Seeing and Believing:

Examining The Role Of Visualization Technology In Decision-Making About The Future

by

Kaethe Selkirk

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Graduate Supervisory Committee:

Cynthia Selin, Chair
Ruth Wylie
Prasad Boradkar

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ABSTRACT

Images are ubiquitous in communicating complex information about the future. From political messages to extreme weather warnings, they generate understanding, incite action, and inform expectations with real impact today. The future has come into sharp focus in recent years. Issues like climate change, gene editing, and smart cities are pushing policy makers, scientists, and designers to rethink how society plans and prepares for tomorrow. While academic and practice communities have increasingly turned their gaze toward the future, little attention is paid to how it is depicted and even less to the role visualization technologies play in depicting it. Visualization technologies are those that transform non-visual information into 2D or 3D imagery and generate depictions of certain phenomena, real or perceived. This research helps to fill this gap by examining the role visualization technologies play in how individuals know and make decisions about the future.

This study draws from three phases of research set in the context of urban development, where images of the future are generated by architects and circulated by built environment professionals to affect client and public decision-making. I begin with a systematic review of professional design literature to identify norms related to visualization. I then conduct in-depth interviews with expert architects to draw out how visualization technologies are used to influence client decision-making. I dive into how different tools manage the future and generate different forms of certainty, uncertainty, persuasion, and risk. Complementing the review and interviews is a case study on ASU at Mesa City Center, a development project aimed at revitalizing downtown Mesa, Arizona.

Analysis highlights how project-specific visual tools affect decision-making and the role that client imagination and inference play in understanding and preference. This research unpacks the social, technical, and emotional knowledge embedded in visualization technologies and reveals how they affect decision-making. Information about the future is uniquely mediated by each technology with decision-making bound up in larger sociopolitical processes aimed at reducing uncertainty, building trust, and managing expectations. This suggests that the visual tools we use to depict the future are much more dynamic and influential than they are given credit for.

DEDICATION

To mom, dad, Michael, and Noah. Your unwavering support and love fills my life.

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CHAPTER ONE

INTRODUCTION

On January 27th, 1986 NASA received thirteen charts. Each chart provided visual evidence that the Space Shuttle Challenger should not launch the following day due to a predicted O-Ring failure (Tufte, 1997). NASA did not heed this warning. On January 28th, the Space Shuttle Challenger launched and exploded. Seven astronauts died. NASA's decision was high-stakes. As Tufte (1997) notes, the "shuttle flies or fails… [NASA's] inferences and resulting decisions were based on various visual representations (maps, graphs, tables) of evidence. The quality of these differed enormously, and in ways that governed ultimate consequences" (p. 53). Tufte's account underscores the importance of visual communication. In the case of the Space Shuttle Challenger, graphic-driven charts were designed to communicate a vital warning about a future event —tomorrow's launch. NASA's launch had not yet taken place at the time of the warning. The charts were depictions of a plausible future, issued in a present moment at a time when loss of life could still be avoided.

While the episode speaks to unheeded warnings in a time of 'normal accidents'[1] (Perrow, 1984), scholars from many fields have used the case to argue for the relevance of their work. Visual communication turns to the Space Shuttle Challenger event to demonstrate the impact of images, organizational management focuses on the perils of groupthink and political stress, statistics focuses on the importance of data fit and graphs, and sociology draws attention to organizational norms, practices, and values (Tufte

[1] Refers to inevitable failures within complex systems.

1997). These perspectives suggest that NASA's failure was not only visual, but as laid out by Science Technology Studies (STS) scholar Vaughn (1996), the failure was rooted in broader sociopolitical practices and systems that govern decision-making. And yet little scholarly attention has been paid to the relationship between visualization and decision-making with regard to futures. How does visualization change when the subject matter is shrouded in uncertainty, distant, and emergent? This lack of scholarship is surprising given the tragic implications surrounding NASA's decision to launch and the broader role that the future plays in decision-making.

What is clear from this event, however, is that ideas about the future are regularly, and sometimes tragically, implicated in decision-making big and small. How we depict futures directly influences how they are produced and how meanings are attached to them. This project stems from a clear and pressing problem: we don't know enough about how futures are communicated using visualization technologies. Generating this understanding is vital because images and other visual depictions are ubiquitous in communicating complex, necessary, and uncertain information about times to come. From political messages, to extreme weather warnings, to O-Ring failure alerts, visual depictions of futures incite or discourage action and inform social expectations with real impact today.

STS has placed decision-making about the future at the forefront of theoretical and empirical investigation in recent years (Borup, Brown, Konrad, & Van Lent, 2006; Brown, Rappert, & Webster, 2000; Jasanoff, 2015; Jasanoff & Kim, 2009; Konrad, Van Lent, Groves, & Selin, 2017; Selin, 2007). Productive ground has been covered in understanding the sociology of expectations, responsible research and innovation,

anticipatory governance, and sociotechnical imaginaries. However, a significant gap remains with regard to visualization technology and the sociopolitical dynamics surrounding various devices. What risks, rewards, and trade-offs can we tie to particular visualization instruments used to depict futures? To complicate matters, as technology advances, visualization tools shape-shift in non-uniform ways. They exist on a spectrum that varies with regard to realism, interactivity, and image fidelity. Depictions also include certain races, classes, and environmental truths while excluding others. These images color our sense of social reality with regard to climate change, equity, immigration, labor, and other vital issues. As such, visual tools can be seen as differing in their sociality, risks, merits, and ethics. It is vital to investigate how these visualization instruments are deployed through the rich lens of STS. The more we know about how visualization technologies depict complex information about futures, and the sociopolitical implications of such depictions, the better we can make informed decisions about how to communicate complex and necessary information.

The study helps to fill this scholarly gap by examining the role of visualization technologies in future-making. Visualization technologies are those that transform non-visual information into 2D or 3D imagery and aim to generate depictions of certain phenomenon, real or perceived. I ask one primary research question: How do visualization technologies affect decision-making and with what sociopolitical implications? STS analysis is uniquely equipped to investigate and answer this question due to its nuanced take on the co-production of tools and values, its systems view of sociotechnical change, and a deep appreciation of the roles that human and non-human actors play in technological systems. I answer the above research question by examining

the interpretive flexibilities (Pinch and Bijker, 1985) that surround the use of visualization technologies as well as the modes of anticipatory knowledge (Konrad et al., 2017) latent in existing and emerging visual tools that are used to depict futures.

This study includes three distinct phases. The first phase is a review of academic and practice-based literature that surfaces dominant views and practices of visualization within design communities. The objective of this phase is to create a foundation of applied and theoretical knowledge for my investigation and to identify existing dominant visualization technologies. The second phase of this study is a series of seventeen semi-structured in-depth interviews with practicing designers in the United States. Phase two is guided by two sub-research questions: 1) How are visualization tools perceived by practicing architects as affecting client decision-making? and 2) What central issues are raised in using visualization tools to affect decision-making? The objective of phase two is to draw out how visualization tools are used as communication and decision-making tools in everyday practice. In meeting this objective, I aim to expand STS understanding of the epistemology of the future by unpacking anticipatory knowledge latent in visualization technology.

Phase three of this study compliments in-depth practitioner interviews by examining a case study of Arizona State University (ASU) at Mesa City Center. ASU at Mesa City Center is a burgeoning urban development project in Mesa, Arizona aimed at revitalizing the city's downtown. The development is on-going and visuals are used to communicate to city officials, community members, and ASU leadership about the city's future. The case study consists of twenty semi-structured interviews with core project stakeholders, twenty-plus hours of participant observation at private and public project

meetings, and a review of relevant documents. Phase three is guided by two sub-research questions: 3) How are visualization tools perceived by clients as affecting their decision-making? and 4) In what ways do clients interpret renderings? The objective of phase three is to understand in what ways project-specific visualization tools communicate and affect client and public decision-making about the city's future. In meeting this objective, I aim to expand STS understanding of the epistemology of the future by revealing how different visualization technologies foster different social meaning.

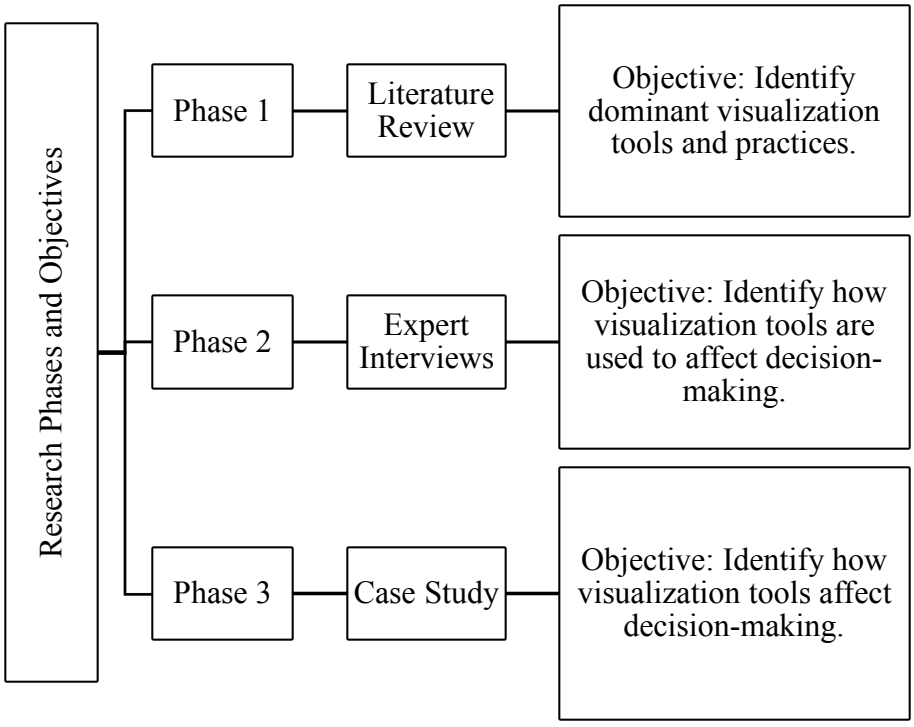

Figure 1. Research Phases and Objectives

I position this research within the specific domain of built environment professionals, specifically architects who must visualize present and future urban conditions for diverse audiences (publics, clients, urban planners, etc.) before they are materially realized. Visual representations range in realism, fidelity, and veracity. They are forms of visual access, knowledge, and understanding about times and conditions to come. In recent years, new visualization technologies, such as virtual reality, have emerged to push the boundary of immersion, realism, and experiential knowing and seeing. These tools are newly integrating into and disrupting design and development practices for uses ranging from public engagement to collaborative design. It is a particularly opportune moment to explore the role that new and old visualization tools play in future-making, as new capabilities and capacities are entering the professional space. In examining visualization tools and their use by built environment professionals, I take architecture and urban development as sites that may have implications for other fields that seek to represent futures.

Dissertation Organization

This dissertation is organized into six chapters aimed at understanding how visualization technologies affect decision-making and with what social and political implications. Chapter two, a literature review, follows this introduction. In this chapter, I draw from STS, Design, Human Computer Interaction, and Future Studies to lay a foundation of understanding about visualization and its relationship to future-making. Focus is placed on academic and practice literatures to identify and surface dominant views and practices of visualization within the design communities. In this chapter, I

highlight theoretical and practice-based insight that is later leveraged towards the study at hand. I also reveal important gaps in understanding that my research seeks to fill. Chapter three lays out the methodology of this research, including data collection, analysis, and study limitations. Chapter four examines how visualization tools are perceived by practicing architects as affecting client decision-making and with what central tensions and implications. Specific focused is placed on how visualization technologies mediate the future and help to generate different forms of certainty and uncertainty, imagination, persuasion, risk, and agency. Findings include how visual tools are used to affect decision-making and the range of social and technical knowledge derived from each.

Chapter five, a case study of ASU at Mesa City Center, compliments in-depth practitioner interviews by examining how visualization tools affect client decision-making. I focus on two distinct moments in the on-going urban development project. The first moment involves the interviews of short-listed architectural firms for the ASU at Mesa City Center design contract. The second is the interview of community members following a Retail, Arts, Innovation, Livability (RAIL) Mesa community presentation which featured a large-scale rendering of ASU at Mesa City Center. Analysis in chapter five draws out how project-specific visualization devices are deployed and perceived by key project stakeholders in communicating about the city's future. Specific focus is placed on meaning latent in and interpreted from the range of visualizations technologies used. Findings include details about how visual tools are perceived as affecting decision-making and the role of interpretation and inference. The conclusion, chapter six, is a discussion of study findings and their implications for decision-making about the future.

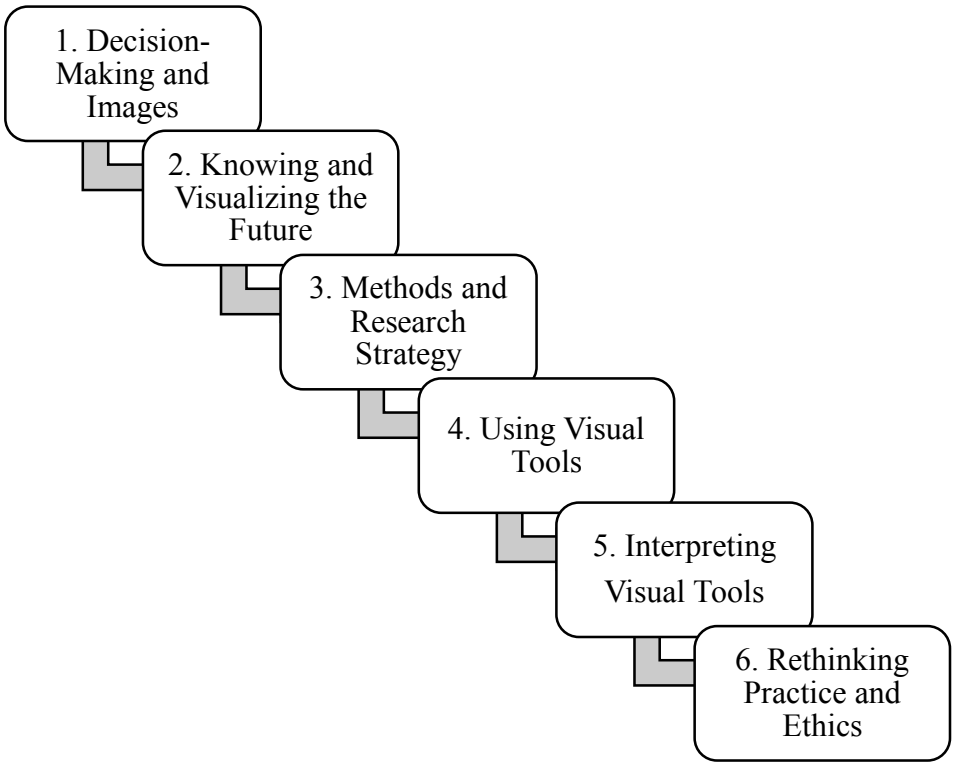

Figure 2. Dissertation Chapter Organization

CHAPTER 2

LITERATURE REVIEW

This dissertation examines how visualization technologies affect decision-making about the future and with what sociopolitical implications. My examination is underpinned by relevant academic and practice-based insight and theory featured in the literature review below. This review is organized into four sections. The first section examines intersections between Science Technology Studies (STS), Future Studies, and the Sociology of Expectations to reveal scholarly understanding of epistemology of the future. I find that quantitative ways of knowing the future, such as population projections and climate models, are well understood. However, knowledge derived from 'other forms of knowing', such as visualization or representation, are not as well studied and known. As such, expanding the epistemology of the future to incorporate 'other ways of knowing'— specifically visualization—is a first objective in this research.

The second section examines STS knowledge of visualization tools and practices. I find that while STS has done significant work to untangle how images operate in scientific and medical environments, little has been done to examine their role in depicting and making meaning about the future. As such, expanding STS understanding by examining how visualization tools generate different social meaning is the second objective of this research. In the final two sections, I introduce literatures of Human Computer Interaction (HCI) and Design to reveal how field-specific insight might be used to push forward STS understanding. Incorporated into this chapter is a structured review of architectural visualization tools and practices described by practice-based

literature –specifically, Architect Magazine. This review provides a baseline understanding of how client-facing visual tools are used in professional practice.

Futures and Science Technology Studies (STS)

Futures have come into sharp theoretical and empirical focus in recent years (Brown et al., 2000; Konrad et al., 2017; Selin, 2008). Science Technology Studies (STS) scholars have taken a leadership role in pushing futures knowledge forward, placing substantial focus on the role and performativity of expectations (Borup et al., 2006), sociotechnical imaginaries (Jasanoff, 2015; Jasanoff & Kim, 2009), and anticipation through the lens of responsible research innovation, anticipatory governance, and technology assessment (Guston, 2013, 2014; Schot & Rip, 1997; Stilgoe, Owen, & Macnaghten, 2013). STS scholarship exploring the role of expectations reveals how future-oriented discourse and practice contribute to future-making. Much work centers on studies of prospective techno-science and provide a robust examination of future representations (e.g. material, textual, promissory) and their performativity (Konrad et al., 2017). Studies are firmly grounded in the core insight that futures are contested, plural and often conflicting (Brown et al., 2000; Konrad et al., 2017). The concept of sociotechnical imaginaries, too, adds significant theoretical depth to future-oriented STS work. Imaginaries are a lens through which STS scholars can articulate how sociopolitical visions and aspirations are materially, institutionally, and temporally manifest. As Jasanoff (2015) writes, imaginaries "…encode not only visions of what is attainable through science and technology but also how life ought, or ought not, to be

lived" (p. 4). Core to this concept is the articulation of desirable and preferred futures that travel across and circulate within the public domain.

The sociology of expectations and sociotechnical imaginaries highlight two conceptual positions futures might take. The first is as an analytical object. This captures the future as 'knowable' and predicable if the correct tools, means, and epistemological methods are applied (Konrad et al., 2017; Selkirk, Selin, & Felt, 2018). In this view, the future is singular, concrete and determined. It does work by shaping expectations and produces variations of hype or caution about events ahead. The second characterization, futures as a conceptual object, acknowledges futures as constitutive of social reality (Konrad et al., 2017; Polak, 1961; Selkirk et al., 2018). Contextual factors, including social norms, practices, and values inform and mold perception of the far term. Here, the future is "…a dimension of the present, [it] is constructed through practice as well as through discourse and thus contributes to the production and reproduction of social reality" (Konrad et al., 2017, p. 473; Selkirk et al., 2018). In the last several years, synthetic work bridging STS and future studies has emerged, opening the field to view the future in a third way—as a resource capable of shaping current action. The STS field has begun to recognize foresight practice and to explore core tenants of futures studies through the lens of anticipatory governance, technology assessment (TA), and responsible research innovation (RRI) (Guston, 2013, 2014; Schot & Rip, 1997; Selin, 2008; Stilgoe et al., 2013). Futures studies is concerned with possible, probable, and preferable futures and the social norms and practices that underpin and propagate them (Bell, 1997). As such, the field generates theoretical and applied insight into the complexity of future-oriented knowledge and practices.

STS, through the lens of TA, RRI, anticipatory governance, and others, draws from futures studies to build a critical lens that investigates constructions of past, present, and future. STS's anticipatory governance, in particular, as an interventionist theory and practice, engages future-oriented inquiry to bring about reflexivity and responsiveness in sociotechnical decision-making. Pioneering scholars define anticipatory governance as "a broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible" (Guston, 2013, p. 219; Citing Guston 2008). In line with this definition, anticipatory governance fosters activities rooted in foresight, public engagement, disciplinary integration, and reflexivity (Guston, 2013, 2014; Owen et al., 2013). Despite significant forward movement in the STS field, however, little attention has been paid to role of visualization technologies in future-making. In particular, how visualization tools make meaning and their particular role in how social actors know and represent tomorrow's complex and uncertain conditions. STS is well poised to make this contribution with its nuanced analytical approach as to how technological devices have politics, carry values, and shape and are shaped by interpretations (Akrich, 1992; Hecht, 1994; Winner, 1986).

One promising pathway towards understanding the meaning-making practices of visualization can be found in recent scholarship on the epistemology of the future. In this literature, tools that produce knowledge about the future and the sociopolitical practices that surround them are a point of focus. STS scholars agree that how we come to know futures directly impacts how we make sense of them (Brown et al., 2000; Konrad et al., 2017; Selkirk et al., 2018). Central, here, is the notion that futures are "…not readily

accessible, at least not to unmediated human cognition. [They] take form in relationship to certain actors, cultures, [technologies, tools], and institutional systems who come to know and define their existence relative to their position in the present and their reconstruction of the past" (Selkirk et al., 2018, p. 5). Underpinning this notion is a view that the future is ontologically indeterminate. This means that the future is not fixed but always in process of being realized in relation to human hopes, expectations, promises, desires, and the technologies that articulate them—reflecting Adams's (2004) immaterial real (Selin, 2008; Selkirk et al., 2018). What is central to the above statements and relevant to this study is an explicit nod to the ways in which futures take shape in relation to different tools or devices that are called upon to know them. All 'futuring' tools, whether a climate model or drawing of a planned urban development, render, represent, and produce knowledge about the future in ways unique to the device and those using it (Brown et al., 2000; Lynch & Law, 1998; Michael, 2000; Moore & Webber, 2008). As colleagues and I have recently written:

> Whether engaging the future as an object of analysis, concept, or resource, different sets of tools and representational techniques can be drawn upon to anticipate and appreciate it. Looking to design studies, we might consider tools or representational techniques that allow us to [render and know] certain futures as "epistemic objects" (Ewenstein & Whyte, 2007; Luck, 2007). Epistemic objects are artifacts…that embody and impart knowledge about a particular subject or object [e.g. the future] through use and engagement [that is unique to the device itself]…[Many] dominant ways of knowing the future pair linear epistemic

> objects with practices that make the future a predictable entity (Adam & Groves, 2007; Konrad et al., 2017; Selin, 2008). From a positivist scientific vantage point, for example, prediction, projection, and modeling provide access to the future through computation and quantitative analysis. Similar linear constructs can be seen in population projections (Isserman, 1984), climate models (Pirtle, Meyer, & Hamilton, 2010), and path-dependent technologies (Selin, 2006). (Selkirk et al., 2018)

Dominant, quantitative, and linear tools for future-oriented knowledge-making, like those discussed above, are fairly well understood within STS (Bowker & Star, 1999; Miller, 2008). These types of knowledge tend to be rooted in reductionist forms of scientific inquiry where the future is framed analytically (Adam & Groves, 2007; Konrad et al., 2017; Selkirk et al., 2018). Focus is often placed on prediction and forecasting to generate long-term understanding (Adam, 2004). Often, retrospective data is projected forward to support an image of the future that echoes the past. This creates a foundation of certainty from which to act on. A useful conceptualization here is the idea of performativity. 'Futuring' tools are performative because they do work to "transform the ways we see and intervene in the world" (Myers, 2014, p. 157; Salter, Burri, & Joseph, 2017). They are crafted and distributed to do something in the world. In the example above, they do work by making tomorrow a more knowable and stable entity. As colleagues and I have recently written*:*

> [Dominant, quantitative, and linear tools] … serve a particular function in engineering, planning, and science by creating certainty in operations and systems

> designed to extend into the future. At the same time, popular quantitative epistemic objects—climate models, economic forecasts, and other representational artifacts—often strip the future of messiness, masking complexity for the sake of usability. Predictive tools become non-negotiable as a result. They structure our engagement with the future down to a limited number of model runs, numbers, or decimal points, when a more accurate representation of futures may include ephemeral and esoteric components existing outside the quantitative device. These tools attempt to predict the future rather than know it through its multiple complexity. (Selkirk et al., 2018)

Often excluded from STS conversations regarding the epistemology of the future is the fact that technical knowledge operates alongside more tacit and subjective ways of knowing. In fact, "while some elements of the future are amenable to prediction, much of what is interesting about the future cannot be easily quantified" (Selkirk et al., 2018). These modes of unquantifiable knowing, these 'other ways of knowing', are rooted in observation, representation, and visualization. They articulate futures as conceptual or resource-based objects (Konrad et al., 2017; Selkirk et al., 2018). These forms of anticipation are bundled as performative knowledge (Myers, 2014; Salter et al., 2017) and materialized and revealed in the daily operation of organizations, actors, and institutions.

While this more tacit practice of future-making is largely understudied within the STS community, it is exemplified by practices of visualization that I explore in this dissertation. I aim to contribute to the STS field by investigating the role of visualization

in the epistemology of the future. I operationalize contribution by exploring decision-making—how different knowledge types are brought together in different visualization tools affect decision-making. Decision-making is narrow slice of future-making, which encompasses the intentional and unintentional actions, decision, choices, events, etc. that lead to the creation of tomorrow. In focusing on decision-making, I seek to expand the field's understanding of non-dominant knowledge-making by exploring how visualization tools, and the images they produce, bring about epistemic realities that order and imbue meaning into social life and futurity. Yet before moving to the creation of new knowledge, we must push forward to discuss the ways in which STS's work on visualization helps to underpin this exploration.

Visualization and STS

Visualization is well studied by communication, design, and digital media scholars, but with less traction in STS understandings of futures. Nevertheless, STS is well versed in the sociality of technology which can be applied to considering sociopolitical practices and implications of visualization tools. Cornerstone STS work on the politics of artifacts contributes an already abundant literature that speaks to the ways in which politics, power relations, norms, and values become materially and institutionally embedded in devices and systems (Akrich et al., 1992; Hecht, 1994; Winner, 1986). STS has also contributed work on visualization in a variety of domains. Through a historical gaze, several studies explore how display and visualization are tools for articulating notions of progress, utopian visions, and sociotechnical advancement at World Fairs (Duranti, 2006; Fotsch, 2001; Smits & Jansen, 2012; White, 2009). Wide-

ranging work has also been conducted within STS to decipher the role of visualization and images in scientific, medical, and laboratory practices. Rosenberger (2011) provides an accounting of core areas where STS scholarship has covered visual agency and the work that visualizations do in techno-scientific settings. The first area of scholarship focuses on laboratory-specific image creation and interpretation. The second area encompasses visual technologies and the knowledge work they do in scientific practice. The third area centers upon the role of imaging technologies in producing of credibility, authority and expertise. The final area includes images and imaging technologies as defining and characterizing corporality and identity. Galison (2014), too, accounts for visualization work within the field of STS. He describes scholarship investigating the entrance of images into scientific discourse and practice, the role of visualization in defining or creating new fields of study, the impact of photography on urban form, and visual practices of information sharing and communication. Futurity, however, is largely absent from these literatures. Nevertheless, STS scholarship in this domain can provide insight into the politics and processes of image production and performativity that is relevant to our larger understanding of the role of futurity in visualization. These insights are teased out below and discussed first in terms of image production and second in terms of image performativity.

Image Production

In the STS literature, visualization, or image-making, most often refers to the work of making natural, social, or technological phenomena visible (Coopmans, 2014; Vertesi, 2014). Production includes all the "various practices associated with making

objects observable and intelligible" (Lynch, 1998, p. 27). Scholars do not view visualization as a neutral or single-handed activity. Rather, visuals are situated knowledge—they are "tissue cultures" of the place and practice that make them (D'Ignazio & Klein, 2016; Haraway, 1988; Lynch & Woolgar, 1990) and a product of combining technology and human skill and judgement (Boradkar, 2001; Lynch, 1985; Selin & Boradkar, 2010). In what Lynch (1998) calls *enframing (*drawn from Heidegger), images are produced when skill, judgement, and technology are leveraged to transform an idea or object into a visual, artificial form. It is at this point that systematic knowledge and sense-making work can be done to understand, manipulate, compare, or record the phenomena (Coopmans, 2014; Vertesi, 2014). Transformation processes are normative, value-laden, and mediated by technology. Thus, scholars view images not as simple pictures of natural occurring objects and ideas but as artificial sociotechnical constructions that "…reach into the world, arrange it in a pose, and cultivate its accountability…" (Lynch, 1998. p. 38).

Images of futures prove particularly interesting here. Unlike, say, a tangible specimen, image-makers are not attempting to depict something lying on a table in front of them. Rather, they are reaching into a largely invisible tomorrow laden with risk and uncertainty and seeking to arrange, cultivate, and represent it. In many ways, they are working from the invisible to create the visible. And while such artificialities of display can be "…blamed for illusions, misrepresentations or distortions... [in the context of visualizing futures] …the artificial appearance of [the] specimen [e.g. the future] is what enables it to be observed and analyzed in the first place" (Frow, 2014; Lynch, 1985, p. 38).

In line with canonical STS work (Akrich 1992; Hecht 1994; Winner 1986), image production is seen as imbued with significant politics, value judgements, and normative decision-making. As Tufte (1997) explains, "displays of evidence implicitly but powerfully design the scope of the relevant, as present data are selected from a larger pool of material. Like magicians, chart makers [and image makers] reveal what they choose to reveal. That selection of data—whether partisan, hurried, haphazard, uninformed, thoughtful, wide—can make all the difference, determining the scope of evidence and thereby setting the analytic agenda that leads to a particular decision" (p. 43). STS scholars and designers alike align with Tufte (1997) and articulate additional sociopolitical factors that influence data selection. These include: the purpose of the image, the composition of the group producing the image, methods of production, context and situation, codes and standards, and norms and expectations about what counts as legitimate (Boradkar, 2001; Danzien, 2013; Lynch, 1985). Moreover, they explain that data is not only selected but often augmented and manipulated to convey the picture maker's message and influence colleague and public decision-making (Amann & Knorr-Cetina, 1990; Knorr-Cetina & Amann, 1990; Lynch, 1985; Lynch & Woolgar, 1990; Tufte, 1997). For example, in the production of scientific images, Lynch (1985, 1990) describes how artificial codes are used to group and collapse otherwise unique data into identifiable and uniform form.[2] This augmentation process makes some data visible while making other data disappear—'inessentials' are omitted. The image or object is stripped of complexity in service of manageability, argument-making, or publication. This sort of

[2] Here, picture-makers can be seen as anticipating future publication and consumption, and as a result, augmenting data to fit their vision for and exception of the end result (Amann & Knorr-Cetina, 1990; Knorr-Cetina & Amann, 1990; Lynch & Woolgar, 1990).

rendering out of complexity refers to what Lynch (1985) calls *civilizing* images.[3] An example of a civilized image might be an anatomical drawing that shows the muscular system to the exclusion of the circulatory system or skeleton. It is the process by which the idea, concept, and natural object —in this example the human body—becomes docile, tamed, and disciplined in service of larger sociopolitical goals—teaching (Tufte, 1997).

Lynch and Woolgar (1990) write that "images are [produced] with a directionality, and forward-facing process can be associated with notions of progress… phenomena under study become more visible, stable, and measureable" (p. 6). Applying this logic to images of the future, we might consider that with each image iteration the future becomes slightly more rendered, more formed, more visualized, more known. While we will return to this concept a design section that follows below, Lynch's (1985) *civilizing* plays a significant role here as unknowns and uncooperative data about futures are progressively managed and tamed. This rendering out may provide cognitive and conceptual room for imagination. However, attention must also be paid to situations where *civilizing* serves as a mechanism for reductive, linear, and quantitative knowing, crowding out situated 'other ways of knowing' (D'Ignazio & Klein, 2016; Haraway, 1988; Selkirk et al., 2018). Image production "is not a question of creating an ever more true or singular image of an object. Instead, we should note how practical work with images shuts down other ways of seeing in order to focus on one aspect, one set of salient relationships" (Vertesi, 2014, p. 31). As Myers (2014) explains, images render "…the

[3] The tools and techniques of this domestication process are what Lynch (1985) terms the *externalized retna*.

world in particular ways: they pull, tear, and torque the world in some ways (if not others) …[and] in the process they shape how and what we come to know" (p. 56).

From an STS vantage point, we know now that images are situated and partial forms of knowledge bound up and embodied in artifacts, systems, technical practices (D'Ignazio & Klein, 2016; Haraway, 1988; Lynch & Law, 1998; Salter et al., 2017). Given the given rhetorical and actual power of images, it's hardly surprising or controversial to say that they permeate daily life and have consequence. From advertising, to design, to technical manuals, they are distributed across society to persuade us, communicate risk, support understanding, and share knowledge, among many others. While STS dives only shallowly, if at all, into the mechanics of how an image is consumed, productive work has been done to explore the work that images do in the world. This is discussed in terms of their performativity.

Image Performance

Performativity refers to the work that images do in the daily life—the ways in which they are meant to intervene to bring about social meaning and action (Batuman, 2008; Dumit, 2014; Giraud, 2014; Jasanoff, 1998; Latour, 1986; Michael, 2000). STS describes images intervening in the world is as authoritative tools for making scientific claims, arguments, and sharing knowledge (Galison, 2014; Knorr-Cetina & Amann, 1990; Latour, 1990; Myers, 2014). An infographic is an example of this. Imagery, text, and graphics are compiled to make an authoritative argument about a specific issue like climate change, poverty, or resource use. In line with this example, images are also described by STS scholars as a way of creating evidence and demonstrating reason—a

process of making things visible for accountability (Jasanoff, 1998; Lynch, 1998), or in the case of nanotechnology, making things visible for imagination (Ruivenkamp & Rip, 2014). Underpinning this work is a common understanding that images do work by persuading people. The perfect image and display can guide viewers to a predetermined understanding and conclusion (Bastide, 1990; Burri, 2012; Mody, 2014).

Images are also performative outside of the scientific enterprise. Jasanoff (1998) provides an excellent accounting of the performativity of images in a legal setting. Looking at the case of O.J. Simpson, Jasanoff (1998) shows that visual authority is something constructed and defended but not without significant contestation over whose 'line of sight' matters. Visual evidence, like photography, has the power to generate a sense that 'seeing is believing'. Bautman (2008), too, analyzes the performance and politics of visual representations in postwar Turkey. He finds that the circulation of cartoons created by urban professionals and artists pronounce and communicate national struggle and contested ideas about the future. We see this in the United States too. Cartoons depicting issues from partisanship, to immigration, to climate change express political disagreement. Additional examples image performativity can be found in Giraud (2014) and Dumit (2014) with the latter powerfully demonstrating how brain scans in trials harness an explanatory power that extends beyond their technical means. Even more, Michael (2000) describes an images role in articulating and enacting power relations, subject positions, and visions of a community's futures. These references strongly demonstrate that images perform, or do work, by politicizing and signifying the social.

Whether scientific or social, images can be seen as what Latour (1986) calls "immutable mobiles"—objects that stimulate thinking and knowing across space and time. These objects, images in our case, are generated to represent something in the world and carry explanatory and interpretive power about it. They are used to "…convince someone else to take up a statement, to pass it along, to make it more of a fact, and to recognize the first author's ownership and originality" (Latour, 1986, p. 5). Latour's immutable mobiles acknowledges an important point: visualizations hold agency. This means that, to one degree or another, they have the ability to shape decision-making among individuals and bring about change in social life.

In STS, the concept of scripts Akrich (1992) furthers material agency by explaining how technologies, objects, and in our case images, "…enable or constrain human relations as well as relationship[s] between people and things" (Oudshoorn & Pinch, 2003, p. 9). The central idea is that designers program into their product future uses and users that become realized when the product enters the marketplace. As Akrich (1992) explains, designers "…define the characteristics of their objects, [and in doing so] they necessarily make hypotheses about the entities that make up the world into which the object is to be inserted. Designers thus define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways. A large percentage of the work of innovators is that of "inscribing" this vision of (or prediction about) the work in the technical content of the new object (p. 207 – 208; Oudshoorn & Pinch, 2003). Connecting to futures literature, scripts echo Adam's immaterial real (2006).

Picture-makers have goals, value-sets, world-views, and audiences for whom they create. When they create images, they insert hypotheses—that manifest through the organizing and manipulating of data—about what work their image will do in the world and who is responsible for doing it. Thus, images can be seen as scripted. This sheds light on our understanding of material agency. They are made to perform "specific programs of action" (Akrich et al., 1992; Selin, 2008) that guide, dictate, and mediate our understanding and behavior. In images of the future, scripts prove particularly interesting because image-makers materialize an otherwise invisible yet predetermined set of uses, contexts, responsibilities, competencies, actions and that users are then asked to imagine (Akrich et al., 1992; Frow, 2014, p. 201; Lynch, 1985). We see this in realistic renderings of public space where fictional images capture how the future space will be used, by whom, what it looks like, and what details of life and social interaction fill it.

The concept of scripts is well studied and articulated in STS. Scholars note its emphasis on material agency. In tension with the concept of scripts, however, and a concept that I seek to push forward, is interpretive flexibility. I say tension here, rather than compliment, because the concepts oppose one another. Scripts emphasize material agency in mediating everyday life and decision-making. Interpretive flexibility highlights the human agency that an individual brings to the construction of meaning. Interpretive flexibility is a concept drawn from the social construction of technology (Klein & Kleinman, 2002; Pinch & Bijker, 1985). It refers to the context-laden meanings given to particular artifacts, in our case images, by a relevant social group. Meaning is often contested because a variety of groups exist, each of which is vying for a design or

interpretation that will resolve their particular problem or else make sense from their vantage point (Klein & Kleinman, 2002; Pinch & Bijker, 1985).

The concept of interpretive flexibility has been applied in a very limited manner to visualization in the field of STS and in an even more limited manner to futurity. Nevertheless, one example of interpretive flexibility in visualization comes from Amann and Knorr-Cetina (1990) and Pinch and Bijker (1985). The authors demonstrate that images are visually flexible phenomena. This means that different interpretations and meanings exist depending on who is seeing. In a lab setting, the authors describe that participants see not only image content but the culture and experience of the laboratory, memories, work processes that led to the creation of the image, the possibility of publication, among others (Amann & Knorr-Cetina, 1990; Pinch & Bijker, 1985). This means that meaning and interpretation is always at sake. The image is a workplace where interpretation is iteratively, interactively, and corporeally accomplished (Alac, 2014; Amann & Knorr-Cetina, 1990; Ewenstein & Whyte, 2007; Knorr-Cetina & Amann, 1990; Luck, 2007; Prentice, 2014). The act of simply 'looking at' misses the true nature of image consumption (Alac, 2014; Prentice, 2014).

As I noted, little work has been done to explore the application of interpretive flexibility in visualization and future-making. To help fill this gap in knowledge, I seek to push interpretive flexibility forward in this dissertation by bringing it into two new spaces—futures and visualization—to examine how meaning-making, design, and problem framing about the future applies to and becomes defined in relationship to visualization practices and devices. As such, this dissertation helps to open up the black-box of futures visualization to explore: 1) how different tools take on different roles and

foster different social meanings and 2) how visualization practices bring about new epistemic and emotive realities, which raises questions about veracity and the sociopolitical dimensions of imagining tomorrow. Before moving to knowledge creation, however, an opportunity exists to inject a more diverse view of technologies into STS approaches to visualization by connecting to literatures of cognition and prototypes that have arisen in the study human computer interaction (HCI) and design. Beginning with HCI, I will now turn to these literatures to introduce insight that helps to advance STS understanding.

Drawing Insight from Human Computer Interaction (HCI)

At its most fundamental, HCI is concerned with human performance and user experience within computer and information systems (Shneiderman, 2005). The field is largely interdisciplinary with inputs from disciplines ranging from social science to design to computer science and psychology (Klemmer, Hartmann, & Takayama, 2006; Rogers, 2012; Shneiderman, 2005). HCI's early and continued commitment to cognitive psychology provides baseline "explanations of the capabilities and limitations of users, in terms of what they can and cannot do when performing computer-based tasks… [while] address[ing] key areas like memory, attention, perception, learning, mental-models and decision making" (Rogers, 2012, p. 21). Early HCI is characterized as an applied science that engages cognitive science theories with a dual purpose of developing useful and usable computational systems and understanding how people make use of them (Rogers, 2004; 2012). Current focus remains on how to design technology to support human performance and cognition and to understand how humans use it. As such, HCI research

and practice is underpinned by a strong understanding of how individuals interact with technology and process information.

HCI scholars largely agree that individuals process information through interactions between internal and external representations. While STS scholars discuss the existence of technologies as external knowledge-making tools, they do not tackle cognition or give insight into interactions between mind and material. Thus, HCI deepens the STS view of technologies and meaning-making by showing how the two relate. Internal representations, one half of the above interaction, can be thought of as mental models. In line with the futures literature (Selin, 2007), they are "small scale internal representations of a real-world phenomenon" (Zhicheng Liu & Stasko, 2010, p. 2). Mental models are central to everyday decision-making because they guide action, reasoning, anticipation, and planning (Norman, 2002; Zhicheng Liu & Stasko, 2010). A core characteristic of mental models it that they are functional rather than accurate (Norman, 2002). They encapsulate the users' *belief* about what is happening within a system rather than what might actually be happening (e.g. internal and external representations do necessary not have the same characteristics). They are conceptual and represent people's "…understanding of how things work" (Norman, 2002, p. 26; Scaife & Rogers, 1996).

Similar to interpretive flexibility (Klein & Kleinman, 2002; Pinch & Bijker, 1985), different people can hold different mental models of the same system. A single person might even hold multiple models of the same system "…each dealing with a different aspect of its operation: the models can even be in conflict" (Norman, 2002, p. 26). Individuals develop mental models based on what things look like, what they know

from previous or similar experiences, what they are told in literatures, what they see in images, and what they learn through people and social context, among others. With regard to futurity, we know that people and organizations hold mental models of the future (Selin, 2007) and can expect that the above characteristics contribute to their configuration. Importantly, information included in a model is not static but temporal, spatial, semantic, relational, and cultural (Zhicheng Liu & Stasko, 2010). And in line with STS, it is always normative and value-ridden and aligned with a particular worldview.

Mental models don't operate alone. Rather, external representations (e.g. material agency) play a role in supporting learning, knowing, and cognition. External representations are things like technologies, objects, and digital and analogue interfaces (Kirsh, 2010; Norman, 1993, 2002). They support cognition not by means of their existence but by means of their use. How we interact with them—how they interact with the mind—determines their usefulness with regard to memory, thought, understanding, reasoning, and cognition (Kirsh, 2010; Norman, 1993, 2002). Images can be considered external representations. They embody and depict particular knowledges, visions, and views. In images of the future, those visions and views are of tomorrow. While HCI is well versed in external representations, the role of futurity is under realized. Thus, we will turn to the literature of prototypes in the following section to fill this gap.

Like STS, HCI echoes concepts of performativity and agency in that external representations are shown to do work. As Norman (1993) and Kirsh (2010) explain, representations serve both as shelves to hold thoughts and vehicles to drive them: "The important point is that we can make marks or symbols that represent something else and then do our reasoning by using those marks" (Norman, 1993, p. 3). Technology selection

plays a significant role here. Different technologies represent and display information in different ways, concealing some insights while revealing others (Norman, 1993; Rogers, 2012). For example, virtual reality generates an immersive experience that might attempt to replicate 'being in' the featured environment. If we are looking at a downtown area using virtual reality, for example, we might put googles on and be transported to a digital street corner. From there we could swivel our head and see a simulated 360-degree view of what is around us. In contrast, a map of that same downtown area is often flat, not immersive, and contains symbolic and key characteristics of the larger area. It does not attempt to bring us into the downtown, but to let us understand its geography or points of interest across wider terrain. In both cases, the medium manages and mediates the information, which in turn, structures what can be known and not known about the site. Echoing the epistemology of the future, then, different devices can be seen as bringing unique epistemic and ontological realities into being. The implication is the world of material has cognitive power (Kirsh, 2010).

HCI brings to STS a vital understanding: internal and external representations come together to foster cognition. This understanding deepens the STS view of technologies and meaning-making by showing how mind and material relate. HCI maintains several theories describing interaction including the Stages of Action Model, External Cognition, Distributed Cognition, and Ecological Psychology (Norman, 1993, 2002; Rogers, 2004, 2012; Scaife & Rogers, 1996; Shneiderman, 2005; Zhicheng Liu & Stasko, 2010). The central insight is that cognition is neither internal or external but a unique combination of interaction between mind and material, where both have agency. This finding helps to bridge STS concepts of interpretive flexibility and scripts (Akrich et

al., 1992; Klein & Kleinman, 2002; Pinch & Bijker, 1985) by demonstrating a co-agency. Mind and material can help to scaffold each other. Iterative action and interaction between internal and external representations process learning, problem-solving, and inference making (Rogers, 2012; Scaife & Rogers, 1996; Zhicheng Liu & Stasko, 2010). For images of the future, we can now see a bidirectional relationship between a mental model of tomorrow and representation intended to inform, persuade, spur, and act upon it.

Cognition occurs through modes of interaction. Affordances (Gaver, 1991; Norman, 2002) are one mode of interaction in HCI that provides a lever of analysis relevant to visualization and futurity. According to Norman (2002), an affordance refers to the relationship between a person and an object. It is a physical or cognitive clue that indicates how to interact with the object (e.g. chairs indicate or afford sitting). The concept of affordances has been broken down over time (physical affordances, sensory affordances, cognitive affordances, etc.) to speak to the diversity of user meaning and action in HCI practice. Most relevant to this study are cognitive affordances. Cognitive affordances are design features that facilitate thinking or knowing through interaction. They are closely associated with semantics and social meaning.[4] An example of a cognitive affordance, according to Hartson (2003), are words on a button that indicate the meaning, function, and consequence of pushing the button. Applying this idea to images of the future, we might see elements in the depiction trigger thinking or knowing with regard to the meaning, function, and consequence of tomorrow's conditions. Importantly,

[4] Semantics refers to layers of latent symbolism and meaning embedded within an image (Jewitt & Oyama, 2004; Kress & Van Leeuwen, 2005; Noth, 2011).

interactions between mind and material described above are not emotionless: "cognition (memory, perception, etc.) and emotion cannot be separated. Cognitive thoughts lead to emotions: emotions drive cognitive thoughts" (Norman, 2002, p. 47). Cognition provides sense-making mechanisms and emotion (visceral, behavioral, reflexive) supports value judgements.

HCI provides handholds into understanding human-technology interaction, and thus a shared agency between mind and material, that STS does not. HCI insight also furthers our understanding of interpretive flexibility by articulating cognitive processes, such as mental models, information foraging, and cognitive off-loading, that move beyond group-level dynamics of 'vying for meaning' and into individual processes of how we come to know, learn, and vie to begin with. Applying the lens of HCI to visualization and futurity, we can now see with deeper clarity how an individual's cognitive configuration of tomorrow might come to shape and be shaped by the representations in front of them. However, a gap remains with regard to external representations. While we understand that they play a role in cognitive processes, we know little about that role with regard to futurity. Thus, we turn to the literature of design, specifically prototypes, to expand our understanding beyond STS and HCI.

Drawing Insight from Design

Boradkar (2001) writes, "all design is a form of problem-solving and planning for the future. The employment of such terms as 'action,' 'change,' 'inventing,' and 'creating' [in definitions] establishes design as a generative process of transformation that leads to tangible outcomes" (p. 2). Design's future orientation extends beyond definition

to include all aspects of practice, including prototypes. Prototypes are design tools. They are tangible artifacts—or, echoing HCI, external representations—that designers use to articulate and test objects, technologies, or conditions that are in the making and will exist in the future. STS and HCI provide a robust understanding of the role of representations and artifacts in meaning-making. However, they fall short with regard to futurity. Insight derived from prototypes can then serve a dual purpose of expanding STS understanding of technology and contributing to the epistemology of the future (see *STS and Futures*) by calling out 'other ways of knowing' intrinsic to representation and visualization.

Design scholars describe prototypes in ways now familiar to us. Echoing STS and HCI, they are physical, external representations or tools that do knowledge work by spurring thinking, knowing, learning, and discovery. Prototypes come in a variety of forms such as videography, sketching, diagramming, rendering, storyboarding, and model-making, among many others (Boradkar, 2001). They create and scaffold information and explore, express, and represent ideas and concepts (Houde & Hill, 1997; Schrage, 1993). Meaning is communicated both symbolically and materially. This makes them primary tools for explaining, articulating, and generating knowledge among diverse stakeholders and ensuring understanding (Ewenstein & Whyte, 2007; Luck, 2007). Like HCI, design scholars view prototypes as forms of unfolding knowledge because they are not the final product. Rather, they create new knowledge as designers use them to explore the idea or future condition (Ewenstein & Whyte, 2007; Luck, 2007; Schrage, 1993). They configure a design problem and solution materially, and in doing so, they impart knowledge through interaction (Boradkar, 2001; Ewenstein & Whyte, 2007; Schrage,

1993; Selin & Boradkar, 2010). Drawing on futures scholarship, we might see prototypes as allowing users a novel and embodied experience of future conditions as they are underway (e.g. the immaterial real) (Adam, 2004; Adam & Groves, 2007; Selin, 2008).

The language of 'design problem and solution' inherent in prototypes, and novel to design, is important, because, when held up to the field's future-orientation, it implies that tomorrow—or some aspect of it or in it—can be discretely problematized and solved conceptually and materially. Pulling insight from STS and the epistemology of the future, we know that problematizing and materializing the future takes work, and in some cases, reductive ways of knowing (Konrad et al., 2017; Selin, 2008; Selkirk et al., 2018). It requires civilizing information and making visible future conditions as a means to better know them (Amann & Knorr-Cetina, 1990; Coopmans, 2014; Knorr-Cetina & Amann, 1990; Lynch, 1985; Lynch & Woolgar, 1990; Vertesi, 2014). The implication for prototypes—and in our case images of the future—is that, like scientific images, various degrees of certainty are constructed for the sake of usability.

Early design-phase photography[5] suggests an example of this. Looking to trade literature (*AIA Magazine*) from architectural practice—the case study focus of this dissertation—photographs are described as capturing and mapping the site and context, identifying initial issues, pinpointing obstacles and damage, showing big-picture relationships, and providing reference information (e.g. mood boards) and evidence (Berg, 2009; Busta, 2015; Hayden, 2000; Herring, 2005; Mortice, 2018). At ground and aerial level (Figure 3), photographs can attempt to depict conditions as they actually are

[5] Photography also plays a role in later design phases where commissioning pictures of finished work and getting them in front of the public or prospective client is a primary way to gain notice and attract business: "If you don't have a good photograph, you don't have a good story. Period" (Beck, 2011; Berg, 2009).

(Boradkar, 2001). Through the lens of STS, this helps to foster certainty about the site and stabilize current conditions so that transformation can begin. As Reeves, Goulden, and Dingwall (2016) write: "only once the future is stabilized can the designer begin their work to exploit it" (p.1). In line with insight from STS, 'constructing' and 'stabilizing' is political work. Technology selection (e.g. drone, smart phone, black and white, etc.) and normative decision-making with regard to framing, viewpoint, exposure, cropping, lighting, props, equipment, and post-production plays a significant role in defining whose line of sight matters and the type, quality, and quantity of information included (Berg, 2009; Heater, 2013; Jasanoff, 1998; Mortice, 2018).

Figure 3. Aerial Photograph of Timber in the City Design Site, Noah Winkler, 2015

As I wrote previously, design scholarship expands STS understanding of the epistemology of the future by calling out 'other ways of knowing' derived from modes of

representation and visualization inherent in prototyping. Houde and Hill (1997) describe three anticipatory knowledge types—each of which provides a lever of analysis relevant to visualization and futurity and novel to STS understanding of technology. They include: ""Role" [which] refers to questions about the function that an artifact serves in a user's life… "Look and feel" [which] denotes questions about…what the user looks at, feels and hears while using it. [And] "implementation" [which] refers to questions about …the "nuts and bolts" of how it actually works" (p. 3). These knowledges are underpinned by a view that the purpose of prototypes, and in our case visualization, is to explore the ways in which the design will be useful to the user in the future. Importantly, prototypes are not without clients just as scientific images are not without scientists and audiences, and computer interfaces are not without designers and users. They are sociopolitical artifacts, and as such, they hold powerful meanings, norms, and values that tie to and anticipate notions of "beauty, utility, safety, accessibility, affordability, sustainability, durability, identity, brand recognition, emotional connection, symbolic meaning" (Boradkar, 2001, p. 2; Schrage, 1993).

Adding to Houde and Hill (1997), Ewenstein and White (2007) and Luck (2007) account for two additional types of anticipatory knowledge associated with prototypes: unfolding and technical. Knowledge that is developing or in process, such as concepts and ideas (Danzien, 2013; Houde & Hill, 1997; Schrage, 1993), constitute unfolding knowledge because unknowns and uncertainties manifest visually and materially. Unfolding knowledge is typically associated with prototypes that are ideational such as drawing, sketching, diagramming, and model making, rough renderings, among others (Boradkar, 2001). Looking to architectural trade literature (*AIA Magazine*), we see these

tools make room for uncertainty and exploration in earlier stages of the design process. They act as physical representations of work flow and process, and are primarily about the ideas embedded in them (Hales, 2007; Hill, 2016; Keegan, 2010). Sketches (Figure 4) and drawings show spontaneity of creation—they capture and communicate spatial and emergent thoughts rapidly (Hales, 2007; Libby, 2011). Models (Figure 5) allow views from any angle or perspective and can change form quickly when glue is not applied (Libby, 2011). Such ideational tools connect mind, hand, and medium (Hales, 2007; Keegan, 2010; Libby, 2011) with processes of drawing, making, and talking crystalizing thoughts and providing a forum and medium for fluid, freer, messier decisions to be made (Keegan, 2010; Libby, 2011; Luck, 2007). As Hill sums nicely, "take a sketch, give it form, learn from that form, go back, do more sketches, do some computer drawings. Work your way through it… They're really about ideas" (2016).[6] Following Selin and Boradkar (2010), theses tools do work by concretizing imagination and speculation about what can and should be. Iterations act as embodied scenarios of the future.

[6] Architectural trade literatures (AIA Magazine) point to hand work and physical models falling out in favor of digital and computer aided design (CAD) and building information modeling (BIM) for reasons ranging from increased efficiency in cost and time to improved decision-making and communication (Brownell, 2013, p. 201; Gerfen, 2007, p. 200; Keegan, 2010; Libby, 2011; McCann, 2008).

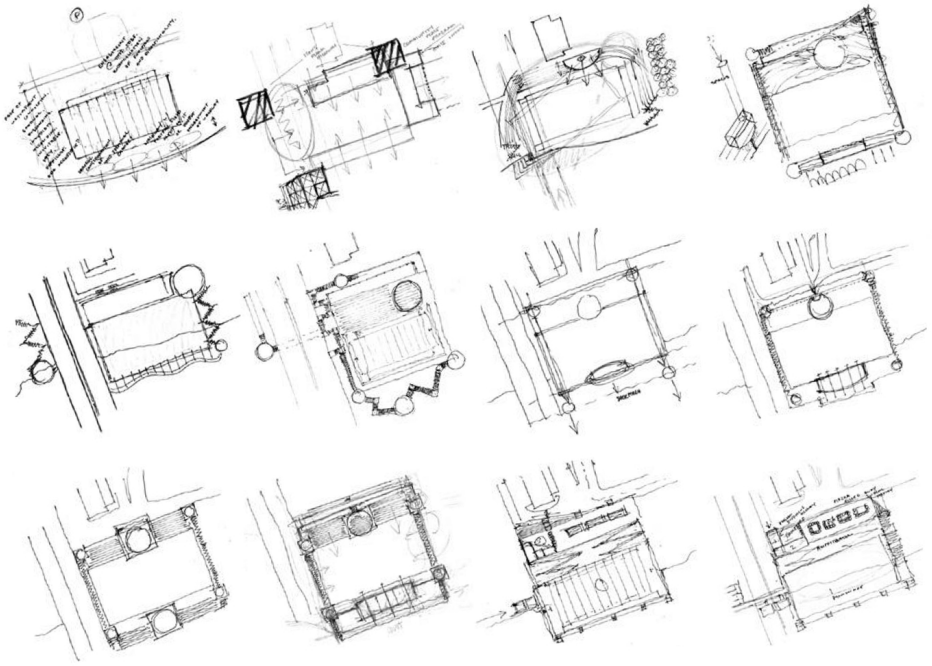

Figure 4. Sketch of Varying Stadium Configurations, Noah Winkler, 2014

Figure 5. Study Models of Vertical Monastery, Alex Warr, 2016

Ewenstein and White (2007) and Luck's (2007) second type of anticipatory knowledge is technical. Technical knowledge closes down uncertainties. It occurs when what was previously unknown formalizes: when "indeterminacy and avenues for further exploration are exhausted and the knowledge object is well defined…" (Ewenstein & Whyte, 2007, p. 83). Ewenstein and Whyte's (2007) rhetoric suggests that these knowledges operate on a scale or spectrum, rather than categorically. Unfolding knowledge gives way to technical knowledge as design problems are defined and solutions are found. Shifting our view to account for this forward-facing nature reveals a unique perspective: prototypes advance with directionality—from unfolding to technical —from uncertain and exploratory to more certain and less exploratory.

The idea of directionality, echoed in STS by Lynch and Woolgar (1990), finds a fuller form in the design concept of fidelity. Fidelity, defined here, relates to how closely a prototype matches the look and feel of the final product (Houde & Hill, 1997). While both concepts speak to the idea that artifacts advance and progress, the concept of fidelity adds that the goal of this progression is to resemble final conditions. Resembling final conditions, whether one is developing a product for market or designing a civic plaza, requires resolving and taming uncertainties about the future—moving from unfolding to technical knowledge (Figure 6). As such, we might turn to view prototypes as moving towards final resolution, or a higher fidelity, as uncertainty is tamed and areas of necessary investigation and exploration are systemically limited (Ewenstein & Whyte, 2007; Selin & Boradkar, 2010). This expands STS and HCI understandings by providing a novel look into visualization and futurity. It also brings forth significant

epistemological tension as the future is laden with uncertainties that cannot (or perhaps should not) necessarily be resolved for depiction.

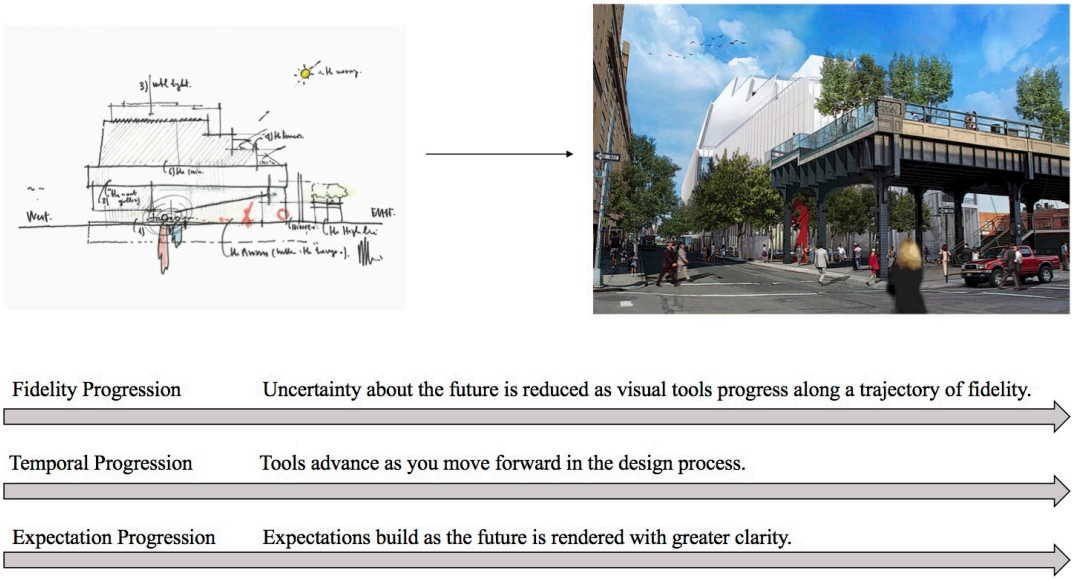

Figure 6. Progression of Design Process, Fidelity, and Expectations[7]
Sketch and Rendering: The Whitney Museum of American Art, Renzo Piano Building Workshop in Collaboration with Cooper Robertson Architects.

As noted throughout this review, different prototypes (or tools) bring with them different knowledges. This remains true for technical knowledge. Technical knowledge can pair with prototypes deployed in later stages of the design process that focus on refinement and delivery, and as a result, are commonly client-facing (Boradkar, 2001; Ewenstein & Whyte, 2007; Houde & Hill, 1997).[8] In high fidelity forms, prototypes can

[7] Images retrieved from ArchDaily (2015) and The Architect's Newspaper (n.d.).

[8] Practitioners describe tension in showing low fidelity ideational work to clients. Hill (2016) writes that "in this era of buildings as objects… you might show these [low fidelity depictions] to clients, and they might say, "OK, but when are you going to show us what the building will look like?" Donoff (2018) ascribes this, in part, to the prevalence of digital technologies. All of design is affected by technology with

depict a legible and perceptually realistic vision for how proposed design will influence daily life and the user (Donoff, 2018; Gendall, 2009; Selin & Boradkar, 2010). Anticipatory knowledges related to role, implementation, and look and feel (Houde & Hill, 1997) may come through with greater visual clarity.

Looking to architectural trade literature (*AIA Magazine*), renderings (Figure 7) and virtual reality can be engaged in higher fidelity work. Renderings, for example, which range from photorealistic to abstract (Libby, 2011), help the project and vision to stand out. They communicate the 'essence', story, and spirit of a design concisely. They show warmth and realism, and inform, seduce, and persuade a client or public to adopt the vision (Gendall, 2009; Keegan, 2007). The best renderings, according to Gendall (2009), communicate "raw realism of a project" and reveal in the blink of an eye context (e.g. material, objects, people), site, sensory experience, impact, audience, and other temporal, emotional, and climatic conditions deemed relevant by picture-maker (Gendall, 2009; Keegan, 2010; Marcellis, 2016).

consequences that range from increased efficiency in cost and time to increased client expectations and new inaccuracies (Brownell, 2013; Donoff, 2018; Gerfen, 2007; Libby, 2011). Also notable is the shift in client expectations. As Donoff (2018) writes and Gendall (2009) echoes: "high-end renderings are no longer reserved for special projects; rather they have become part of our normal design process. In turn, we have found that as these capabilities grow, so do our clients' expectations."

Figure 7. Rendering of Essex Crossing, Alex Warr and Amy McDonnold, n.d.

Technical knowledge must advance for these rendered details to come through (Ewenstein & Whyte, 2007). As Libby (2011) explains, "With our physical models we have a no-glue policy. You can change it right there…With a very finished rendering, obviously that isn't the case." Virtual reality[9] can operate in a similar manner, with authors noting the ability to work with greater realism; rather than 'looking at' users are "immers[ed]…in a simulation of unbuilt project" (Brownell, 2012; Liao, 2016).

It is important to note that while renderings and virtual reality are often client facing, they are also used in practice for in-house studies, charrettes, experimentation and testing, and exploratory work (Brownell, 2012; Liao, 2016; Libby, 2011). Renderings, for example, offer architects a chance to examine a project: "Internally, we study the project, test our own ideas, see if what we have designed is right" (Gendall, 2009). This suggests

[9] Significant hype exists around virtual reality including its ability to inform and empower client decision-making, increase their agency in the design process, foster better understanding, revolutionize workflow and communication, and lead to greater experimentation, testing, and novel discussion (Brownell, 2012; Liao, 2016).

that the anticipatory knowledge spectrum not only moves from unfolding to technical, but also, perhaps, from technical back to unfolding.

Donoff (2018) writes that "…designers and their clients must not lose sight of the fact that what you see on a screen…is not going to be exactly the way things look in reality. Light just has too many subtleties, nuances, and surprises for that to ever be the case…" While Donoff (2018) writes in the context of artificial lighting, we might easily replace 'light' with the word 'future'. The future has too many "has too many subtleties, nuances, and surprises for that to ever be the case" (2018). Bringing the concepts of fidelity, directionality, and technical knowledge to bear, we can now see with greater clarity an epistemological tension between the desire to depict final conditions and our ability to actually do so. As Moore and Webber (2008) perfectly put it: "picturing how we want to live and actually materializing the world is not the same thing" (p. 297).

Conclusion

Moore and Webber's (2008) tension has significant implications for visualization and futurity as images and visualizations are deployed to do work work in everyday life. Visualizations catalyzes expectations. They set and mold client vision, hopes, fears, and desires for tomorrow (Borup et al. 2006; Konrad et al. 2017) and are circulated to convince, convey, catalyze, sell, and persuade (Lovett, Appleton, Warren-Kretzschmar, & Von Haaren, 2015; Sheppard, 2001). They "control… what [a] person sees" (Gendall, 2009) and impact decision-making with real consequence today (Tufte, 1997). Given the power of visual tools, understanding in what ways visualization technologies affect decision-making and with what implications is vital. I take a small but significant step

towards this understanding by examining the role of visualization in how we come know the future within the context of urban development. The literature review above took a first step in this study by establishing theoretical and practice-based knowledge and gaps in understanding. Chapters four and five constitute a second step by presenting original data and analysis aimed expanding our understanding of decision-making and visualization from a practitioner and client perspective. Before moving to these chapters, however, we must turn to review the methodology of this dissertation.

CHAPTER 3

METHODS

The aim of this study is to understand how visualization tools affect decision-decision-making and with what social and political implications. I position this research within the domain of built environment professionals as they are charged with designing and building future cities on a daily basis. The study draws from three primary data sources: a systematic review of practice-based literature, expert-interviews, and case study analysis. The objective of this dissertation is to expand STS understanding of the epistemology of the future by examining the knowledge work that images of the future do in architectural practice and how different visualization tools foster different social meaning. The below section provides an explanation of the methods and procedures underpinning this research. I begin with my theoretical standpoint and methodological strategy. I then discuss data collection, analytical procedures, and study limitations.

Theoretical Standpoint and Methodological Strategy

I take a social constructivist vantage point within this research. This vantage point positions me to interpret qualitative and quantitative findings from the following perspective: "…individuals seek understanding of the world in which they live and work. Individuals develop subjective meanings of their experiences—meanings directed towards certain objects or things. These meanings are varied and multiple, pleading the researcher to look for complexity of view rather than narrowing meaning into a few categories of ideas" (Creswell, 2009, p. 8). In line with this perspective, my questioning and examination is broad and open-ended. This allows participants to make and derive

their own meanings within the social context. The goal of my methodological strategy is to "…relay as much as possible on the participants' views of the situation being studied [the]…intent is to make sense of (or interpret) the meanings others have about the world " (Creswell, 2009, p. 8). Unlike positivism, I did not start with a hypothesis but rather worked inductively to develop patterns of meaning.

In line with social constructivism, I take an approach to this research informed by grounded theory. Grounded theory "is a strategy of inquiry in which the researcher derives a general, abstract theory of process, action, or interaction grounded in the views of the participants" (Creswell, 2009, p. 13). Grounded theory is a systematic process that consists of iterative and comparative processes of code creation and categorization. Rather that starting from preset theories or conceptualizations, codes and categories emerge from the data as means of theory creation (Glaser & Strauss, 1967). Process is central to this methodology and emphasis is placed on careful and iterative coding and categorization of data throughout the research endeavor.

Two cycles of coding were conducted on interview research data. First cycle (e.g. initial coding or open coding) coding included two rounds. In the first round, I cleaned the data by listening to and reading the transcripts simultaneously. Provisional codes were developed while doing this. In the second round, I reread the data line-by-line and omitted, generated, or redeveloped content codes. First cycle codes were initial, tentative, and iterative. They were generated to surface early meaning and were operationalized by "…facture[ing] or split[ting] the data into individual coded segments" (Saldana, 2016, p. 55). This work allowed me to break the data down, reflect on its content, and surface and

examine similarities and differences along respondents (Glaser & Strauss, 1967; Saldana, 2016).

Second cycle coding was used to "…compare, reorganize, or 'focus' the codes into categories, [and] prioritize…[and] synthesize them to formulate a central or core category that becomes the foundation for…" theoretical explanations (Saldana, 2016, p. 55). Second cycle coding (e.g. selective coding or theoretical coding) was deployed to determine central themes of the study. Core categories were constructed to encapsulate the "…major conflict, obstacle, problem, issue, or concern [of] participants… all categories… [were then] systematically integrated around the central/core category, the one that suggests the theoretical explanation for the phenomenon" (Saldana, 2016, p. 150). Memos, notes, jottings, and outlines were kept throughout the analysis to help make sense of codes and emerging patterns.

Data Overview

The primary data types informing this dissertation include semi-structured interviews, participant observation, and trade and practice literatures. Research methods support triangulation (Creswell, 2009; Saldana, 2016) and the development a comprehensive understanding of the study question at hand. The qualitative analysis and coding procedures detailed above were deployed in analyzing all interview data collected. Systematic literature review procedures, discussed below, were deployed for trade and practice literatures. Observational data was integrated to provide contextual understanding of the analysis. In the below subsections, I detail methods and procedures

undertaken in each chapter. I begin with the literature review and then move to discuss chapter four and chapter five.

Structured Review of Practitioner Literature

Incorporated into the literature review of this dissertation is a structured review of visualization as articulated by primary study actors, architects, in professional practice. The structured review was designed to yield an understanding of dominant views of visualization within the design communities and a data-driven understanding of the range of tools deployed for client use in everyday practice. I choose to prioritize the dominant views, rather than the marginal, because my study seeks to understand practices of visualization that are pervasive across the professional field. Particular emphasis was placed on two core components of visualization: 1) views, opinions, and contexts of use; and 2) visualization technologies themselves. The first component, views, opinions, and contexts of use, generates an understanding of how and when visual tools are deployed and with what expectations for decision-making. The second component, visualization tools themselves, reveals what tools are most dominant in practice.

To operationalize this systematic review (Saldana, 2016), I set a framing question for the review: What dominant visualization technologies exist and how are they used in practice? I then moved to identify relevant literature from the American Institute of Architecture (AIA) Architect Magazine. This publication was selected because it is the primary publication of the AIA professional society. It is a central resource among practicing architects working in public, private, and governmental organizations and it speaks directly to norms and trends.

Prior to engaging the review, I established pre-defined search criteria to support the answering of my framing question. Criterion included visualization technologies and key words related to visualization and excluded all other information. Example key words included: visualization, visual, technology, simulation, drawing, rendering, prototype, collaboration, tool, engagement, photography, etc. An excel database was kept of all key word searches that did and did not surface results relevant to the predetermined criteria. I terminated the search after: 1) articles were repeatedly and successively found using the array of search words; and 2) no new articles were found. I had, to the best of my knowledge, found and exhausted the relevant resources. Relevant articles—a total of 46 from between 2007 to 2018—were downloaded, compiled, and stored in an excel database. All articles were read for themes and quotations relevant to answering the framing question. Themes and quotations were marked and copied into an excel spreadsheet that was organized by visualization tool. I then synthesized the information and integrated findings into the literature review of this dissertation.

Expert Interviews

Chapter four focuses on discourses of visualization in the architectural communities. I ask: 1) How are visualization tools perceived as affecting client decision-making by architects? and 2) What are the central tensions in using visualization tools to affect client decision-making? These questions highlight how visualization technologies are used to affect client decision-making and with what sociopolitical implications. In this phase, I dive deeply into expert interviews to determine the role visualization in architectural work environments. I focus specifically on how visualization technologies

mediate the future and help to generate different forms certainty and uncertainty, imagination, persuasion, risk, and agency. Expert interviews draw out practices of visualization and how specific visualization technologies are deployed to communicate urban futures in professional practice and support client and public decision-making. Chapter four was operationalized using semi-structured verbal interviews with protocol topics approved by Internal Review Board (IRB). Expert and highly focused interviews allowed me collect information about and make sense of dynamic study subjects, their perceptions, and the social environment (Arksey and Knight 1999). I engaged analysis and coding methods detailed above (Creswell, 2009; Saldana, 2016).

Expert-interviews were conducted with seventeen practitioners immediately linked to the field of architecture and engaged in public projects. Public projects, a selection criteria for respondents, are projects typically financed by a governmental entity. They can be owned and operated by that governmental entity or leased to and operated by another party. Public projects are often local assets such as libraries, community and art centers, or hospitals. My reason for focusing on public projects as criteria for respondent selection is two-fold. First, visualizations developed for public projects are circulated to wide audience members, like community members and city officials. Given my interest in how visualization affects public decision-making, targeting respondents who have professional experience in developing and circulating visualizations aimed at public consumption aligns the research question and data. Second, focusing on public projects allows me to connect expert interviews with the ASU at Mesa City Center case study featured in this dissertation. ASU at Mesa City Center is a public-facing urban development project. As such, respondent criteria targeted those who had

not only participated in a public development project, but had participated in one with characteristics similar to ASU at Mesa City Center.

I began the solicitation process by first identifying projects in the United States that maintained characteristics similar to that of the downtown Mesa project. This included public projects that were educational in nature, maintained park facilities, were aimed at promoting economic development, and/or were touted as a technology or community hubs. Urban development is not an uncommon practice across the United States and many public projects emerged through simple searches and on architectural websites such as Archdaily.com. However, given the human needed to engage large-scale public projects like ASU at Mesa City Center, I quickly found that qualifying projects were typically associated with large to medium size firms. I catalogued relevant projects in a private database as I discovered them. Information catalogued included the name of the project, the firm, project characteristics as related to the case study and the name and contact information for project designers and architects. In some cases, direct contact information was not listed on the website. Press or media email addresses were recorded in lieu.

The first round of cataloguing included thirty distinct firms with roughly thirty distinct projects. I then moved to solicit interviews with associated project architects via email using a recruitment script approved by IRB. Upon agreement to participate, interviews were conducted via phone or in person and, when permitted, audio recorded. Interviews lasted between 20 and 60 minutes. They were conducted individually, with the exception of one firm where two respondents chose to interview together. These

respondents are referred to and quoted using the pseudonym Brad and Kim in chapter four. All interview respondents are referred to using pseudonyms.

Questioning followed a uniform protocol featured in the Appendix of this dissertation. Given that these interviews were semi-structured, conversation did deviate when appropriate. Types of architectural practitioners included project architects and managers, firm principles, visualization specialists, and urbanists—all of whom work within the study context to execute public built environment projects. In addition to the set of interviews described above, I incorporated interviews conducted in 2017 with practicing architects into the data set. These interviews were included to expand the dataset with regard to our understanding of virtual reality, a new and emerging tool in architectural practice. The technology has not integrated into the workflow of all firms. It is, however, increasingly used to enable communication and decision-making in the kinds of large-scale projects that align with the case study. As such, the interviews provided additional and relevant insight. Saturation was reached at seventeen interviews which triggered the conclusion of data collection in this domain. Saturation was determined when respondent comments converged thematically. All interview data was professionally transcribed by Rev.com and analyzed using MAXQDA software.

Case Study

Chapter five explores how visualization technologies affect decision-making through case study analysis of ASU at Mesa City Center. I ask two specific research questions: 1) How are visualization tools perceived by clients as affecting their decision-making? and 2) In what ways do clients interpret renderings? The ASU at Mesa City

Center development project provides a unique opportunity to ask and explore these research questions because of the social and political tension surrounding ASU's development in the downtown core. The case study methodology draws from a theoretical vantage point that in-depth understanding of small cases in real-world contexts provide invaluable, deep, and novel understanding of the study area and subject (Yin, 2012). The method is appropriate for descriptive or explanatory investigations where data collection occurs in natural settings, thus supporting my aim to understand how visualizations were deployed in a real-world context and with consequence.

To operationalize phase three, I conducted in-depth semi-structured verbal interviews with core project stakeholders, as well as participant observation at key moments within the case study. Semi-structure interviews were conducted in accordance with the methods and analysis detailed above (Creswell, 2009; Saldana, 2016). Case study moments were selected due to their focus on visualization and decision-making and my ability to gain access to the proceedings. Moments focus the study and research question in time, place, and activity, and thus, are tools for bounding the case study. The first moment was architect interviews. Architect interviews were jointly conducted by the City of Mesa and ASU in September 2018 to determine who would be hired to build the ASU at Mesa City Center building and plaza. The selection of firms followed a Request for Qualifications (RFQs) and a short-listed selection of firms (City of Mesa, 2019a). I was invited by the City of Mesa and ASU to observe short-listed firm interviews, which occurred over two days. Observation at the architect interviews was granted, directed, and overseen by gatekeepers at the City of Mesa and conducted accordance with IRB and provisions agreed upon between myself and the City of Mesa. Gatekeepers were notified

of my plans to interview panel members. I interviewed the ten primary selection committee members to understand role of images in communicating information and their impact on decision-making as related to the initiative. Due to the personal and confidential nature of the interviews, data is reported in a general manner with significant sensitivity to parties involved. Pseudonyms are used consistently and job titles are omitted. The only identifying feature is affiliation, which is binary: ASU or Mesa. Similar to chapter four, I solicited interviews with potential respondents via email or in person using a recruitment script approved by IRB. Upon agreement to participate, interviews were conducted individually in person and, when permitted, audio recorded. Interviews lasted between 20 and 60 minutes. Questioning followed a uniform protocol featured the Appendix of this dissertation. Given that these interviews were semi-structured, conversation did deviate when appropriate. All interview data was professionally transcribed by Rev.com and analyzed using MAXQDA software.

The second moment focused on a Mesa Retail, Arts, Innovation, Livability (RAIL) meeting. RAIL is an active community group in Mesa, Arizona. ASU leadership gave a public presentation about the future development on September 26th, 2018 at a RAIL meeting. I attended the public meeting and interviewed nine stakeholders following it. Four of the nine respondents were ASU stakeholders related to the project and study moment. My goal in interviewing them was to understand their intentions with the presentation. Five respondents were Mesa community members who viewed the presentation. My intention in interviewing community members was to understand their reception of a featured rendering and what impact it had on their decision-making. I interviewed all community members that I was able to speak with and who were willing

or able to speak with me. Pseudonyms are used consistently and job titles are omitted. The only identifying feature is affiliation, which is binary: ASU or Mesa. I used photo-elicitation to scaffold the community member interviews. At its most basic, photo-elicitation inserts photography into a verbal interview which has cognitive (e.g. memory) and interpretive benefits (Harper, 2002). The 'photo' used, in this research setting, was the PDF PowerPoint presentation given at the RAIL meeting itself. Specific permission was given by its authors to incorporate the presentation into this research. Interviews lasted between 20 and 60 minutes. They were conducted individually and in person. Questioning followed a uniform protocol featured in the Appendix of this dissertation. Given that these interviews were semi-structured, conversation deviated when appropriate. All interview data was professionally transcribed by Rev.com and analyzed using MAXQDA software.

Importantly, not all community members present at the RAIL meeting were reached for interview. Engaging a snowball method, I was limited by willingness to participate, timeframe, and number of contacts. Similar to Chapter four, I solicited interviews with potential respondents via email or in person using a recruitment script approved by IRB. Upon agreement to participate, interviews were conducted in person and, when permitted, audio recorded. Observation was approved by IRB but did not require speaker permission because it was public. However, the primary speakers were informed and specific approval was given to use the ASU PowerPoint slides in the research study.

Study Limitations

All researchers bring epistemological, ontological, and methodological commitments to their work. These commitments do work by influencing perspective, interpretation, judgement calls, language, subjectivities, and levels of personal involvement throughout the process (Saldana, 2016). In recognizing my role, I follow Haraway (1988) and acknowledge the situated nature of my work and perspective, which is always partial and incomplete.

Beyond my own situated actions, views, and perspectives as a researcher, the process of qualitative coding is a tricky art and there is disagreement in the qualitative community over coding processes: "Some…feel that every recorded fieldwork detail is worthy of consideration…Others…feel that only the most salient portions of the corpus related to the research questions merit examination" (Saldana 2016, p. 17). As a qualitative researcher, I side with the latter who believe that salient portions of text are the primary areas of productive coding. I coded relevant text with a focus on key moments, topics, and passages across respondents. While what is salient can only be determined after a thorough examination of the manuscripts, a potential hazard is that important text and unknown unknowns were discarded. Another limitation is solo coding, which prompts questions of validity of assessment and bias in interpretation. To ameliorate issues surrounding this, I employed three techniques including: 1) regular discussions with mentors about dilemmas, issues, ideas, connections, and thinking; 2) an initial round of coding when cleaning the interview transcripts; and 3) maintaining reflective notes, outlines, jottings, and writing and memos.

A final limitation of this study has to do with sample size and respondent demographics. In chapter four, nearly all interviews were conducted with male architects in leadership roles at large firms in the United States. While this may be representative of relevant demographics, the lack of gender balance necessarily means an integral subset of the working population is not represented. Similarly, many of the respondents were advanced in their career, and thus, likely older in age. While young professionals were contacted, few responded, perhaps due to firm dynamics. The representation of larger firms, rather than smaller firms, is also a limitation and suggests that 1) larger firms may more frequently be the recipients of large-scale public projects; 2) are more apt to list email contact information for individual employees. In chapter five, we again see limitation in sample size. I was unable to contact and interview all participants from the RAIL Mesa meeting, and thus, do not have a full accounting of the present perspectives. With methodology in mind, we now turn to chapter four to explore how visualization tools are perceived as affecting decision-making by practicing architects.

CHAPTER 4

USING VISUAL TOOLS: CLIENTS AND PRACTICE

This chapter examines two research questions: 1) How are visualization tools perceived by practicing architects as affecting client decision-making? and 2) What are the central issues raised in using visualization tools to affect client decision-making? To answer these questions, I conducted seventeen semi-structured interviews with practicing architects using a protocol of ten questions (Appendix) that sought to draw out everyday practices of visualization and how they contribute to future-making in the architectural profession. The interview data is shared throughout the chapter, using direct quotes from interviewees who are recognized with pseudonyms. Focus was placed on client-facing tools, such as drawings and renderings, rather than those internal to the design process, like BIM models or construction documents, as one of several ways (*see methods*) to connect to case study moments featured in chapter two.

Findings in this chapter meet the first objective of this dissertation. This objective is to expand STS understanding of the epistemology of the future by examining the knowledge work that images of the future do in architectural practice. To meet this objective, this chapter draws from STS and design literature and uses foundational insight from these fields to inform its analysis and findings, both of which are woven as narrative throughout. Importantly, this chapter begins from a position laid out in my literature review and introduction. That is: design is a process of future-making, thus, images produced by architects are images of futures and produce knowledge about the future. It is also vital to note that while visualization tools are analytically separated and

categorically organized for conceptual clarity below, they are very much linked and used iteratively and alongside one another in practice (Ewenstein & Whyte, 2007).

This chapter has two sections. The first section answers the first research question by examining how visualization tools reported by respondents' affect client decision-making. Tools are presented and discussed categorically. I begin with diagrams and then proceed to drawings, renderings, and models, ending with virtual reality. The second section answers the second research question, presenting and discussing central issues involved with using visualizations to affect client decision-making. I will now turn to part one, beginning with a discussion of diagrams.

Pseudonym	**Role**	**Gender**	**Position**
August	Architecture	Male	Senior
Zack	Architecture	Male	Senior
Lou	Architecture	Male	Senior
Brad	Architect	Male	Senior
Kim	Visualization	Female	Junior
Max	Architecture	Male	Senior
Rolland	Architecture	Male	Senior
Jerry	Architecture	Male	Senior
Lewis	Architecture	Male	Senior
Joseph	Architecture	Male	Senior
Lola	Urbanism	Female	Senior
Burt	Architecture	Male	Senior
Tye	Visualization	Male	Senior
Sam	Visualization	Male	Junior
Heidi	Architect	Female	Senior
Reed	Visualization	Male	Senior
Michael	Urbanism	Male	Junior

Table 1. Respondent Pseudonym, Role, Gender, and Position

Visualization Tools

Diagrams (2D)

Burt describes diagrams, whether hand drawn or computer generated (e.g. pie charts), as tools for developing and demonstrating reasoning that drives decision-making early in the design process. This is visual reasoning, Burt, Max, and Rolland explain, and it expresses logic underpinning decisions about the future environment such as building configuration, the spacing of social and physical infrastructure in a civic area, zoning, adjacencies, urban fabric, and growth strategies. The type of knowledge depicted in diagrams is described as largely analytical. Knowledge takes a reductive bent where, like quantitative anticipatory tools, variables like zoning and program are abstracted to simplify content, context, understanding, and decision-making.

We see the diagram's analytical characteristics in Rolland's description of their use in client decision-making about library collections. He explains that "… if we're talking about adjacencies of where certain [library book] collections go, we'll usually just do a simple bubble diagram that they [the client] can kind of react just specifically to… [so that we can get] …the decision that we're trying to grab from them." Here, we see complex questions of how to arrange library collections[10], which are informed by organizational norms and values, reduced to abstract bubbles (e.g. bubble diagram) in an effort to focus decision-making. This suggests that too many variables might elicit an undesired response, and that response can be controlled with tools that limit the amount of tacit and explicit information available. In addition to their analytical role, diagrams

[10] Questions of arrangement refer to where and how far apart to place different library sections. For example, placing the children's reading room next to the children's book stacks.

can also be used to engage clients in early collaborative decision-making about the future building. Lewis describes using hand-drawn bubble diagrams or cut outs to tangibly determine how the building's program[11] will be pieced together with clients (Figure 8). The goal of the interaction is to bring clients into the design process, which ultimately, supports consensus building, begins to limit uncertainties, and reduces the number possible configurations that the building might take. In other words, decisions about the future building are whittled and set through a collaborative process of stating and resolving 'what-if?'.

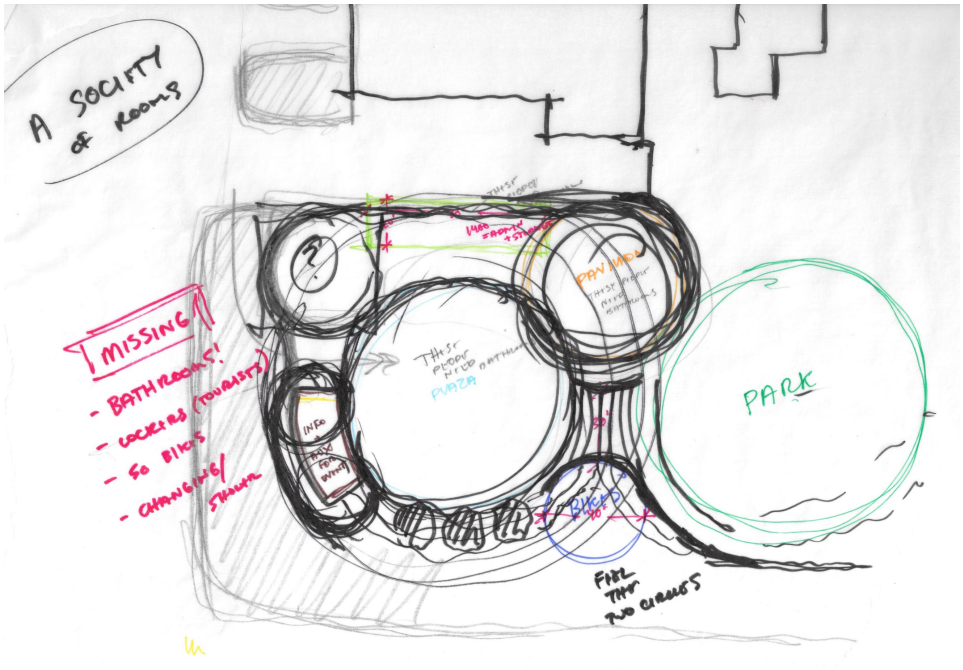

Figure 8. Example Bubble Diagram, Noah Winkler, n.d.

[11] Program refers to the use of the building or space. For example, a library is a primary program. A secondary program might be a reading area.

Importantly, while Lewis describes deploying diagrams for early consensus building, others believe that diagrams are of less concern to clients. Burt states: "[I] feel like most clients aren't really concerned about the diagram. I feel like the diagram is important to me. They like the result." In discussing the design of a large urban park, Lewis adds that: "When it came to the actual park ... I think we're really concentrating on what would it be like to experience it, and not so much to intellectualize it… We didn't do probably as many diagrams… But we spent a whole lot of time doing very literal…drawings." Jerry's comment suggests that the diagrams 'intellectualized' nature might operate separately from, or to the exclusion of, more emotional anticipatory knowledge forms that allow the client to differently know and make decisions about the future space. These knowledge forms are found in higher fidelity tools, like drawings, renderings, and virtual reality, that are more often deployed as the design develops (Boradkar, 2001; Selin & Boradkar, 2010). We will turn to drawings next.

Drawings (2D)

As laid out in the literature review, visualization tools are tied to the stage of design. They move with a directionality, or toward a higher fidelity— beginning with diagrams and loose drawings as ideas unfold and develop and ending with detail oriented renderings and finalized technical documents as information formalizes (Ewenstein & Whyte, 2007; Houde & Hill, 1997; Lynch & Woolgar, 1990). Drawings, like the diagrams discussed above, tend to be lower fidelity. They illustrate emerging design ideas, constitute unfolding knowledge, and are not often closely matched to the look and feel of the final product (Ewenstein & Whyte, 2007; Houde & Hill, 1997). Technical

documents, such as plans, sections, and elevations, described as a different type of drawings by respondents, require a level of expertise, literacy, and familiarity to read that many clients do not have. As Zack explains, "you have to assume a lot of clients don't understand drawings at all." As such, they were not a primary focus when discussing client decision-making.

Respondents describe drawings in a similar manner to trade and academic design literatures. As forms of anticipatory knowledge, drawings make room for and help to resolve unknowns. Following design and STS scholars, they support processes of 'figuring out' and are iterative, not finalized, and largely illustrative of core concepts and ideas (Boradkar, 2001; Ewenstein & Whyte, 2007; Houde & Hill, 1997). Adding to this, however, respondents add that drawings begin to communicate emotion, experience, and the feel of the future building or space. As Lou explains, you're communicating "…how the building is going to work, this is what it's gonna look like, and here's some choices from a planning point perspective… Or maybe you're looking at materials or you're looking at space and you wanna communicate the feel of it, but you're not necessarily communicating the inherent detail of it… not everything is worked out."

Early in the design process, multiple design options—or plausible futures—are available. While a diagram may help to determine adjacencies, how the building looks or how you enter the front doors likely remain open questions. Burt and Max[12] describe using drawings to help resolve open questions by directing client attention and thinking toward certain decision points. In terms of attention, Burt describes using drawings to

[12] Max adds that drawings help to anchor client discussion around project scope and context and, thus, direct thinking "to [conceptual] issues [and] ideas [of] rhythm, harmony, proportion, scale, mass…".

maneuver client conversation and focus, which allows him to "…quickly direct the project away from some things or toward other things… to make big moves." Here, we see the architect holding a large amount of agency in determining options for the future building. In terms of thinking, Lou explains "… when you're showing something in a sketch form that's done by hand, it's kind of loose. You can say well what if we laid the building out this way… what if we had more glass here?" This is, perhaps, a tactic to spur imagination. Rolland adds that "something a little more open-ended [e.g. drawings] … [can spark] thought on their part [e.g. the client] and then we can grab onto those [thoughts] and use [them in the design]."

Figure 9. Open-Ended Drawing, Noah Winkler, n.d.

Lou and Rolland's comments suggest that agency does teeter toward the client as they express preference and options. Importantly, however, just as drawings can expand 'what-ifs' they can contract them as well. Drawings are not without politics. As we will discuss later in this chapter, the architect's hand is always positioned (Hecht, 1994; Winner, 1986). They do normative work by concealing or revealing the possibilities and options presented to clients to begin with.

Importantly, drawings are described as doing work by demonstrating an architects vision of the future and how that meets client objectives. For example, Zack describes using a perspective drawing to show how facing a civic building east would anticipate downtown growth. Economic development was part of the client's agenda, as was making sure that the civic building would fit into the aesthetic of old town. Zack explains that "[the client] wanted to make sure that building fit into what they call Old Town. That meant, in my interpretation of it…we were using stone or brick…so there were special drawings featuring just that." Zack's comment suggests that initial drawings are, perhaps, rapport or trust building tools where the architect establishes their role and ability to: 1) interpret the client's needs and aspirations and bring their client's desired future into reality, which requires vision, problem-solving, and technical ability, among others. It also suggests that drawings, on the trajectory of visualization tools, are increasingly laden with social meaning and knowledge described by STS scholars such as Batuman (2008), Jasanoff (2015), and Michael (2000), to name just a few. Zack's drawings, for example, began to contain knowledge about and depict a future shaped by the municipalities' hopes, expectations, and ideals regarding economic development, tradition, and growth.

Models (3D)

Continuing down the trajectory of visualization tools, we encounter models. Models can take a variety of forms (Figure 10 and 11), including digital and physical and high and low fidelity. Brad and Kim explain that physical models range from rough chip board models "show[ing] how a plaza might ultimately look" to full scale, life-like mock-ups made out of cardboard, to highly detailed 'wow-factor' models taken to interviews to win prospective work or public support. Digital models, constructed in software like BIM (e.g. Revit), Rhino, SketchUp, and others, range from study models that roughly block out what materials might be used and where windows might go, to models that test daylighting, to high fidelity depictions that attempt to replicate how future space will look and feel after construction.

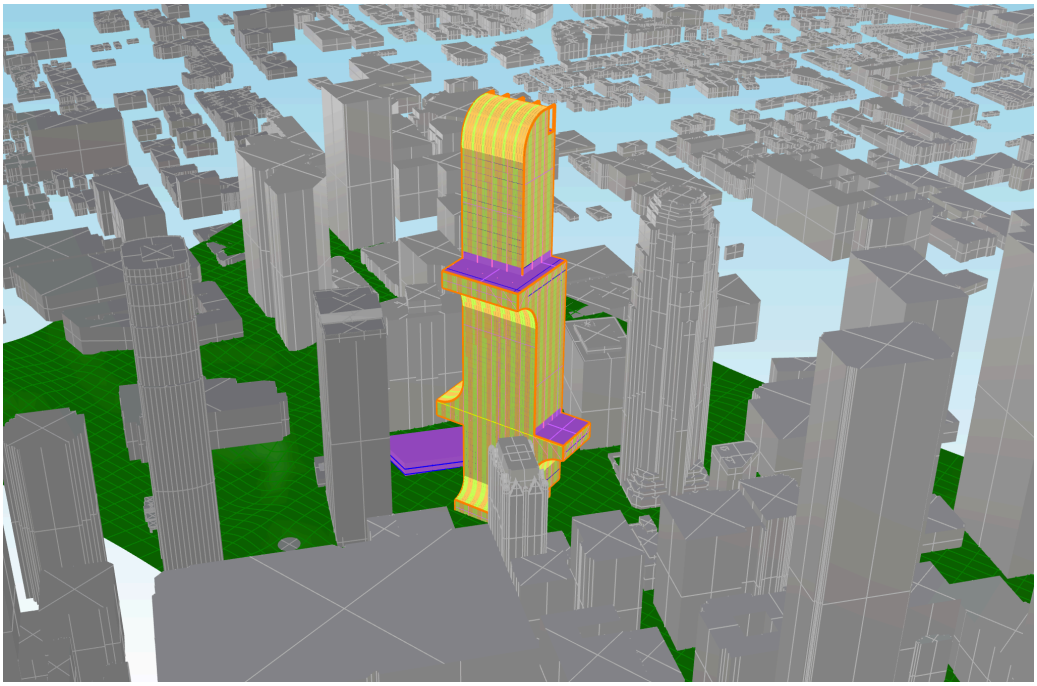

Figure 10. Digital Model of Skyscraper, Noah Winkler, 2016

Figure 11. Physical Model of Essex Crossing, Alex Warr and Amy McDonnold, n.d.

Focusing now on the higher fidelity end, respondents describe models as providing increasingly realistic depictions of the present and future urban environment. They allow clients to envision and understand future conditions by layering temporally disparate information together (e.g. present and future). In other words, they blend fact and fiction in 3D. As Lou explains, "…we… photograph[13] and film the actual context of

[13] Although not largely discussed by respondents, photographs play a role throughout the design process. In competing for new projects, they are deployed by firms to demonstrate their management style and ability. As Joseph explains, photographs of "… [the firm] working, people working together, maybe pictures of us on the site. Pictures of Gantt chart schedules. [These] pictures that illustrate our management style…" Visualization, Joseph continues, is their firm image—photographs, in particular, are a means of establishing and conveying reputation and ability. Echoing STS and futures scholars, then, photographs, like renderings, play a constituting role in generating expectations, hype, imagination, excitement, and credibility of a firm to create a client's envisioned environment (Borup, Brown, Konrad, & Van Lent, 2006; Selin, 2008).

Photographs also serve client understanding during the design process. In early design phases, Rolland describes that developing ideas are related to current and past projects: "If we can relate it to another project, then we do that as well. We'll take photographs of other venues and say it's similar to this."

where a site is located, and actually put the visualization model in the actual context of where the building is gonna be so that people have a good understanding of how it ultimately will look in the context of other built pieces of architecture around it." The reported impact on client decision-making is a greater understanding of present and future site. When discussing physical models, Brad and Kim also report greater understanding of complexity, concept, and future use because testing and physical interaction resolves existing uncertainties[14] and, perhaps, builds trust between designer and client.

Part of the power of models in client decision-making, respondents explain, is that unlike 2D depictions, models provide multiple perspectives and support 360 degree viewing. This means that clients can move around or in the model. They can look at a scaled representation of the design in its site and context. Viewing from different vantage points facilitates dimensional and spatial understanding. As such, August explains and Zack and Rolland echo, models have "the opportunity to convey details of the arrangement of the building, and a physical model… most clients can understand [that]

Rolland's comment suggests that photographs serve as reference points. Just as past and current population data is compiled to project growth (Isserman, 1984), past and current photographs of built work are compiled to demonstrate future ability. Respondents report that this referential understanding generates a sense of certainty and supports client's wiliness to make design decisions. As the design develops, photographs transform into evidence of what the client will get. As Rolland describes, "when we get into kind of materials and finishes… a lot of times we'll use photographs from existing installations… so that the client can kind of visualize the material and we're not having to describe it and then risk them interpreting it one way when we have this other vision in our head." Similar to renderings, this suggests that photographs are deployed as visual agreement about what the future product will be.

[14] Models are also described as communicating complexity to clients, serving proof of concept, and supporting cognitive role play—all of which supports client decision-making. In communicating complexity and serving as proof of concept, Brad and Kim describe a client being suspicious of and not understanding of how a library could be lit with skylights. To assuage suspicion and support understanding, the firm built a model demonstrating the idea's viability, which "…help[ed] [the clients] to understand what the experience would be like."

better than anything else." The 3D nature of model, unlike drawings or diagrams, allows for a multi-sensory, and at times tangible, way to imagine and engage the future space. Following Lynch (1998), models "…reach into the world, arrange it in a pose, and cultivate its accountability…" (p. 38), allowing clients to increasingly test and resolve uncertainties about the future conditions.

Renderings (2D)

Renderings, a fourth category of visualization tool, moves along the trajectory of fidelity to convey formalized information about the future building or public space. As Burt explains, sketches and drawings help you make big moves with "renderings being able to fine tune and make small moves." Following Ewenstein & Whyte (2007), Houde & Hill (1997), Lynch & Woolgar (1990), Selin & Boradkar (2010), renderings, as more formalized depictions, suggest that unknowns, uncertainties, and previously plausible design directions have become increasingly defined and resolved. In other words, the envisioned is taking shape with greater certainty.

While renderings can be low fidelity, respondents more often describe them as high fidelity, client facing tools. They can be photorealistic and depict life-like and future-like information about materials, colors, textures, finishes, light, season, environment, and people. In line with STS scholars, they can be seen as full of and filled with social meaning and context (Konrad et al., 2017; Selkirk et al., 2018). August explains that the most affective or compelling client renders are "…ground-level photorealistic perspectives, with not just buildings, but entourage of trees, and people, and other surrounding buildings for context." The intended goal, according to Rolland, is

to communicate and convey the feel and experience of the space, which bolsters client understanding, excitement, and buy-in. Context, scale, and humanizing and emotional elements play a key role.

Renderings are described as affecting client decision-making in three ways. The first, Zack describes, is by showing future potential that catalyzes decisions, engages publics, and nullifies skeptics: "By doing the planned renderings, we were able to show the potential for the growth, the infill growth in the town. As a result of that, the center was built, and there were a lot of skeptics at the time, [but now] it's used virtually every day, every evening. It's unbelievable the level of...participation [renderings] have with the public, that sort of thing." Zack's comments points to a recurring theme of sparking imagination while also controlling desired outcomes. Zack also describes using renderings as persuasive tools—putting forth arguments showing advantages and pitfalls of pursing some options, or futures, over others. In line with futures and STS literature, this illustrates the performative nature of renderings. As STS scholars like Borup et al. (2006) and Selin (2008) lay out, renderings do work by setting client and public expectations, generating hype and excitement about what is to come, and influencing decision-making.

The second way renderings affect decision-making is by conveying with increasing detail what is envisioned so that there is shared understanding between parties. As Rolland explains, "… [there] is a limited and kind of a subjective kind of interpretation of what you're describing. If you're saying, oh, we want to use a gray carpet, everybody has their own interpretation of—is it a light gray, is it dark gray, is it patterned, is it textured, all these different kinds of characteristics. So, the renderings help

you really convey, this is exactly what I'm proposing." In line with Rolland's comment, we might see renderings as visual agreements that reduce intersubjective uncertainty by laying out a shared understanding of and structured form for the future. Associated with this, then, is the work that renderings do in pulling information together for collective sense making—creating a fully articulated scene that allows the client to conceptualize and understand the design so that agreement can be reached.

Lastly, respondents report that renderings convey a highly experiential and feeling-based sense of space which allows clients to really see how a design might work and feel (Figure 12). Here, we might see Houde & Hill's (1992) prototype characteristics of role, implementation, and look and feel of the future building or space come through with increasing fidelity and perhaps reflecting designer visions and client desire for greater realism. As Lou describes, with renderings, "…it looks finalized. You've got details, you've got shadow, you've got reflections, you've got grass, you've got plants, you've got all the components of making it complete and it looks very, very complete."

Figure 12. Rendering of Essex Crossing, Alex Warr and McDonnold, n.d.

Jerry adds "the very best thing for them [the client] was [a rendering] that was almost photographic, [so] that they could really experience it." Rolland continues that "…a more realistic kind of photoreal …tends to get people a little bit more excited about the space…"[15] The reported client impact is increased understanding, excitement, anticipation, buy-in, comfort, and willingness to invest and proceed with the proposed future, and perhaps, according to Zack, even to be persuaded to expand the scope of work. Using renderings this way positions them, perhaps, as set expectations—with the future taking shape through buy-in and commitment to take action among parties capable of realizing it. We will see in the section below (see *timing*), however, that expectation setting through high fidelity depictions is not without caution.

Virtual Reality (3D)

Virtual reality, a relatively novel tool within the architectural portfolio, is described by respondents as possessing greater fidelity through embodiment. In other words, clients come to know and experience the future space as if it were materially real because they can enter a virtual simulation of it. The greatest impact that VR has on client decision-making, respondents describe, is enhanced understanding. As Brad and Kim explain, "it's like these people don't read plans, don't read elevations. [With VR] …they all of a sudden understand what you've been trying to tell them for weeks… Being able to toggle really quickly between [two options] so you can just push a button and you

[15] Stated in the context of using photorealistic renderings for donor clients.

see the differences. … It's actually allowing them to be in the space and understand that they do need it."

Promissory elements of VR abound and respondents echo them in discussing the technologies' affective role. Brad, Kim, Lewis, and Rolland describe the device as leaning toward the empathic. This allows users to associate VR with real-world experiences. Tye states that, unlike renderings, the technology is not scripted and operates without a fixed field of view. This provides the client freedom and flexibility—a more realistic experience of the future state—and allows the designer to work less hard to keep client attention. This may be at odds with the more controlled knowledge forms described earlier. Sam, Heidi, and Lewis explain that VR game engine technology allows for infinite interaction, allowing more than 'just' a viewing experience, but a greater feeling and understanding of the proposed space and, thus, ability to make decisions. Sam and Lewis explain that VR more accurately relates to the real, material world. This provides clients a sense of being there before it exists. As Sam states, "I'd say the biggest benefit is just the ability to step in to the space and get a feel for how it actually feels. Because in architecture you can't design a building and then step inside it before it's built, it has to go through the whole construction before you can get a feel for how it was back in the design."

This type of interactive anticipation, Lou reports, is persuasive and fosters new levels understanding. The result for clients, respondents explain, is an enhanced ability to approve design decisions, a greater ability to test options, more comfort in design decision-making, and a better ability to get everyone on the same page. As Heidi explains: "I think it's allowed us to offer more comfort to our clients, because it's almost

like they feel, I mean allowing someone to use your money to design a space that you can't necessarily imagine, even with the tools that they provide you, is very scary. So, I think sometimes when you can provide something that shows a little bit more reality to it, then kind of take a deep breath and be like, 'Okay, I do like this space. I feel like I've walked it.'" With this promised ability, however, we are reminded of Donoff (2018) who writes: "… designers and their clients must not lose sight of the fact that what you see on a screen… is not going to be exactly the way things look in reality." Although VR may appear to simulate tomorrow, the future "has too many subtleties, nuances, and surprises for that to ever be the case" (2018).

Donoff's (2018) comment provides ample segue to part two of this chapter which examines essential issues that respondents report in visualizing futures. Up to now, we have discussed the different tools deployed for client decision-making, how they are perceived as affecting decision-making, and the work they do in bringing futures into being. The discussion is organized around the concept of fidelity, with each tool described as rendering and realizing future conditions with greater clarity than the previous. Yet, high fidelity depictions are discussed not without warning from respondents. In fact, two essential tensions in using visualization tools center around when to deploy high fidelity tools and what to include as content. A final core tension speaks to managing uncertainty more broadly.

Central Tensions

Timing

Lola explains that in the design process "things start out more as sketches and diagrams, and then they end up getting more refined and more realistic." As things get more realistic, Zack continues, "clients [are] able to better visualize the outcomes, [and] they tend to get more excited about certain options or possibilities than they would have without that visualization." As such, Lola finishes, there is "always an interest in leaping to the more realistic one because it's understandable…" Along this spectrum, however, respondents describe tension in deploying higher fidelity tools for decision-making. As Max explains, "It's the timing of when and how you use your visualization, to what degree, you know. I think it's super powerful. I think it's wonderful, a wonderful tool. But you have to understand the client psyche and understand how they're viewing this and how they're gonna use it."

Concern around timing focuses on when to deploy higher fidelity tools that affect client attention, expectations, and agency. Showing high fidelity work too early, Lewis, Rolland, and Max explain, can generate a sentiment that the design is finalized. Client attention is then diverted to elements that the designer is not prepared for. As Lewis explains, "they start picking at things that you don't want to pick at…You really just wanted to try and make sure relationships are right, and views are right, but they're looking at a handrail instead of the bigger picture." Lola adds that showing high fidelity work too soon can also suggest certainty. This, in turn, creates expectations that the future building will actually be built and look as depicted. As Max explains, "you start to get clients that think that what they see on a 3D image is exactly what they're gonna get."

Lola continues that when certainty is suggested and expectations aren't made actionable, the credibility of the designer, the credibility of the design and participation process, and the potential for future action are all undermined. Even more, Brad and Kim emphasize the ability of high fidelity visualizations to "…actually convey the real experience. If you make little changes, you've somehow screwed around with this thing they thought they [the client] understood."

Showing high fidelity work too soon can also constrain agency. With regard to clients, Lou explains, high fidelity work can shut down their imagination: "…you're showing something so finalized, they may not know how to respond to it… it kind of clamps down [on their imagination] because [they're] looking at something that is kind of more representational of what it's supposed to be." He continues that "…you're presenting something that has a finished look, particularly when you're dropping in the context of realistic surroundings, or realistic context, and your renderings or your visualizations can be almost—you can't tell it from a completed building." Max suggests that it also constrains agency of the designer. He adds that showing high fidelity work too early can cut off conversation that is vital to establishing the architects' authority as the leader in the design process.

With timing of high fidelity work a central concern, respondents describe paying careful attention to what is visualized (e.g. *content* discussed below), and importantly, when it is visualized. As Rolland explains, we carefully, "tailor the type of visualization to the decision that we want to get." Brad and Kim add, "it's kind of like stripping away all the other information that might distract them from that conversation that we want to have." Through the lens of STS, we can see this as a process of scripting (Akrich et al.,

1992; Selin, 2008) not only content, in STS's traditional sense, but also of time. Designers maintain a careful temporal script that dictates when to deploy high fidelity visualizations in service of guiding, dictating, and mediating client thinking. These scripts, like traditional ones, hold preprogramed ideas about how clients will react to certain devices and at what time and stage in the design process. As such, they are not void of politics. Rather, temporal scripts carry with them specific assumptions about client behavior, agency, attention, imagination—all of which is acted out through social iteration.

Content

Michael writes "…a lot of architecture renderings… they're these really beautiful images that get people excited, [but] that's not necessarily what the experience of being by that building is going to be [in] reality… [there are] going to be streets, and there's going to be a garbage can out front. It's a little bit idealized…" Michael's statement points to a core tension in visualizing futures—one that Zack lays out plainly and is alluded to in the section above: "It is an issue—what you include and what you don't include [in your visualization]."

This tension is particularly acute in higher fidelity depictions that often feature and idealize content that animates daily life—context, environment, people, color, light, season, and so on. Burt, for example, depicts buildings in "…the season that [the] space will best shine in." We know, however, that there are twelve months in a year and separate seasons. The season it will best shine in is only a sliver of the buildings lifetime. Rolland describes attempting to convey the feeling of the future space, and in doing so

includes “entourage, so people, trees, just to give a sense of scale. And I guess sometimes we take a little bit of artistic license and we'll drop out trees or pull columns…but in the rendering, it would prevent you from kind of getting a good feel for the whole space.” Taking artistic license, Rolland notes, is not surprising at all given that visualizations are artificial (Frow, 2014; Lynch, 1985). Nevertheless, the architect is constantly making choices about what elements of life to include or exclude as a means of shaping, if not inventing, what a “good feel for the whole space” means. This begs the question: good for whom and with what consequence? The positioned and political nature of visualization is made clearer by Jerry who adds that people in depictions must reflect the client’s envisioned environment: “We're doing a building for a traditionally black university, and we didn't get enough African Americans in the entourage. And whoa, that was just immediate. The first thing was, “Whoa, those aren't our people” … We had another client that the cars were way too upscale. No, no, we're not going to have cars like that in this environment.”

In all cases, as Burt explains, “[realistic depictions are] carefully planned—the time of day and trying to capture people in the space. But it's trying to capture something.” What you’re attempting to capture, respondents describe, is the feel, character, and emotion of the future space. Visualizations, then, are described as a means of communicating this ‘capture’ to clients. It gives them, as Zack states, “…an opportunity to see things much more clearly, to understand them more clearly.” And from this understanding, respondents explain, comes buy in. As Brad and Kim explain, “[in] trying to help the person that has to decide to pay for it or use it, you've got to find a way for them to understand it.”

Importantly, however, understanding does not necessary mean showing more, according to respondents—it means showing right. This is obvious from Jerry's discussion of rendered individuals and cars. In line with STS's Myers (2014), Vertesi (2014), and Lynch (1985), it means arranging and civilizing the future in particular ways that include some information and views while excluding others to support client vision and goal. In other words, it is always political and positioned (D'Ignazio & Klein, 2016; Haraway, 1988). For some, like Burt, showing right means exaggerating so that a perceived gap in client understanding of the future space is filled. For others, like Max, it's about being precise and accurate with the correct detail but without showing too much: "The correct detail. Make sure that it's accurate in scale, and in color, and in whatever… But if you start to show… too much… You start to get clients that think that what they see on a 3D image is exactly what they're gonna get." Still more for others, it's about generating excitement and buy-in. Across respondents, misleading the client is never the goal. Rather, there is a careful walking between "…trying to be as accurate as possible to show the impact that it [the design] could have" (Lou), managing expectations about the future state, and "telling a story that people get excited about for the future, but then also trying to understand how the future is actually going to work, so that things can actually be built" (Michael). What this comes down to, perhaps, is a balancing between a literal truth, one that attempts to capture exactly what the future site will be, with an emotional truth, one that gets the client excited and enables a feeling of being there. As Burt explains, "I don't think it's necessarily a lie. It's just filtered. It's like any good photographer. They don't just walk up and take the photo… [it's like photographs of] any family this time of year in a pumpkin patch. The reality isn't that photo of the kids

behaving…The reality is the 30 other photos that you took. But that one photo that gets posted."

Uncertainty

August states: "I'm a big baseball fan and one of my favorite Yogi Berra quotes is: Predictions are difficult, especially when they're about the future…I think [this] conveys the difficulties of projecting what may happen in the future that's not under the direct control of the people involved in reviewing it and may, in fact, involve a great many parties with different motivations over long periods of time." He continues: "…people don't seem to want to recognize uncertainty as a design element" but, in fact, there is significant uncertainty. This uncertainty exists, according to respondents, in a range of areas including politics, the real estate market, labor quality and availability, feasibility of construction methods, and contextual and environmental factors such as climate change, policy prices, and local trends (e.g. walkability, among others (Max; Lou; Burt; Brad and Kim; Michael). And these uncertainties, Michael explains, are magnified by the timescale of the project. A building might be built start to finish in five years, for large-scale transit projects, perhaps 10 years, and for landscape projects even longer if you consider the time it takes for vegetation to mature.

A core tension for designers, then, is how to manage this uncertainty—how to tame and visualize it so that the project can advance. Though Lynch's (1985) lens, this is a process of civilizing the future; of stripping it of unknowns in service of larger sociopolitical goals. Respondents describe four ways that the future is civilized and uncertainty managed. Importantly, these techniques are not mutually exclusive. Like the

visualization tools featured in part one, they can be analytically separated but are linked in practice.

The first technique suppresses uncertainty by extending current conditions. Respondents describe “working with blinders on” and making explicit assumptions that current conditions won’t change. As August explains, "[uncertainty] is normally handled at a level of… we're going to design and visualize this project based on the current circumstances with a knowledge that other things may occur in these areas in the near future or the far future. But we don't have control over those. So, we have limited ability to respond appropriately to that unknown.” Similar to qualitative tools that assume the future will be like the past, this stance controls the unknown by stabilizing current conditions, positioning the designer as reactive to future events outside the immediate site. A second technique manages futures through interpersonal agreement. Clients and designers jointly speculate about and agree on a set of assumptions that determine what will or will not happen in advance of the project beginning, or as project direction is determined (August). These speculations might be informed by data, such as population projections and planning documents that capture planned developments and trends (August; Max; Rolland; Lewis). Here, we see future constructed as an agreed upon entity through social process. Parameters and variables of uncertainty are defined by interpersonal agreement—ones mutually constructed through discussion and data. A third technique described by respondents is role playing and testing. As Brad and Kim explain: “Before you spend a thousand dollars a square foot to build this thing, figure out if it's gonna work… You’re testing ideas about the future. You're putting ideas into tangible, visual material things that help you make decisions down the line whether you're an

architect or a client." Here, taking a positivist bent, uncertainty and future conditions might be seen as external elements and capable of being tested, reduced, and eliminated. A fourth technique is scenario construction. In line with futures literature and practice, respondents create different future development scenarios to anticipate an array of possibilities. August, for example, "display[s] either different scenarios about how the future could play out or a speculation… showing different views of different points in time to show how things evolve" when discussing options with clients. Given the temporal distance, Max adds that visualization can aid in the expression and understanding of what-ifs to clients: "…what we try to do is… visualize and try to really articulate and present to our clients… kind of worst case scenarios if you will. Not that they're worst case scenarios, but what ifs. Really sort of think about the what ifs." Here, we can see the range of what is possible in the future widened and uncertainty brought out through the presentation of different directions and options.

Wrapping these modes, however, is an acknowledgement that visualizations like diagrams, sketches, models, renderings, and so on, are in and of themselves modes of managing uncertainty. Each tool brings a unique technical and social application that constrains what can be known about the future and what information is brought bear. Diagrams reduce and abstract variables, drawings define design direction and possibility, models test and resolve unknowns, renderings provide a point of interpersonal agreement, to name just a few. In other words, each tool does work to not only manage, but also define and constrain future conditions for productive use. Productive use, very broadly speaking, is decision-making that allows the design process to move forward. As such, we can now see technical tools play a uniquely social role in the design process. They

scaffold social interaction, support understanding, and guide emotion and decision-making. This social life of visualization is a theme that will follow us into chapter five.

Conclusion

This chapter examined two primary research questions: 1) How are visualization tools perceived as affecting client decision-making by architects? and 2) What are the central tensions in using visualization tools to affect client decision-making? Drawing from seventeen semi-structured interviews with practicing architects, I aimed not only to answer these questions but to expand STS understanding of epistemology of the future by examining the role of visualization decision-making about the future.

Several core findings now light our way forward. Adding to the epistemology of the future, we can see clearly that persuasion, control, imagination, and expectations are core components of anticipatory knowledge and brought out explicitly as images of the future are rendered with increasingly fidelity. Each tool is shown to have a unique role in client decision-making that ties not just to information conveyed but emotion brought out and uncertainties resolved. We also see that visualization tools are social tools. They convey information, emotion, feeling, and vision to convince, build trust, argue, prove, establish expertise and credibility, and direct decision-making in ways deeply entwined with interpersonal interaction. Content leveraged is not neutral but positioned and reflective of both parties' (client and designer) norms and values. We also see that time and process are scripted (Akrich, 1992) just as much as content a means of walking a tricky line between inciting emotion, seen as necessary for clients envision and buy into tomorrow, without overpromising—or over rendering—futures that cannot be delivered

on. Managing expectations itself, then, might be seen as a means of hedging against uncertainty as much as scenario construction, testing, interpersonal agreement, and assumption making. As such, we now know that knowledge about the future is technically, socially, and emotionally managed to guide decision-making about the future and reduce uncertainty. Technical management refers to how each tool conveys or depicts information. Social management refers to the way in each tool guides the design process and is entwined with interpersonal interaction and relationship building. Emotional management refers to the creation or suppression of excitement, expectations, uncertainty, persuasion, and other emotions that help generate support and make sense of the future.

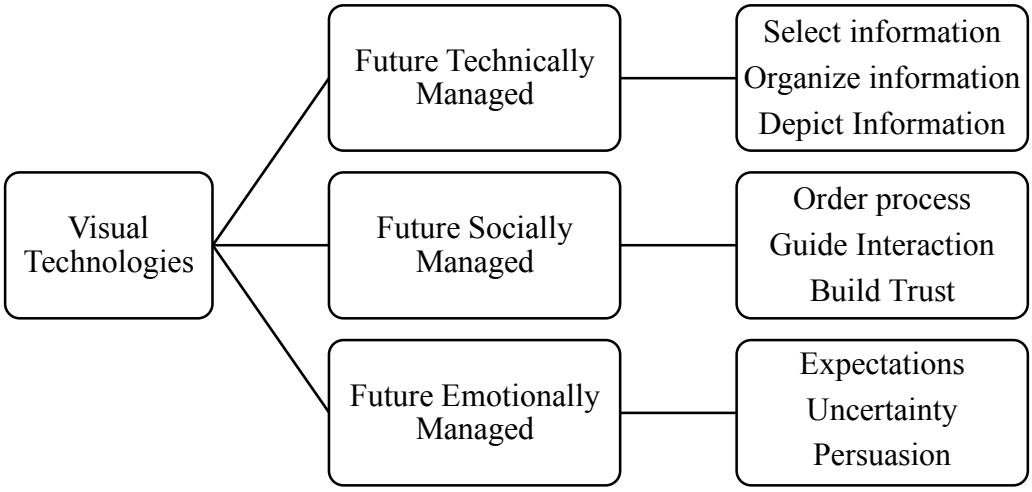

Figure 13. Knowledge Types Managed by Visualization Technologies

We now move into chapter six which explores how visualization tools affect client decision-making. Chapter four focused, in part, on the emotional and imaginative

knowledge types that visualization tools are reported to bring out. We will see in the following chapter with greater clarity that the knowledge types described by clients are not simply emotional and imaginative but also relational. In other words, visualization tools are also read to understand the social characteristics and traits of its maker and the future at hand.

CHAPTER 5

READING VISUAL TOOLS: ASU AT MESA CITY CENTER

Chapter five examines two research questions: 1) How are visualization tools perceived by clients as affecting decision-making? and 2) In what ways do clients interpret renderings? To answer these questions, I conducted a case study analysis of the ASU at Mesa City Center development project in Mesa, Arizona. ASU at Mesa City Center is an on-going urban development project aimed at revitalizing Mesa's downtown core and promoting economic development. The project is multifaceted and the case can be examined for a variety of issues relevant to city building including economic development, community engagement, and university-municipal partnerships. The goal of this dissertation, however, is to understand how the future is implicated in the present and the modes of anticipatory knowledge latent in visualization technologies. As such, this case study focuses on how visualization technologies are deployed by relevant design and planning professionals to communicate and affect decision-making about Mesa's future.

As mentioned throughout this dissertation, design and development professionals constitute the primary study population because they are future-focused professions charged with imagining and visualizing potential buildings and public spaces before they are physically built. They produce a large amount of knowledge about the future through images and other forms of visualization. Thus, I position architecture and urban development as practices of anticipatory knowledge-making. Practitioners are consistently engaged in world-making through the deployment of speculative

visualizations that describe how the future will look, which classes, genders, climates and races are included, and how daily life will differ once it arrives.

My case study analysis focuses on two unique moments. The first moment is the interviews of short-listed architectural firms for the ASU at Mesa City Center design contract. The second moment is the Retail, Arts, Innovation, Livability (RAIL) Mesa community presentation which featured a large-scale rendering of ASU at Mesa City Center. These moments are discussed in detail below. This chapter draws from participant observation, in-depth interviews, and the review of relevant documents. Respondents are identified using pseudonyms (Table 2). In moment one, focus is placed on how visual tools used by the interviewing firms are described as affecting decision-making of ASU and Mesa project stakeholders. Some attention is also paid to respondent's interpretation of renderings. In moment two, focus is placed on how the large-scale rendering of ASU at Mesa City Center featured in the RAIL presentation is interpreted by community members.

Findings in this chapter meet the second objective of this dissertation. This objective is to expand STS understanding of the epistemology of the future by examining how visualization tools foster different social meanings. To meet this objective I draw from STS, most prominently, interpretive flexibility and Human Computer Interaction (HCI). Findings and analysis are woven as a discussion throughout. As in the previous chapter, tools described below are analytically separated for conceptual clarity but are very much linked in practice (Ewenstein & Whyte, 2007). It is also important to note that while talk is a vital component of the design process and decision-making (Luck, 2007),

it is largely absent from the analysis below. Answering the questions posed required a strict focus on visualization technologies themselves.

This chapter is divided into three sections. The first section provides historical background on the ASU at Mesa City Center development project and introduces case study moment one in detail. The second section focuses on case study moment one. In this section I examine how respondents describe visualization tools as affecting their decision-making. The third section introduces and focuses on the second case study moment, the ASU at Mesa City Center rendering. In this section I discuss the social meaning and politics that respondents associate with the rendering. We now turn to section one.

Pseudonym	Affiliation	Gender
Dylan	ASU	Male
Chester	City of Mesa	Male
Omar	City of Mesa	Male
Eric	City of Mesa	Male
Willis	ASU	Male
Bret	ASU	Male
Noah	ASU	Male
Corbin	ASU	Male
Berney	ASU	Male
Ann	City of Mesa	Female
Bryce	ASU	Male
Rosa	ASU	Female
Kira	ASU	Female
Curtis	ASU	Male
Perry	Mesa Community	Male
Alissa	Mesa Community	Female
Fred	Mesa Community	Male
Katie	Mesa Community	Female
Jessica	Mesa Community	Female

Table. 2 Respondent Pseudonym, Affiliation, and Gender

ASU at Mesa City Center Background

In 2012, City of Mesa voters approved a $70 million Park Bond that funded the "first step in the design and development of a distinctive place which will capture and enhance the urbanizing momentum of Mesa's downtown core" (City of Mesa, 2019b). The bond provided funding for a signature building and public space that would serve as a community asset while providing an anchor for economic development, a priority in Mesa. Ann, a respondent from the City of Mesa, explains that under this charge, Park Bond funding was allocated to a "…design competition [and to creating] a final master

plan[ning] document… but [that] it was based on no particular building use. It [included] private-public partnership type things, retail, just what would be feasible to create around the city plaza area." Arizona State University (ASU) had not formally entered the picture. However, during this time, Ann continues, "…discussion started with ASU… [with regard to) ASU being the main anchor."

Dylan, a respondent from ASU, adds that early project meetings between ASU and the City of Mesa revolved around "…how we could create an ASU presence in the Mesa City Center." This, Dylan explains, was not an entirely new conversation. ASU and Mesa have an existing relationship around the Polytechnic Campus located near Phoenix-Mesa Gateway Airport. Dylan describes shared interest in creating a partnership resembling what had developed between ASU and the City of Phoenix to support economic development and higher education. The Phoenix partnership, he continues, was a collaboration where the City of Phoenix developed a plan and "went to the voters, to ask for bond money… They got approval for $230 million dollars of bond money to fund ASU buildings… Phoenix would construct [the buildings] with ASU's strong input, since we would operate the buildings for the life of the buildings… And so, the [current] concept was to try to do something somewhat similar in Mesa. Their goal was to get Mesa voters to approve a sales tax to fund several phases of development…"

Such efforts are not without politics and Dylan describes ASU's awareness of this while developing the partnership: "We were thinking about the political landscape… How do you get something approved by voters, [what about] the financial and business terms? What would we want academically here? What do we want physically here? … Where would we put buildings? And what does Mesa want in terms of that? And then, in

addition to the sort of academic and research, we [were] also, [and] Mesa was very interested in [the] entrepreneurship and innovation aspect of what we're doing. How does this help create business? Help entrepreneurs, help spur entrepreneurship, et cetera…" Curtis, a respondent from ASU, explains that significant work went into determining academic and research programs, which, in their first iteration, focused on performing and visual arts.

The project moved forward, and in March 2016, ASU and the City of Mesa entered into a memorandum of understanding to determine location, scale, and financing of the proposed development (Polletta, 2016b). In June 2016, ASU and Mesa reached an intergovernmental agreement (IGA) finalizing "campus plans, cost estimates and financing options, and the council [had] until the end of June to decide whether to put the project on the November ballot" (Polletta, 2016a). The building was funded through a proposed sales tax hike nested in a larger package that included funding for public safety with higher education. Dylan describes that the "… intergovernmental agreement anticipated the city [getting] the votes, getting approval from the voters in November for [the] sales tax increase. They decided to package it with public safety… [and] that was a point of contention for sure. I think they did that, precisely because public safety is probably more popular than funding universities." However, voters rejected the package.

Dylan recounts that, "…we thought, basically, we're done. And then, I don't remember at what point they said: "We don't wanna be done. We think we can do something at a little bit smaller scale. That in our opinion, the voters didn't reject the notion of ASU coming, they rejected the tax increase." Rosa, a respondent from ASU,

recalls a similar experience: “The mayor called Dr. Crow [President of ASU] and said, “Nope. This is still vital to the redevelopment of Mesa, and we need to have something.” And everybody knows, just by virtue of studies around the world, if you have a higher education anchor, many, many good things will happen. Development will happen. You know, you have innovation, you have economic development, you have education.” The project moved forward. Moving forward meant retooling the nature of the academic programs and physical development. Mesa wanted something “more-meaty”, explains Rosa. They wanted something that would pull and excite companies and spur invention, innovation, and economic development. ASU responded with a revamped digital technology program including media arts, gaming, film production, and an innovation studio (Faller, 2019).

Retooling also required Mesa to know the cost of the building and to generate a mechanism for financing it. In March 2018, Dylan describes signing a new IGA that “was skinned down, and was more aspirational… But, one of the things it says is, we're gonna work together to develop a master plan, design standards, and a budget for this.” Next steps included creating a secondary master plan, renderings, and floorplans from which to develop the budget for the plaza and building infrastructure. Ann explains that the “… [second] master plan… was based on… the continuing conversations of maybe a reduced presence but still having ASU here; still creating that plaza area for events and student gathering and that kind of thing. But that's why it was revisited and a separate master plan was created to represent the ASU presence there as the main anchor.”

In 2018, a 99-year lease agreement with ASU was approved by Mesa City Council (Altavena, 2018). Passing an intergovernmental agreement by city council vote,

the city's new plan did not include a tax increase but pulled funding from the enterprise fund which draws directly from utility revenue, sales tax, and permit fees (Altavena, 2018). The project budget was estimated at $63.5 million (City of Mesa, 2019b).

ASU at Mesa City Center Moving Forward

Support for the project rallies around calls for economic development. For example, "in his State of the City address, Mesa Mayor John Giles said the new economy needs technology jobs... 'I consistently hear the words 'augmented reality, artificial intelligence, 3D design,' … Mesa is very excited about what is now the reality of ASU coming to our downtown Innovation District" (Faller, 2019). Opposition argues that the agreement was 'squeezed through against voter will'. Curtis, a respondent from ASU, elaborates on oppositional issues: "Some [people] had issues with… why are we giving ASU money when ASU has a billion dollars? … They misunderstand the nature of a foundation endowment and what it can be used for. And it's broken up into billions of individual pieces, most of which are spoken for specifically." Others, Curtis continues, "… were like, why are we giving ASU this much money instead of giving it to public safety or any of the number of other things? Which is a political decision on behalf of the city. That was actually less the problem than they felt like the city council had gone around them, right?" Curtis also explains that "… people [may] have a lot of resentment because even then the city council had tried to bury the ASU piece underneath public safety. Like, they had sold everybody on... and none of the marketing mentioned ASU, it was always "public safety and fire and ASU", and I think that was a bad tactical move."

Politics aside, ASU at Mesa City Center is projected to open in 2021 with ASU acting as the "central pillar and investment partner in the innovation district" (Altavena, 2018). The building is a "five-story, approximately 118,000 square-foot academic building, located at the northwest corner of Pepper Street and Centennial Way, that will house programs offered by the Herberger Institute for Design and the Arts related to digital and sensory technology, experiential design, gaming, media arts, film production and entrepreneurial development and support" (City of Mesa, 2019b). Accommodating more than 750 students and faculty, the school will "utilize augmented reality, virtual reality and 3D modeling and visualization to develop technology with the potential to impact industries as diverse as health care, aerospace, manufacturing and entertainment" (City of Mesa, 2019b). The ground floor of the building will orient towards the public and contain community engaged programs such as an exhibition gallery, theater, and café. The upper levels are dedicated to classrooms, studios, production space, and a 3,000 square feet immersion studio for industry, academic, and community collaboration (City of Mesa, 2019b).[16]

In addition to the building, the development includes The Plaza at Mesa City Center, a two to three acre public space featuring an ice rink, community space, and water features (City of Mesa, 2019b). This is a mainstay of the development. Bernie, an ASU respondent, explains that ASU will pay for landscaping related to the building

[16] "In addition to the primary academic programs, a number of co-curricular programs are planned to amplify the student experience and connect the facility's programs to the larger innovation district. So far, those programs include Entrepreneurship + Innovation and FilmSpark. Along with the ASU building, the City is designing Mesa City Center as part of a burgeoning downtown innovation district. The first phase is made up of a 2-3 acre gathering space called The Plaza @ Mesa City Center and an adaptive reuse of Mesa's first library at the southwest corner of First Street and Centennial Way into The Studios @ Mesa City Center. The Studios will allow the collision of ideas between industry leaders, entrepreneurs, students and the public" (City of Mesa, 2018).

envelope. The Plaza at Mesa City Center will be paid for through the Parks and Recreation budget as well as through funding from a bond project that passed in 2018 (City of Mesa, 2018). Bernie continues that the "…bond is going to pay for the park, the street improvements, the connections between the new building and the council chambers, and also that IT building, they're doing some tenant improvements in there as well."

Case Study Relevance

The ASU at Mesa City Center project provides a compelling place to look at questions of visualization and decision-making because, throughout this still-unfolding case study, visualizations are primary tools used by designers, city officials, and other project stakeholders to convey the future of Mesa's urban core to the community at large. For example, as part of a 2012 funding package introduced earlier, Colwell Shelor (Landscape Architecture), West 8 (Urban Design and Landscape Architecture), and Weddle Gillmore (Architecture) were hired to develop a concept report for Mesa City Center that included public engagement and initial visualizations ranging from site plans to photorealistic renderings of the signature building and public space (City of Mesa, 2019c). Images contained information, ranging from technical to experiential, that conveyed an idea of what Mesa can and should be as a community and commercially viable place. A second visual set was published by The Arizona Republic Newspaper in 2016 as a 'first look' at developing degree programs. These visualizations and plans depicted ASU's presence in Mesa with rendered clarity (Polletta, 2016a). Once again, depictions ranging from photorealistic renderings to conceptual site plans convey the

Mesa community with a harmonious and community-oriented presence of ASU. Additional visuals are seen in the 2018 ASU Mesa City Center Master Plan created by a new design team which included, Orcutt Winslow (Architecture and Planning), Perlman (Architecture), and Trueform. (Landscape Architecture). The new plan focused largely on ASU's integration into and presence in Mesa (ASU and City of Mesa, 2018).

We explore this case study at two unique moments. The first follows the development of the 2018 master plan when ASU and the City of Mesa are undergoing procurement of an architectural firm to design the ASU building and community plaza. This moment is publicly identified on the City of Mesa's website as ASU at Mesa City Center / The Plaza at Mesa City Center Design Consultant Selection: Project No. CP0871ASU (City of Mesa, 2019a). Short-listed firms were based on a public Request for Qualifications and a selection process. The City of Mesa and ASU jointly conducted interviews with short-listed firms to determine who should be awarded the contract. Firm interviews provide a particularly compelling opportunity to answer the following research question—how are visualization tools perceived by clients as affecting their decision-making?—because they were highly visual presentations. Diagrams, drawings, renderings, plans, and in some cases virtual and augmented reality technologies were deployed by interviewing teams to communicate to and persuade panel members of the firm's fit for hire. Thus, observing the interview process and subsequently interviewing panel members about the efficacy and impact of visualization provides insight into how different tools influence decision-making. Clients here include ASU and City of Mesa professionals who were present or sat on the interviewing panel. Due to the sensitive nature of my participation, the data below is stripped of personal identifiers with regard

to panel members, interviewing teams, and specific presentation content and visualizations. Similar to chapter four, I begin with a discussion of visualization tools as they are perceived by respondents. I then turn to a discussion of their social meaning, with particular focus on questions of collaboration and creativity. We now turn to moment one, Architect Interviews.

Moment One: Architect Interviews and Visualization Tools

Diagrams (2D)

Respondents describe diagrams as affecting their decision-making by demonstrating a firm's technical and sociopolitical know-how that is vital to project success. On the technical side, respondents agree that diagrams indicate whether an interviewing team understands the project and its contextual factors. As Ann explains, diagrams allow us to see "…if that team grasped [all] the factors that [are] influencing [the project]." For ASU at Mesa City Center this meant, in part, that interviewing firms depicted a range of on and off-site factors such as traffic and pedestrian circulation, surrounding buildings, experience of and proximity to light rail, and weather conditions. Depicting contextual factors using diagrams, however, was not only about demonstrating knowledge of the site. For respondents, it also indicated a firm's problem-solving abilities because creating the diagram required thinking and discretion— firms selected, chose, arranged, and represented the contextual factors subjectively. This suggests that for respondents, diagrams are not only inventories, but a way to understand a firm's cognitive and problem-solving ability. As Bret, an ASU respondent, explains: diagrams demonstrate the skills "they'll need to have eventually to work on a problem… [I prefer]

to see something like [diagrams] 'cause it tells me that: "Hey, we don't know what the solution is. But we know what some of the problems we're gonna have to deal with [are].” Importantly, these skills are not only about the present moment but demonstrative of future ability. The design process will take place after the firm is hired. As such, diagrams show skills today that firms will use and need tomorrow.

The above example illustrates a recurring theme throughout this piece: visuals are read for more than their immediate content. They are read for social qualities, capabilities, or characteristics that help answer a decision-driving question of respondents: ‘who is going to be able to work with us?’ Social meaning is generated not only through content itself but how the tools are read by clients. We see another example of this in respondent descriptions of organizational charts. For respondents, charts are not only lists of faces and names. Rather, they convey sociopolitical factors relevant to the project such as firm dynamics and pathways of accountability. Ann and Chester, respondents from the City of Mesa, agree that organizational diagrams indicate key players and how and at what level decisions are made. And while that may be obvious, Ann describes reading into these diagrams and imagining implications for work-related processes such as accountability, communication, and point-of-contact. This suggests that charts are not only tools for understanding actors, but tools that help to reveal and align organizational politics between client and firm. Interestingly, they are also described as implicit contracts. Ann explains that design teams can reorganize after a contract is awarded. Organizational charts are a way of “try[ing] to hold [hired teams] accountable for [who they] presented [would be on the design team] since it’s what [their award was] based on.” The concept of ‘revealing’ is well documented by STS and HCI scholars

(Norman, 2002; Tufte, 1997) and often speaks to the politics of what is or is not shown by the designer. What is less covered, however, is the proclivity of the viewer, as we see above, to read into the visual social traits of its makers, perhaps beyond what the designer intends to show. This interpretive flexibility (Klein & Kleinman, 2002; Pinch & Bijker, 1985), or imaginative flexibility, plays a substantive role in client decision-making.

Drawings (2D)

In line with literature and chapter four findings, respondents describe drawings as demonstrating creativity and flexibility. As Chester explains, "[firms use drawings] to show you: "we're going to pull out our wax paper… [and] we're going to draw it one way" and then [they say]: "Oh you want it this way? Okay, then we're going to change this façade to this…" So, what they're showing you is [that they are] creative [and that they are] problem solvers." Willis, an ASU respondent, adds that drawings demonstrate creativity in the designer's skillset. Compelling drawings, he continues, indicate a team's ability to put information together in unconventional and creative ways while delivering on functionality. Building upon our understanding of diagrams above, this further suggests that visualizations are read for social and technical ability and characteristics. It also reveals that visualizations can be read for multiple meanings simultaneously. We see respondents inferring both creativity, problem-solving, and functionality. HCI has done productive work to investigate how images and other representations spur thinking, reasoning, and cognition (Kirsh, 2010; Rogers, 2012). Applying this work to the futures landscape, we might see that the type of congition and thinking refers to skills and characteristics perceived as useful for designing and building of tomorrow.

While respondents spent comparatively little time discussing interview drawings as opposed to diagrams, photographs, and renderings, several provide novel insight by stating that drawings demonstrate work ethic and power. This again echoes respondents inferring of social characteristics in technical tools. With regard to work ethic, Chester explains that drawings say: "I roll up my sleeves— elbow grease — I'm going to solve this." With regard to power, Bret adds that drawings say: "We're open. We like to keep it sketchy. We're willing to listen and we can put the input down quickly. We'll put it down quickly but we're not fixed on it yet. We're willing to change or willing to listen." Bret's note on power is particularly important given sensitivity across the respondents to imagined or anticipated issues of collaboration within the ASU at Mesa City Center project.

Futures scholars tell us that the future is full of hope, fear, desire, and excitement (Konrad et al., 2017) and we see here that future relationships are not immune. Respondents wanted to ensure that any firm hired would lead a design process that was open and collaborative for all parties involved—including ASU and Mesa community members—rather than closed-off and overtly expert-driven. Sketchy lower fidelity drawings, then, as Bret suggests, were one tool that respondents read as indicating a willingness to do so. Drawing from Norman (2002) we can see that this sense-making is not emotionless. Respondents were concerned over issues of power, and that concern was brought to bear in perceiving and evaluating the visual at hand. While collaboration is discussed later, we might move to see that tools carry social affordances (Norman, 2002). Drawing from HCI, visual tools contain clues that indicate to, or are read by their viewers, a containing certain social meaning.

Photographs (2D)

Unlike the preceding chapter, respondents emphasize the role that photographs play in decision-making, particularly when demonstrating firm experience, expertise, and understanding. Respondents describe two types of photographs: 1) photographs of projects completed by the interviewing firm; and 2) photographs of projects completed by other firms (precedent photographs). Each type of photograph is described as influencing decision-making in a unique way and revealing particular abilities of the team.

The first type of photograph—photographs of projects completed by the interviewing firm—are described as compelling in three ways. First, they demonstrate depth of experience and ability. As Willis states and Omar, a City of Mesa respondent, echoes, they reveal technical and aesthetic capacity, showing "… not only can [the firm] meet the technical demands of what you're asking for, but [they] can put it inside of this wrapper that is amazing." Second, Bret and Omar explain that photographs are evidence of ability. They show that you have finished a project successfully in the past and imply that you are able to do it again. In line with STS scholars, this reaffirms that photographs are evidentiary and trust building tools (Galison, 2014; Latour, 1986). In line with this thinking, photographs might be conceptualized as data points. Like past weather or population data, individual photographs of past projects aggregate to project future work ability (Isserman, 1984). Thirdly, photographs indicate understanding of project direction and alignment with client vision. Eric, a City of Mesa respondent, explains that photographs[17] of aligned projects such as technology centers or educational campus show

[17] Eric speaks about both precedent and firm images here.

that a firm has "…read through what we put in our materials; [that] they have their understanding of what ASU is trying to accomplish with the building… and that they understand… how [the building] should be programmed." Chester and Corbin, an ASU respondent, add that 'aligned' photographs provide a working model of what we're trying to achieve in the future; they are exemplars of what our future might look like.

Chester's comment reaffirms that photographs can act as promissory artifacts (Konrad et al., 2017). They are full of information of what has been done and are leveraged to communicate what can be done in the future. Drawing from HCI, we can see photographs doing work by informing and molding a client's mental model of the future. Mental models are internal representations that people hold of the world around them and the future before them. They are central to everyday decision-making because they guide action, reasoning, anticipation, emotion, and more (Norman, 2002; Selin, 2007; Zhicheng Liu & Stasko, 2010). As we see above, photographs inform mental models by communicating the range of what is possible at the future site. They provide examples from which individuals can build their ideas, wants, and desires for the future development. Importantly, however, photographs, like all other visualization tools, are inherently political. Designers have a real hand in selecting, editing, and choosing what photographic possibilities to present.

Precedent photographs, a second type of photograph, are described as affecting decision-making in two ways. First, they incite imagination and expand the possibility of what the future building or plaza may become. Bret explains that some of the most affective photographs were of example parks that Mesa could learn from. Providing 'options' in this way, Bret continues, indicated a firm's investment in the project. It

showed that the firm had engaged the creative challenge and was doing research to expand what was possible. Eric and Chester echo this sentiment. Eric explains that precedent images "…tell me that they've thought about it—that they put their time into doing their background research and [that] they started looking at other best practices." Second, precedent photographs demonstrate 'big ideas'. As Chester explains, "…[firms] show the Empire State Building, the Eiffel Tower, whatever else out there—these big grand places—[the] Taj Mahal…things that you would never get. But then [they show] how you can look at [them]… what makes them iconic, what makes them special, and [they] show how that can be brought from that [big] level to my level so that it can be part of the project." These 'big ideas' and options simultaneously feed imagination and ground it in the future site. They are visual narratives about possibility that, Omar adds, might be places "I would want to take my family to and be a part of…"

Respondent comments suggest that precedent images do work by indicating a range of future possibilities in line with "what [stakeholders] already think [their] future is" (Chester) or want their future to be. As Eric continues, they can compel decision-making by demonstrating an "understanding of where Mesa believes it's going and what we're trying to accomplish with our investment in ASU." Mirroring sentiments in chapter four, we might see that photographs also do work by reducing uncertainty. They align and generate a vision and understanding among the parties about what future will take shape.

Renderings (2D)

Corbin states that: "I, like all people, find visuals of really exciting spaces—whether renderings or photographs of built spaces—to be incredibly compelling." Willis adds that as visual people we "are fascinated and captivated by [renderings]. It's almost like an emotional buy, really." Eric describes the affect that renderings can have: "I'm always drawn to the ones that are just beautiful and make you inspired… renderings are to the point where they're so photorealistic… you can actually imagine the building being there." Drawing from HCI, this aspect of 'being there' is a cognitive affordance (Norman, 2002) —a visual characteristic that, as Bernie explains, enables the tool to depict and translate ideas about what the future can and should be in a compelling way[18].

Respondents describe two ways that renderings influence their decision-making. The first, expanding on chapter four, is their ability to reveal a designer's vision and its alignment with the client and project values. As Ann explains, "I think the renderings are important 'cause [they] help us understand where they're starting to head in their vision of what they're gonna implement… I think it's important that they show it, and if they're completely missing the vision of what was put into the master planning documents … it's an important time to see that." Achieving 'the vision' is in part factual depiction—showing components of the site such as a building, a plaza, roads, etc.—and, in part, about how those roads, builds, and plazas are displayed and what that display reveals

[18] Respondents are not blind to aspects of sales, expectations, or risk. As Willis explains, "renderings have a great marketing ability…Because they sort of close the sale… we're visual animals. We like to grasp those things that are a lot more legible than having to read through a paragraph describing what this beautiful building does. And you're able to see it in your mind. [It] engages with all the senses… So, renderings are very effective, sort of, for initial sales." Bernie agrees, adding that being able to take depictions of what the future site is "… really going to look like, to me it's powerful and it's a good selling point for not only this project, [but for] every project for when you go to get funding."

about the firm's understanding of project values. Willis, for example, looked for firms that visually conveyed ASU's educational mission in one form or another. This meant, for example, depicting the building as a flexible space that meets student and technological need over time, rather than an iconic structure. Eric looked for visual indications of budget management, building longevity, and maintenance. He was compelled by depictions showing "…high quality architecture and design while still having a very basic construction type or more efficient construction type to keep the costs down… Renderings that reflect their ability to design something simple but timeless…" Ann looked for indications of feasibility as shown by the configuration or depiction of the plaza's ice rink and splash pad and flexible classrooms for incoming students.

Importantly, respondents explain that they can pick up on value and feasibility clues. In other words, they describe being able to read into, or see behind the image, to understand and imagine the implications of the future presented. In reading into the images, however, respondents don't just see project values and implications but personal ones as well. They infer from the depiction how the proposed future will personally affect them. HCI likely attributes this phenomenon to the interaction between internal and external models (Kirsh, 2010; Rogers, 2012; Scaife & Rogers, 1996), and perhaps a cognitive affordance (Gaver, 1991; Hartson, 2003; Norman, 2002) where elements of representation facilitate knowing, meaning, and consequence. Expanding upon this, however, we see imagination and inference are a core piece of cognition spurred. Viewers see the depiction and imagine and extrapolate personal implications. As Eric explains, "[you] pick up on some [clues] … from some of the renderings that they did… How am I going to change that light that's 100 feet in the air? How am I going to clean

this window that's behind a piece of metal, like we've got on a few of our buildings now?" For City of Mesa and ASU respondents, personal impact was a question of management, construction, and maintenance among others. For City of Mesa residents, who we will turn to in moment two, it was a question of community.

The second way renderings are described as influencing decision-making is by demonstrating horsepower of the firm and imaginative ability. Noah, an ASU respondent, explains that horsepower refers to whether the firm has "enough people to do the drawings and to respond quickly to changes, and just get the product done." It is a question of capacity and ability. Horsepower was a concern for the ASU at Mesa City Center project given its size and complexity. Respondents wanted any contracted team to be able to handle the size and scale of the project. In line with the social communication of technical tools, renderings and other high-tech tools[19] served for some as a proxy or indicator of this ability. Bret explains that high-tech tools, including virtual reality and digital models, can generate a perception that the firm has resources, technical ability, and human capital. Such logics of technology and power are well-covered in STS (Galison, 2014; Marx, 1987) and here we see it extended into questions of design and decision-making.

[19] Respondents spent little time discussing technical visualizations, such as Building Information Modeling (BIM). However, they agree that the technology demonstrates technical ability. As Bernie explains, it shows "…constructability and [if it is] actually possible to do what you want to do here…" Part of the importance of technical tools (e.g. BIM), according to Eric and Corbin, is demonstrating whether a team can produce high-quality construction documents. Omar remarks that this skillset is particularly important for the ASU at Mesa City Center project. Imaginative and conceptual capability must be matched by technical competency due to "…the software and hardware and aspects of technology" that drives the program. Interestingly, Omar also adds that showing technical drawings indicates a technological fluency and process and cost efficiency that is compelling, although not a stand-alone decision point.

Imaginative ability refers to a firm's ability to see beyond the immediate planning documents—to envision and create something better presently imagined. As Chester explains and Omar and Corbin echo, in renderings, firms try "…to show us [that] they have a fresh set of eyes—they can do it, they've looked at it. They've spent time— they've spent time with the building, they've spent time with the programming to understand it, and this is what they could come up with [that they think is better]." Bernie explains that successful renderings showed what the space could be in a number of different ways. They took data from the master planning documents and broke it up into different configurations, which demonstrated flexibility and creativity, two important elements given panel concern over issues of collaboration. Corbin adds that "general subtext at every team's presentation was: "We have the skills, knowledge and expertise to accomplish this project" … Their goal, all of [the teams], was to make us understand that they understand [the project]. Then, the next step is, of course, [to] make us really excited about what could be." Demonstrating 'what could be' was central in creating excitement and buy-in about the future development. It was also important, respondents explain, for generating excitement about working with that particular firm and about the working relationship itself. This suggests two elements of hype (Borup et al., 2006; Selin, 2008) at play during the interviews: hype about the physical built environment and hype around the social relationship and process of making it.

Virtual and Augmented Reality / Models / and Video (3D and Animation)

Respondents describe 3D, animated, and other video-based visualizations similarly. Physical models were not mentioned, likely because physical models were not

brought to the interviews. Like renderings, respondents describe virtual and animated environments as attention-getting. As Chester explains. "… anything visual, fly over, moving, you've got my attention." Noah adds: "I rivet myself to videos more than I do to pictures...Videos capture attention in a different way." The power of these tools, Bret explains, is their ability to simulate what the building will look like: "you can't deny the power of: "That's what the building's gonna look like" as far as leaving an impression, you can't erase that." Bernie adds that "being able to see it built before it's built, or see it while it's being designed, in my opinion is just the coolest thing." Chester continues that seeing final conditions as if they are fully realized (e.g. the immaterial real from Adam, 2010; Selin, 2008) generates a more robust understanding of the future conditions.

While respondents explain the benefits of these interactive and attention-getting tools, others speak to their drawbacks. Chester explains that they can distract from core issues at hand. He continues: "[some] people tend to overemphasize the technology sometimes and we've got all these tools and techniques… Yeah, we know everybody's got all this AR and VR, whatever. Great. Let's get to the meat here." Getting to the meat meant different things to different respondents. Some were more concerned with substance and programming while others were more concerned with feasibility, highlighting again the presence of interpretive flexibility (Klein & Kleinman, 2002; Pinch & Bijker, 1985). Respondents largely agreed, however, that part of the meat is "read[ing] into who's going to be able to work with us" (Ann).

Getting to the Meat

Answering "who's going to be able to work with us" is a combination of interpersonal dynamics and firm characteristics inferred from the visualization tools (Figure 14). Determining fit was important to respondents because the project would be complicated, collaborative, involve community-engagement, and guided by an educational mission that prioritized access, among other things. Respondents wanted a firm with aligning values, one that would uphold priorities, and one that would see ASU and the City of Mesa as partners. As such, respondents describe looking for 'chemistries'.

Tool	**Example Inference**
Diagrams	Problem-Solving Ability Critical Thinking
Sketches	Work Ethic Flexibility Creativity
Photographs	Due Diligence and Research Ability and Capability Project and Vision Understanding
Renderings	Imaginative Ability Value Alignment Feasibility
AR/ Animations/ High Fidelity Models	Resources Horsepower Technical Prowess

Figure 14. Example Inferences from Visualization Tools

As Willis explains, "[I was] looking for the interpersonal relationship. Are you gonna be able to work for me? Am I gonna be able to work with you? Or are we gonna struggle?" Eric considers: "Is this the group that would be the best fit to work with us, [the] city, ASU—to work with me personally? Does this person seem like they're organized? Do they seem like they're a good communicator?" Interpersonal dynamics were revealed in how teams presented themselves. Participation—or, more specifically, who was brought to the interview—mattered as well. ASU at Mesa City Center includes building and park/plaza components, and different respondents had different interest in and responsibility to each component. Showing up to the interview without members who could speak to all components was nearsighted for some. Persona played a role as well. Chester explains viewing one presentation and "subconscious[ly], [seeing] how [he/she] is going to run the project. [He/she is] going to lead it, [He/she is] going to run it, [He/she is] not the expert on everything but [he/she] will pull in the expert at that time. And as an owner, you love that because we don't like it when I have to talk to eight people." Respondent comments suggest that body language, dynamics, and persona were read as clues about how work and communication would unfold throughout the design process. Visualization tools also served as cues about how work and communication would unfold. Emphasizing the social work that technical tools do, respondents look for cues about creativity, feasibility, and collaboration in the depictions and devices themselves.

Creativity vs. Feasibility

Respondents described looking for firms that show creativity and vision without compromising feasibility. As Corbin explains, "…the teams that were most successful

took the master plan and did stuff to show us that there were different ways of looking at the building's program. [For example:] “you had this stuff distributed here, but what if we moved it here?” Compelling teams provided a novel and unique look; bringing the right amount of new information and ideas to the table and visualizing them. This generated excitement not only about the future of the development project but the future client-architect relationship and design process.

Showing the ‘right’ amount of creativity meant neither showing too little nor showing something without demonstrating feasibility. Too little creativity, Corbin continues, was perceived when photographs weren’t thematically relevant or when information taken from the master plan and request for qualifications (RFQ) was rearranged rather than improved upon. Lack of feasibility was felt when teams did not “bring [their] vision down to reality… [when they didn’t demonstrate] here's how we bring it downtown and stick it on your road [and] on your street.” As Omar explains, “if you can talk about this great [element over] here but you can't show me how it's gonna come together [then] it hasn't done any good.” Omar continues that his job is to deliver something usable and functional. “I have to know”, Omar continues, “can they do their job so that I can do mine?” Omar’s question hints at the personal nature of futures, a theme that we will encounter again in moment two.

Showing the right amount of creativity and feasibility was not the domain of one particular visualization technology. Rather, as we saw throughout the discussion above, information inferred was spread across devices with each device described as playing a unique role. Bernie, for example, explains a diagram where an existing space was “actually moved to the middle of the building. [They] showed how it could be—it could

be a teaching space, it could be a film studio, it could be a VR space… I [could] see how this space is now flexible…It [was] really cool to see the ideas and what a space could be." Chester describes plans that were tweaked to improve and enhance the City Center site. Omar describes expanded project scopes where teams included surrounding blocks and the downtown while remaining attuned to political preference and vision. For Omar, there was a middle ground between creativity and demonstrating your ability to create something that meets all the practical and technical requirements. Balance, Omar suggests, was using the visual tools to show that you are component in both. Respondent comments reaffirm the presence of interpretive flexibility in how tools are perceived. They also suggest that while tools foster meaning individually, they also do work collectively. They were read, at least in this case study, as a whole—as part of a larger interview process aimed at understanding who would be the best fit. Tools and the interviews themselves served a higher purpose of reducing social uncertainty.

Collaboration

Respondent decision-making was influenced by whether teams were perceived as collaborative. As Corbin explains, with some firms, "you could tell the process wasn't gonna be as open and collaborative as it would be with the other teams." Willis continues: "I'm trying to decide first are you willing to work with us and learn? Or not? Some of them are actually adamant about holding their idea and we dispense them." Those who hold too tightly onto their ideas, Corbin explains, suggest a "…level of hubris and a level of: "We've already thought all this through, and we don't even need you in this process. You guys can go away, we'll give you a building that you want."

Willingness to collaborate was perceived, in part, visually. For example, Ann explains that going "off on a completely different tangent" from the master planning documents suggests that the team may not listen well to direction and that they may not incorporate opinions and hear everybody's feedback. Bret adds that the "least compelling show: This is where we're gonna put this, and this is where we're gonna put this, and this … Anything that says: hey, we've already solved the problem. That says you're full of BS, and you're not the right one for us." It's too early to suggest certainty of this kind, Bret continues. It's not possible to know where elements go when the communities have not been engaged.

Given concern over power and participation, panel members read visuals for indications of collaboration. Willis describes being compelled by teams that conveyed general ideas without giving the sense that the community and client had no part in decision-making. Corbin explains collaboration as a sweet spot. It was a middle-ground where, similar to the section above, fresh perspective was visualized without making it appear finalized —as though clients and community were unnecessary in the project. Successful teams did renderings and sketches at a lower fidelity—as blocks and massing in different configurations. They demonstrated possibility and potential without "make[ing] us feel like it was a fete accompli, that they had gone down the road so far that they weren't willing to listen to our ideas." According to Corbin, hitting that sweet spot was a combination of illustrating effort, diligence, and a new vision that was surprising but not so developed "that it feels like there's no place for you in it anymore." It was working creatively within the framework given, according to Eric, and visually accounting for the values underpinning the clients' vision of the future—one in which

"ego and the presence of the individual maker is de-emphasized in favor of collaborative, consultative, engaged work."

Up to now, we have looked at how visualization tools have affected the decision-making of ASU and City of Mesa stakeholders. We found that these respondents, the clients, look not only at content but what they believe that content says about the firm itself—their problem-solving ability, power dynamics, imaginative ability, horsepower, and more. We have also found that clients look for, or read, project values in visual depictions and consider how the proposed future will affect them personally. Whether it's about collaborative ability or 'being able to do your job so that I can do mine', respondents anticipate how the future will affect them, perhaps as a means of creating certainty. This sentiment holds true for City of Mesa community members. We now turn to moment two to further explore this.

Moment Two: RAIL Presentation and the ASU at Mesa City Center Rendering

Moment two focuses on a large-scale, realistic rendering shown in a community outreach presentation developed by the University City Exchange office and deployed at a Retail, Arts, Innovation, Livability (RAIL) meeting on September 26th, 2018. RAIL is a Mesa organization with a mission to create "a stronger, healthier, more resilient community and economy with access to quality jobs, transit, housing, and world-class education for all" (RAIL, 2019). The presentation, Dylan explains, was designed to tell a bigger story about "…why the university is interested in Mesa, and how we can be part of Mesa's story…" He continues that the presentation spoke to ASU's planned role in Mesa, city partnerships, current events and community engagement, research programs,

entrepreneurship and innovation, and more. A central idea, he continues, was to show what communities and families would get out of the development: “It's not just ASU's coming to Mesa, ASU is becoming an integral part of Mesa.”

Our analytical focus, a large-scale rendering, is slide fourteen of the twenty-three slide presentation. Like firm interviews above, the presentation contained a range of images, from diagrams to photorealistic renderings, each of which was designed to help communicate ASU’s presence and support and sway decision-making. I had the privilege of attending the meeting and, with permission from ASU leadership, interviewing consenting community members using the presentation to answer the following research question: In what ways do clients interpret renderings? Here, clients refer to City of Mesa community members. I focus solely on the rendering rather than the entire presentation because the rendering received the most conversation from all respondents, both through my prompting and their own volition. While respondents did speak to other slides, there was not consistent commenting among the five respondents to derive meaningful patterns. Thus, the data was outside of my scope. I begin with a discussion of the rendering from the perspective of project leadership and then move to discuss its interpretation from the vantage point of five City of Mesa community members.

The ASU at Mesa City Center Rendering

The RAIL presentation was an image-centric, twenty-three slide PowerPoint which contained a wide array of images, including photographs, diagrams, site plans, renderings, and text. According to Curtis, it was designed to drive three core points home: 1) community collaboration around building programs and physical features that

will be useful to community members and their families; 2) incentivizing technology development, getting people excited about innovative media, “and mak[ing] sure that they know it isn't just a bunch of kids playing video games and making zombie films”; and 3) Mesa is part of a larger ASU network that extends across the world. He continues that “all the images in the thing [the presentation] align with one of those points, either showing an array of all the things we've already done and people we're already working with in terms of establishing our credentials and working with community.”

The rendering (Figure 16) is slide fourteen of the presentation. Figure 15 is a google image of the design site as it is currently in June 2019. Curtis explains that the intention with the rendering, “as with any concept art, is to provoke excitement about the building.” Curtis continues that the rendering provokes in two ways. The first being that it is architecturally interesting and the second being that it references “significant public amenities, the park and also the idea of outdoor screening, it's using an LED screen.” In other words, the rendering is meant to speak to the Mesa community and demonstrate how ASU integrates into the site and community. Importantly, however, Curtis states that the current rendering is not intended to be the final direction of the architecture. But without a depiction—“if we just showed up with building blocks and say that it's going to cost this much money… nobody gets excited about it and buys into it.”

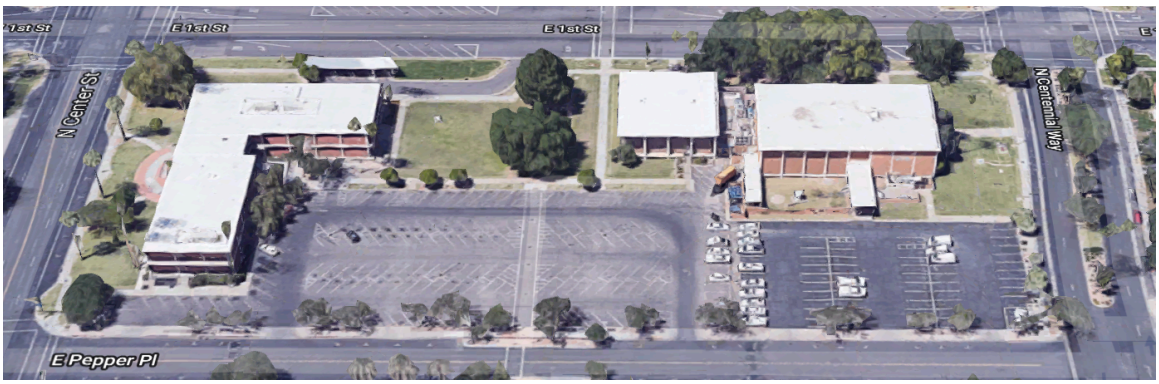

Figure 15. ASU at Mesa City Center Design Site as of June 2014, Google Image

Figure 16. ASU at Mesa City Center Rendering, RAIL Presentation

Respondents describe both risk and benefit associated with the rendering. In terms of risks, Curtis explains that "the risks are, we sell this image of concept art and then we go through an entirely different design schematic phase when we present them with something completely different [and if budget or construction is not feasible and we have

to sacrifice any part of the public amenity or iconic imagery] … then we've sold a bill of goods that we then didn't deliver." Other respondents state concerns that the depiction may give an impression that more is known about what will happen than is actually known. The screen, for example, may not happen. Its disappearance is potentially problematic if the image is aligned with or engrained in the public vision of the future. In other words, the rendering implies certainty to a public that may or may not understand that it is not certain.

In terms of benefits, respondents explain that the rendering enables a degree of understanding, excitement, and buy-in that is not matched by drawings and photographs. As Curtis explains, "the more realistic you can make something… [then] understanding…becomes a little bit [clearer]." Kira, an ASU respondent, adds that while excitement and buy-in may be a consequence of the depiction, it is important to remember that enabling understanding among community members and generating the same understanding is not the same thing. Community reaction might vary from "Oh no. I don't want a building that big [to] Oh, where'd all the parking go? [to] How do I get there?" Kira's comment returns us to the concept of interpretive flexibility (Klein & Kleinman, 2002; Pinch & Bijker, 1985), which highlights that while understanding may be achieved, what is understood, and in our case seen, differs among individuals. Interpretation is personal for Mesa community members. And as we saw in the preceding section, it is related to how the project is imagined as or anticipated as affecting them. We turn to this below.

Citizen Views of the ASU at Mesa City Center Rendering

Katie, a City of Mesa community member, describes feelings of community, including warmth and connection, when looking at the rendering. Alissa, a City of Mesa community member, "loved seeing" it and what it says about Mesa as a place for interaction between the community and ASU. Jessica, a City of Mesa community member, describes liking the depiction and being compelled because it "puts people at the campus, it puts people doing things at the campus, [it shows] liveliness... I also like the fact that you can see the people off here in the distance walking, living, doing things." Jessica continues that while her impact is limited because she is not a film student[20], it remains relevant to her because there will be more community events, more money coming into the local economy, and more opportunity for artists, her kids, and for her kids to sell their art. For Katie and others, it is a future that "I look forward to living in."

The prospective nature of Katie's comment provides an apt bridge to an important component of respondent interpretation. This is that respondents do not only read the image for what it contains, such as people walking and doing things. They read it for what they want their future to be or for how they would like the proposed development to affect them and their community. Katie, for example, speaks to potential community cohesion when she sees the rendering. She thinks beyond the image's borders and describes Mesa's ethnic stratification and her hope that ASU will be an "uplifting thing for the area... I'd like to think for … kids who don't have books in their home, if they go

[20] "How do you tie the relevance to me so that I care about you and your project for all those film students? And the answer is that I understand where it is, that I feel like it will benefit the community in how many ways, and that it will tie to the other things you're saying are going to support it" (Jessica).

to see something there, that it'll spark a dream of what they can do, or a better future for themselves. That without this they would not be able to visualize or imagine."

Alissa and Fred, City of Mesa community members, speak to the formulation of a new identity for Mesa that relates to larger sociopolitical aspirations. Alissa wants "[Mesa] to be more of a 21st century city." She explains that the rendering illustrates elements of a 21st century Mesa while remaining engaged with the community—it shows the community growing in tandem with economic growth. Fred agrees: "I want [Mesa] to be a forward-looking community and I think this rendering says that…Mesa is the third largest city in Arizona, yet we treat it as...We don't even think if it being that big…We need to act as such. We need to be more forward-looking and advanced and futuristic." Futures scholars such as Konrad et al. (2017) tell us that the future is a place where we lay our hopes, desires, fears, and dreams. We hear this echoed quite clearly in the comments above where respondents see in the rendering a vision for the city and community as a whole. This suggest that the rendering is not only laden with but read for social meaning.

While some respondents cast a forward-focused vision onto the rendering, others recall their experience of the past—they recall history. Perry, a City of Mesa community member, brings this vantage point into focus. Recounting the origins of the project in 2012, he questions why previous designs that incorporated community input are not present: "We selected a landscape architecture firm [in 2012]. Why aren't they involved in this? Give me a reason why they're not [here]…this doesn't look anything like the work that was done before…What happened to that community input?" Perry's comment suggests that the rendering is not just a depiction of what will be, but for some, a

depiction of what has happened already. Perry's viewpoint expands STS understanding of the epistemology of the future by suggesting that in addition to placing our hopes, dreams, and desires in the future, we also place our past. This means that interpretation, like knowledge, is not only personally situated but temporally situated as well (Haraway 1988).

Perry discusses the rendering with a range of questions that highlight social and political context: "All the people sitting out there staring at the side of a building—why are these people here? What's going on here that encourages these people to go here? Plus, these are all old white people…It doesn't make any sense" He continues that the trees are not trees that they have in their downtown and wonders where the students are in the image and where the people who look like they live nearby are. For Perry, the image makes the decision for you about what the future will be: "The future is what you make of it, so I mean, if that is what they plan on doing…" He continues that the building looks expensive, and questions if it is "promising more than we're going to get."

Perry's comment highlights a reality of expectations at play. Expectations have been a central theme throughout this work. We encounter expectations in our review of STS literature, in chapter four, and in the preceding section when respondents describe concerns about suggesting that more is known than actually is. Here, we see expectations take shape in community perception. Jessica, for example, explains that the rendering sets real expectations for her about the future, particularly about what the building and park will look like and how social life will unfold once they are built. As Jessica states: "I have the expectation of reality, but until you actually see architectural designs do you know that it's going to look like that? So, my expectation, [is that what] they're

representing [is] what I'm going to see in three years when it's built. I'm going to see them doing community events, I'm going to see them have this structure that looks like that, and I'm going to see that they're going to bring in mature trees that look 12 years old and plant them." Expectation of social activity is particularly interesting here. Designers can plan for and render activity. In reality, however, they have little control over what social activity and events unfold. A social event, for example, requires organizers, attendance, and publicity, among other things, all of which a designer does not typically control. The designer simply lays out the space for that activity to occur. Depicting social activity, then, suggests certainty about or control over something that they have a lesser role in realizing. This tension returns us to chapter four, where truth in rendering is a question of balance between depicting what is literal and capturing the conditions of the site and what is emotional or aspirational and helps convey a sense of being there.

Rendered suggestions of certainty do not go unnoticed by Fred. He knows that uncertainties still loom for ASU at Mesa City Center. He explains that "if you were to show me a photograph of a building…show me a drawing in pencil and sketches that are not realistic— I'm gonna be still figuring out what are you trying to do. You don't have your mind set. When I see something is more realistic and complete, then I say, Okay, yeah, we're in line." He explains that if the final outcome is close, he will be pleased. However, if "we end up with something that is not even close to it…it will be like: "Oh, man" … [if] we get people excited about it and then we turn around, knowing that this is gonna be so expensive that we're just gonna go with a standard building, then I would say that was a big lie." The result, Fred suggests, is a loss of trust and credibility among the public.

Latour (1986) would likely call the rendering featured above an immutable mobile. It is a powerful and persuasive depiction circulated to convince others to take up its message. Fred's comment, however, points to an underbelly of our rendered mobile: while future depictions may successfully persuade and enable buy-in today, they exist in the imagination and are part of a larger process that extends into the future. A lack of follow through, like the one Fred suggests, will be interpreted just as the rendering itself. As such, we might move to see that interpretation is not bound to the material rendering itself but also attached to the processes and timelines that the rendering is part of, all of which are interpreted in service of understanding and making meaning about the future development.

Conclusion

Chapter five examines two research questions: 1) How do visualization tools affect client decision-making? and 2) In what ways do clients interpret renderings? We walk away from this chapter now with two primary understandings: First, visual tools are read for more than content. They are read for social dynamics and the capacities of their maker. Decision-making is not simply a question of technical knowledge conveyed through the visual tool but social and emotional knowledge inferred from it (Figure 17). This knowledge is invisible, subjective, and interpretive, but nevertheless important in constituting how we come to know and make decisions about future conditions.

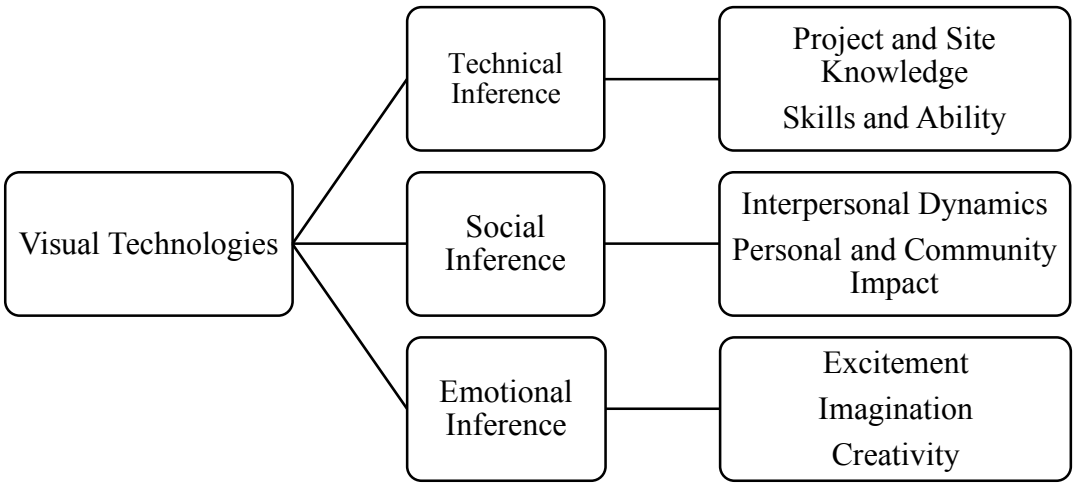

Figure 17. Knowledge Types Inferred from Visualization Technologies

We saw that diagrams inferred problem-solving ability, drawings were read as revealing creativity and flexibility, photographs suggested expertise, renderings indicated imaginative ability, and more. Visualization tools, then, foster different social meaning by virtue of how they are used and perceived. Second, images are read with regard to how the content depicted—in our case the future—will affect the viewer personally and professionally. Interpretation is always socially and temporally positioned. This underscores the importance and politics of expectation setting, the emotion and vision inherent in renderings, and reveals that interpretation is not bound to the artifact in front of you. The social process, just as much as the visual tool and depiction, is up for interpretation. With this in mind, we now turn to the conclusion of this dissertation for a larger discussion of visualization and its implications for decision-making about the future.

CHAPTER 6

CONCLUSION

Images are ubiquitous in communicating complex information about the future. From political messages to extreme weather warnings, they generate understanding, incite action, and inform expectations with real impact today. The future has come into sharp focus in recent years. Issues like climate change, gene editing, and smart cities are pushing policy makers, scientists, innovators, and designers to rethink how society plans and prepares for tomorrow. While academic and practice communities have increasingly turned their gaze toward the future, little attention is paid to how it is depicted and even less to the role visualization technologies play in depicting it. Visualization technologies are those that transform non-visual information into 2D or 3D imagery and generate depictions of certain phenomena, real or perceived. This research helped to fill this gap by examining the role visualization technologies play in how individuals know and make decisions about the future.

This study drew from three phases of research set in the context of urban development, where images of the future are generated by architects and circulated by built environment professionals to affect client and public decision-making. I began with a systematic review of professional design literature to identify norms related to visualization. I then conducted a series of in-depth interviews with expert architects to draw out how visualization technologies are used to influence client decision-making. I dove into how different tools manage the future and generate different forms of certainty, uncertainty, persuasion, and expectations. Complementing the review and interviews was a case study on ASU at Mesa City Center, a development project aimed at revitalizing

downtown Mesa, Arizona. Analysis highlighted how project-specific visual tools affect decision-making and the role that client imagination and inference played in understanding and preference. This research unpacked the social, technical, and emotional knowledge embedded in visualization technologies and revealed how they affected decision-making. Information about the future was uniquely mediated by each technology with decision-making bound up in larger social and political processes aimed at reducing uncertainty, building trust, and managing expectations. This demonstrated that the visual tools we use to depict the future are much more dynamic and influential than they are given credit for.

Findings and Implications

This study was set in the context of urban development where images of the future are deployed to garner attention, obtain buy-in, and direct decision-making. Chapter four examines how visualization tools affect client decision-making and with what central tensions. Analysis in this chapter meets the first objective of this dissertation: to expand STS understanding of the epistemology of the future by examining how visualization tools are deployed in professional practice. Analysis reveals that knowledge about the future is technically, socially, and emotionally managed to guide decision-making and reduce uncertainty. Technical management refers to the ways in which tools convey or depict information. Social management refers to the way tools guide the design process and are entwined with interpersonal interaction and relationship building. Emotional management refers to the creation or suppression of excitement as well as expectations, uncertainty, and persuasion that underpin decision-making and

preference. From a technical vantage point, for example, diagrams reduce and abstract variables to enable early logic and understanding while whittling down ‘what-ifs’. From an emotional vantage point, renderings and virtual reality communicate feeling, potential, excitement, buy-in, and persuasion. Socially speaking, every tool mediates information about what is possible, scaffolds interaction, directs attention, and facilitates understanding.

These findings expand STS understanding of the epistemology of the future (Konrad et al., 2017; Selin, 2008; Selkirk et al., 2018) by revealing the substantive role that social and emotional knowledge play in how we know and make decisions about tomorrow. Previous STS studies focus more exclusively on technical knowledge like prediction, projection, and modeling (Isserman, 1984; Pirtle et al., 2010; Selin, 2006). These more dominant quantitative tools tend to be rooted in reductionist or positivist forms of inquiry. Prediction generates long-term understanding and retrospective data is projected forward to create certainty. This research demonstrates that imagination, excitement, expectation, and social interaction play an equally formative role in how we know the future. Operating through forms of visualization and representation, they do work to catalyze expectations, convene agreement, and direct individual and collective action toward preferred outcomes. Social and emotional knowledge operate alongside technical knowledge in every tool and they do work as a unit to affect decision-making.

Importantly, visualization technologies do not only operate individually. They also do work as a system to advance the design process. The future takes form as uncertainty is reduced tool by tool. Fidelity increases and persuasion, excitement, and expectations are harnessed as part of the design process to influence and guide client

decision-making. Viewing technology as part of large and complex sociotechnical systems and processes aligns with dominant STS, Design, and HCI literature. Scholars like Winner (1986), Tufte (1994), Kirsh (2010), Selin and Boradkar (2010), and more demonstrate that sociotechnical systems are not linear or cut-and-dry. This research reaffirms and expands this understanding by revealing that images are intimately tied to the environment they operate in. Use and interpretation is not separate from the contextual, political, and interpersonal dynamics that mobilize them. This means that visual tools are not objects but socially situated artifacts. Meaning resides among the person, context, and image and it depends greatly on the commitments, aspirations, and responsibilities of the person engaging it. Given the social life of images, respondents in chapter four explain real tension and nuance in using visualization tools to affect client decision-making. The time at which high fidelity depictions are deployed and with what content is carefully considered, arranged, and planned as to manage expectations and not suggest more certainty than exists. This suggests that Akrich's (1992) concept of scripts can be expanded to include order, meaning, and social dynamics inscribed into design processes and timelines themselves.

This work recognizes an inherent tension in building tomorrow's conditions. STS scholars agree that our ability to create the future lies in the present. We make plans, drawings, and calculations today that attempt to order, know, and create certainty about tomorrow. Difficulty arises because we can never quite know what tomorrow will be until we are there. This means that all plans, drawings, and calculations are best attempts and approximations. They are designed to provide certainty by narrowing uncertainty. When depictions are too real, too photographic, too rendered, the line between

approximation and reality can be hard to find. And while blurring this line may create and promote excitement and buy-in, over-promising has social consequences such as loss of credibility. As such, we see that those who make futures must toe the line between fact and fiction. Scientists include error bars, politicians speak broadly, designers work at lower fidelity and reduce uncertainty incrementally. Future-makers must manage political reality of needing buy-in through the illusion of certainty and the temporal reality of never knowing for sure.

Real tension exists in how images of the future operate. They present both real and unreal, fact and fiction simultaneously. In cities, for example, we know poverty, class difference, and climate change exist alongside public parks, community events, and popular shopping destinations. The former elements are not aspirational, exciting, nor sales points, but they are real aspects of everyday life. Yet they are often hidden from view in renderings of future urban development. The reasons for this are not difficult to imagine or understand. However, it bears pointing out that how we know the world to be and how we often capture it in development projects can diverge in significant ways. And if images are powerful in their ability to spur action, we must move to think deeper about what is lost and gained when we exclude some elements of life and include others.

Chapter five examines how visualization tools are perceived by clients as affecting their decision-making and in what ways clients interpret renderings. Analysis in chapter five meets the second objective of this dissertation: to expand STS understanding of the epistemology of the future by examining how visualization tools foster different social meaning. Chapter five examines an on-going case study of ASU at Mesa City Center. Findings from this chapter are two-fold. First, I find that social, emotional, and

technical meaning is inferred by clients from the visualization tools themselves. They read the tool, its contents, and its use within the interview setting for social characteristics and abilities of the firm. Diagrams, for example, are read for problem-solving ability. Drawings are read as suggesting creativity, collaborative interest, and work ethic. Photographs are read as establishing credibility. Renderings and virtual reality are read as demonstrations of vision, creative ability, and technological power. Affirming the concept of affordances (Gaver, 1991; Hartson, 2003; Norman, 2002), we see that these tools spur knowing and thinking. Expanding upon this concept, however, we also see that inference, imagination, and temporal thinking are core components of anticipatory cognition. Importantly, tools were viewed for more than their immediate content. They were read for clues about how the future development and working relationship would unfold with the interviewing firm. Interviews, then, like the visualization tools themselves, are a means for whittling down social uncertainty. They are testing grounds; roles are assumed and relationships projected forward to gain insight into the future relationship.

The generalizability of inferences remains an open question in this work. Given our understanding of the concept of fidelity (Houde and Hill 2003), it seems reasonable to hypothesize that inferences related to collaboration and openness, for example, are associated with sketchier and less developed depictions. Likewise, we might reason that inferences of technical ability and horsepower are typically tagged to the most novel or emerging technology used. Nevertheless, given the situated nature of interpretation that we have seen across this study, more testing is needed to confirm the degree and depth of generalizability. This is a ripe area for future study.

As I stated earlier, STS has done productive work to investigate how knowledge about the future is created from a technical and quantitative standpoint (Pirtle et al., 2010; Selin, 2006, 2008). This dissertation pushed these fields forward by investigating how knowledge about the future is made using more qualitative means. We know from chapter four that things like excitement, expectations, buy-in, and persuasion are components of anticipatory knowledge. And, now, from chapter five, we see explicitly that anticipatory knowledge also includes imagination—a proclivity to infer from technologies and social interactions a range of interpersonal characteristics and creative and technical abilities otherwise unseen.

While I cannot speak to the range of factors that inform social inferences, I can suggest that professional and personal values and vision for the future play a role in what respondents look for. I can also suggest that values and vision vary widely across respondents depending on their stake in and responsibility to the situation. As such, the second finding from chapter five is that clients look for or read values from visual depictions. This affirms HCI's connection between internal and external representations and cognition spurred from their interaction (Norman, 1993). Looking at content, respondents consider how the depicted future will affect them at a personal, professional, and community level. ASU at Mesa City Center leadership, for example, read and judged depictions in reference to values important to the city and institution as well as how the proposed future would impact their professional duties. Mesa community members saw in the ASU at Mesa City Center rendering how the proposed future would affect their lives, their community, and what impacts and outcomes they did or did not want. As such, interpretation moved off the page and into the larger development process itself.

Adding to the STS concept of interpretative flexibility (Pinch & Bijker, 1985), this finding suggests that interpretation is not bound to the visual but attached to the past and present processes and timelines that it is part of. This also reaffirms the socially situated nature of images.

Depicting and perceiving futures is political. In line with STS, Design, and HCI scholarship, the designers' hand and the viewers eyes are always positioned. This emphasizes a well-trodden understanding in STS about the politics inherent in sociotechnical interactions. Expanding on this understanding, however, we see that politics also exist with regard to literacy—the ability to read images and anticipate the impact and feasibility of the depicted future. Respondents from chapter four describe two types of truth conveyed through visualization. There is literal truth that attempts to depict the site as it is and as it will be to demonstrate feasibility. And there is emotional truth that aims to convey the experience and aspirations of a future site and what activities will take place. While this is a reductive dichotomy, the ability to read these truths and distinguish between what is put forward as literally true versus emotionally true is a question of visual literacy. And the question literacy is a question of politics.

Respondents in the planning professions with past experience in city building emphasized things like feasibility and collaboration in their decision-making. They inferred from the depictions more technical or literal issues like budget, construction, and maintenance over time. Respondents from the community emphasized issues like cohesion and economic development and pulled from the depictions more emotional or aspirational considerations like city identity and community activity. Each group read or saw a different truth in the image—aspirational, consequential, or literal—and that truth

was unique to their place, experience, and perspective. Drawing from STS scholar Haraway (1988), visual literacy, like knowledge, is situated and partial. The implication is significant because images of tomorrow are powerful actors. They blend fact and fiction and are circulated daily to convince, convey, catalyze, and support decision-making. When the future is too rendered and photographic, what some see as fact others know to be fiction. Distinguishing certain from uncertain, feasibility from sales, and reality from persuasion is not uniform. It is situated and learned. In an era where truth is challenged and novel technologies increasingly uproot the notion that seeing is believing, attention must be paid not only to visual content and technology but also to who is viewing, in what context, and with what literacy, responsibility, and reason to see.

I began this dissertation with a story about the Space Shuttle Challenger. NASA engineers used graphics to convey to agency officials that the shuttle launch should not take place due to probable O-ring failure. Unfortunately, officials did not heed the warning. The shuttle launched and exploded the next day. Seven astronauts were killed. One of many lessons from this tragedy is that imagery has real consequence. Another lesson illuminated in this research is that images are socially situated. They are not neutral objects but contextually embedded artifacts. Interpretation, use, and decision-making is tied to politics, expectations, values, priorities, and needs. Meaning is constructed between the person and the artifact. Meaning, along with decision-making, depend greatly on the interpersonal and organizational dynamics at play.

Given the affective power of visuals, this dissertation took a first step in untangling how images affect decision-making and with what social and political implications. My hope is that this research sets the groundwork for new studies exploring

the practice, politics, and ethics associated with visualizing uncertainty as a design element—whether present or future—and the continued role that social and emotional knowledge play in making sense of the future. Productive ground can also be covered in understanding how visual tools—as compared to text and physical objects—convey information about times to come and how they catalyze or disincentivize action. As I mentioned earlier, future work should also be done to understand the generalizability of inferences associated with different visualization tools to expand our understanding of the design process, decision-making, and the affordances of visual technology. Finally, this work builds a foundation from which to continue cataloguing and analyzing the range of tools used across professional practices, whether design, business, engineering, or otherwise, that are used to make decisions about the future.

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APPENDIX A

INTERVIEW PROTOCOLS

PHASE 2: INTERVIEW PROTOCOL WITH PRACTICING ARCHITECTS

What are the primary types of visualizations (e.g. diagrams, photographs, models, renderings, etc.) that you use during client interactions?

Other than the buildings themselves, what types of information do you include in these visualizations? What types of information are intentionally or unintentionally left out?

What are the risks of using visualizations to engage client decision-making? Do the risks differ by visualization type? If so, how?

What are the opportunities of using visualizations to engage client decision-making? Do opportunities differ by visualization type? If so, how?

Do visualizations affect a client's imagination? If so, how does imagination vary by visualization type?

Do visualizations give clients decision-making power? If so, how is decision-making power different when certain visualizations are used?

How are visualizations used as persuasive tools? Are some visualization types more persuasive than others? If so, how?

In creating visualizations, do you face particular dilemmas or opportunities when depicting urban environments that will exist in the future?

How is certainty and uncertainty about the future articulated and/or managed using visualizations?

PHASE 3: INTERVIEW PROTOCOL FOR ASU AT MESA CITY CENTER

ARCHITECT INTERVIEWS

What were your impressions of the architect interviews?

What feelings or reactions did you have to the different presentations?

What visuals did you find most compelling and why?

What visuals did you find least compelling and why?

What do you think they were trying to achieve by showing you renderings? Were they successful or not?

What do you think they were trying to achieve by showing you site plans and diagrams? Were they successful or not?

What do you think they were trying to achieve by showing you photographs? Were they successful or not?

What do you think they were trying to achieve by showing your technical drawing and sketches? Were they successful or not?

How did the different visualizations affect your decision-making and preferences?

What were the different futures presented by different firms? How did you know it was that kind of future?

Were these futures realistic and truthful?

Was anything missing from these futures?

What alternatives were foreclosed in the futures presented?

PHASE 3: INTERVIEW PROTOCOL FOR ASU AT MESA CITY CENTER RAIL RENDERING – COMMUNITY MEMBERS

What are your thoughts on the Mesa City Center development?

What are the pros? What are the cons?

Is there anything that stuck out to you in the presentation?

Prompt: We are now going to go through the presentation. Please stop me at any slides that you would like to comment on for any reason.

Rendering: Stop and prompt with the following questions:

- Is this realistic?
- Truthful and representative of Mesa's future?
- What is missing?
- How does this affect your imagination?
- How do does visual affect your decision-making?

In the presentation, how do the visuals seen affect your decision-making and preferences?

PHASE 3: INTERVIEW PROTOCOL FOR ASU AT MESA CITY CENTER RAIL RENDERING – UNIVERSITY RESPONDENTS

What considerations went into the development of the PPT?

How was it envisioned and deployed as a tool for communication?

How was it envisioned and deployed as a tool for decision-making?

What politics are associated with project and communication tools?

What risks are associated with project and communication tools?

What opportunities are associated with project and communication tools?

What do you want Mesa community members to see or know?