, understanding creativity is generally perceived as "precisely the kind of problem which eludes explanation within one discipline," [11, p.22]. Even so, the creativity research community has come to agree on two criteria that must be met for something or someone to be considered creative. As formulated by Runco and Jaeger [26], the standard definition of creativity presupposes that creativity involves originality and effectiveness, or closely related descriptors such as novelty, surprise, and uniqueness, and value, usefulness, fit, and appropriateness, respectively. In the present study, which is further motivated by the fact that creativity always occurs in a specific context, we rely on a more detailed definition as proposed by Plucker, Beghetto, and Dow [23] who understand creativity as "the interaction among *aptitude, process, and environment* by which an individual or group produces a *perceptible product* that is both *novel and useful* as defined within a *social context*" [23, p. 90, orig. emphasis].

In response to the ontological complexity of creativity, many conceptual models have been offered in order to help discern specific aspects of creativity. Among the most influential of these contributions are Rhodes' [24] seminal 4 Ps model from 1961, which distinguishes between person, product, process, and press (from the given surroundings) and, more recently, Glaveanu's [12] 5 As framework, which, based on socio-cultural psychology, differentiates between actor, artifact, action, audience, and affordance. By emphasizing the importance of the socio-cultural context of creativity, and how we in our daily lives try to make sense of creativity, the latter model is related to another central model of creativity—the Four-C model as suggested by Kaufman and Beghetto [17]. Motivated by an historical tendency to rather rigidly separate eminent creativity (how geniuses work), here called Big-C, from more mundane forms of creativity (how the rest of us solve everyday problems), here called little-c, the Four-C model introduces two additional c's. Mini-c is creativity derived via transformative learning, while Pro-c "represents the developmental and effortful progression beyond little-c (but that has not yet attained Big-C status). Anyone who attains professional-level expertise in any creative area is likely to have attained Pro-c status." [17, p.5]. This means that "the concept of Pro-c is consistent with the expertise acquisition approach of creativity" [17, p. 5].

Although the relevance of the little-c vs Big-C distinction has caused some debate [20, 25], people who do not identify as creativity experts seem to be able to distinguish between mini-c and Big-C [17]. The same study, however, found the little-c vs Pro-c distinction to be harder to assert. This conceptual difficulty may owe to the fact that creativity research has seen surprisingly few studies of creative professionals [17] as opposed to the substantial body of research on eminent creators representing Big-C [30]. This lacuna is even more critical with regard to studies of how creative professionals use digital tools to support their Pro-c practice. The need for more interdisciplinary insight into digitally supported Pro-c practices has led some scholars to advocate a closer collaboration between creativity research and HCI to advance current understanding of how professionals across creative domains deploy digital tools [8]. This arguments rests on the observation that the vast majority of Pro-c studies focusing on digital tools has actually been conducted within HCI.

Creative Professionals' Use of Digital Tools

As previously mentioned, studies of professional creatives and their use of digital tools are infrequent, and predominantly from HCI or related fields. In this subsection we review empirical contributions that a) have an explicit focus on the tools of technologies employed, and b) involve professionals within a creative domain.

In 1999 Streitz et al. [33] developed the I-land and interactive room-based system to support cooperative creative work in dynamic teams. The presented system relied on an empirical study of five teams self-described as creative and working within four large companies in Germany (automobile, oil, advertisement, and consultancy) [33]. The case studies present a strong focus on the setup of the physical facilities for the teams, which are described as generally analog with few exceptions, such as "[n]o active creative of content during the meetings was done with the aid of computers" [33]. In some cases, however, digital equipment such as laptops and projectors were used when presenting ideas to clients and externals [32]. The findings from this work are on a relatively high level of abstraction, considering current analog processes and practices together with the participants' attitude towards possible (digital) futures.

Terry & Mynatt [35] provided a rare close account of how digital tools are used the creative process. The use of an unnamed, but popular, image manipulation application was examined through three cases. A former newspaper employee working with image toning, a professional artist designing a graphical user interface (GUI), and an amateur artist deciding on color schemes for a scene to be painted on wood were all interviewed and asked to demonstrate typical tasks [35]. Through the use of Schön's theory on reflection-in-action, Terry & Mynatt [35] presented three central activities derived from the case studies: Near-Term Experimentation, defined as efforts intended to discover and instantiate the next move or command; Variation, which involved a deeper exploration of

alternatives either sequentially or in parallel; and Evaluation, in the form of either short-term or long-term critical evaluations framed as back talk, possibly following the two prior activities. Furthermore, tool support for as well as limitations to all three activities were then discussed in order to reach recommendations for better support of the individual activities and, eventually, creativity. This work, albeit 17 years old, offered highly relevant findings in terms of providing close descriptions of the interactions, which to some extent may resemble those presented later in this paper.

Digital technology and the use of the hands in creative, artistic practice was investigated by Treadaway [36] in a case study looking at a fine arts practitioner over the course of six months. Using photography, research journals, video recordings, and verbal reflections, Treadaway highlighted how digital technology might result in both positive and adverse influences on the process of the artist [36]. Treadaway found that technology accelerates the process and the breadth of ideas explored, while still encouraging convergence over divergence "due to the intensity and proliferation of decisions that are constantly required in the selection from menus, tools and options, [whereas] slower hand making processes provide the artist with more time for free thinking and reflection." [36]. Treadaway concluded by emphasizing the artist's preference for physical activities over the use of the computer, as it stimulates a feeling of satisfaction as opposed to frustrations from haptic insensitivities in the digital realm. By going into depth with one specific, and highly idiosyncratic, artistic process, the findings from this particular case provided a very subjective account of a user's experience with different tools.

Myers et al. [21] conducted nine semi-structured interviews with users of Adobe Photoshop, ranging in experience from novice to expert, to inform their re-design of the undo mechanism. The participants' use of layers as a mechanism to explore different ideas and test out different alternatives were highlighted by the authors: "When beginning a creative exploration, participants often duplicated layers or saved a version of the whole picture, to facilitate backtracking" [21]. Only a few participants used the history panel in Photoshop, and users were in general wary of the history tool, as it is not persistent and limited to 20 'moves'. The authors subsequently developed Aquamarine, which supported a different 'selective' undo model while demonstrating that the tool could provide actual benefits to users. The detailed descriptions of the use of the tools and the further usability test of the tool developed offered a rare, close, and precise account of a feature that is pervasive in many digital tools today.

A similar pervasive feature is the color picker. This has been investigated by Jalal et al. [14], who interviewed eight artists and designers to identify the five most common color manipulation practices. Especially interesting is the practice named History, that is, interaction with past actions highlighted the iterative nature of exploring alternative paths without having to start over, i.e., by using previous versions of the color to creative a nuanced set of new colors [14].

Stolterman & Pierce [31] conducted an interview-study of 11 designers about their relationship to their tools using a broad definition of 'design tool'. The findings of this study pointed out that the designer's own reflection on the rationale behind the choice of a tool could be interpreted as both rational and personal/cultural. While commonly mentioned reasons for the choice of tools involved efficiency, ease of use, flexibility, and support for collaboration, the identity, habit, prescriptiveness, and community feeling related to a tool were also important. This may be seen as a smaller, but important, contribution in relation to our work insofar as this study emphasized the abolishment of a purely rational tool-choice.

The relationship to new tools has been investigated within the domain of fine art furniture making by Cheatle & Jackson [6], who conducted an in-depth study of how 3D scanning and printing and CNC robotics could augment a forty-year-old craft-based practice. Findings highlighted, among other things, the ability of an additional exploratory step added by being able to manipulate a digital model in 3D [6]. While freeing up some historical design constraints of the material, the CNC machine is mostly considered in terms of a productivity enhancer with a focus on its merely executing functions. The findings from this case-study represented an original, in-depth insights on how the creative process may change as a result of new digital tools, and how they eventually end up being embedded in the socio-cultural practices of the creative professionals.

Bermudez & Jones [4] conducted a study of how tools and technologies were used in collaborative creativity and problem solving within the domain of design. Using a small-scale online survey of 37 practicing designers and follow-up interviews with eight designers, they found that the all participants had participated in both structured and informal collaborative creative practices to varying degrees. Immediacy and flexibility were highlighted as two important interaction qualities for tools, both analog and digital, used by the designers. This work, while only representing one domain, thus managed to highlight some important generic preferences for early stage creativity.

Chung et al. [7] sought to validate whether enterprise mobile applications could encourage the creative process of the employees by acting as a creativity support system. Based on a survey of 411 participants who used enterprise mobile applications, the authors concluded that a perceived positive job performance through using enterprise mobile applications correlated well with perceived job creativity. The perceived job performance was influenced directly by task-technology fit for the application as well as habitual use of the application.

Technologically mediated creative collaborations were studied by Aragon et al. [2] within two different domains of astrophysicists and children aged 8-15. By observing and logging online activity and interviewing participants in both communities, the authors "learned that one of the key elements for designers of systems to foster social creativity is a low barrier to entry" [2] and that "Lightweight tools that can be accessed by anyone on any platform facilitate the kind of easy, open sharing and communication that is a key component of creative collaboration" [2]. An important insight from these cases was perhaps the long-term behavior adaptation resulting in repurposing and augmentations of communication technologies.

Using a related approach with data logs and interviews, Bailey & Horwitz [3] studied an idea management system for grassroots innovation in a large organization. In this study, the authors found high-level recommendations for improving the design of idea management systems such as "Measure and appreciate outcomes beyond revenue" and "Support the users who want to advance to their own ideas".

Luther et al. [19] investigated online creative collaboration using a mixed-method approach in order to reach five predictions on the factors for success. The findings from the this study delivered insight into the overall organizational and communicative structures of these types of online creative collaboration.

The preceeding background work in creativity studies and creative professionals' use of digital tools covers several in-depth studies about discrete uses and impact on creative professionals' everyday work practice. We highlight, however, that further investigation into common strategies and practices in digital tool use across creative domains is needed. This study is therefore motivated by our interest in the broader use and effects of off-the-shelf digital tools for Pro-c creative professionals in their everyday practice.

METHOD

We initiated our cross-domain study of digital tool use among creative professionals in the fall of 2017, when we began preliminary interviews with potential participating companies and people.

The nature of the study was qualitative and exploratory at its core, yet one research question has guided the study: *What characterizes the use of digital tools among creative professionals across domains?* This research question provided clear guidance to some aspects of both data gathering and the subsequent analysis while still leaving enough room for analysis. Conversely, it specified a rather precise focus on the interaction between tools and creative professional as it has developed through use. Furthermore, it emphasized explicitness about domains, which is central to studies of creativity, but not which domains which enabled some degree of flexibility in terms of recruiting appropriate participants and the (in)practicalities that often ensue.

Five Domains for Studying Use of Digital Tools

We contacted representatives of companies employing different types of creative professionals to inquire about the possibilities of doing field work there. Once the company agreed to the general terms of the study, they identified a suitable project. The main selection criteria for projects were that they should be representative of the company's general work-practice, and that the client would approve it so that we could use the data for research purposes. We selected a sub-sample of five creative domains from this list based on which practitioners responded to our call for participation, and which were not constrained by a non-disclosure agreement (NDA). The following subsection provides a brief overview of the five domains covered and the participants from each domain.

Music Production

This case study was based on two independent music producers, who worked in the same co-working space for musicians and audio-based work. Technically speaking, the majority of their work involved mixing and mastering, but the boundaries between these two creative processes were blurry. During this case study, participant P1 worked on mastering an EP using a self-designed workbench tailored to his own work processes. The workbench featured a combination of physical mixing and mastering tools and Adobe Logic Pro X software. The other participant, P2, worked primarily on mixing and had a completely digital work space, using Logic Pro in combination with commercially available software programs supported by the MIDI-format.

Video Production

We conducted this case study at a small media agency specialized in creating high-end visual content. The participant, P3, was a video producer working on an advertisement for a client. We observed a video being finalized, known in the film-industry as post-production, where video clips were aligned, cropped, edited, and placed in the right order to fit the particular narrative of the advertisement.

Industrial design (3D-modeling)

In this third case, the participant, P4, was working on a second iteration of the casing for the company's own electronic outdoor device for environmental data gathering. P4 used the software Autodesk Fusion 360 together with the Swipes app for tracking progress (of collaborative tasks in the team), and Google Chrome for looking up dimensions of electronic components. The articulated overall goal was to juggle the practical fit of the electrical components with the aesthetic and practical abilities of the final device.

Graphic Design

Our fourth case involved participant P5 doing graphic design and layout for a magazine using Adobe's software InDesign. It was the second time this company had been hired by this particular magazine, so P5 focused more on tweaking and improving smaller graphical features than the overall layout.

Service Design

This case took place at a larger design company, where three participants (P6, P7, and P8) were working collaboratively on designing the process for an upcoming service design project for an existing client. They used custom-built software that allowed for cross-device access in collaborative ideation and structuring sessions. The goal of this project was to come up with possible new initiatives and reach an overall structure of a creative process that could accommodate these requirements.

Data Collection

Empirical data collection was done following the same protocol for all five creative domains detailed above. Three types of data were captured from this field work, namely video documentation of the participants using their digital tool environment to work on their tasks; in-situ observation and collection of notes of activities of immediate interest; and post-hoc

semi-structured interviews. All the data material was collected by this paper's first author (hereafter referred to as 'the researcher').

Each participant's session began with a ten-minute presentation from the researcher about the project during which the participant could ask clarifying questions. Before data collection began, a Go-Pro video camera with an extra battery was mounted to capture video of the participant and the screen and desk in an unobtrusive way. High-quality audio was recorded using a external digital voice recorder to capture possible utterances by the participant/s. This enabled similar data collection across the five creative domains. In order to reduce distractions in their creative processes and workflows, participants were not instructed to think aloud or speak with the researcher during their work.

As the participants worked on their daily tasks, the researcher, who took on the role of overt observer, conducted **observations** by noting down activities of immediate interest.

Participants were not interrupted in their tasks by the researcher, and sessions ended when participants either went for a break or finished their current task. After a short break, the researcher conducted **semi-structured interviews** with each participant. The interviews focused on motivational aspects of the participant's choice of tool and their individual creative workflows and preferences. The interviews also included follow-up clarifications of the researcher's observed activities of interest.

Finally, the Go-Pro cameras captured a view of both virtual and physical workspaces on **video**, which enabled subsequent analysis and documentation of interesting activities on micro-interactions level.

Data Analysis

The research team analyzed a total of 4 hours and 48 minutes of video data using a thematic analysis approach [5]. While this only amounts to approximately one hour per domain, the video recording sessions were purposely sampled in collaboration with the participants to ensure a high level of intensity and relevance as proposed by methods such as short-term ethnography [22].

The goal of the thematic analysis was the transformation of unstructured data into a detailed account of the most salient aspects of the activities. We used a six-step thematic analysis approach as described by Braun & Clarke [5] to analyze our data, with one exception; the first step of *familiarizing* with the data minimally requires a rigorous and thorough transcript. Our analysis focused primarily on the video data collected of participants' interaction with their digital tools, based on mouse, keyboard, touch, etc., and were mostly silent. Additionally, very little verbal data was present in the video and audio during observation of the participants' work sessions. We completed the remaining five steps of *generating initial codes*, *searching for themes*, *reviewing themes*, *defining and naming themes*, and *producing the report* in accordance with the guidelines provided.

Participants	Margins	View-shifts	Domain
P1		x	Music
P2	x		Production
P3	x	x	Video Production
P4		x	Industrial Design
P5	x	x	Graphic Design
P6-P7-P8	x	x	Service Design

Table 1. Prevalence of themes across the five domains

For the *generation of the initial codes* step, we made descriptions of the participants' interactions with the digital tools. We undertook this step without any explicit theoretical concepts in mind, making use of a data-driven rather than theory-driven approach for the third step, *searching for themes* (we move to a theoretical positioning of the two themes in the Discussion section). During the fourth step, *reviewing of the themes*, we excluded themes with overly conflicting code, leaving us with the resulting two themes, which we *name* as: **margins as buffer for ideas** and **view-shifts between component and composition**, defined and detailed in the Results section.

While the two themes are primarily based on the video data collected, both the in-situ notes based on researcher observations and semi-structured interview data strengthened our analysis by providing context and latent motivations of the participants. These themes were determined in terms of their relevance to our research question and frequency of appearance across cases. There were few instances that did not have codes for the use of either *margins as idea-buffers* or *view-shifts* within a given domain applied, as illustrated in table 1. Considering the focus on the interaction between the participants and their digital tools, the themes were categorized as latent rather than semantic as "the development of the themes themselves involves interpretative work"[5].

RESULTS

In this study, the term *digital tools*, in all of the creative domains studied, refers almost exclusively to software running on a screen-based device (desktop, laptop, phone, or touch-enabled large display). The few exceptions was P1's use of custom-made input devices for music and P4's use of a simple digital caliper. We now present the two themes resulting from our analysis of digital tool-use. These two themes described in the following subsection can be considered as *strategies* in the sense of being specific ways of working professionally with digital tools as we have observed across the five creative domains.

Margins as Buffer for Ideas

We define *margins as buffer for ideas* (from this point on referred to simply as the *margins* strategy) as *the strategy of storing, placing, or manipulating something in a separate space adjacent to what can best be universally described as the 'production area' of a given software tool*. This strategy appears in different forms depending on the domain and tool,

but is similar in the action of temporarily storing an unfinished idea in the marginal space of a document so that it can subsequently be dragged into the working space if and when it becomes relevant. Since this is a strategy that recurs across different domains of creative practice, we deliberately employ an open and inclusive understanding of what is meant by an 'idea' in this context. This may, for instance, be an idea for a part solution, a piece of potentially useful inspirational material from another domain, or an idea for how to approach the work in a new manner [13]. In that sense, the document containing unfinished ideas in its 'margins' lies somewhere between saving a new version or branch of the document, and simply copy-pasting one item (also observed in this study and in others' work [35]). Below are three examples of participants using the *margins* strategy in music production, graphic design, and video production.

Examples

The first example of the use of *margins* was from the music producer, P2, and involved the use of multiple tracks in the mixer window in Apple Logic Pro X. While the participant searched for the right 'feel' of a guitar that had to align with the overall album, multiple versions of the same guitar were kept as tracks.

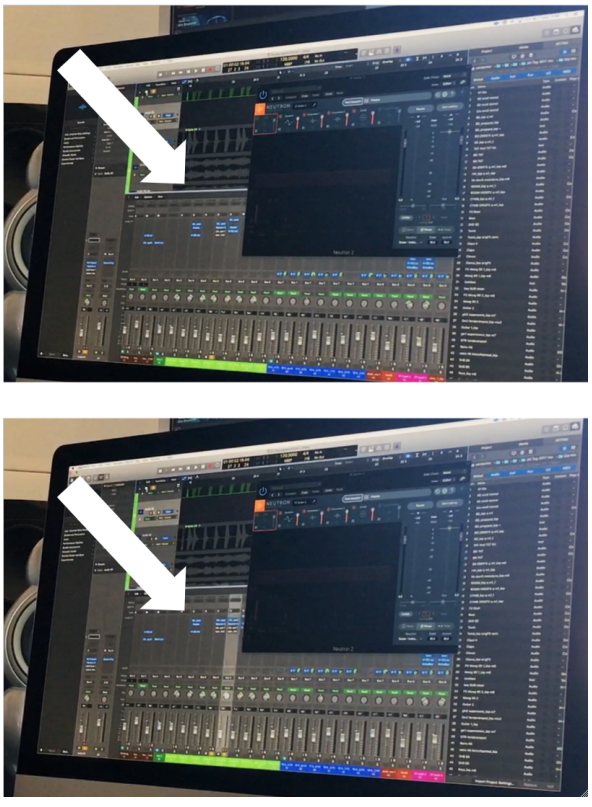

Figure 1. Multiple juxtaposed tracks at the same time. In order to explore an idea for a new way of editing a track, a duplicate was made (the slightly brighter stripe on the second image). Once it had been explored, it was either implemented, kept for later, or removed to save computational power

.

By pressing one button, P2 was able to toggle between the tracks that were currently being worked on, and make copies that were then named as alternatives, temporarily allowing the exploration and manipulation of ideas while still keeping the 'main' version as is (see figure 1).

A second example of the *margins* strategy was observed within graphic design, where P5 was working on the layout and graphics for a magazine in Adobe InDesign. P5 used the digital margins of the actual page, known as the pasteboard in InDesign, to store graphical elements that may or may not be used at a later stage (see figure 2).

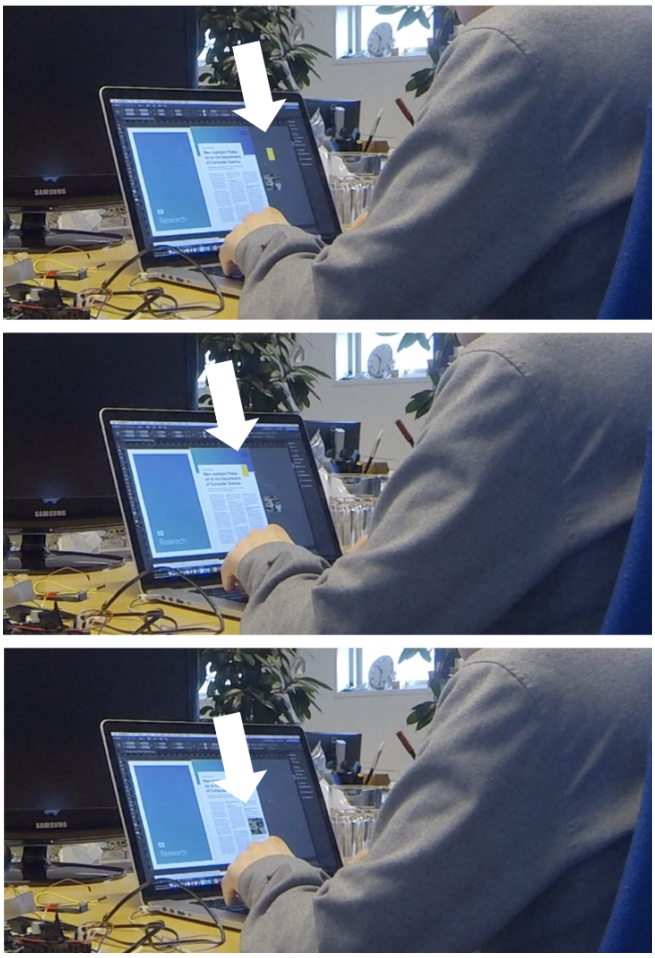

Figure 2. Different elements were stored in the margin of the actual document (magazine), and were then dragged in and out to form different designs

While the elements in this marginal space would not be included if, for example, P5 were to print the document, these elements were still part of the document, and could be recalled when reopening that document at a later stage. By serving the purpose of being a digital margin and visual clipboard for ideas and elements, the InDesign pasteboard became a buffer for ideas or elements that could later be incorporated.

A third example of the active use of digital *margins* was from the domain of video production, where P3 used multiple storylines to keep and manipulate possible clips that could be suited for inclusion in the main storyline, which would become the final rendered movie (see figure 3).

Figure 3. The secondary storylines worked as margins for ideas in the form of alternative clips, transitions, or different effects, which could be added to the final storyline.

Juggling multiple possible clips at the same time was accomplished through the use of multiple storylines, allowing clips to be previewed and trimmed before being merged into the main storyline.

View-shifts Between Component and Composition

We define *view-shifts between component and composition* (from this point on referred to as the *view-shifts* strategy) as *the strategy of deliberately shifting the perspective or view of the workspace in order to move between a view of the whole composition and a component that is part of it*. A view-shift can, for instance, happen after a bout of edits in order to inspect the overarching results of the edits on the entire project. This strategy appears in different forms depending on the medium. As a view in a digital workspace does not necessarily correspond to a person's physical gaze, it can refer to e.g. a shift from a zoomed-in detail view to an overall view of a larger workspace, and vice versa. *View-shifts* appear to serve the purpose of providing a different perspective on new ideas after they have been realized and integrated into the product. In the following, we offer three examples of *view-shifts* in the domains of service design, music production, and product design.

Examples

The first example was from service design, where a group of participants brainstormed ideas for an upcoming project on an interactive whiteboard with touch and stylus input. After organizing ideas (yellow sticky notes, see figure 4) into clusters under headlines (the purple notes in figure 4), P7 put down the stylus, and P8 zoomed in and readjusted the view of the canvas before also taking a step back. Almost immediately after zooming out and stepping back. P8 grabbed the stylus again to add a separating line between three clusters of ideas. The zooming and readjusting of the screen marked a shift in the participants' view towards considering their newly implemented ideas.

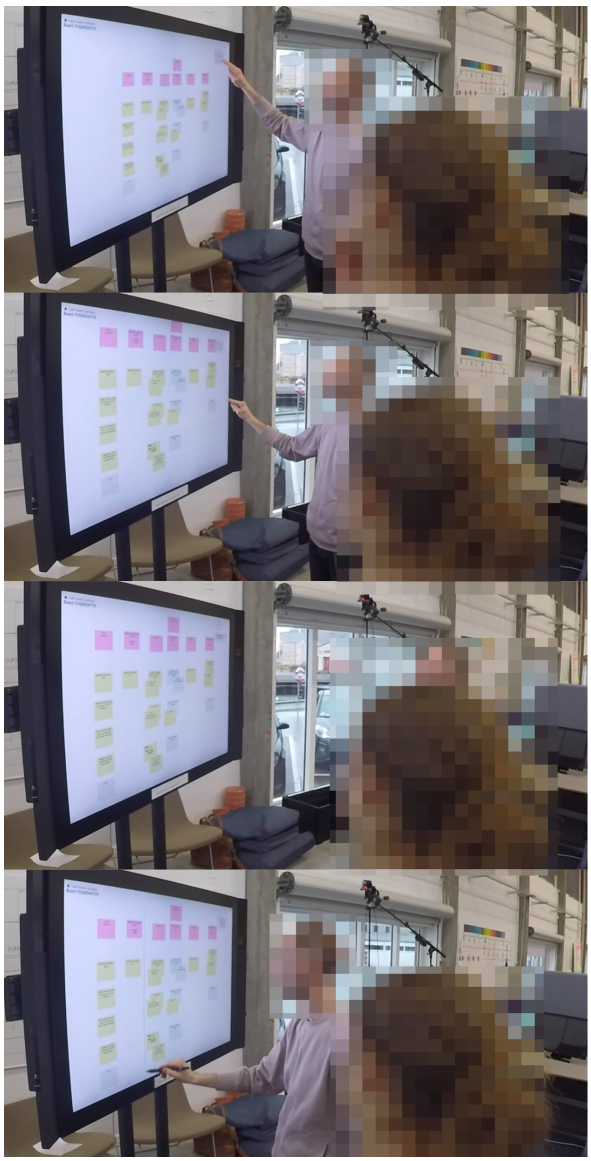

Figure 4. Shifting the digital and physical view before P6 realized the need for an added separation between two ideas (last frame)

The arrangement and organization of ideas and overall structure mattered a great deal for the task undertaken by P6, P7,

and P8, but did not require the same level of attention to detail as P6, who carefully adjusted the alignment of the canvas, as evident from the use of the digital (and in this case sometimes even physical view-shift).

The second example of digital view-shift was P1, who upon receiving a new audio track for the EP, spent five minutes to "acquire" [P1] the sound of it, i.e., become familiar with it, by listening to it. P1 then visually inspected the visual representation of the audio waveform of the track for particularly interesting areas.

Figure 5. Digital view-shift from auditory to visual view in the beginning of the process.

Zooming in and out also provided guidance towards particularly interesting parts of the track, in which P1 could "simply see that there is more energy" [P1]. While the activity in this exact case was not creating an edit, it still provided the participant with initial ideas about how to approach the task at hand.

A third example of *view-shifts* came from product design, in which P4 modelled the plastic casing for a company's new product. After working on finding the right width and thickness of the top edge of the plastic container, P4 continuously zoomed in and out and orbited the model to inspect it in terms of both wholeness and detail.

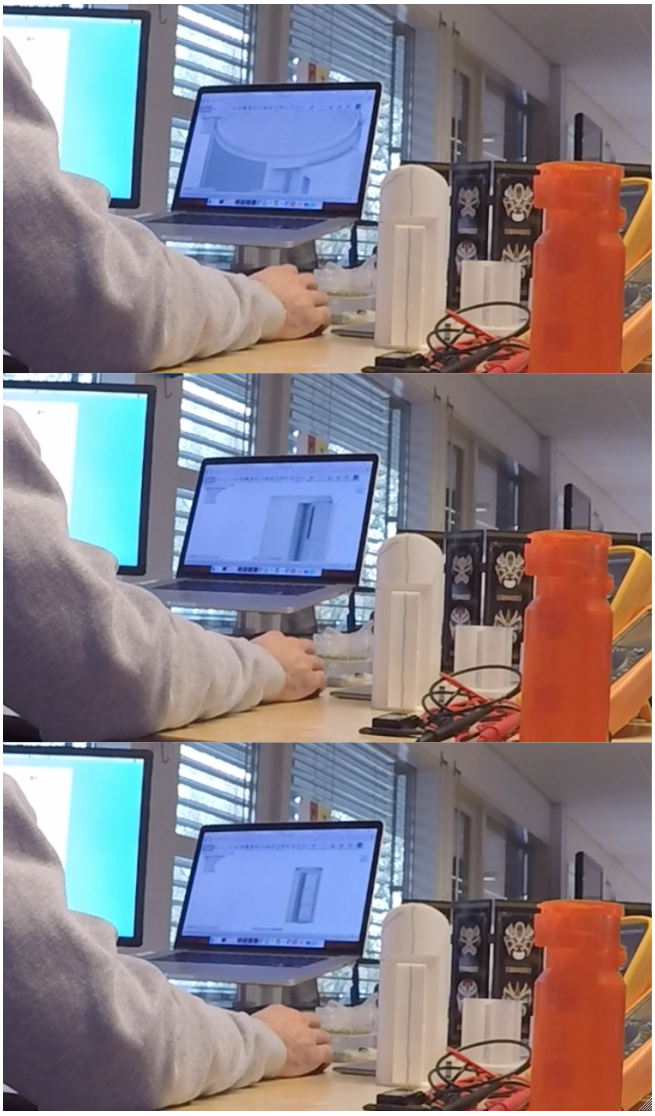

Figure 6. P4 continuously shifting the digital view in Autodesk 360 Fusion by panning and zooming

Throughout the session, P4 repeatedly inspected the model from multiple angles and levels of detail following smaller edits, and the process became a repeated exchange between 'doing' and 'view-shifting'. While this strategy seemed to be working most of the time,, for instance, at one point during the session, P4 pulled out a digital caliper to take a measure in thin air. In the interview following the observation, P4 explained how all the panning and zooming sometimes made him "lose sense of direction and scale" [P4], thereby creating the need to physically take a measure of a component to 'calibrate' the understanding of the model.

DISCUSSION

We present our discussion in three sections. First, we discuss the *margins* and *view-shifts* in relationship to each other, and their occurrences across the five distinct domains. Second, we revisit related work to draw possible connections to existing

empirical findings of related concepts or strategies. Finally, we discuss hypotheses developed on the basis of the *margins* and *view-shifts*, including how they could be evaluated, and what implications they may hold in terms of designing new digital tools to support creative work.

Experimentation, Constructive Perception, and View-shifting

Terry & Mynatt's [35] notions evaluation can add to our understanding of *view-shifts*. Evaluation certainly resembles the digital view-shift, where the tool is used to inspect the idea at hand in the sense of back-talk. The interface support for evaluation was, however, discussed by the authors in terms of lack of side-by-side comparison, which perhaps distinguishes the two from one another by denoting a comparative evaluation rather than a holistic one.

Another relevant example of related work is Kerne et al. [18], who provided six strategies for free-form web curation, one of which, Shift perspective, is highly related to the digital view-shift in this work. Unlike our study, Kerne et al. went beyond the description of the strategy and implemented a digital free-form curation tool with specific features to support this strategy. In this tool, the strategy was manifested by a pan and zoom operation, using the conventional interaction modalities for either mouse or touch-input, but with no predefined resolution allowing for infinite zoom. This tool was evaluated using 1,247 students over four semesters using logs from the system, and findings indicated that operations such as pan, position, zoom, and scale "were performed intensively" [18]. This work presented a strong quantitative argument for the view-shift (or shift perspective) as a central phenomenon in creativity mediated by digital tools, and may serve as a methodological triangulation.

In an effort to develop sketching tools for novice designers, Suwa & Twersky [34] investigated how architects use free-hand sketches in the early stages of design. Using a video of 45-minutes sessions of designers working on an art museum, protocol analysis revealed that designers actively re-examined their own sketches to discover new things, but experts were able to see functional, unobvious ideas as opposed to novice designers [34]. This work was later extended to look at what Suwa & Tversky termed 'constructive perception,' which can be described as an active reconfiguration of sketches for finding meaning in them, with the goal of promoting new design ideas [38, 37]. Especially *view-shifts* can be seen in the light of this meta-cognitive skill, which allows the creative professionals to work through their ideas as both parts, whole and their functional inter-relations. Perhaps the observed *view-shifts*, and what we have thought of as a edit-see cycles, might be very akin to what Schön & Wiggins [28] reported as seeing-moving-seeing and Suwa & Tversky [34] as sketch-inspect-revise. In our study, the cycle or iterative nature might simply look different considering the different domains and formats (i.e., what does a 'sketch' look like in the realm of video production?) in which our participants work. If this is the case, our study hints at a cognitive process, which persists across domains, but which has, perhaps for practical reasons, been mostly studied in architectural designers sketching with pen and paper.

Margins as a Space for Open Ideas

Terry & Mynatt's [35] notions of near-term experimentation, and variation may also advance our understanding of the *margins*. We may consider Near-Term Experimentation and variation as two points on a continuum of possible moves on ideas, where the distance is either very short and instantly reversible (e.g.. by using the undo feature) or longer (branching out by saving different version), and where the use of margins as idea-buffers could be placed somewhere between the two as an intermediate form of manipulating variations or ideas. The fact that such similarities exist despite more than 15 years between these two studies perhaps tells an interesting story about the historic development (or lack thereof?) of digital tools for creativity work, or about human creative cognition in general.

Margins might be viewed as a general creativity-relevant process as proposed by Amabile [1], which we speculate would make it a proxy for fluency and elaboration, or as a successful creative thinking strategy. Simply having multiple 'open' ideas at the same time denotes at least some level of tolerance for ambiguity, which is highly correlated to creative performance [16, 1]. Digital marginal space is one way of working with many ideas at once, in a format that somewhat resembles that of the final product. The degree to which these margins are exploited might hint at where a process is in terms of oscillating between divergence and convergence. While this discussion extends creativity research, margins have actually been investigated within an HCI context. For example, Wolfe [39] provided insights into how students engaged with text depending on how the texts were annotated, further describing different ways of annotating text both in the context of reading and writing from medieval readers to future digitally supported annotation tools [40]. Recently, Karlesky & Ibister [15] developed the concept of 'physical margin space' surrounding digital workspaces by introducing Fidget Widgets, which is tangible implementation of the concept, hypothesized to have a positive impact on productivity and creativity. While these contributions are intriguing, they approach the idea of margins from a different perspective: these margins are intended to 'contain' either fidgeting or annotations, which we argue is qualitatively different from serving as a buffer for ideas or parts of ideas.

Limitations of the Study

The *margins* and *view-shift* strategies were clear and recurring. However, we must emphasize that the strategies are not necessarily used exclusively in creative work, nor that they are the only recurring strategies in creative professionals' use of digital tools across domains. While our methodological decision to carry out in-depth studies of real-life creative practice can lead to rich insights into local practices, it is simultaneously limited in terms of the scope and generalizability of our findings. It is possible that the strategies are not prevalent in other domains of creative work, and that close studies of other domains would have led to the identification of other strategies. During our studies of the five different domains, we also encountered two instances where the strategies seemed to be challenged. The first example was P1, who deliberately used an analog workbench to adjust the EQ and add "the special

color" while mastering audio tracks [P1]. While this actually hinders the participants in using the *margins* strategy, the idea exploration in this case became (very) near-term in the framing of Terry & Mynatt, when physical tactile knobs and sliders are manipulated in real time while listening to the audio for instant feedback.

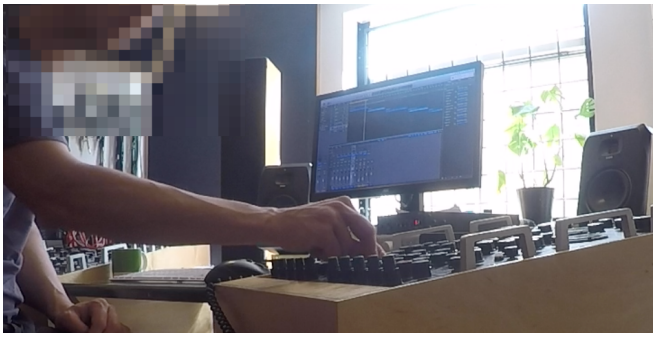

Figure 7. P1 using only physical knobs and sliders with no margins for ideas as a deliberate part of the process

The second example was P4's use of digital calipers to take a measurement in thin air before returning to the software. P4 explained in the following semi-structured interview that this move is a way of dealing with the inevitable confusion, which occurred after working in the 3D modelling software for a while, which often leads to all sense of direction and dimension being lost. The *view-shift* to the hand-held digital caliper tool worked as an alternative to the continuous digital *view-shifts*, which resulted in a loss of direction and scale.

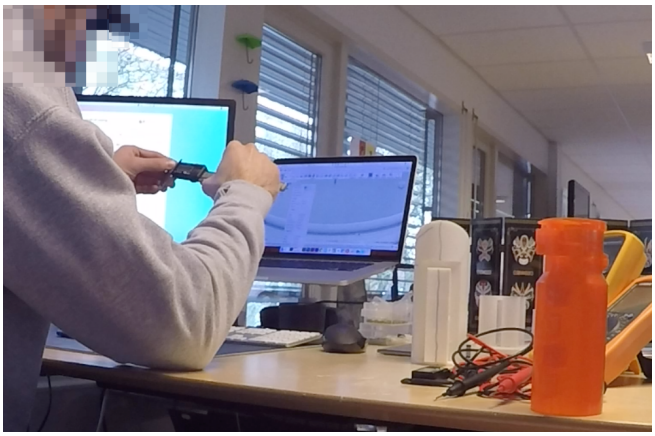

Figure 8. P4 picked up a digital caliper to overcome the loss of direction caused by continuous *view-shifts*

Perhaps these contrasting examples of 'workarounds' have been developed over time, as a way to cope with the inevitable limitations of the available digital tools, thereby enabling more idiosyncratic ways of working. As we study the interplay between digital tools and creative work practices, it is pertinent to consider if the features to create and support the use of *margins* and *view-shifts* in current professional tools are a result of deliberate design decisions, or if the strategies have emerged as a result of generic strategies in human creative action.

Future work

We propose that further studies be carried out to examine if the strategies can be identified in other forms of creative work. For instance, the process of writing this manuscript prompts considerations about whether a feature such as LaTeX support for commenting out inline text can actually be perceived as a feature supporting the *margins* strategy. Similarly, in software development, the process of commenting out code is a central way of temporarily storing an unfinished idea in the 'marginal' space in order for it to be easily retrieved moments later. We therefore hope to further broaden the scope of domains to represent an even more diverse group of activities. This goes not just for domains that rely heavily on 'textual' representations such as writing and coding, but also for domains with a more intangible quality such as virtual or augmented reality, which could result in richer and more nuanced understandings of the two strategies. Moreover, we propose to further examine which potential as *implications for design* the two strategies might entail. We have here focused deliberately on studying the use of existing tools in well-established professional, creative work practices, but given the prominence of the two strategies, obvious next steps would be to examine how to design CSTs that better accommodate these strategies. This could both be 'in-app' features, e.g., by enabling users to *view-shift* rapidly between a set of custom-defined perspectives and zoom levels, or cross-software functionality, such as a persistent space for storing ideas across different applications employed in combination to carry out a task, e.g., to support a writer who moves between a reference manager, an online repository, a mind mapping application, and a word processor, in order to better support and enrich the *margins* strategy.

CONCLUSION

This paper has presented two strategies for creative professionals' use digital tools across five dissimilar domains. The two strategies, **margins as buffers for ideas** and **view-shifts between component and composition**, can be described as the activity of storing, placing or manipulating something away from what can best be universally described as the 'production-area' of a given software tool and a deliberate, and often recurring, digital shift in perspective or view during the creatives process. The strategies have been discussed in relation to existing creativity and cognition research, and connections to existing similar concepts have been drawn and discussed. Finally, the paper has reflected upon possible future studies and research questions that should be of interest to all HCI researchers with an interest in how to design digital-interactive tools to support human creativity.

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