Communicating Design-Related Intellectual Influence: Towards Visual References

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ABSTRACT

Prototype-driven design research often involves collecting and analyzing designed artifacts in annotated portfolios and design workbooks. These collections constitute important sources of intellectual influence for researchers, yet communicating this influence presents unique challenges, such as the difficulty of translating the aesthetic, material, or interactive qualities of a designed artifact into written text. Building on discourses of visual thinking and visual imagery in science communication and HCI research, this paper introduces, and elaborates, a novel research communication design concept called "visual references," which combine bibliographic information with photographic images, textual annotations, and diagrammatic annotations in order to communicate design-related intellectual influence.

CCS CONCEPTS

• Human-centered computing → Interaction design → Interaction design theory, concepts, and paradigms

KEYWORDS

Citing and referencing, visual references, visual thinking, visual communication, science communication

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1 INTRODCTION

> *Those who think in words—on subjects [that] are thought about effectively in words—can think of a sentence and then utter it for others to hear. If one visualizes a piece of machinery, however, and wishes to communicate that vision to others, there is an immediate problem. Speech (and writing) will provide only a garbled and incomplete translation of the visual image* [24].

Research in Human-Computer Interaction (HCI) involves designing mock-ups and prototypes of interactive artifacts and systems [14, 18]. Prototype-driven research involves collecting existing designs into annotated portfolios [7] and design workbooks [15]. These activities can be understood as analogous to a literature review wherein, instead of written texts, the researcher collects and analyzes relevant designs, which shape and influence their design work. However, while the content of a literature review can be adequately accounted for in scholarly communication in the form of quotes, citations, and references, acknowledging the content of an annotated portfolio or design workbook as a source of intellectual influence can be challenging.

This is because it is not always easy to translate the aesthetic, formal, interactive, or material qualities of designed artifacts into written text. Visual images communicate these kinds of concrete design-related details, and written text abstracts these details. Visual images also take up page space, and, so, although it is possible to account for particular visual qualities to some degree, researchers are constrained by page- and word-count limitations when they write research papers and essays.

One possible way to address with these challenges is to upload annotated portfolios, design workbooks, or exemplar collections as supplemental materials or to provide relevant, representative visual images in a manuscript's appendix section. However, supplemental material, as a category, arguably devalues their significance, and legitimacy, as sources of intellectual influence [13].

It would be appropriate to upload data in the form of interview transcripts, survey results, or user sketches as supplemental material. However, when the contents of an annotated portfolio, design workbook, or exemplar collection directly influences design work, then, we argue, it is no longer appropriate to categorize them as data or supplemental material. They have exerted *design-related intellectual influence* and should therefore be accounted for alongside other sources of intellectual influence.

One way to do this, without violating page- or word-count limitations, is to redesign the way we communicate intellectual influence via reference lists. Building on a tradition of visual thinking and visual imagery in inquiry and scholarly communication [4, 7, 9, 15], we elaborate the concept of visual references. Visual references incorporate visual images to communicate design-related intellectual influence. They consist of four parts: (1) bibliographic information, (2) a photographic image, (3) a textual annotation, and (4) a diagrammatic annotation depicting a relevant theory or model. We use design methods, including sketching and prototyping, to examine the strengths and limitations of visual references.

In the balance of this paper, we discuss the role of visual imagery in scholarly communication--focusing in particular on the science communication and HCI research literatures. These literatures motivate our argument that, although visual images have been examined in terms of their role and contribution in scholarly communication, including as tools for knowledge building and organization, there is potential value in exploring how visual imagery could be leveraged to communicate design-related intellectual influence. We describe our use of sketching and prototyping as a way of developing the concept of visual references. Then, we explain each new element of visual references: the photographic image, textual annotation, and diagrammatic annotation. We end with a discussion about communicating design-related influences as well as the value in rethinking the practice of citing and referencing in scholarly communication.

2 BACKGROUND

Visual imagery has been a topic of study both in the science communication literature and, more recently, among HCI researchers who integrate design methods into their scholarly inquiry--especially researchers who conduct what has been characterized as research through design (RtD) [26, 27] and practice-based research. In this section, we summarize key topics of interest in the science communication and HCI research literatures, including: visual literacy, the role of visual imagery in knowledge production, and visual imagery as a knowledge contribution. The role of visual imagery in scholarly communication has not yet been considered in terms of citing and referencing. We argue that, given the ubiquity of digital authoring and publishing tools, iterating on references to account for visual sources of intellectual influence is an intriguing opportunity for communication design researchers.

2.1 Visual Imagery in Science Communication

Visual imagery is a key component of science communication. Yet, historically, science has been construed as a *primarily* linguistic process [2] where the use and role of visual imagery to facilitate and communicate science did not receive much attention [16]. In recent decades, however, science communication scholars have examined the role of visual imagery in scientific practice [8, 19], scientific presentations, as well as journalistic reports on scientific findings. These examinations have explored questions such as how visual imagery influences the communication and reception of science, how visual imagery shapes how scientists understand the phenomena they study [22, 23], and, relatedly, how visual imagery constitutes scientific knowledge production [11].

While there seems to be broad consensus with regard to the importance, and centrality, of visual imagery in science communication, paradoxically, there are questions as to whether science communicators possess the necessary literacies to design and interpret visual imagery. For example, how do chemists learn to make 3D models of the objects of their inquiry? And how do `readers' of these models cultivate the necessary visual literacies to make sense of what they read [22]? A related but under-examined question is how readers of more creative scholarly work, such as that in the fine arts and design disciplines, make sense of visual imagery in relation to linguistic elements of science communication [20]. What visual literacies are required for scientists to `read' a painting or piece of performance art or a design artifact as a knowledge contribution in itself? What tools do scientists have at their disposal to facilitate this process of sense-making among their readers?

The advent of digital authoring and publishing tools brought with it the possibility to radically reimagine the design of science communication (e.g. [21]) and yet, for the most part, journal articles, conference papers, and book chapters are consistent with their predecessors. They are still primarily language-based—albeit with an apparent increase in the use of visual imagery. In our view, HCI research constitutes one such case of where the role/use of visual imagery in science communication has increased in recent years. Moreover, it is a research community where the role/use of visuals has been discussed in depth.

2.2 Visual Imagery in HCI Research

The value of visual images in HCI scholarship is well known. Visual images have become valued ways of communicating research findings as well as researchers' possible epistemological commitments [9]. Images can also draw attention to social and political problems, and, perhaps, strengthen calls for social activism. The growth of pictorials as a category of archival knowledge [5] in HCI research, the emphasis on images in HCI conference publication templates, and the proliferation of graphical abstracts, which are "single, concise, pictorials and visual summaries of the main findings of [an] article" [12] indicate a trend towards embracing visual images as core aspects of scholarly communication in HCI as well as in other intellectual communities.

With regard to designing, and designed artifacts, images can communicate many different things [15, pp. 1557-1558], such as how an artifact or system functions. For example, in an annotated portfolio of nine different artifacts produced by the Interaction Research Studio at Goldsmith's, University of London, John Bowers describes their "interactive qualities." The Photostroller, he writes, "works with a simple controller to select [a] photo category from six options and then a degree of semantic drift around that selection" [7, p. 73]. Bowers acknowledges that, without an image, it is not

possible to fully understand this description. The text *depends* on "traceable connections to [a] design" [7] for its meaning. Likewise, designs are made meaningful through text.

Images can document sources of design inspiration [6], and they can communicate what is meaningful about "everyday scenes" [3]. Capturing images of everyday scenes is one way designers can deepen their knowledge of the contexts, and people, they are designing for. Furthermore, for prototype-driven research, images can communicate design materials (what is it made of), aesthetics (what it looks like and/or the form it takes), and interactivity (how it behaves), i.e. visual forms that are difficult to capture with text alone [15]. The example design workbooks in Gaver's text [15, pp. 1555-1556] illustrate the crucial role images can play in communicating the concrete details of a design. Each workbook contains multiple design proposals, each of which combines text with imagery. One proposal, for example, is the *Nonessential Object Autosort*, which is a system that identifies and redistributes unused household objects to newfound storage space. The text briefly describes how the system works. The images reaffirm and extend the text by specifying the *aesthetic* and *material* characteristics of the system. The images also communicate *functional* details left out of the textual description, such as how an autonomous trolley relocates unused items.

More generally, images can be used to communicate what is novel about a design concept [25], including sources of design inspiration or aesthetic or material qualities, in relation to an existing class or category of designs. Communicating general, design-related qualities is one purpose of an annotated portfolio. In this sense, then, images can serve both as records of intellectual influence and as grounds for claiming a knowledge contribution. Pictorials, a newer category of archival knowledge in HCI research, are papers where the visual components are as important, if not more important, than the text. These components can be design process diagrams, sketches, annotated images, and photographs (https://dis2019.com/pictorials/), and they can be considered central to the knowledge contribution. That is, the images themselves, or the images and text *together*, constitute a contribution. And yet, when it comes to citing or referencing, researchers have limited options that may not adequately reflect the fact that visual images can be more than an add-on [13].

2.3 Synthesis: Citing & Referencing Visual Imagery

As new ways of producing and communicating knowledge develop, it becomes possible, and perhaps necessary, to re-think citing and referencing practices, which have remained largely static. Even radical departures in the design of scholarly communication [e.g. 21] end with standard reference lists that are only ever linguistic in nature. This makes sense if the sole purpose of a reference is to provide readers with the information they need to find source material. But, in addition to supporting information seeking, references also provide an overview of the intellectual influences and discourses that motivate/shape a text. Visual imagery can be a source of design-related intellectual influence. Yet traditional, linguistic formats for citing and referencing do not adequately account for formal, interactive, material, aesthetic, persuasive, temporal, and other design-related aspects of an artifact or system that could be construed by an author as influencing their own work. The notion of visual imagery in science communication has not yet been examined in the context of citing and referencing. We see this as an opportunity, and in the balance of the paper we explore this opportunity using visual design methods to mock-up one way to reference visual sources of influence in science communication.

3 RESEARCH AND DESIGN

Our aim is to explore the possibility of iterating on the design of reference lists in scholarly communication in order to better account for visual sources of intellectual influence. If visual imagery is central to scientific knowledge production, and science communication, then we believe that it would be pertinent to explore ways to integrate visual imagery in reference lists while keeping in mind the need to support sense-making activities amongst readers with differing visual literacies. We take a designerly approach to this inquiry. This means we use visual design techniques, primarily sketches and mock-ups, to design possible visual references. All the authors are academic human-computer interaction (HCI) and design researchers. The first two are early-career academics (assistant professors) with several years of professional communication and instructional design experience, and the third is a senior academic HCI researcher with nearly 20 years of experience as a design practitioner.

We used Adobe Sketch on an iPad to create five initial mock-ups of possible visual reference formats (Figure 1). Since we—the researchers—submit manuscripts primarily to Association for Computing Machinery (ACM) conference venues, our digital sketches primarily reflect the widely used two-column ACM format. We used these sketches and mock-ups to facilitate discussions amongst the research and design team, which included all three authors of this paper. In this way, the sketches and mock-ups functioned as "design probes" to inspire and motivate critical reflections on the concepts of intellectual influence, visual imagery in science communication, and visual literacy.

We considered whether visual references ought to be separated from textual ones, whether they could/should serve as `links' to other content (e.g. videos of an artifact or system), and, crucially, what other elements would be necessary to effectively communicate source(s) of influence. That is, if our purpose is to communicate intellectual influence, what are the necessary elements of a visual reference to accomplish that goal? Some of the other questions that came up during our discussion were: *Is it enough just to include an image, or should there be a textual annotation? Does it make sense include a diagram or model so that a visual reference also serves as connective tissue between an artifact or system and a theory or model of interaction, design, rhetoric, etc.?* Following this discussion, we created three high-fidelity mock-ups in Photoshop (Figure 2), and reconvened for another round of critique and reflection. This second round dealt with many of the same issues and questions as the first. However, it

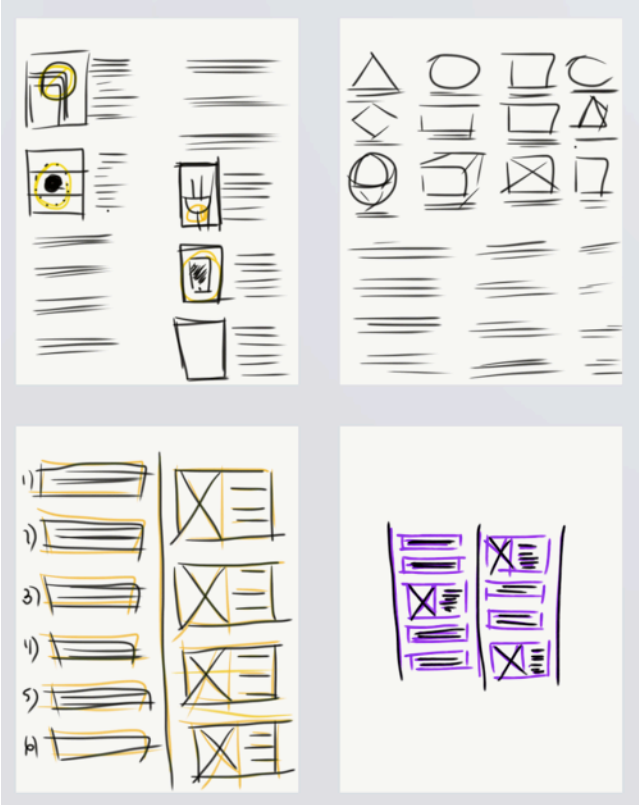

Figure 1. Low-fidelity sketches made with Adobe Sketch on an iPad.

provided us with the opportunity to identify the strongest candidate for what a visual references could be.

4 ELABORATING VISUAL REFERENCES

Our conception of visual references contains four main elements: (1) bibliographic information, (2) a photographic image, (3) a concise textual annotation, and (4) a diagrammatic annotation. Elements 2-4 constitute three types of "argumentative" material: (1) photographic, (2) diagrammatic, and (3) textual (Figure 3). These three types are known in the elaboration of academic arguments--written text being the most common. However, in many papers, especially in pictorials, the use of visual imagery is crucial for clarifying and strengthening an argument. In our view, images are as valid and legitimate as textual material when it comes to the dissemination of knowledge, and we see this reflected in literature on visual thinking in HCI [3, 5]. In this section, we will examine the photographic, textual, and diagrammatic argumentative materials that distinguish visual references from primarily linguistic references.

Throughout this section, we will refer one of the visual references in our mock-up, reference [7] to Djajadiningrat et al.'s paper, "Tangible Objects: Redressing the Balance Between Appearance and Actions," as a way of clarifying claims and ideas. In these mock-ups, we discuss connections between theoretical concepts and designed artifacts. However, these discussions are speculative illustrations of how visual references are intended to work and not reflections of *actual* links between the theoretical concepts and designed artifacts to which we refer. For example, when we describe the relevance of an interaction profile [17] for the camera designed by Djajadiningrat et al. [7] we are *not* identifying a an actual connection that the researchers discuss (or imply) in their paper. Rather, we are showing how visual references frame visual images in relation to diagrammatic annotations, which can connect a designed artifact with a theoretical concept.

4.1 Photographic Imagery

Visual imagery—including sketches, diagrams, 3D models, or photographs of physical artifacts and systems—can communicate details of a design that readers may find difficult to visualize and comprehend on the basis of purely linguistic descriptions. Consider the difference between a linguistic description of the camera designed by Djajadiningrat et al. [7], which we feature in our high-fidelity mockups, and an image. Our textual annotation describes how "moving [a set of] scalers influences the pixel size of [a photographic] image." By itself, this description is probably insufficient to communicate the scalers' appearance, materials, or behavior. What do they look like (aesthetics)? Are they digital or are they made of plastic or metal (materiality)? How do they feel when touched, and how do they respond to touch (interactivity)?

We could expand this description and explain that the scalers are parallel, thin pieces of metal overlaid on an LED screen located on the back of a camera body and that they can be widened (to increase the number of pixels) or narrowed (to decrease the number of pixels). We could add that a user must make a motion using their thumb and forefinger, similar to that of enlarging or minimizing an image on a touch screen, to manipulate the scalers and, thus, the pixel size of the image. This expanded description would communicate a partial picture of the scalers' aesthetics, materiality, functionality, and interactivity.

In order to give readers a sense for the scalers' aesthetics, materiality, or interactivity—such that that might be able to imagine what the scalers look like, what they are made of, and how to interact with them—we have to add details that can be more efficiently and effectively communicated with an image. However, it is also the case that images do not effectively communicate *all* relevant design-related details. For example, if we rely only on a photographic image of the scalers, then it might not be possible for readers to understand that interacting with the scalers changes the pixel size of a digital image--let alone that their interactivity is the most salient or influential for an author. In this sense, a visual image is a way of "quoting" some aspect of a design, and a textual annotation, which we discuss in the next section, serves as a brief elaboration of the quote—pointing to its relevance for the work at hand.

Quoting, citing, and referencing all already do this for other sources of intellectual influence; in some cases specifying which page numbers in a text to peruse in case a reader wishes to consult the source material themselves. These artifacts situate, and establish the fluency of, scholars within particular academic discourses; they align

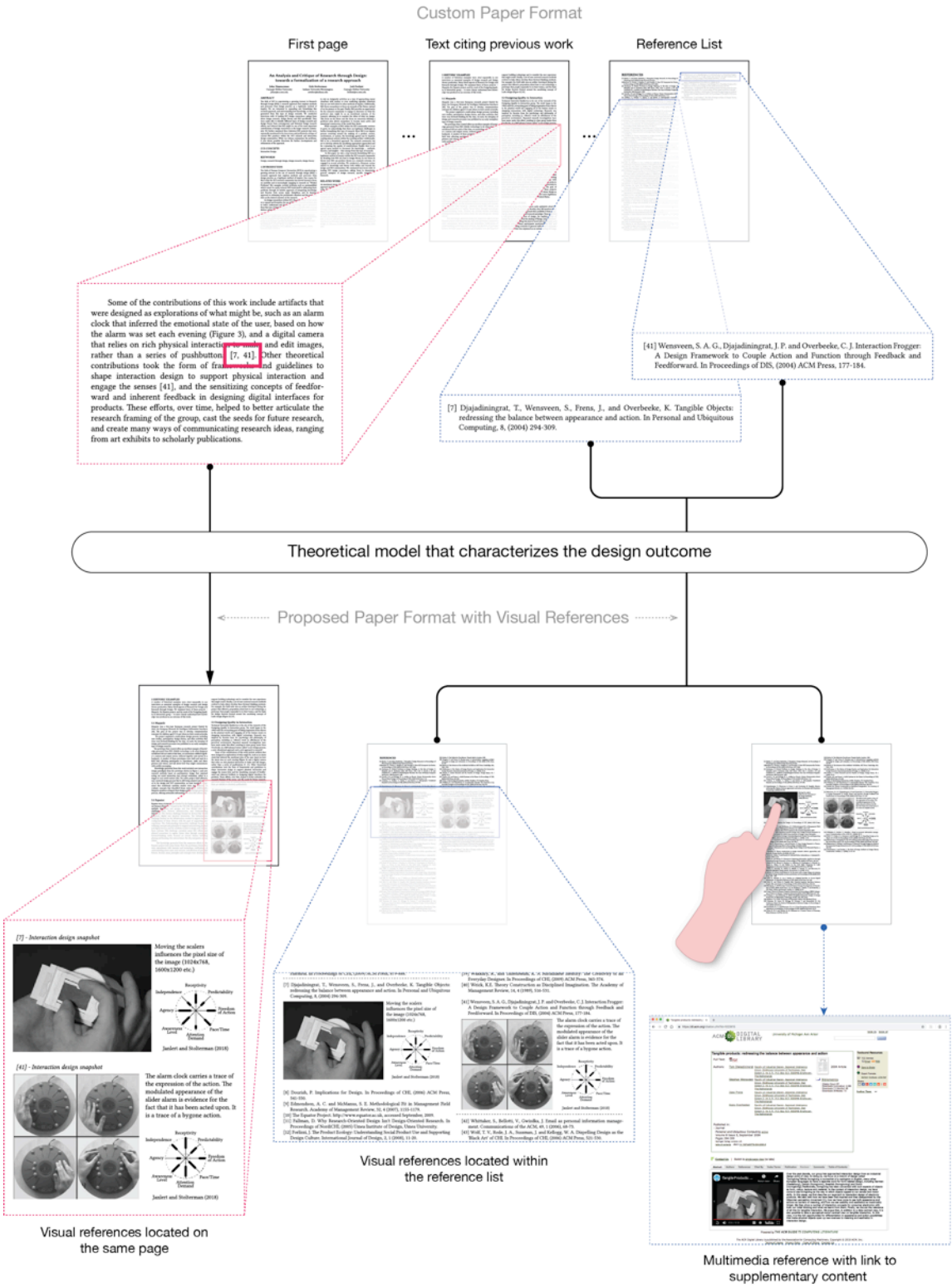

Figure 2. High-fidelity sketches of possible visual reference formats. Ultimately, we identified visual references located within the reference list as the most viable concept given our project aims.

authors with certain intellectual influences, which, in turn, communicate particular ontological and epistemological assumptions, among other things. All of these things together communicate why and how an author thinks about a topic in a certain way and, crucially, how their thinking complements existing work. Visual references start from the position that, when it comes to design-related work, images can provide clearer insight into why and how a researcher designs as they do and, crucially, how their designing complements existing work [25]. Two or more visual references communicate design-related influences and values that are not necessarily possible to communicate through text alone.

4.2 Textual Annotations

A key point of concern in the science communication literature regarding the use of visual imagery is *visual literacy*, which refers to an authors' ability to make high-quality images as well as to readers' capacity to make sense of those images. Both aspects are pertinent to visual references. However, throughout our conversations, we focused primarily on the question of how to support readers in making sense of a visual image--acknowledging that authors play a crucial role in that process. This focus may have resulted from our interest in the visual references themselves rather than the activity of creating them. If we had focused on designing the tools that would help authors create visual references then we might have foregrounded questions like, "*What makes for a good textual annotation?*" and "*How can we support authors in writing strong textual annotations?*" These are important questions. However, at this stage our focus remains primarily on readers. When we include photographs, sketches, diagrams, and the like, in our scholarly communication, do readers possess the requisite knowledge and skills to interpret them? How might visual references support readers' interpretation of visual images?

Images can effectively communicate a lot of information, but it may not be clear to readers which piece(s) of information are the most relevant. Textual annotations can provide valuable insights and guidance. For example, as we mentioned, readers looking at our mock-up may not realize that our intent is to draw attention to the fact that moving the scalers changes the pixel size of a digital image--that manipulating a tangible object causes a digital effect. The image communicates a lot of information about the aesthetics, behavior, and structure of the scalers but not necessarily their function. To communicate their function it is necessary to annotate the image with linguistic text. Textual annotations are brief elaborations of key details of a visual image. They clarify, or reaffirm, just what it is than an author wants to emphasize for a reader. In principle, textual annotations in visual references are similar to linguistic elaborations of other quoted source materials--they clarify and communicate significance, meaning, and relevance, each of which may not be obvious from a quote alone.

Textual annotations are brief. They are intended to be concise, pithy sentences pointing directly to the source of design-related influence illustrated by the visual image. Although the length of the annotation could change on the basis of the reference format (e.g. APA, Harvard, ACM, etc.), we created mock-ups in the style of the standard ACM two-column reference format, which means we worked within particular page-space constraints. We agreed that a textual annotation could fall somewhere between 50-150 characters in length.

4.3 Diagrammatic Annotations

Diagrams allow researchers to model how abstract theoretical concepts relate to the design of new artifacts. They can synthesize key components of a theory, or theories, that influence design decisions and, thus, constitute part of a design rationale. We assume that researchers have knowledge of theory, and any diagrammatic representation thereof, that they might incorporate into a visual reference. Moreover, we assume that such theory has been endorsed by an intellectual community of scholars in some way, which strengthens the credibility of the theory and the diagram. In Figure 3, our fictional visual reference [7] represents the *interaction profile* of the camera designed by Joep Frens. According to Janlert & Stolterman [17], an interaction profile is a set of eight interaction dimensions, including: receptivity, predictability, freedom of action, pace/time, attention demand, awareness level, agency, and independence. This profile can be visually communicated through a radial diagram [17, p. 61] that indicates estimated values for each dimension.

Diagrammatic annotations add another layer, or perhaps even multiple layers, of meaning to visual references. Textual annotations may make an image more understandable by making explicit the relevant aspects of an artifact or system. They can "shape how artifacts might be appreciated and understood with respect to a design project and what scientific and aesthetic value(s) artifacts can have" [7, p. 71]. Diagrammatic annotations do not necessarily do this. In some cases, a diagram may condense several pages of text into a single visual image, which creates a need for more interpretive work. So, why include them in an effort to communicate design-related intellectual influence?

Readers who are familiar with the concept of interaction profiles will most likely interpret the meaning of the radial diagram and recognize its relevance for the visual image. Readers who are unfamiliar with the concept, on the other hand, may need to consult an additional source, in this case Janlert & Stolterman's book, *The Things That Keep Us Busy* [17], to learn more about interaction profiles in order to make sense of the diagram and its relevance for the scalers. However, it is also possible that, by reading the rest of the research paper, they will acquire additional context for the design work that might also facilitate their making inferences about the diagrammatic annotation. From this perspective, it does not matter whether a reader is familiar with concepts of receptivity or attention demand. What matters is that they can see that receptivity seems to be a bit more spread out and in the middle of its axis whereas attention demand seems to be closer to the edge and more concentrated. If an author uses the same radial diagram to annotate a different designed artifact in a separate reference—as we did in Figure 2—then a reader would see how artifacts can be characterized in different ways along the same dimensions, which would provide

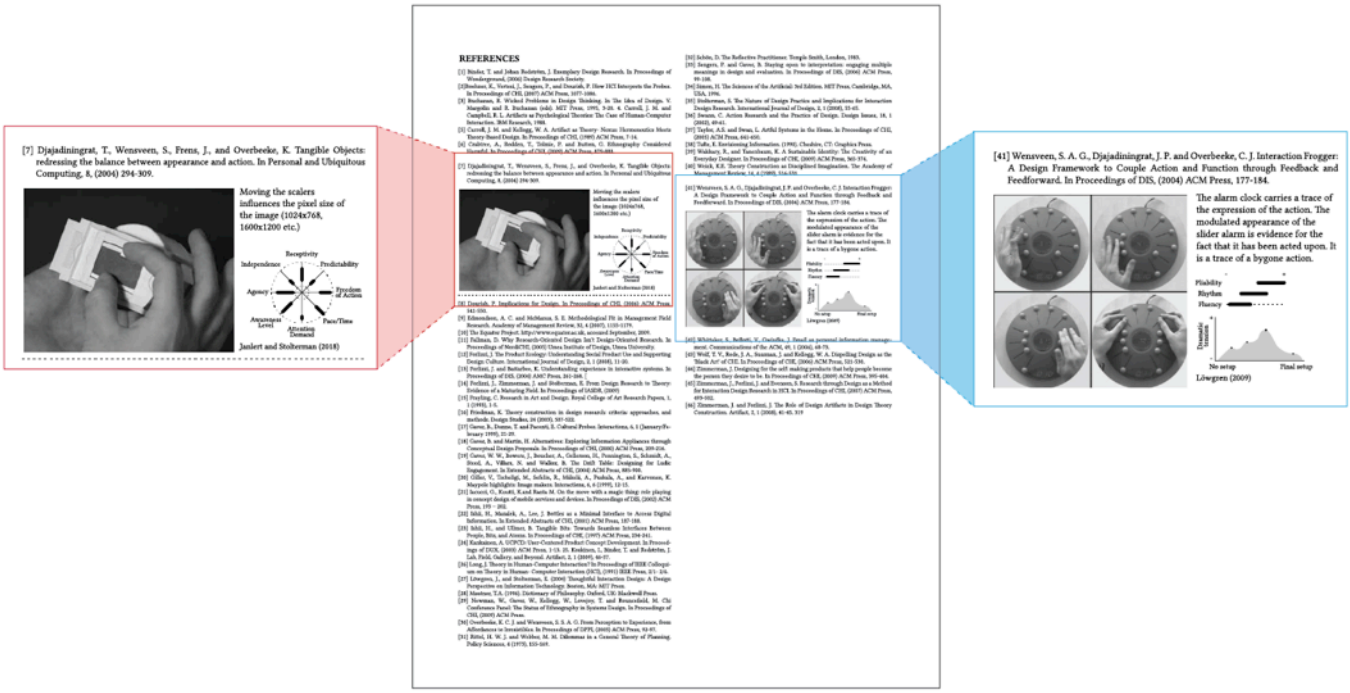

Figure 3. Sketch of visual references in a fictional ACM conference proceeding format.

insight into how an author applies theoretical concepts to their design work.

A theoretical model helps explain why a designer made the choices that they did, which is not always possible to present in detail but *is* an important part of communicating a replicable design process [26]. Whereas textual annotations may point to details about aesthetics, functionality, materiality, or structure, diagrammatic annotations, as we construe them, illustrate key theoretical concepts that underpin a designed artifact. Theoretical underpinnings would be crucial for communicating the conceptual contribution [25], if relevant, of a design. The diagram becomes a visual meta-characterization that readers can use to make sense of key design characteristics or elements.

4.4 SUMMARY

In addition to standard bibliographic information, we propose that visual references could include (1) a visual image, (2) a textual annotation, and (2) a diagrammatic annotation. The image communicates what can be difficult to communicate in text. The textual emphasizes a key aspect, or aspects, of the image. The diagrammatic annotation links the image with relevant theory. Taken together, visual references are intended to communicate design-related sources of intellectual influence--sources that cannot be adequately accounted for using written text alone.

5 DISCUSSION

Visual references are made up of standard bibliographic information, photographic images, textual annotations, and diagrammatic annotations. Taken together, these four elements communicate sources of design-related intellectual influence. While it is possible to account for this influence in appendices or supplemental materials, we believe that doing so devalues the role that design-related sources of influence can have. In the following sections, we discuss the challenge of communicating designerly influences and why we think visual references are a good approach. We also discuss how the concept of visual references requires rethinking how researchers go about citing and referencing when they write.

5.1 Communicating Design-related Intellectual Influence

Designed artifacts are complex. As John Bowers puts it, "[they] lie at the intersection of multiple concerns," [7] including aesthetics, behavior, functionality, and materiality, among other things. Research in HCI involves designing prototypes of interactive artifacts and systems as a part of intellectual inquiry. Research through Design and project-based research are two approaches that emphasize the role and contribution of design methods and artifacts. Like scholarship, design does not happen in a vacuum. It draws motivation and inspiration from existing designs, which can be

collected and annotated in portfolios and design workbooks. Collecting and annotating designs is an intellectual activity akin to conducting a literature review. Yet, while is it common practice to account for linguistic sources of intellectual influence by summarizing key concepts and quoting sources in related work and/or background sections, we lack adequate mechanisms to account for design-related intellectual influences.

In HCI research, scholars have been innovating new publication formats that elevate the role of visual imagery. For example, pictorials (https://dis2019.com/pictorials/) position visual imagery—photographs, diagrams, sketches, among others—as having equal or greater value than the written text. Visual communication researchers have also provoked thinking about the design and aesthetics of scholarly communication. Mark Roxburgh, for example, published an episodic "visual essay" [21] in which text, diagrams, and photographic imagery are juxtaposed in a reflection on historical conceptions of design and the implications of these conceptions for design-based inquiry and practice. In these cases, however, the visual images are author-generated. They do not reflect, say, previous visual work that may have influenced the author's own style, and it is this aspect that we are interested in exploring with visual references.

Accounting for design-related intellectual influence within the body of an article is challenging because, in many cases, there is not enough space to incorporate visual images to account for design-related influence. This is a consequence of page- and word-count limitations. Linguistic quotes and citations take up relatively little page space when compared to photographic images, diagrams, or sketches. Moreover, visual images potentially necessitate additional written text to communicate their content and relevance. Given these issues, one possible solution would be to compile visual images in an appendix section or provide them as supplemental materials (e.g. an annotated portfolio or design workbook). But this approach seems to us to perpetuate the notion of visual materials as "an add-on instead of being an integrated part of the whole" [13].

With visual references, our aim is both to achieve stronger integration and to communicate that aspects of designed artifacts, such as their aesthetics, materiality, or interactivity, can be interpreted as sources of intellectual influence—shaping the way researchers think about, and apply knowledge of, designing and designs. This interpretation advances the idea that images are a key material for building and communicating knowledge.

5.2 Changing Current Practices of Citing and Referencing

Communicating intellectual influence with visual imagery raises a number of important challenges for information and interaction design research, including: how to facilitate the activity of creating visual references. A key takeaway from our project thus far has been that visual references have implications for how researchers go about collecting and organizing source texts as well as how they create in-text citations and references in text editors. Many academic researchers use reference management systems, such as Zotero, which is a popular open-source system, to collect and organize primary artifacts and documents and secondary sources in a digital library as well as automatically generate citations and reference lists in accordance with any of 9,000 citation and reference styles [1]. Zotero, and other similar tools, streamline the process of generating a digital library and formatting its contents in accordance with stylistic constraints set by academic publishers. Visual references necessarily change these activities.

To create a visual reference, a researcher would need to find the standard bibliographic data as they would for most other secondary sources. This is easy enough to do using search tools and a reference management system like Zotero. However, in addition, they would also need to find and document relevant visual images to illustrate relevant aspects of a designed artifact. If a researcher has curated an annotated portfolio [7] or created a design workbook [15], then it is possible they already have many of the images they would need to construct a set of visual references. For a detailed discussion of image-making techniques for design workbooks, which could work well as a preliminary guide to creating images for visual references, see Gaver [15, pp. 1557-1558].

Moreover, in some cases, visual images of designed artifacts appear in manuscripts. In our mock-ups, for example, we used found images of the scalers and alarm clock from their "parent" manuscript (i.e. [7]). We construe these screenshots as visual quotes of the cited source material, which, we believe, comply with fair use copyright law. However, we can also imagine cases where high-quality visual images of a designed artifact might be copyright-protected or unavailable. For example, a source text might only include small, low-resolution images. Alternatively, the images might not be composed such that the relevant aesthetic or material characteristics were depicted. In these cases, a researcher might need to create images themselves by taking high-quality digital photographs of a designed artifact or taking screenshots, which would require cultivating certain visual literacies [22].

In addition to visual images of designed artifacts, researchers would also need to know about and have access to diagrammatic representations of relevant theory as well as some way of specifying the relationship between the diagram and the artifact. For example, in our mock-up (Figure 3), the researcher is aware of interaction profiles (in red) and dramaturgical structure applied to interaction design (in blue). They also know where to find diagrammatic representations of these concepts as well as how to digitally manipulate these representations to annotate different designed artifacts. Creating high-quality visual images and diagrammatic annotations are substantive undertakings that would seem to alter the activity of citing and referencing such that it takes more time and effort but, in the end, communicates a richer story of intellectual influence.

6 CONCLUSION

Design-oriented research often involves collecting and analyzing designed artifacts in the form of annotated portfolios [7] and design workbooks [15]. These activities are analogous to literature reviews

of relevant scholarship, but instead of analyzing written texts, researchers analyze designed artifacts, which, in turn, shape their own thinking and design work. We suggest that such designed artifacts constitute sources of intellectual influence, and, although these sources can be accounted for to some extent, they are difficult to acknowledge in traditional publication formats. Providing annotated images of artifacts in appendices or as supplemental material, in our view, downgrades their significance as sources of intellectual influence. Moreover, page- and word-count constraints reduce the likelihood that the content of an annotated portfolio or exemplar collection can be adequately summarized, with visual imagery, in the body of the research publication. In this paper, we proposed a communication design concept called visual references. Visual references (Figure 3) are a novel proposal for a publication format integrating photographic images, textual annotations, and diagrammatic annotations into entries on a paper's reference list. Visual references are intended to communicate design-related sources of intellectual influence. We recognize that there are limitations to implementing visual references, not least of which is the need to secure institutional buy-in from an organization like the ACM, which would include thinking through what would need to change in current publishing models to make visual references a viable possibility. However, we also believe that it is well past time for communication designers and researchers to rethink referencing and citing in design-oriented research communities.

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