SketchBoard: Conceptualizing Interactive Communication Media for the Design Review Process

by

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A THESIS

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Abstract

As a synthesis, this doctoral thesis offers the opportunity to rethink the status of current technologies within the design review process. It suggests the potential for transforming the complex participatory, communicative, and technical nuances of the design review process to coexist with the affordances of the new genre of digital media.

Furthermore, the goal of this research is to create an interactive communication medium, called SketchBoard, that embodies intelligent and intelligible behavior to remedy the vagueness of visualization. This thus renders an insight into improving participatory communication within the design review process using mobile interactive surfaces. Moreover, this research provides a means of characterizing the existing urban planning desktop computer applications and more recent interactive surfaces. The research findings also suggest the possibility of supplementing existing urban planning desktop computer applications with mobile interactive surfaces, while interacting in a participatory design review process.

This thesis thus contributes to the intersection of the design review process with interactive surfaces while presenting a four-part empirical and design research study. The first study undertook an initial exploration of urban planners’ current work practices with their typical tools and technologies. The second, third, and fourth studies were conducted with urban planners at the City of Calgary’s (Canada) urban planning department. The second study explored the design review process, and as such comprises the zoning ordinance process that dictates the ultimate form of a building through which technological systems are constituted. The third study further explored these aspects by investigating the design specifications of SketchBoard. In the fourth study, the design and evaluation of SketchBoard for the design review process is presented.
On the methodological level, a postmodernist, qualitative perspective combined with the methodology of ethnography and contextual design as empirical approaches and minimalism as a design technique were exploited to address the multidisciplinary notion of the research. The research methods used were semi-structured interviews, participant and non-participant observations, structured surveys, and experimental digital paper prototypes. Finally, overall, this four-part research study foresees urban planners’ experience and expectations with interactive surfaces that will provide an impression for the directions of future research.
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Finally, for participating in my research study, my deepest thanks to the urban planners, urban designers, and architects working at the City of Calgary, who gave generously of their time to provide input about their work processes, technologies used, and needs for more optimal digital media.
Dedications

For my parents
Publications from This Thesis

Portions of the materials and ideas presented in this thesis may have appeared previously in the following peer reviewed publications:


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Design must be an innovative, highly creative, cross-disciplinary tool responsive to the needs of men. It must be more research-oriented, and we must stop defiling the earth itself with poorly-designed objects and structures.

Chapter One: Introduction

Design review work is conducted by a diverse group of agents who belong to different socio-economic-political institutions, where each agent is a contributing entrepreneur in the ecology of the urban planning enterprise. While “communication is always imperfect,” urban planners and other agents contribute to translate, communicate, debate, and reconcile in order to work together. Urban planners are gatekeepers of information and access. Other agents try to indicate the translation of concerns into those of the urban planners’ simultaneously. Communication in the process of design review is not participatory; consequently, when the institutions of these agents intersect difficulties appear. Simply described, Planning in the Face of Power is an apt summary of the design review process. Basic features of design review agency involve communicating politically to share technical knowledge to “create common understandings” or “make sense together.” Design review process is a socio-economic-political agency where there are winners and losers. At the same time, these agents require coming to a discursive agreement or compromise over what is possible and allowed in this complex design process [1] [2] [3] [4] [5] [6].

There is now a wide array of immobilized, single-user digital media that could support information and visualization needs of the design review process [7]. However, mobility is fundamental for visual perception [8]. Specifically, the design review process requires mobility that supports spontaneous interaction and participation, exchange of useful information, local communication, and mutual awareness. Technology for this process should support self-explanatory operations without significant training through mutual intelligibility of individuals and technological interactions [9] [10]. Yet, these aspects of the design review process are not supported by exiting technology that is tied to desktop computers and afford explicit
communication [11] [12]. There is, however, an absence of intelligent and intelligible 3D visualization media that allows participatory communication and ubiquitous, interactive behavior. Having such media could reduce the time needed to examine development proposals within the design review process. This media may also result in the preparation of development proposals that does not require knowledge of Computer Aided Design (CAD), Planning Support System (PSS), and Geographic Information System (GIS). Furthermore, the proliferation of interactive surfaces and their chameleon-like quality have pervaded both the public and work environments, and in education and entertainment, however, the role of representational affordances and properties provided by such surfaces within the design review process is still largely unexplored [13] [14].

This thesis consists of a four-part empirical and design research study that investigated the communication between urban planners and mobile interactive surfaces for the participatory production of mutual intelligibility within the design review process. These studies were all conducted in Calgary, Canada and included participants from the United States, Canada, and most European countries. First was Study I, “Perception and Reality: Can Technology Enhance Participatory Communication within the Urban Planning Process?,” which was interview-based and explored what urban planners currently do with desktop CAD and GIS computer applications, and what they would like to do with interactive surfaces in the course of working. Next, this exploration continued in Study II, “Design Review Process: Can New Technology Improve the Art of Participatory Communication?,” which was also interview and observation-based with a crystalized focus on understanding the role of desktop computer applications and interactive surfaces within the design review process. The viability of design specifications for creating an interactive communication medium derived from this study was investigated in more
detail in Study III, “Explorations in Perspectives on User-Centered Design of SketchBoard for the Design Review Process,” which was survey-based. In Study IV, “Morphing the Building Environment: Conceptualizing SketchBoard for the Design Review Process,” the research findings contributed to the creation of SketchBoard and an interview and survey-based evaluation of SketchBoard, a tablet-based digital paper prototype. Ultimately, this thesis focuses on informing the design specifications for creating SketchBoard, an interactive communication medium that is participatory, procedural, spatial, and encyclopedic. Participatory affordance that represents shared dialogue with others, and procedural affordance that represents rule-based behavior assist in making SketchBoard interactive. Spatial affordance that represents navigable space, and encyclopedic affordance that represents logical, symbolic representations of a process assist in making SketchBoard immersive [15]. Furthermore, SketchBoard introduces a ubiquitous, pseudo intelligent, and geo-located method for 3D visualization and computation of the zoning ordinance, specifically the Floor Area Ratio (FAR). SketchBoard also provides a vision for simple, intuitive, and intelligible interactions within the participatory communication around the future shaping of cities.

In the following sections, practical urban planning theory and critical communication theory of society, urban planning practice, urban planning review, design review scenario and persona, and the role of current and future technologies in urban planning provide a brief background to this research. This chapter continues to discuss the following aspects of this research: goal, questions, objectives, methodological process, contributions, limitations, as well as thesis organization.
1.1 Background to the Problem

1.1.1 Practical Urban Planning Theory and Critical Communications Theory of Society

Although the thesis is not about Forester’s Practical Planning Theory or Habermas’ Critical Communications Theory of Society per se, these theories are used as the substantive topics around which the different contributions explore various aspects of communication and participation within the design review process.

Urban planning is a complex political communicative action that may thwart or foster a liberal democratic and participatory urban planning process. Urban planning guides future actions through its pragmatic, empirical, normative, interpretive, and practical contents. Urban planning encompasses many areas including policy, design review, environmental, health, land use, infrastructure, and transportation planning. Urban planners are engaged in both “problem-work” that is technical (e.g., visualizing the zoning ordinance and calculating the permitted FAR) and “people-work” that is socio-political (e.g., communication and participation within the design review process). Urban planners shape attention practically and politically to argue about future possibilities and make decisions. They have the power to influence the systematic pattern of communication, delay the urban planning processes, also to manage uncertainties, reshape problems, and seek solutions. The use of the term “urban planners” refers to a wide spectrum of expert stakeholders who work on problems with non-professionals including developers, the public, and private sectors who seek to “make sense together” in a “socially constructive” fashion [1] [2]. Moreover, urban planners assume several personas or roles to deal with complex, dynamic, and unpredictable social and political issues. What urban planners do is to explore uncertain, complex, and controversial urban planning tasks to provide unbiased professional advice that is needed in making decisions [5] [16] [17].
Urban planning includes both communication and technical actions. Communication is a way to integrate the technical and socio-economic-political aspects of urban planning. Communicative action is fundamental to cooperative work that is a process of seeking and reaching a common understanding within an ongoing process. Ideally, the goal of urban planning is to acquire knowledge of the surrounding society to make decisions, and to generate and implement solutions to urban problems within a participatory setting [1] [2]. However, urban planning model of communication and interaction are impacted by the situatedness of individuals’ socio-economic-political activities. In addition, in spite of individuals’ role in the urban planning process, urban planning stakeholders as ordinary individuals are contingent and unpredictable contextual entities who improvise based on their motivations, perceptions, interpretations, and misinterpretations [5] [6] [18].

As opposed to the goal-oriented instrumental action, the communicative action is a deliberative action that is based on cooperation of individuals and mutual argumentation. The political-economic structure of society is based on communicative action, which is systematically distorted [2] [5]. The statement “urban planning is political” describes that information in urban planning is not straightforward, meaning that urban planners are affected by socio-economic-political environments in which they are working [2] [7]. Thus, the systematically distorted nature of urban planning communication contrasts with agenda free communication, which remains open to other viewpoints and understandings. Urban planning should be deemed a participatory activity that deals with conflicts [16] [17]. Urban planners communicate to make promises, encourage, and discourage by using typical statements such as “leave it to us.” However, imperfect information, misinterpretation, and distorted communication are unavoidable within any socio-economic-political context, whenever people communicate [1] [2].
There is a diversity of opinions among practitioners of urban planning practice, who focus on the realities of everyday practice versus urban planning theory, which is concentrated largely in the domain of academia. It is argued that there often is a disconnect between academics and professional urban planners. Specifically, professional urban planners often either lack or do not practice some of the technical knowledge and academic theory that would enhance their practice. For example, many urban planners may not be familiar with CAD and GIS. As a result, they may have to ask for the assistance of a technician, thus delaying the urban planning process. Furthermore, the urban planning literature also places an emphasis on physical design, which may or may not happen in practice. Thus, in addressing the shortcomings of a plan, attention must focus on a range of concerns including spatial analysis, ethics, and communication. Such a practical difficulty can be handled by supplementing on urban planning education and teaching urban planning practice by exploring the neglected research areas [1] [2] [7] [19] [20].

1.1.2 Urban Planning Practice

Urban planning practice involves considerable technical and communicative activities. Technical actions include architectural and aesthetic techniques and design, as well as drawing, computing, calculating, making plans, interpreting, and developing policy. While, communicative actions involve communicating with the public, granting permissions, and administrating guidelines and regulations [7]. As negotiators, urban planners must work closely with their respective city councils, mayors, and the developers. Their work often requires them to submit proposals on behalf of the communities they represent. The review of urban development plans and proposals is a political process that requires participation and communication amongst all stakeholders. During this process or reviews, building proposals are analyzed, negotiated, investigated, and delayed. Oftentimes proposals are sent back to the developer with requested changes. In many
cases, the decisions of urban planners must deem issues of aesthetics, politics, law, and design. Even the most straightforward conversations can raise complex issues for assessment [1].

However, the technical character of urban planning actions can be difficult for the layperson to comprehend. This can entrench an intellectual divide between urban planners and non-urban planners on a range of issues. Limited public access to information can also increase misinformation. A reliance on sophisticated technical tools such as CAD and GIS also contributes to this divide between urban planners and the public. However, developing shared understanding of the issues and creative problem-solving through communication and participation amongst stakeholders is key to the practice of urban planning. Therefore, attention must be made to the strategic shaping and planning of communicative action and the building of a cooperative working relationship in order for the developers, the community, and bureaucrats to trust the technical information [1] [2].

1.1.3 Urban Planning Review

The urban planning review process involves the parallel activities of design and decision. In the process of reviewing a plan, alternative solutions are often created. A plan can change in response to government regulations or the need to generate a specific level of profit. At each stage in the design process, experts need to consult with the public. Ideally, the end product of this participatory process should be a plan that respects the aesthetics and socio-economic-political context of a proposed development project [7]. Furthermore, the urban planning review process must resolve conflicts which arise out of a diversity of opinions among stakeholders. Conflicting demands in urban planning review mainly arise when private profit and the public good clash. Depending on the political situation surrounding the design review process, one of the parties involved in the political endeavor wins or loses [1].
1.1.4 Design Review Scenario and Persona

To provide concrete context, a typical design review scenario from the perspective of an urban planner is described. This scenario incorporates three concrete elements of communication and participation around technical activities that is based on the researcher’s day-to-day engagement with the urban planners in a city planning department’s offices. A precise description of pretend users who are fictional characters and what they want to accomplish is provided, and the design concept is developed for them. The cast of characters including Don, a developer; Pat, an urban planner; and Sydney, a member of the public who is also the primary persona, are created to narrow down the spectrum of users for a design. This scenario further develops into a mature and coherent pattern for personas that was captured in defining the design specifications for SketchBoard (see Chapter VI, section 6.11) [15] [21].

**Idea Generation.** Don is a developer who plans to apply for a permit for a multi-building, multi-family development. He requests a three-hour pre-application workshop with Pat, an urban planner who works for the city. At their first meeting, a number of design concepts are discussed. Pat provides feedback, anticipating issues that Don may encounter within the design review process. Together they work on potential design solutions. This design charrette session involves the use of paper and pencil to draft and discuss possibilities. Because Don is an experienced developer, he does not need information about the design review process, however, Pat would provide this for a less experienced developer.

**Application Refinement.** Following this session, Don refines the design and submits the initial development application to the urban planning department as a large set of physical and electronic documents. Pat shepherds the application through the city’s design review process. With his team, Pat reviews the development application by cross-referencing the design against
bylaw and policy requirements. Through several iterations, Pat identifies details of Don’s design that need to be clarified or may need modification. Some of these changes could conflict with Don’s original plans, and he will need to refine several features of his design. Often, this involves intense phone conversations with Pat; other times, they meet to discuss the city’s concerns, and how best to resolve this issue. Sometimes this process involves marking up printed plans with markers and pens. Together, Pat and Don meet many times to negotiate, identifying opportunities for exceptions on the formal building code to address the city's concerns. Don's project is not too far out of the ordinary, but communications continue for well over three years. Once communications wrap up, and changes are satisfactory to the city, as well as Don, and he is granted a provisional development permit.

Public Consultation. Sydney is a civic-minded citizen who attends every event at his local community center. One of these is a Public Consultation session run by Pat. Here, Pat gives an electronic slide-based presentation to Sydney about the new proposed development, perhaps with a scale model provided by Don. This discussion is aimed at understanding the impact of the development on the community. Sydney, one of the few members of the public at the session, feels very strongly against the plan, as it will impede his view of the park. He voices his concerns to Polly who is an elected official. If these concerns are taken into account, the process may bounce back to the Application Refinement phase. When they are finally resolved or ignored, if the political consequences are not major, Pat releases the final building permit to Don.
Figure 1.1 (below) illustrates the cast of characters for the design review scenario.

**Don**
- A thirty-five year-old developer who plans to apply for a permit for a multi-building, multi-family development.
- He requests a three-hour pre-application workshop to discuss potential design solutions.
- He uses paper-based 2D plans, elevations, and sketches to draft and discuss the possibilities.
- He modifies the development application several times to meet the city’s requirements. This process varies from a few months to a few years.
- He has limited software skills.

**Pat**
- A fifty year-old urban planner who works at the land use planning and policy department.
- He provides information about the design review process and feedback in the design charrette sessions.
- He reviews the development application by cross-referencing the design against bylaws and policy requirements.
- He releases building and development permits if the requirements are fulfilled.
- He also gives a presentation about the new proposed development and the impact of the development on the community.
- He has to work with CAD and GIS in the course of his work, but he has limited software skills.

**Sydney**
- A thirty year-old member of the public who attends every event at his local community center.
- He voices his concerns about the new proposed development to authorities including the elected officials.
- He hardly understands the 2D plans, elevations, and sketches.
- He also has very limited software skills.

Figure 1.1. The Cast of Characters
1.1.5 Urban Planning Technology

There is a dichotomy between visual and verbal cues of urban planning Computer Mediated Communication (CMC) versus urban planning face-to-face communication. Pattern of user interaction is largely dictated by the urban planning technology rather than diversity and creativity of the users. Traditionally, urban planning technologies include substantial use of paper-based plans, maps, and text documents. Currently, urban planners rely on digital technologies, which lack mobility. Because they require specialized software, urban planners tend to stay in their offices to use software, such as CAD and GIS. Further, urban planners who cannot leave their offices require visualization aids for informational and communicational needs, which allow them to conceptualize the potential impact of new building projects. In addition to visualization, urban planning decisions are made in a participatory fashion, another function that technology should support for participatory communication [7] [22] [23].

Everyday life of the design review work is shaped by corporate and bureaucratic systems where contemporary capitalist practice entails inequality, differences, and power relationships. Optimistically, participation technology for urban planning communication could potentially re-shape social and cultural differences evident in the structure of the design review process. Technologies that support participation comprise an increasingly important part of the Information Communication Technology (ICT) infrastructure in organizations, including process improvement and teamwork. Electronic participation (e-participation) that encompasses computer mediated collaborative work refers to use of digital media among different individuals to accomplish a common task. E-participation is increasingly being used in industry to promote collaborative activities, tools, and functionalities embedded in large enterprise systems. Implementation of e-participation exercise in the context of urban planning technology could
move towards enhancing the participatory decision-making process in democratic participation. Accordingly, in automotive industry, the application of e-participation is used for effective coordination of product development in real-time. 2D drawings are not easy to understand, but automotive industry still relies heavily on them to access technical product information. By trading 2D drawings for 3D visualization, the automotive industry uses technological substitutions for traditional exchange of information to replace face-to-face participation and paper-based product development with e-participation [22] [23] [24] [25] [26] [27].

1.1.6 Adaptation of Digital Media in the Design Review Process

Urban planners’ failure to adapt to rapidly advanced computers highlights the limitations of computer aided planning. These limitations derive from impoverished concepts of participatory, intelligibility, mobility, automation, flexibility, and efficiency of interface and interaction design of urban planning technology. For example, CAD and GIS require an extensive technical training before the user becomes proficient in their use. This requirement for training has prevented the development of non-professional genre of urban planning technology. This example offers a starting point for exploring the potential of digital media for the design review process, one which suggests that the user’s competence should be broadened and improved. It further suggests that the digital media used in the design review process should require user’s rudimentary or experimental knowledge. In addition, the use of interactive digital media within the design review process should provide communication platforms, which inhibit the problem of software non-professionalism [7] [28] [29] [30].

Furthermore, the rapid evolution of ICT has influenced the socio-economic-political structure of the design review process through decentralized coordination of activities as well as reshaping the cultural technologies of this process. In particular, the availability of information through
constant mobile communication has transformed the way individuals interact, communicate, and participate. Moreover, the participation paradigm in the design review process assumes that a technology for group work should allow the urban planning stakeholders to actively participate and engage in the design process. The integration of digital media and ICT with the emergence of groupware into the structure of the design review process could increase the opportunity for participation. E-participation in conjunction with ICT can provide tools for engagement via delivering better quality information to geographically dispersed locations [24] [28] [29] [30] [31].

More advanced technological support should be given to support an achievement in essential tasks of the design review process such as visualization and communication of plans for future cities. This could also promote an efficient and a shared environment for the urban planning stakeholders. Yet, the use of conventional urban planning tools and technology is not likely to be suppressed. In addition, cultural technologies for the design review process where media, context, and power relations are assembled has not been matched to potential forms of education and training necessary to acquire socio-economic-political knowledge and skills to make use of the digital media. Thus, it is not yet evident whether digital media in urban planning can evolve enough to become a mainstream technology that could potentially take advantage of advances in computing technology [7] [10] [29] [32] [33].
1.2 Research Overview

In this thesis, a four-part research study involving interviews, observations, surveys, and demo of digital paper prototypes was conducted. The rationale for designing these studies was to inspire urban planners to envision a new genre of digital media for the design review process. In particular, this thesis employs a minimalist standpoint that allows defining aspects of simplicity for the design of SketchBoard that could potentially support the participatory communication between urban planning stakeholders as well as their visualization of the zoning ordinance, and computation of FAR as specific technical activities within the design review process in a simpler and faster fashion. Figure 1.2 (below) illustrates the definition of FAR.

![Diagram of FAR](image)

**Figure 1.2. Floor Area Ratio (FAR)**

The zoning ordinance is a prime text-based source of information on land use and district regulations. It is regularly referred to and used by urban planners, property owners, developers, attorneys, local governing bodies, and members of zoning appeals boards. However, there is a lack of comprehensibility of the technical information and concepts on the zoning ordinance document that causes frustration and bewilderment for urban planning stakeholders. It is also uncommon to have accompanying maps, graphics, and diagrams that support the readability and
intelligibility of the zoning ordinance document. Thus, computing and visualizing FAR are difficult activities when referring to the text-based document. FAR refers to the ratio of a building’s total floor area compared to the size of a building’s parcel. In addition, setbacks that are specified under a zoning ordinance can impose constraints which can make it impossible to achieve the permitted FAR. Even though these definitions are somewhat clear, without illustrations they are cumbersome to comprehend [34].

Furthermore, the work conducted within the design review process is complex because it requires enhancements to the participatory communication aspects; participatory communication refers to creating shared understanding, perception, and knowledge between urban planning stakeholders within a collective decision-making environment. Moreover, participatory communication within the design review process should empower the voice and visibility of urban planning stakeholders through simple visualization, thus discovering solutions to their complex design problems [35]. However, these various aspects of the design review process significantly rely on conventional tools such as paper, pen, pencil, tape measure, large binders, multiple stacks of bylaws, and so on, as well as desktop computer applications such as CAD and GIS software. Yet, these existing tools and technologies used in the design review process lack simplicity, usefulness, and mobility.

Although, mobile, small interactive surfaces are proliferating, there remains a gap in determining whether computer aided planning can fully capitalize on the benefits of interface and interaction design of such surfaces. Specifically, there is an absence of empirical research studies to identify how urban planning stakeholders can benefit from using mobile, small interactive surfaces within the design review process. Yet, by characterizing the contemporary trend of interactive surfaces, perhaps as one solution amongst many, this thesis speculates that integration of a
mobile, small interactive surface such as a tablet with SketchBoard could potentially enhance the participatory communication and visualization needs within the design review process.

1.3 Research Goal

The goal of this research was to develop an understanding of how to create SketchBoard, an interactive communication medium that can support the participatory, communicative, and technical activities of the design review process.

1.4 Research Questions

**Question I.** How can urban planners potentially interact with CAD and GIS if provided with interactive surfaces in a participatory urban planning process?

**Question II.** What do urban planners do and what tools and technologies do they use within the design review process?

**Question III.** What is the importance of SketchBoard in assisting urban planners to visualize and communicate the zoning ordinance within the design review process?

**Question IV.** To what extent does SketchBoard support the participatory, communicative and technical activities around visualizing the zoning ordinance within the design review process?
1.5 Research Objectives

**Objective I.** To investigate the needs and expectations of urban planners in their overall day-to-day work. This objective aimed to explore urban planners’ work practices, tools, and the technologies they use in the course of their work, the role of desktop CAD and GIS computer applications, and the influence of interactive surfaces in their work practices.

**Objective II.** To understand the needs and expectations of urban planners in their day-to-day work, specifically within the design review process. This objective aimed to examine urban planners’ workflows and intentions of work; the desktop CAD and GIS computer applications and paper and text-based documents urban planners use; also their challenges and complexities over the course of working within the design review process.

**Objective III.** To refine the set of design specifications for SketchBoard that supports the design review process. This objective tended to provide an understanding of the importance of participatory design, the urban design and planning process, and aspects of visualization and analysis.

**Objective IV.** To design, refine, and evaluate SketchBoard for visualizing the zoning ordinance. This objective attempted to understand the participatory, communicative, and technical activities around the computation and visualization of the permitted FAR.
1.6 Research Methodological Process

In this thesis, the research methodological process is explained in more detail in Chapters II-VI. In Chapter I, the research methodological process section illustrates the overall meanings and perspectives used in this thesis. This thesis thus employs subjectivism as the epistemological view, postmodernism as the theoretical perspective, ethnography and contextual design as the methodology, and semi-structured interviews, participant and non-participant observations, structured surveys, and experimental prototyping as the methods. These meanings and perspectives are explained in the section below. Figure 1.3 (below) illustrates the research methodological process for Studies I-IV.

Figure 1.3. Research Methodological Process for Studies I-IV

In this thesis, the “postmodernist qualitative research method” was applied to determine an open-ended and evolving dialogue based on imaginative, interpretative, and descriptive practical reasoning. Postmodernism declares the ambiguity and uncertainty of the complex and non-linear nature of qualitative contexts by declaring the inapplicability of certain criteria within qualitative research [36] [37].

This thesis presents an interdisciplinary research methodological process from design, social science, and Human Computer Interaction (HCI), which constitutes activities outside the
laboratory, “in-the-wild.” The empirical field studies in this research were conducted using the methodology of cognitive ethnography and contextual design. This research also employed minimalism as a design technique to create SketchBoard. The main underlying goals for this research encompassed both a design and empirical study in which to answer the research questions from a design and empirical perspective [38] [39] [40].

In this research, cognitive ethnographic studies develop an understanding of the individual urban planner’s behavior, knowledge, and everyday practices to design new technologies better suited to the needs of the users. Cognitive ethnography uses a multiple data collection and analysis method to provide an understanding of the interaction among urban planners and tools and technologies as both urban planner and tools and technologies are culturally immersed and socially distributed in the environment. Furthermore, cognitive ethnography investigates the functional relationship between distributed elements such as participants and artifacts engaging in a cognitive process, which is an important aspect of this research [6] [41] [42] [43].

Moreover, this research used contextual design to help urban planners crystalize and articulate their work experiences. Contextual design was combined with the cognitive ethnography technique to develop an understanding about the work practices of urban planners. This understanding formed a basis for developing SketchBoard to support urban planners’ work within the design review process. This research also combined contextual design, cognitive ethnography, and minimalism to create a digital paper prototype [38] [40] [44].

Taking these approaches, this thesis included a four-part research study. The methods used in Study I were semi-structured interviews; the methods used in Study II were semi-structured interviews, and participant and non-participant observations; the methods used in Study III were
structured surveys; and the methods used in Study VI were to design digital paper prototypes and evaluate SketchBoard via semi-structured interviews and structured surveys. In addition, to be epistemologically consistent throughout this thesis, the subjectivist perspective of Studies III and IV adapted a qualitative method to ascertain meanings from the quantitative data collected and used structured surveys. Thus, to answer the questions posed by this research, Studies I-IV were empirical in nature while Studies III and IV also included design. Additionally, each individual study answered a different set of questions.

The empirical research began with the study of a large and broad sample group. In these four studies, purposeful sampling strategy was also employed. To plan for these four qualitative studies, criteria for whom and what to study was determined. Participants, specific processes of their work, and their tools and technologies used in the course of their work were purposefully selected to provide an in-depth understanding of the research problem and its main issues.

Furthermore, to define the sample size, these four studies followed the general guideline in qualitative research. The intent was to focus on a few individuals and elucidate particular and specific aspects, events, experiences, and incidents. This allowed for the collection of extensive detail which deepened the researcher’s understanding of each participant, their process of work, and the artifacts used in the course of their work [39].

Study I focused on investigating the types of tools and systems that are needed to support the work of urban planners using interactive surfaces. It also provided an understanding of what urban planners currently do with desktop CAD and GIS computer applications, and explored what urban planners imagine as the potential use for interactive surfaces.
Study I formed the basis for the second empirical study. The scope of Study II was narrowed down to focus on the following questions: what do urban planners do?; what information, documents, and tools are used by urban planners?; how are the information, documents, and tools organized?; what specific challenges, problems, and complexities are associated with the design planning review process?; what physical urban planning tools including CAD and GIS do urban planners use in making decisions concerning the built-environment?; what factors currently restrict the flow of information in decision-making?; what tools and technologies could they use to make them more effective urban planner?; what is the current set of tools and technologies urban planners use?; what paper and text-based documents are currently in use including reports, files, and maps?. Furthermore, what is the role of CAD and GIS, and is there a technology that would improve communication and the flow of information to help urban planners make informed decisions in a timely fashion.

From Study II, a series of findings provided a deeper understanding of the design review process and sub-processes. In addition, a set of design specifications for the creation of SketchBoard arose, which was the basis for Study III. Furthermore, the goal of Study III was to measure the importance of the participatory design, urban design and planning process, visualization and analysis in the context of given zoning and FAR scenarios. This inquiry helped in refining the set of design specifications for creating a digital paper prototype in Study IV.

Study IV through the use of the digital paper prototype, combined both a minimal design technique and empirical perspectives to explore the potential of design specifications identified for SketchBoard. Minimalism, as a design technique employed in this study, aims to accommodate the design review’s workflow process, specifically pseudo visualization of the zoning ordinance and computation of the FAR. In addition, other design specifications for
creating SketchBoard include: pseudo three-dimensional, intelligent, and geo-located interaction; mobile, participatory, intelligible, and intuitive interaction; as well as minimalist aesthetics. Furthermore, the goal of Study IV was to evaluate the usefulness and simplicity of SketchBoard in the form of a digital paper prototype to enhance participatory communication within the design review process.

Yet, there is a wide range of planning support systems, and each system has a set of unique specifications. But, the goal of this research was not to measure the effectiveness or efficiency of each technology. In fact, it would be cumbersome to evaluate the usefulness of all software urban planners utilize. However, that was not the purpose of this research. The goal of this research was the creation of a vision of a new generation of communication media that could be supported by interactive surfaces. Thus, combining both design and empirical research should provide a useful case study for urban planners, interaction designers, and researchers. The research methodological process has only been briefly described, but will be explored in greater detail in Chapter II, and in each of the four studies.
1.7 Research Contributions

On a design and empirical level, this research specifically contributes to the visualization, communicative, and participation aspects of the design review process and mobile interactive surfaces. Below, each individual contribution is described briefly. Figure 1.4 (below) illustrates different individual research contribution relates to the other.

![Figure 1.4](image.png)

**Figure 1.4.** Research Contributions: Abbreviations Refer to Inline Headings

### 1.7.1 Visualizing the Zoning Ordinance’s Impacts on Design Decisions (VZOIDD)

A primary contribution of this thesis will be a discussion about how the introduction of SketchBoard could improve the intelligent and intelligible 3D visualization within the design review process. SketchBoard offers participatory communication and visualization to coalesce groups of the urban planning stakeholders together through replacement of vast amount of paper-based and textual information by presentation of visual information that is not prerogative of experts. Communicating the zoning ordinance involves visualization and computation of the FAR. In their deliberations, urban planners must also consider how the number of floors, setbacks, building height, and floor heights will impact the design of the development. Specifically, this research will show how visualizing the zoning ordinance on an interactive surface such as a tablet could help with participatory communication processes even for those
who lack knowledge of design or perspective. The integration of a tablet with SketchBoard strives to provide a mobile interaction that supports both mobility and participation within the process of the design review. Besides the standard mouse and keyboard combination, SketchBoard supports a simple interaction with information to enhance visualization and computation. Additionally, the interface and interaction design of SketchBoard are designed to work in conjunction with the current technologies. This will demonstrate how interaction design can be used to help urban planners solve a specific problem within the design review process.

1.7.2 Interacting with CAD and GIS on Interactive Surfaces (ICGIS)

This thesis provides an opportunity to demonstrate how urban planners could potentially interact with CAD and GIS if they are provided with interactive surfaces in participatory environments. Inspired by the findings of the field studies, this thesis will represent the possible implications for the technological shift that brings the flow of interaction with the exiting complexities of the desktop CAD and GIS computer applications more under the urban planning stakeholders’ control while interacting with one another. Furthermore, the findings from this research show that the advances in mobile, small interactive surfaces such as smartphones and tablets could potentially have a significant impact on the way urban planner users interact with traditional CAD and GIS environments. Alternatively, fixed, large interactive surfaces such as tabletops and large wall displays are not accessible to many of these users currently. Hence, they have not had a significant impact on the way urban planning users interact with CAD and GIS and are not considered in this research.
1.7.3 Characterizing the Computer Aided Planning’s Interface and Interaction Design (CCAPIID)

This thesis will contribute to an understanding of the current use of urban planning desktop computer applications and more recent interactive surfaces. This involves how the type of interface and interaction design of computer aided planning has an impact on the outcome of the design review process. Furthermore, the interface and interaction design of computer aided planning could help influence both the communicative actions that frame the political and participatory design decisions as well as the technical actions that form the visualization and analytical spectrums of the design review process. Moreover, this research provides insight into how interactive surfaces are used as part of the visualization and communication in participatory design review process. Findings from this research will demonstrate that interactive surfaces are potentially more natural alternatives to the traditional mouse and keyboard paradigm. However, at present, interactive surfaces do not support current CAD and GIS software designed for desktop computers’ mouse and keyboard interactions.

1.7.4 Urban Planners’ Change of View towards Technology as a New Paradigm (UPCVTNP)

With the development of accessible urban planning technologies for interactive surfaces, this thesis offers a new spectrum to rethink the old assumptions of considering the desktop computer aided planning as mainstream. Furthermore, this research provides an opportunity for designing a participatory, interactive communication medium which creates a context where urban planners, individually and collectively, participate to reshape and contextualize the design review work’s content. Expanding the potential of participation adds greater diversity of perspective that supports to strengthen the communication process around technical activities, also to accommodate the urban planning stakeholders’ interests and voices within the design review
process. Such a medium should also support intelligent and intelligible interactions for 3D visualization, which empowers the urban planning stakeholders’ communication and participation as an important political right within the design review process. Moreover, findings from this research will show how urban planners’ experience and expectations with interactive surfaces could undergo transition which offers a snapshot of the future directions of this research.

1.7.5 Research on the Methodological Level (RML)

As part of the research methodological process presented in this thesis, a postmodernist, qualitative approach employed the methodology of cognitive ethnography and contextual design for field studies in-the-wild, as well as minimalism as a design technique which expanded on the semi-structured interviews, participant and non-participant observations, structured surveys, and experimental digital paper prototyping settings of Studies I-IV. By combining empirical and design research strategies, this thesis contributes to the novel notion of multidisciplinary research that attempts to bridge the technological gap at the convergence of two fields: the design review process and interactive surfaces. In addition, in this research, execution of the research and analysis of the data offer a unified vocabulary, common methodology, and analytical guideline that can be applied to design-related studies with a similar focus of exploring the design processes, challenges, needs, and tools and technologies used throughout these processes.
1.8 Limitations of Research Methodological Process

This research took a qualitative methodology of ethnography and contextual design that were time-consuming for both data collection and analysis. Furthermore, the sampling strategy employed in this research tends to discover extensive detail about a specific context under study. Even small samples will generate a large quantity of data. However, while participants were purposefully selected to fulfill informational needs, the small sample size for this research may not meet the criteria for statistical representation. Giving careful attention to uncontrolled conditions, personal characteristics, and events uncovered the uniqueness of the situation in this research, which is new and differs in context from other situations. Generalization generally modulates context-free, deterministic values with the aim of prediction and control. However, in this thesis, the researcher wished to communicate a “naturalistic generalization” of personal accounts of the external representations within the design review process into a shared form of exchange. Thus, the transfer and application of these research results to other contexts could be useful in such disciplines as industrial design, media design, urban design, architecture, computer science, and engineering. Moreover, this research was both conducted, and the collected data analyzed, by the researcher. Thus, the researcher’s personal thoughts and feelings concerning the overall research process might have created bias in the thoughts, feelings, and ideas of the participants and in the hypotheses generated from this research. However, to maintain neutrality as an important criterion in qualitative research, participants’ voices are separated from the researcher’s voice by including quotes made by the participants. In the following, more detail about the limitations of each study is provided [38] [39] [45].

In Study I, interviews were conducted in a large sample size, but due to lack of time and an unmanageable, large amount of data, only a small sample size of interviews were transcribed
verbatim and thoroughly analyzed. Furthermore, the vast majority of interviewees are currently employed in industry and academia in Calgary, and one participant is employed in the UK. Thus, it would have been more optimal if more participants from other cities and/or countries had participated. This would then have given an opportunity to explore more diverse information about the target users.

In Study II, interviews and observations were conducted amongst the limited target population of participants within the City of Calgary. Therefore, the small sample size of urban planners, urban designers, and architects might not represent the majority of urban planners in Alberta and/or other countries. Hence, it would have been better if more participants from other cities and/or countries were interviewed, if there had been enough time. This would have allowed for collecting diverse and deviant information about the context under study. However, if more participants had been included, the downside would be that each country and/or city has a different urban planning process, jurisdictions, and political systems, therefore, the data analysis would have become extremely unwieldy. Also, and unfortunately, the public were not involved in the study. Moreover, during Study II, the only recording methods used to roughly paraphrase participants’ comments and the researcher’s interpretation of observed activities were manual note-taking and the capture of digital images of the physical work, meeting, and storage locations of the City of Calgary’s urban planning department. Additionally, to see the distinction between what participants said and what they did, the analysis might have been more insightful by incorporating audio and/or video recordings of the participants in their natural work environments. This would have allowed the researcher to capture more detailed information about what participants do and how they interact with tools and technologies in the course of their work.
In Study III, the web-based survey reached new participants as well as participants from Study II. The sample size in Study III was small and might not represent the majority of urban planners, urban designers, and architects’ population. Furthermore, the survey was designed to measure the importance of participatory design, urban design planning and process, visualization, and analysis. This might give useful information for defining the specifications of a potential interactive communication medium. However, it seems not to provide enough evidence of participants’ actual interaction with given tasks in the zoning and FAR scenarios on the proposed medium. Thus, conducting Study IV assisted in dealing with this issue by creating SketchBoard.

In Study IV, the low fidelity digital paper prototyping was used as a simple, quick, flexible, and low-cost method for evaluation of the design in a real world setting. However, it did not demonstrate full interactions with tasks in a comprehensive way. Furthermore, having unexpected results were some of the elements of risk in deploying digital paper prototypes. Moreover, this study might have gained some insights from a working prototype to assist in measuring the accuracy and completion time of the given tasks, such as visualizing the ordinance and computing FAR and therefore comparing the results of the study with a working prototype versus the current methods using traditional technologies.
1.9 Thesis Organization

This thesis is organized into seven chapters. Chapter II reviews the previous research and describes the research methodological process applied in this thesis. Chapter III outlines the first step in empirical investigation, which includes Study I. Chapter IV outlines the second step in research, which includes Study II. Chapter V outlines the third step in research, which includes Study III. Chapter VI outlines the fourth step in research, which includes Study IV. Chapter VII summarizes and reflects on the thesis and outlines the future research directions inspired by this research. Appendices I-IV present research material for Studies I-IV. Finally, Appendix V notes the Glossary of terms.
Chapter Two: Research Background & Methodological Process

This chapter seeks to explore the subject of the design review process and its engagement in digital media, with a primary focus on mobile interactive surfaces. Although a growing body of academic research on the topic is increasing, there is a gap in envisioning how aspects of the design review process can optimally engage with digital media. To bridge this gap, this research focused on an approach that borrowed from a combination of disciplines, including urban planning and communication theories, and socio-economic-politics and ethics. This chapter draws on the leading theories and academics’ and practitioners’ perspectives in these fields to provide an overview of underlying contributors to the design review process including the interaction between urban planning stakeholders and tools and technologies. The main contributions of this thesis combine both empirical and conceptual design components to support the design and evaluation of SketchBoard, a proposed new interactive communication medium that uses interactive surfaces to engage with different aspects of the design review process.

Chapter II is divided into two sections, specifically Research Background and Methodological Process, which are detailed below:

Part I, “Research Background” gives an overview of the multidisciplinary notion presented in this thesis that lies at the intersection of two fields: the design review process and the implications for interactive surfaces. Although this thesis is not about urban planning or communication theory per se, these domains are used as the substantive topics to explore various aspects of the design review process. This will be discussed together with an overview of urban planning technologies followed by integrating these topics into considerations for improving visualization, communication, and participation in conjunction with digital media. The sections in Part I concern the urban planning process and theory, and technologies for participation.
Part II, “Research Methodological Process,” accordingly, is dedicated to describing the integrated methodological process of the research, which combines ideas and methods from design, social science and HCI. To understand the mechanism of the conceptually complex topic of the research, these approaches need to explore the nature of technologies relative to the situated socio-economic-political and ethical context of the design review process. Methodologically, to conceptualize, implement, and analyze the proposed approaches between urban planners and technology in the design review process put forth, this research drew on a design-oriented technique such as minimalism and empirical-oriented approaches such as contextual design and cognitive ethnography integrated with experimental methods such as digital paper prototyping. Characteristics and limitations of these methods and how they were applied to conduct the research are discussed. Finally, the sections in Part II concern research through cognitive ethnography and contextual design, triangulation, notions of design and minimalism, affinity diagraming, and limitations of research methodological process.
Part I: Research Background

2.1 Urban Planning Process and Theory

2.1.1 Practical Urban Planning Theory

This thesis applies Forester’s Practical Planning Theory to clarify the structural obstacles to a democratic urban planning process, such as misinformation, misrepresentation, and counter-production in the technical urban planning process.

Urban planners are gatekeepers of information which is a complex source of power. Urban planners also have the power to silence or empower other voices. As future-oriented actors, urban planners shape information to focus attention practically and politically to argue about future possibilities and to make decisions. Moreover, in their positions, urban planners have the power to manage uncertainties and to reshape problems and possible solutions through specialized knowledge and technical expertise. Therefore, urban planners’ approaches as both pragmatists and liberal-advocates can influence the socio-economic-political premises of urban planning communicative actions [1].

Furthermore, urban planning is fundamentally an argumentative and communicative action rather than an instrumental action. Urban planning relies on the complex communicative performances of many diverse participants who transmit information. However, the organizational and political context of urban planning systematically attempts to distort communication and withhold information from stakeholders. Thus, imperfect information and distorted communicative interaction are the inevitable, avoidable, systematic, and ad hoc outcomes that are a part of the socio-economic-political structure of the urban planning process [1][5].
Moreover, the critical and ethical structure of urban planning theory focuses on distorted communicative interaction and imperfect information. Urban planning theory stresses that the distorted nature of communicative interactions employ profit-seeking, unrealistic expectations, unnecessary dependency, and misinformation about benefits and dangers to the public. Urban planning theory also focuses on the precariousness of social and democratic institutions. However, social interactions depend highly on mutual understanding where there is freedom from domination. However, because the contextual complexities of the urban planning process often makes it difficult to achieve such understanding, less criticism of the communication and technical activities surrounding the urban planning process would make more sense [1] [5].

2.1.2 Critical Theory and Urban Planning Practice

This thesis applies Habermas’ Critical Communications Theory of Society to urban planning practice to illuminate urban planning as communicative action; urban planning as a socio-economic-political process; and obstacles of the transmission of information in the participatory urban planning process.

Habermas’ theory argues that communicative action is fundamental to collective and cooperative working relationships while seeking a common knowledge and understanding within an ongoing process. Habermas’ ideology seeks pragmatically effective communication, which leads to mutual understanding, trust, and cooperation, however, in reality communication often results in misinformation, mistrust, and misrepresentation. Furthermore, whether intentional or unintentional, imperfect, and distorted information and communication can obscure issues and manipulate trust and is inevitable to communicative interactions [2] [5].
Habermas’ theory can serve as a basis for the urban planning processes as a politically-charged phenomenology. His theory probes the contingency of urban planning processes, while “making sense together” is a social accomplishment. Habermas’ theory can raise a concern with social epistemology and the political implications of urban planning as a fundamentally communicative, intersubjective, empirical, and institutionally situated action. Moreover, while, the universal pragmatics or four norms of ordinary communication are comprised of comprehensibility, sincerity, legitimacy, and truth, yet, the socio-economic-political structure of the urban planning communicative action is systematically distorted [2] [5].

However, Forester’s theory argues that the spectrum of urban planning actions broaden from technical to communicative actions. The practical communication in urban planning structures the analysis of technical aspects such as calculating specifics parameters, solving equations and revising and reviewing policies and plans. Nevertheless, urban planners attempt to reduce the accessibility of information by defining problems as excessively technical or complex for non-professionals to comprehend. Forester argues that typical communications by urban planners such as, “leave the analysis to me; I’ll give you all the results when I am through; you can depend on me,” are prime examples of communicative actions that could lead to a distortion of communication and a misinterpretation of problems [2].

Traditionally, the urban planning process predominately involves isolated technical work, whereas urban planning software is limited to immobile desktops. This isolation impedes the active participation and communicative interaction of urban planning stakeholders within the urban planning process, thus, misinformation and misinterpretation are inevitable. In addition, to improve the productivity and efficiency of urban planning processes, the perpetuation of power versus powerlessness relationships amongst urban planning stakeholders should be reduced.
Hence, the urban planning communicative and technical actions could be improved through an enhanced use of emerging technologies. Such technologies could bridge the gap between significant participation in deliberative democracy and an increase in accessibility to information, systematic search for design alternatives, and construction of new design ideas in a collective brainstorming setting [2] [24].

2.1.3 Urban Planning Education

Studies reveal that there is a tenuous relationship between the urban planning academy and professionals. The divide between academics and practitioners of urban planning is an oft-recognized phenomenon. On one hand, differing opinions reflect that urban planning practitioners focus on the realities of everyday urban planning practice. On the other hand, urban planning academics focus on foundational knowledge and methods, as well as providing professional practices for urban planning practitioners. This then necessitates maintaining participatory relationships between the perspectives of urban planning academics and practitioners [19] [20].

From an academic perspective, urban planning practice is not defined as substantive knowledge, but as socio-political knowledge for collaborative and future-oriented decision-making and problem-solving strategies. An urban planning professional perspective argues that urban planning deals with unusual problems. This fact also forces urban planners to play several roles to resolve complex, dynamic, and unpredictable socio-economic-political problems. In addition, studies demonstrate that urban planning practitioners concentrate more highly on public participation rather than technical skills, such as design, budgeting, statistical analysis, forecasting, and GIS [19].
However, urban planning academics argue that urban planning’s unusual problems can be resolved by focusing on multidisciplinary functions that include physical and spatial design, and communication and ethics, while acquiring fundamental and substantive knowledge and methods of urban planning through the history and theory of urban planning practice. Furthermore, various studies argue that it is difficult practically to design curricula to address the diverse skills and separations of all urban planning students who come from different academic backgrounds and experiences. In particular, some researchers discuss the challenges of teaching computer technologies and quantitative analysis to students with different educational backgrounds and levels of knowledge in the subject area. Moreover, it is indicated that urban planning academics overemphasize history and theories, which are remote from the realities of urban planning practice. However, urban planning practitioners have difficulties in understanding the relationship between abstract notions and today’s urban planning problems. Most importantly, many studies point out that there is somewhat of reluctance amongst urban planning practitioners and urban planning students towards using digital technologies [19].

According to today’s urban planning accreditation, students are required to “collaborate with peers in more explicit joint learning activities organized to produce a plan or urban planning product for a relevant professional clientele …” Hence, the gap between the expectations of urban planning professionals’ career profiles and their acquired academic knowledge is an inherent complexity pertaining to urban planning as a discipline and profession. Such inherent difficulty could be reconciled through an exchange of knowledge by urban planning academics and the practical expertise of urban planning professionals through the use of participatory technologies such as digital communication-focused media that facilitate shared knowledge and understanding [19] [24].
2.1.4 Urban Planning Computer-Based Participation and Group Learning

Studies demonstrate that participatory urban planning is both a collaborative and collective process, comprising a broad spectrum of stakeholders with the intention to generate mutual understandings and adjustments to achieve some degree of agreement. The participatory urban planning process aims at transferring technical knowledge and producing new knowledge through engagement and interaction of a wide array of stakeholders. Moreover, some studies further argue that the fundamental objectives of a successful participatory and consensus-building urban planning process are “joint learning about technical and political aspects of a problem,” “shared understanding of each other’s needs and situations,” and “shared problem definition” [46].

However, computer-supported participation and network-based procedures only support the technical aspects of urban planning participation. In addition, the Internet-based supported urban planning computer applications that involve text-based material focus on a specific type of interaction. Such technology ignores the complexity of the socio-economic-political context of communicative and participatory interactions in urban planning and design activities. In addition, the usability constraints of current urban planning computer applications make them cumbersome technology to use. Therefore, despite varying degrees of expertise for stakeholders involved in the urban planning process, only experts are able to operate urban planning computer applications somewhat effectively [47].

Reviews of the past failures of urban planning technologies outline the use of inappropriate technologies for specific kinds of urban planning problems. They also present the need for generating unambiguous information required to deal with empirically and conceptually complex topics in urban planning. Recognition of these challenges should lead to different ways of
involving the urban planning stakeholders and tools and technologies in the participation activities for generating design ideas and discussing the socio-economic-political implications of those ideas. These messages guide the design of a platform explicitly for communication that improves participation in empirically and ethically significant socio-economic-political decisions in urban planning. Although, there is no single pathway that characterizes the relationship between urban planning stakeholders and the communicative and technical activities, perhaps incorporating new digital media would enhance liberal participation in pursuit of existing and future urban planning and design activities [7] [24] [47].
2.2 Technologies for Participation

2.2.1 Role of Technology in Urban Planning

Computers have evolved from expensive, fragile, remote, and hard-to-use devices to inexpensive, small, easy-to-use, fast, and more powerful microcomputers. Furthermore, visualization in CAD, PSS, and GIS has taken advantage of the development of fast, high resolution, and full-colored display computers. Moreover, practice of urban planning has become more accessible with significant improvement in the capacity and speed of data storage and communication devices from Local Area Networks (LANs) to the Internet. In addition, this trend introduced the paradigm of “virtual organization” that enables information to be available to urban planners independent of their geographically dispersed locations [7] [10] [33] [48].

In the past, without computers, urban planners previously worked with paper-based documents such as spreadsheets and sketches, as well as crafted material. However, urban planners optimistically began using computers for urban planning and design purposes in the 1960s. In that period, computer-assisted planning was used in professional practice for large-scale metropolitan land use and transportation models integrated with municipal information. Consequently, the failure of these models in the 1970s demonstrated that the rationale of science for urban planning in creating such models was mostly inappropriate for public participation. Nonetheless, the development of microcomputers in the 1980s and the availability of GIS in the 1990s reignited urban planners’ optimism in using computer aided planning [7] [10] [33].

Fundamentally, however, urban planners continually fail to use computers to perform urban planning functions in their professional practice. This problem originates primarily from the limited understanding of urban planning technologies by urban planners, which is a result from
failing to consider the human element. Additionally, the underlying rational for the design of a new urban planning technology that supports the current attitude in urban planning practice is to understand the particular needs of urban planners. However, focusing on a particular technology or an expert system that requires extensive technical training limits the introduction of a new urban planning technology [7] [10] [33].

The concept of PSS (see section 2.2.2) suggests that the combined use of a different range of information technologies and models can enhance the specific professional responsibilities of urban planning. An interactive style of computer manipulation has been made possible with the use of electronic spreadsheets, database management systems, and graphical-multitasking operating systems. But, computers in urban planning are mainly used for general-purpose tasks such as office functions, processing documents, monitoring budgets, and maintaining records, thus, failing to take full advantage of the benefits of technological tools [7].

In urban planning, stakeholders normally find it difficult to understand and digest technical actions, such as quantitative analysis. A solution to this is more technological advancement in urban planning. Moreover, visualization is also a valuable source of information that could assist communicative interaction by providing more visual thinking and understandable representation. Ultimately, urban planning’s fundamental premise is to develop an understanding of solving problems through communication and collaboration among many participants [1] [7].

In the 1960s, urban planning as an applied science, suggests the fundamental transition of urban planning perception from design, which focuses on the traditional design of the physical city to an applied science, which is concerned with social science theories and quantitative techniques. In addition, the applied science model of urban planning describes information as a value and a
politically-neutral resource. This perspective requires that urban planners should provide useful information that informs and improves the policy-making processes [7].

In the 1970s, urban planning as politics, describes that information in urban planning which is not straightforward. Computer-based information and analytic techniques were used then in urban planning to transmit information from inaccurate paper-based record to a more accurate and current digital form. As a result, this led to increased public awareness surrounding the urban planning process as previously obscured issues began to be revealed and became one of the most important political implications of urban planning computer-based information systems [7].

In the 1980s, urban planning as a communicative action, describes urban planning as a collection of information for improving the policy-making process. Urban planning also involves formulating policy, making plans and revisions, negotiating, explanting, interpreting legal status, and undertaking quantitative analysis [7].

Today urban planning, as a collective and communicative design process, suggests that urban planners’ computer-based tools and technologies must support collaborative urban planning and collective decision-making processes. Currently, social and ethical views on urban planning communication focus on lower levels of abstraction on decision-making processes. These views suggest “collective common sense” and “deciding and acting” within an “interactive and inter-subjective communication” that follows the knowledge and consciousness of individuals [7] [10] [33].

Furthermore, the evolution of information technology has been critical to the organization and analysis of data, and ultimately, the creation of knowledge. This can be viewed as an evolving concern in urban planning that data changes into different forms of information within systems
such as Urban Information System (UIS) and Land Information System (LIS). Information can support knowledge-based systems, which focus on analytical modeling capabilities such as Spatial Decision Support System (SDSS) [7].

In the following sections, examples of applications that address the issues of urban planning and design review are discussed. CommunityViz and CityEngine are selected to introduce these commercial applications as they are occasionally used throughout the urban planning and design process. URP is also selected to introduce a tangible system created for academic research that also supports the urban planning and design process.

2.2.1.1 CommunityViz

CommunityViz is a modeling and scenario evaluation planning and decision support system with visual and interactive components for community planning and design. This software is based on Esri’s ArcView GIS that integrates words, numbers, maps, diagrams, and images in an interactive real-time and multidimensional environment. Furthermore, this multi-agent simulation system integrates 2D mapping information, 3D visualization, and policy simulation technologies. CommunityViz is an open-ended process that allows users to test and evaluate the implications of plans for communities and for viewing existing and proposed buildings simultaneously [49].

Moreover, CommunityViz is composed of a series of integrated modules. Scenario Constructor works as the spatial component within the ArcView two-dimensional GIS framework. TownBuilder 3D displays 2D data in a 3D virtual world and receive instantaneous visual feedback in real-time. Policy Simulator is a multi-agent simulation module that is designed based on complexity theory. Urban planners and designers, members of community, and elected
officials are the audience for CommunityViz [49]. Figure 2.1 (below) illustrates CommunityViz. Also, Table 2.1 (below) summarizes the features of CommunityViz.

![CommunityViz](image)

**Figure 2.1. CommunityViz. Courtesy of CommunityViz**

<table>
<thead>
<tr>
<th>CommunityViz</th>
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<tbody>
<tr>
<td><strong>1. Scenario constructor module</strong></td>
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<tr>
<td>1.1 Interactive exploration of present and proposal landscape scenario</td>
</tr>
<tr>
<td>1.2. On-screen feature editing</td>
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<tr>
<td>1.3 Automatic calculation of attitudes for each new or edited feature</td>
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<tr>
<td><strong>2. TownBuilder 3D module</strong></td>
</tr>
<tr>
<td>2.1 Creation of terrain models</td>
</tr>
<tr>
<td>2.2 Texture mapping of orthophotographs</td>
</tr>
<tr>
<td>2.3 Creation of 3D models representing buildings, tree canopies, roads, rivers, fences, hedgerows, and other natural man-made features</td>
</tr>
<tr>
<td><strong>3. Policy Simulator module</strong></td>
</tr>
<tr>
<td>3.1 Forecasting the probable land use, and demographic and economic changes in a community given alternative governmental and community choices</td>
</tr>
</tbody>
</table>

**Table 2.1. Features of CommunityViz**

**2.2.1.2 CityEngine**

Esri CityEngine is a 3D modeling software that uses GIS for geo-design based on 2D and 3D data. Furthermore, CityEngine is used for 3D city modeling in a virtual urban and architectural environment, simulation, game development, and film production. It also provides tools to generate and modify buildings, layout and edit street networks, distribute street furniture, create
3D road profiles, control the shape of the skyline, and analyze urban planning projects and aggregate geospatial data. Moreover, CityEngine has features for sharing 3D city scenes, editing tools, texturing façade, generating reports, visualizing 3D zoning rules, and integrating with ArcGIS. In addition, urban planners and designers and architects are the audience for CityEngine [50]. Figure 2.2 (below) illustrates CityEngine. Also, Table 2.2 (below) summarizes the features of CityEngine.

![CityEngine](image)

Figure 2.2. CityEngine. Courtesy of Esri

<table>
<thead>
<tr>
<th>CityEngine</th>
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<tbody>
<tr>
<td>1. Share smart 3D city scenes</td>
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<td>2. Easy-to-use editing tools</td>
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<td>3. Façade texturing</td>
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<tr>
<td>4. Instant report generation</td>
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<tr>
<td>5. Visualizing 3D zoning rules</td>
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<tr>
<td>6. Integrated with ArcGIS</td>
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</tbody>
</table>

Table 2.2. Features of CityEngine

### 2.2.1.3 URP: A Luminous-Tangible Workbench for Urban Planning and Design

URP is an urban planning and design and architectural system for a physically-based workbench setting. It further explores for facilitation, manipulation, exploration, and discussion how several
variables relate to physical objects. Furthermore, it employs several luminous-tangible interactions to present visual information related to physical architectural objects. URP also aims at facilitating the constraints of future urban design and considers the existing architectural structures. In particular, URP focuses on visualizing measures of distance, shadows, and reflections at different times of day, as well as wind-flow around buildings. Moreover, URP tends to focus on providing fluid and easy-to-understand manipulations to facilitate computation and thus the concrete realization of an abstract concept of the building plan. Urban planners and designers are the audience for URP [51]. Figure 2.3 (below) illustrates URP. Also, Table 2.3 (below) summarizes the features of URP.

![Figure 2.3. URP. Courtesy of MIT Media Laboratory](image)

<table>
<thead>
<tr>
<th>Feature</th>
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<tbody>
<tr>
<td>1. Shadow</td>
</tr>
<tr>
<td>2. Distance measurements</td>
</tr>
<tr>
<td>3. Reflections</td>
</tr>
<tr>
<td>4. Wind effects</td>
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<tr>
<td>5. Site views</td>
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</tbody>
</table>

**Table 2.3. Features of URP**

2.2.1.4 *CommunityViz, CityEngine, and URP Critique*

However, CommunityViz, CityEngine, and URP are cumbersome systems to operate. While both CommunityViz and CityEngine are integrated with ArcGIS, working with such software requires knowledge of GIS, which conflicts with the skillsets of urban planners or the public.
Furthermore, the limited adaptability and availability of URP as physical architectural structures to various design scenarios are some of the shortcomings pertaining to this system.

Moreover, due to the complexity of the CommunityViz, CityEngine, and URP, these systems are not commonly used during negotiations between urban planners and developers, nor between urban planners and the public. In contrast, these discussions rely on more conventional tools, such as pen and paper. To some degree, tools such as pen and paper support visual and spatial thinking and explication that would enhance collaborative and collective decision-making during the negotiation and discussion phases of the design review process.

Yet, it remains unanswered under what circumstances systems like CommunityViz and CityEngine would work well for facilitating communication and to what extent a system like URP could be applied in the practical circumstances of urban planning. Furthermore, what subtleties or nuances in the goals of these urban planning activities impact the design requirements for such tools?

2.2.2 Planning Support System (PSS)

Planning Support System (PSS) is a decision support tool that facilitates the preparation and evaluation of plans. PSS attempts to promote collaborative communication and interaction amongst urban planning stakeholders. Further, it allows urban planning stakeholders to visualize their future cities, also to provide a better understanding of their decisions. Furthermore, PSS uses analytic tools and computer simulation models along with visual displays to focus on urban and regional economic, demographic analysis and forecasting, environmental modeling, transportation planning, predicting future development, and land use patterns [7].

Moreover, PSS is also a multidimensional application based on complex attributes such as
mathematical theories and theories focusing on the structure and behavior of urban entities, urban planning processes, and spatial representations. As an information framework, PSS also tends to provide an interactive, integrative, and participatory information infrastructure for urban planning procedures. On the contrary, GIS is a fundamental component of the PSS, which requires spatial thinking skills and knowledge of GIS, thus, complex and challenging features of PSS may contradict with the skillset of urban planning stakeholders. Thus, PSS does not offer the ultimate solution to urban planning problems, and it seems unlikely to replace conventional tools and technologies in urban planning. CommunityViz and METROPILUS are both examples of planning support systems [7].

2.2.3 Urban Planning and Visualization

The urban planning process involves extensive visualization of 2D digital maps and 3D digital models. New digital technologies such as CAD, PSS, and GIS are becoming available to support the visualizations needs of the urban design and planning process. However, there is a gap in characterizing the primary concerns of urban planning stakeholders’ software skills and functions that urban planning software provides [7].

In particular, design review is an iterative process that begins by first understanding the problem context through data collection and analysis to find possible design solutions. The design review process further attempts to implement alternative plans within parallel design and decision activities, which converge through government mandate or profitable solutions. In most cases, design solutions are defined in a cyclic fashion, which depends on mobilizing the knowledge and expertise of several diverse professionals involved in the process of design review. Additionally, in the design review process, plans and various stages of design and decision-making require communication between experts, professionals, and the public. The end results of these
communicative and participatory activities are plans that visualize aesthetics, economic, social, and functional issues [7].

Furthermore, there is a complex connection between urban design and planning and the socio-economic-political institution that ultimately impacts the appearance of cities. Oftentimes, decisions that are made within socio-economic-political processes tend to address the consistency between land use, transportation, and air quality conflict with the analytical methods of urban design and planning. For example, transportation planning attempts to reduce congestion through a decrease in carbon dioxide (CO2) emissions. Thus, to enhance the stakeholders’ comprehension, the socio-economic-political implications of urban design and planning actions should be accessible in visual formats [7].

Specifically, the development of new digital technologies has moved visualization to be one of the most important activities in the urban planning and design process. For example, visualization technology for the urban planning and design process can help in problem-solving, evaluating plans and presenting spatial information that informs analysis, prediction, and optimization. Recently, decision-making systems have been combined with Virtual Reality (VR), Cave Automatic Virtual Environment (CAVE) and holobench. These tools combine CAD, GIS, and multimedia or 3D GIS tools that include all of the functionality of 2D GIS. However, today, there is no evidence that CAVE is commonly being used by municipalities [7].

Moreover, most of the current urban planning digital technologies focus on forward visualization that involves developing visual tools to support the public and interested groups. Yet, there are specific digital technologies developed for backward visualization that involves developing visual tools to support experts and professionals. However, absent is the presence of a
visualization aid that specifically supports the value and significance of communication and participation in the design review process deliberation. As opposed to the current trend, such a visualization aid should avoid the separation of target users, depending on their level of expertise. Creating a balance between the needs of users would allow for integration of the workflow of urban planning stakeholders from naïve to expert, to address their challenges in a participatory manner [7] [10].

2.2.4 Groupware and Computer Supported Cooperative Work in Urban Planning

Urban planning has recently been involved with computer-supported techniques that try to maximize collaboration. These techniques include groupware, Computer Supported Cooperative Work (CSCW), and cooperative and participatory design. Furthermore, “Groupware is an umbrella term for the technologies that support person-to-person collaboration; groupware can be anything from email to electronic meeting systems to workflow.” Groupware also includes shared drawing, group decision support, and scheduling and project management. As well, groupware allows urban planning activities within groups to negotiate spatially while designing plans and sketches and writing documents [52] [53].

In addition, to enhance work efficiency in the design review process, three important elements should be considered. First is agile communication and interaction, which aims at sharing information amongst urban planning stakeholders to negotiate possibilities and solve conflicts. Second is good information, which concentrates on cross-referencing submitted building proposals against bylaws and regulations. Third is effective processing and visualizing tools, which aim at providing spatial data handling tools and office automation functions [54].
Integration of these elements with groupware communication and interaction could be a useful mechanism to increase efficiency in the process of design review. For example, by having access to the Internet, groupware provides more opportunities for urban planning and design processes. This involves participation, increased productivity, fewer meetings, automating routine procedures, and the integration of geographically disparate teams. However, groupware involves limitations such as a lack of training and education for practitioners and the business community. The virtual workbench and virtual reality systems such as virtual cities are examples of a groupware setting [52] [53].

2.2.5 Role of Interactive Surfaces in the Design Review Process

Digital media that would enhance visualization should be characterized by unpacking the ethical, communicative, and participatory challenges embedded within the socio-economic-political institution of the design review process. This issue should be characterized by the relationship between users from expert to naïve and technologies from old to new. Recognition of these challenges could lead to an attempt to reconcile pluralistic values in the design of a new generation of a communication medium for the design review process using interactive digital media. There is a growing corpus of academic and industry work on this topic, however, drawing on Habermas’ and Forester’s theories, there is a gap in the characterization of many aspects that would enhance the significance of visualization, communication, and equal participation in deliberation tied to the use of interactive surfaces [1] [2] [24].

Specifically, from a socio-technical point of view, the design review process is not adequately understood. In the design review process, technical and political conversations are media for making sense together. Communication throughout the design review process is a guiding instrument for back and forth and the iterative process of design. The design review process
involves the participation of various individuals such as architects, developers, urban planners and politicians, who sketch, present, and modify ideas and concepts, also to review the paper and text-based bylaws and regulations. Furthermore, the design review process yet relies on the culture and use of traditional and somewhat inefficient tools and technologies [1] [2].

Examination of the design review process reveals that mobility is critical to the participatory work of urban planners. Mobility could possibly enhance tasks and responsibilities of urban planners. Local mobility that is a fundamental element to access individuals and shared resources is also essential to the design review process. Technology that supports local mobility would ease the informal and participatory interaction and awareness within the design review process. However, the requirements to support mobility in the participatory process of the design review have received little attention [11] [55].

In particular, “micro-mobility” refers to mobilizing and manipulating artifacts within the organizational setting, where various activities occur. Studying the design review process shows the “micro-mobility” of tools and technologies is critical to the work and communication amongst urban planning stakeholders. It is widely recognized that the access to real-time information, and the need for immediate collaboration with others, are essential parts of the design review process. However, the design review process still depends highly on the use of traditional paper and text-based documents [12].

Exploring the design review process provides another lens of understanding about how the complexities of computer aided planning have not been featured in empirical studies of the communication and participation activities within the design review process. What has not been identified is that computer aided planning systems are currently bound to inflexible desktop
workstations, whereas all urban planning stakeholders do not have access to the technological tools to participate in communication and design processes. In addition, typical single-user urban planning desktop computer applications do not support participatory and multi-user interactions required within the design review process [12] [55].

Moreover, participation that is a sensitive part of the socio-economic-political context of the design review process has been impacted by the traditional trend that has kept computer aided planning routinely at stationery workstations that have become increasingly complex. Group feedback has also been largely neglected by the limited movement of individuals who are still tied to complex and inflexible technologies. In exploring different stages of the design review process, the mobility of urban planning stakeholders, information, documents, and artifacts is considered fundamental in enhancing participation and communication [12] [35].

In the absence of a technology that provides a platform for generating a shared understanding through visualization, the manipulation of conversation occurs. As a result, urban planning stakeholders could interpret basic parameters differently. Thus, it can be argued that the process of participatory design and communication of the design review is significantly tied to the role of fixed technologies that are not easily accessible to all stakeholders. These fixed technologies are not self-evident, thus they require a certain level of knowledge and expertise to perform urban planning work. Therefore, the prolonged process of the design review, a lack of knowledge of design and perspective, and insufficient comprehension are the results of inaccessible and inefficient exiting urban planning technologies, wherever the urban planning stakeholders attempt to participate and communicate [1] [2] [7].

The adaptation of fixed interactive surfaces to traditional desktop computers has recently become
a concern to the research and industry communities. Such surfaces are becoming important tools for solving problems in urban planning. For example, the research community has explored that interactive surfaces are used for the planning and designing neighborhood [56]. The research community has also investigated the design of a collaborative PSS for use on a multi-touch tabletop [57]. Furthermore, an urban planning, non-immersive virtual environment is designed for spatial analysis [58].

In addition, Mixed Reality (MR) that is used for a bimanual handheld urban planning interface supports searching, inserting and creating contents [59] The Urban Sketcher is also designed to improve real-time communication amongst urban planning stakeholders [60]. Further, augmented and mixed reality and interactive tangible tabletop and 3D printed models of buildings are used to improve participation in urban planning through the communication of digital models [61]. On a commercial level, CommunityViz, in combination with fixed interactive surfaces, provides regional information through the collective use of digital maps [62].

Although this thesis does not tend to propose an optimistic scenario of new media for the design review process, the cultural technologies of digital media imply user empowerment through enhancing individual liberty and social harmony. All of the arguments deemed above may further suggest directions for designing a mobile communications technology for the design review process to access geo-located and real-time information while on the move. This mobile communication technology could increase mobility and create a balanced communicative and participatory relationship between urban planning stakeholders by reaching a wide audience. The combination of mobile with fixed interactive surfaces would support the different forms of participation required for the design review process. This system should also have a limited
amount of textual and diagrammatic documents, and instead have more graphical tools to clearly visualize ideas and concepts [10] [14] [33].

In a nutshell, traditional urban planning technologies highlight several shortcomings and challenges that require the consideration of complex accounts to be ameliorated. Although the use of interactive surfaces is not naïvely overrated, the purpose of this thesis is to capture reflections on the complexities and challenges of thinking through improving visualization, communication, and participation as fundamental components of the design review process in the governance of new digital media genre [10] [14] [33].
Part II: Research Methodological Process

2.3 Epistemology, Theoretical Perspective, Methodology, and Methods

This research undertook a postmodernist approach in qualitative research that is removed from theory-centered reasoning. Positivism relies on reliability and validity criteria as an enabling condition in qualitative research, and argues “no criterion can ever be independent of our own construction of it.” However, postmodernism moves beyond criteriology in which skepticism is advocated instead of certainty, also understanding instead of knowledge. Thus, the notion of “probable truth” in a postmodernist perspective recognizes that “no set of standards can ensure confidence that research findings are indeed entirely valid” [36] [37] [39].

This thesis presents a four-part research study that integrated subjectivism and design as the epistemological view outside of laboratory settings, in-the-wild. The advantages of research in-the-wild that drives innovation and informs the design are its real world context, gathering rich data, and generating facts that emerge from the user’s unanticipated data. The disadvantages of research in-the-wild are a large volume of data, a long timescale, the challenge of recruiting participants, a lack of reliability and validity, and difficulties with data analysis and in reporting the results [39].

Studies I and II applied a methodology of cognitive ethnography and contextual design to investigate the design review process, challenges, needs, and technologies used within this process. The data clustered through the affinity diagraming method in Studies I and II was used in Study III to explore the importance of participatory design, urban design and planning process as well as for visualization and analysis for defining the design specifications of the potentials of SketchBoard for the design review process. Study IV integrated experimental, design, and
ethnographic approaches to investigate urban planners’ experience and their expectations of SketchBoard using an interactive surface.

In the following sections, cognitive ethnography, contextual design, notions of design and minimalism, affinity diagraming, and digital paper prototyping are described as the general methodological approach used in Studies I-IV. Specific details of the meanings and perspectives for each study are discussed in the following chapters.

2.3.1 Research through Cognitive Ethnography and Contextual Design

In this research, non-theoretical approaches in design research, including cognitive ethnography and contextual design, were used. Traditionally, cognitive ethnography is associated with cultural and cognitive anthropology. Cognitive ethnography is the attempt to study the pattern of shared understanding and its evolution over time in relation to individual minds [42] [43]. Contextual design originates from the organizational challenges of designing general-purpose systems. This methodology engages the user with the participatory design process. Contextual design considers principles in psychology, anthropology, sociology, and hermeneutics in designing computer systems [38].

Cognitive ethnography and contextual design aim at studying work-in-context along with concrete details of cooperative work. In contrast to abstract, recognizable, and in general theoretical detailed descriptions of workaday activities, these methods offer a radical approach to the study of work in situ. Such subtleties of socially constructed work practices provide an opportunity to understand “what is really going on,” in the course of design review process work; “what is really the problem,” and what the possible design solutions might be [44].
Cognitive ethnography focuses on events and seeks to understand “what individuals know,” “how they acquire the knowledge,” and “how they use the knowledge to do what they do.” It is also necessary to understand situated human cognition, how individual minds process information, how the information to be processed is coordinated with social and material actions. Cognitive activities consist of internal and external resources. Understanding the context of actions in relation to internal and external resources provides meanings to social and material actions [42] [43].

Contextual design aims at identifying an appropriate way of gathering helpful information about participants involved in similar work practices and organizational challenges. Contextual design tends to transform individuals’ and teams’ work practices through the use of computer systems, including hardware, software, services, and support. To achieve this, contextual design provides an understanding about the user’s work practices. This then forms the basis for designing a medium that will support the user’s work. This process can be combined with a participatory design method such as mock-ups to co-design a medium [38].

However, obtaining benefits from user involvement is a difficult task and challenges arise, for instance, partial understanding of the verbal communication between researcher and participant is inevitable. In verbal communication, the researcher and participant need to become familiarized with one another’s different interactional dynamics. Normally, use of prototypes can stimulate the conversation and reduce the dependence on verbal communication, however this introduces design limitations. Furthermore, conducting interviews is generally part of ethnographic studies. Interviews provide a description of activities in which participants are engaged. However, there is a distinction between what participants say and what they do in everyday activities. In some cases, participants are not prepared with the knowledge and skills to
fully articulate their ongoing activities and they may be unable to reflect upon them. In this case, interviews can be combined with both unobtrusive and participant observer roles. Moreover, conducting surveys is another well-established and common technique of compiling data through reaching a wider demographic group at the same time [41] [63] [64].

2.3.1.1 Distributed Cognition

In this research, ethnographic field studies were used to investigate the phenomenon related to the distribution of cognition within the design review process. Distributed cognition, as the most socially-oriented activity, focuses on understanding the whole environment where urban planners and technologies interact within the design review process. The characteristics of the design review process create a unique cognitive ecology that includes the urban planning stakeholders and artifacts they use in their functional system. The distributed cognition approach is used to touch upon the cognitive processes that emerge from interaction among internal (mental) and external (cultural) resources within the design review process. Distributed cognition suggests a radical reorientation of how to think about designing and supporting SketchBoard, a user-centered interactive communication medium for the design review process [42] [43] [44] [64].

2.3.1.2 Context, Partnership, and Focus

In this research, the three principles of contextual inquiry process were used; these are context, partnership, and focus. Context provides an understanding of the urban planners’ work within the design review process through observation of the urban planners during their ongoing work and through ongoing dialogue with them while they use work artifacts in their actual work environment. Partnership with the urban planners through dialogue needed to be established to direct the area of concerns, along with empowering urban planners to lead the conversation and articulate the nature of the design review process and subtleties pertaining to the zoning
ordinance. Hence, the focus of the inquiry was to uncover urban planners’ experience of work and their use of technology within the design review process and to develop a series of Flow, Sequence, Artifact, Cultural, and Physical Models of work for the design review process (see Chapter IV) [38] [40].

2.3.1.3 Combining Distributed Cognition, Context, Partnership, and Focus

Distributed cognition, context, partnership, and focus can provide an understanding of the urban planners’ work settings through exploration of the design review process. This could lead to a set of concepts that describes the complexities and challenges within the design review process. The distributed nature of cognitive phenomenon can discover the context within the design review process through forming a partnership with urban planning stakeholders, and therefore focusing on artifacts, and internal and external representations of such a process. These issues can further be described in terms of the design review’s communication and technical pathways such as poor communication, ineffective propagation of information, and coordination of different technologies. This results in a contextual description of the urban planning stakeholders’ work that stresses information and its propagation through the cognitive system of the design review process [6] [38] [42] [43].

However, integrating various contextual perspectives and influences of the urban planning stakeholders and urban planning technology into the participatory nature of the design review process is challenging. Distributed cognition can elaborate on functional relationships between elements that participate in the design review process where a group of minds without a unified mindset seek to store their distributed knowledge in external artifacts such as sketches, models, and documents. The design review process is a cognitive functional system, in which the boundaries of the unit of analysis for cognition are defined by the functional group, rather than
considering individual minds. This functional group consists of the urban planning stakeholders and their organized processes and interactions with one another and artifacts. The relation between these distributed cognitions needs to be contextualized and coordinated effectively to accomplish a new functional skill in a dynamic functional system that could lead to the design and evaluation of SketchBoard for the design review process [4] [6] [42] [43] [64] [65] [66].

In Studies I and II, a methodology of cognitive ethnography and contextual inquiry were used to develop a descriptive understanding of urban planners’ actions and work practices. These methods for data collection were performed by looking at the communicative and technical complexities across the design review work practices such as routines, procedures, workarounds, breakdowns, incidents, unusual happenings, and communication failures. Conducting these approaches also helped urban planners to articulate their current work practices within the design review process and provided an understanding of a shared and consistent vision among urban planners. In Studies I and II, the semi-structured interviews and participant and non-participant observations served as an introduction to urban planners’ work and tools, and the technologies used to accomplish the work practices of the design review process. During these interviews, urban planners were asked to provide demographic information, also to describe individuals with whom they interact, work practices they are engaged in, and the tools and technologies they use. All interviews were recorded as field notes and were the basis for choosing to observe in detail the artifacts in use, such as technologies, software, hardware, and documents as they move from office-to-office and person-to-person. In all observation sessions, and in some of the interviews, urban planners were asked to demonstrate the software or computer applications they use.

In Studies III and IV, insights from Studies I and II provided the basis for creating SketchBoard which supports urban planners’ work within the design review process. In Study III, a
methodology of cognitive ethnography and the contextual design helped to build various scenarios within the design review process, such as zoning and FAR. In an exploratory fashion, this study recommended a set of features for creating SketchBoard which supports the work conducted within the design review process. Study IV employed minimalism as a design technique to refine a set of design specifications, and then an experimental digital paper prototype was used as a method for the process of co-designing SketchBoard with urban planners. This study also attempted to gain further understanding about the urban planners’ needs and experiences while designing an exploratory SketchBoard that visualizes the zoning ordinance and facilitates communication of the design review work in a real world setting. In this study, a methodology of cognitive ethnography and contextual design were used to evaluate urban planners’ expectations of SketchBoard and their reaction.

2.3.2 Triangulation

In this research, cognitive ethnography and contextual design used triangulation to ensure that all aspects of a phenomenon under study had been investigated from multiple perspectives. To enhance the quality of the research, triangulation was used to provide various methods of data collection such as semi-structured interviews, participant and non-participant observations, structured surveys, and demos of the digital paper prototypes. To complete the understanding of the concepts, a range of data sources such as a variety of individuals, spaces and times were chosen for interviews, observations, surveys, and demos of the digital paper prototypes. This ensured that final representation of the data accurately reflected the experience [45] [64].

2.3.2.1 Interviews, Observations, and Surveys

In this research, a series of field studies involving a combination of semi-structured interviews, participant and non-participant observations, and structured surveys were conducted. The semi-
structured interviews with the urban planners involved open-ended questions, and the participant and non-participant observations of the urban planners involved studying the urban planners within the design review process. Extensive note-taking and audio recording were used to document interviews and observations. The structured surveys with the urban planners involved closed-questions [38] [39] [40] [41].

In particular, the interview, observation, and survey-based design process of creating SketchBoard for the design review process focused on three key parameters. The first focused on the urban planners as they went through their daily routine (person focus). The second focused on the urban planning activities at the urban planners’ work environment (place focus). The third focused on the life history circulation of urban planning documents as they moved between different offices and amongst different individuals (object focus) [39] [40] [41] [64].

2.3.2.2 Digital Paper Prototyping

In this research, digital paper prototyping was used to communicate the design concept, collect audience feedback on the flow of interaction, and work throughout a design. For the purpose of prototyping, different scenarios and personas and subsequent storyboards were imagined and allowed to practice through combining the paper prototype and a tablet. In general, the first and most important step in the prototyping process was to understand the audience and the intent of the prototypes’ objectives. The second step began with planning on a whiteboard or with paper and pencil, and then drawing and drafting rapid iterative versions, reflecting incremental and evolutionary prototyping. The third step was to set expectations by determining the right level of fidelity and key functionality. The fourth step was to sketch out the idea and to write the labels. The fifth step was to make or fake the prototype by assembling a series of images and basic hide
and show interactions built into the prototype. Finally, interactive surfaces were used for creating basic interactivity by adding a few hotspots to each keyframe [67].

2.3.3 Notions of Design and Minimalism

In this thesis, minimalism was used as a user-centered design technique for creating SketchBoard. The notion of minimalism as a means of reductionism focuses on reducing complexity to define different aspects of simplicity, and thus to reach a “good design” in the new genre of digital media for the design review process. Inspired by the idea that “form follows function,” thus, minimalism combines both usefulness and aesthetics to create SketchBoard. In particular, for the design of SketchBoard, four notions of minimalism were employed, including the function, structure, architecture, and composition of the interface and interaction design [68]. These four notions are described below:

1. Functional minimalism intended to reduce complexities for “accessible functionality” in the interface and interaction design. A functionally minimal interface and interaction design for SketchBoard were simply created to reduce unnecessary functions for the user, thus the interface and interaction design were useful only for a single purpose [68].

2. Structural minimalism intended to reduce complexities of the “perceived access structure” of the interface and interaction design. A structurally minimal interface and interaction design for SketchBoard were created in a manner that did not involve the user with unnecessary navigation [68].

3. Architectural minimalism intended to reduce complexities for the “externally visible distribution of responsibility” of the interface and interaction design. An architecturally minimal interface and interaction design of SketchBoard were created in a manner whereby simple
elements were combined transparently; this thus provided a comprehensible and recognizable interface and interaction design that allowed the user to understand and predict the interface and interaction design’s behavior [68].

4. Compositional minimalism intended to reduce complexities of the interface and interaction design through a “specificity for planned tasks” that extended the usefulness of the interface and interaction design beyond a single application or environment. A compositionally minimal interface and interaction design for SketchBoard were created in a manner that did not involve the user with unnecessary workflow [68].

2.3.4 Affinity Diagraming

In this research, affinity diagraming was used as an analytic method for analyzing the data through structuring ideas from a set of unstructured ideas. The affinity diagraming derives from “seven quality processes,” also known as K-J methods. This is a manual, non-computational technique commonly used in contextual design for illustrating the participants’ problem context by focusing more on the practical side of the design process. It aims at interpreting and organizing the qualitative data collected during interviews, observations, surveys, and the digital paper prototypes through inductive, bottom-up reasoning. It is also used for analyzing the data by dividing the data into elements. Then, each element is categorized in a meaningful way with an appropriate granularity. Categories of the data that emerged from participants’ insights and ideas are defined by the goals of the study. This also helps organize the data into a hierarchy presenting common patterns and structures. These patterns and structures emerge from the data, rather than from a predefined scheme [38] [64].
Specifically, affinity diagraming conceptually groups and regroups the data. It structures common themes and records the explicit piece of data on individual notes that are printed on post-its. Each note tells the most optimal insight into the affinity. The first step in the process of consolidating the data is to place one note on a wall. Next, to look for other notes by using a similar search strategy to find a similar note that has the same affinity and expresses similar issues or intents. The data captured on the note infers the meaning of the word. This helps look at the data from a particular focus, inquiring into the meaning of the words, interpreting the words, and creating a certain kind of affinity. Based on the focus of the research, notes are clustered together in themes. While data analysis progresses, common issues and categories are inductively and iteratively organized into affinity diagrams. The second step in the process of organizing affinities is that while groups accumulate many notes, they are broken into a structure with a three-level hierarchy. When groups are formed, they are given a succinct name that represents the summary of the content of the particular group. Then, a color-coding technique is used to assign a unique color to each level. The first level is assigned green, the second level is assigned pink, and the third level is assigned blue. The steps are illustrated below in Figure 2.4. However, affinity diagraming is a time-consuming, complex, and intensive method, which may require modification in steps based on the requirements of the research [38] [64].
2.3.5 Limitations of Research Methodological Process

In this research, conducting qualitative research using the methodology of cognitive ethnography and contextual design was distinguished by complexities and nuances. Collecting valuable qualitative data in the context of the participant’s own environment and experience was the main challenge faced in qualitative studies conducted as part of this thesis. Furthermore, participants tended to speak about their work practices in abstraction, which may lead to failure in designing a system. Biases are also inevitable in the uncontrolled nature of cognitive ethnographic studies and contextual design settings. In this thesis, studies that were conducted through cognitive ethnography and contextual design focus on describing in detail the experience of the phenomenon under study for further investigation. Although, this maximized the understanding
of particular issues with a few participants, nevertheless findings of these studies enable generalizability in similar design-oriented contexts within disciplines such as industrial design, media design, urban design, architecture, computer science, and engineering [45] [69].

2.3.5.1 Biases

In this research, qualitative research methodologies such as cognitive ethnography and contextual design always coexist with personal biases that reflect the researcher’s motivations and perspectives. Because conducting cognitive ethnographic and contextual design studies requires interaction between the researcher and participant, somewhat, at a personal level, this may influence how interviews are conducted in an uncontrolled setting. Furthermore, the data analysis can be influenced by the researcher’s personal interpretation during interviews, observations, surveys, and demos of the digital paper prototype. This problem can be avoided or reduced by the researcher constantly maintaining awareness about the focus of the study while involving multiple researchers to analyze the data. The neutrality of the findings can also be increased throughout the research process by prolonged engagement of the researcher and participants and the use of the triangulation method. This is because the longer a researcher engages with participants, the more insight he or she usually acquires. Moreover, to decrease inevitable biases generated by the researcher, participants’ original quotes are also included in the data analysis sections [36] [37] [45].

2.3.5.2 Generalizability

In this research, qualitative research was characterized by the unique nature of every research situation, however, findings can be somewhat generalized to certain other disciplines such as industrial design, media design, urban design, architecture, computer science, and engineering. In a broad sense, characteristics that define generalizability are unrestricted to time and space,
hence they must be universal and have pervasive influence. However, this thesis argues against using generalization as a grand formula for the socio-political institution of the design review process. Hence, this thesis employs naturalistic generalizations that “reside-in-mind in their natural habitat.” In this thesis, naturalistic generalizations combine formal knowledge of the design review process with the personal experience of the researcher obtained throughout the empirical and design explorations. Furthermore, in the course of this research, the generalizability and reliability of data gathered through cognitive ethnographic studies and contextual design are concerned with the same or similar design-related studies. Each study in this research was designed to focus on a particular scenario, which somehow differs from other studies in the same or similar domain. In these types of studies, the data analysis results from the researcher’s interpretations which may be different from other researchers’ interpretations. Therefore, the perspective of the researcher in this thesis for designing the studies and in analyzing the data is a personal task that has influenced the results of the study. Consequently, the researcher’s perspective may be different from how other researchers would potentially design the study or analyze the data [36] [37] [45].

2.4 Summary of the Chapter

In this chapter, background to this research is described. This includes previous work related to this research and an overview of the general research methodological processes that are discussed in Part I and II. This research investigated the role of contemporary mobile interactive surfaces in the pursuit of improving visualization, communication, and participation goals within the design review process. This was premised on the understanding of the technical and communicative contexts of the design review process, individuals, artifacts, tools, and technologies involved in this process and the interaction between them.
Part I describes practical urban planning theory and critical theory and urban planning practice that provide the theoretical foundation for this research. Furthermore, examining the participatory technologies for urban planning reveals the shortcomings pertaining to such systems. Moreover, studies around using interactive surfaces in the urban planning domain are largely unexplored. More recently, fixed interactive surfaces are being used for collaboration purposes in urban planning. Yet, it is still unclear exactly how mobile interactive surfaces within the design review process can enhance communication, active participation, and unambiguous visualization.

Part II focuses on describing the multidisciplinary design and empirical methodological approach used in this research. This approach borrows from cognitive ethnography and contextual design as qualitative empirical methodologies and minimalism as a design technique, which were used to conduct Studies I-IV. In addition, the main limitations of this research are a small sample size and the time-consuming process involved with analyzing and interpreting large volumes of data. Biases and the issue of generalizability pertaining to this research methodological approach mean that the researcher’s personal opinions and interpretations might have influenced the way this research was conducted. The specific focus of this research may also affect the generalizability of the findings.
Chapter Three: Study I: Perception and Reality: Can Technology Enhance Participatory Communication within the Urban Planning Process?

3.1 Introduction

Oftentimes, within the urban planning process, urban planners and GIS experts must work together using desktop CAD and GIS. However, participatory communication and visualization which are important in the urban planning process, are not a central focus in the design of current computer-aided planning technologies. Furthermore, most existing desktop CAD and GIS technologies are designed with the idea that urban planners and GIS experts are at their desks. However, such conventional systems do not fully fulfill the mobility and participatory communication needs required in the work of urban planners and GIS experts [11] [12] [35].

Consequently, much more effort needs to be directed towards the development of new technologies that support both mobility needs, and participatory communication and visualization as compared to current desktop workstations in the work settings of urban planners and GIS experts. Additionally, although there is a perception that interactive surfaces are useful in enhancing participation between urban planners and GIS experts within the urban planning process, there is insufficient understanding about the specific communicative needs of urban planners and their stakeholders in these contexts [7] [13] [14] [56] [57].

For this reason, this study provided an understanding of technological challenges and complexities that urban planners and GIS experts encounter while engaging in a participatory environment during the urban planning process. This study also explored the perceptions of urban planners and GIS experts about the potential impact and usefulness of interactive surfaces in their practices. Thus, a series of semi-structured interviews was conducted with urban planners and GIS experts involved in the urban planning process. These interviews offer a snapshot of
urban planners’ and GIS experts’ needs and expectations while interacting with CAD and GIS when provided with interactive surfaces. Finally, analysis of the interviews revealed that participatory communication, visualization, and computation within the design review process could potentially be supported by using interactive surfaces.

3.2 Scope of the Study

This study had the following objectives:

1. To investigate the types of tools and technologies that are needed to support the work of urban planners and GIS experts using interactive surfaces.

2. To develop an understanding of how urban planners and GIS experts currently use desktop CAD and GIS computer applications.

3. To explore what urban planners and GIS experts envision as potential uses for interactive surfaces.

3.3 Study Methodological Process

This study intended to explore current desktop CAD and GIS computer applications and the potential use of interactive surfaces in urban planners’ and GIS experts’ work practices. This study was conducted in two continuous steps for each participant. Step one involves semi-structured interviews, step two was a demonstration. The interviews also consisted of two parts. In the first part, participants were asked about their background, knowledge, and experience. They were then questioned about the tasks they normally perform using CAD and GIS computer applications. In the second part, participants were asked specifically about their experience using interactive surfaces with CAD and GIS computer applications. For many of those interviewed, their answers to questions about the use of interacting with CAD and GIS on interactive surfaces
were based on little to no experience with these new technologies, but primarily drew on their general CAD and GIS expertise. Furthermore, information was gathered during and after the demonstration of the mock-up. The semi-structured interviews and demonstrations took approximately one and one half hour for each participant.

3.4 Participants

In this study, ten participants, including six urban planners and four GIS experts, were recruited. Purposeful sampling strategy was used to select the participants [39]. Moreover, the snowball sampling technique and an email distribution list was used for recruiting participants from urban planning and GIS domains. Participants were interviewed individually; they had the freedom to explain their background, existing knowledge, prior experience and preconception of the tasks. Table 3.1 (below) shows participants’ biographical information.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Urban Planners</th>
<th>GIS Experts</th>
<th>CAD-Experience-Yrs</th>
<th>GIS-Experience-Yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>N</td>
<td>Y</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>P2</td>
<td>Y</td>
<td>N</td>
<td>N/A</td>
<td>20</td>
</tr>
<tr>
<td>P3</td>
<td>Y</td>
<td>N</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>P4</td>
<td>Y</td>
<td>N</td>
<td>N/A</td>
<td>8</td>
</tr>
<tr>
<td>P5</td>
<td>Y</td>
<td>N</td>
<td>15</td>
<td>15</td>
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<td>P6</td>
<td>Y</td>
<td>N</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>P7</td>
<td>Y</td>
<td>N</td>
<td>N/A</td>
<td>19</td>
</tr>
<tr>
<td>P8</td>
<td>N</td>
<td>Y</td>
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<td>N/A</td>
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<td>P9</td>
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<td>P10</td>
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<td>Y</td>
<td>N/A</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1. Participants’ Biographical Information

3.5 Interview Method

The first step in Study I was semi-structured interviews. The goal of these interviews was to discover how the participants use CAD and GIS computer applications in their work practices, as
well as how they envisioned interactive surfaces enhancing their work. The exploratory nature of this study involved changing the semi-structured interview questions as the study progressed. Each interview involved twenty-three questions. The interview questions were designed to be sufficiently open and flexible to allow shifts in plans and exploration. While the interviews progressed, depending on participants’ prior knowledge or experience, they were asked slightly different questions. Each interview began with the same set of open-ended questions. The purpose of the first questions was to gather demographic information about the participants. The interview session took roughly one hour for each participant (see Appendix I.I for the twenty-three interview questions).

3.6 Demonstration Method

The second step in Study I was a demonstration. The purpose of the demonstration session was to show the participants CAD and GIS computer applications combined with the use of interactive surfaces. For the purpose of the demonstration, a mock-up was employed to present a participatory environment for viewing and manipulating CAD drawings and models, and GIS maps using Microsoft digital tabletop and iPad. During the demonstration session, participants were asked about their understanding, needs, perception, and suggestions pertaining to the use of CAD and GIS-based mock-up on interactive surfaces. The demonstration sessions varied between fifteen to thirty minutes for different participants.

3.7 Data Collection and Analysis

All the interviews, including the demonstrations, were audio recorded, and then transcribed manually. In this study, an affinity diagraming technique was used to analyze the data [38]. This approach enabled the organization of ideas and statements gathered during the interviews and demonstrations. As part of the data analysis, each category was divided into more detailed
categories in a meaningful way as determined by the goal of the study. Below, Figure 3.1 shows how the main categories were manually organized. However, in the next steps, Microsoft Excel was used to computerize the categorizing and analyzing of the data. Thus, five main categories of practices that need to be supported were articulated, including: General Practices with CAD and GIS; CAD and GIS Operations and Software; CAD and GIS and Interactive Surfaces; Desktop Computers and Interactive Surfaces; and Perceptions of Users. Figures 3.2-6 (below) illustrate the affinity diagrams. The results first focused on discussing the general urban planning and, CAD and GIS practices that participants have experienced with desktop CAD and GIS computer applications and interactive surfaces. Following this, a variety of elements and activities were investigated. In addition, in the results sections, representative quotes, along with participants’ numbers next to the quotes, are listed to further anonymize the results.

Figure 3.1. Manual Affinity Diagram: Inductive Process of Clustering Notes
3.7.1 General Practices with CAD and GIS

All participants commented on their General Practices with CAD and GIS throughout the course of their work, and certain, specific comments are pointed out in the section below. Figure 3.2 (below) illustrates an affinity diagram of General Practices with CAD and GIS.

![Affinity Diagram of General Practices with CAD and GIS](image)

**Interactive Surfaces.** Two participants stated that they had used their personal iPads to interact with CAD and GIS, whereas four participants had never used interactive surfaces; and four participants only had a brief experience using interactive surfaces, such as smart-boards to interact with CAD and GIS in demonstrations.

**Experience and Software.** Participants had between eight and twenty-five years of experience in academia and industry. They used a variety of combined desktop CAD and GIS computer applications. Out of a total of ten participants eight used CAD and/or GIS software; five used only GIS software; and three used both CAD and GIS software, as shown in Table 3.1.

**Participatory Practice.** All participants stated that their work requires them to collaborate with technical staff, clients, and researchers. Three participants mentioned that they collaborate with other researchers and students from different disciplines for writing academic papers. Three participants also collaborate with others to improve community engagement. This requires them to work with a diverse group of stakeholders from the public to civil, transportation and
geomatics engineers, urban planners, architects, and environmentalists. Furthermore, four participants collaborate with others to find solutions to technical problems. This collaboration includes the Information Technology (IT) departments responsible for customization and optimization of the database, quality control, creating a GIS database and working on data policies and standards.

**Experience with CAD and GIS.** Participants had a wide variety of experience with CAD and GIS. Two participants had experience in teaching CAD and GIS, as well as industry experience such as managing a GIS team, and have worked in marketing, sold GIS software and implemented large enterprise GIS systems for mobile clients. Four participants also had experience in teaching CAD and GIS university undergraduate and graduate courses. These participants were also involved with research in areas such as applied GIS and wildlife management, which involve the use of the GIS to build predictive models for wildlife habitat use. For these participants, CAD and GIS was a tool for mapping, making basic queries, and 3D visualization.

In addition, four participants had experience working in the industrial sector. One of these participants used GIS to determine the location of unexploded bombs. Others used change detection to support decision-making in agriculture and forestry. Mapping was also done to support urban planners and stakeholders in making land use decisions. Property management was another use of GIS for those in industry. Generating risk assessment models for sanitary sewer back up for an insurance company in Canada was an example of how spatial data could be used in industry. One of the participants also conducts research in the use of CAD and GIS for making decisions on visualizing places in 3D virtual environments. As a participant pointed out;
(P5): “If we are going to locate a retail facility … on a site, we want to make sure that it is visible from a number of points, and then we use CAD and GIS 3D to practically make it possible for the potential investors to make sure they are investing in the right place.”

3.7.2 CAD and GIS Operations, and Software

All participants commented on their experiences with CAD and GIS Operations, and Software throughout the course of their work and some of these comments are stated in the section below. Figure 3.3 (below) illustrates an affinity diagram of CAD and GIS Operations, and Software.

Figure 3.3. Affinity Diagram of CAD and GIS Operations, and Software

**CAD and GIS Operations**. Only one participant used CAD and GIS in a daily basis. Instead, most of the participants in this study used GIS for analyzing and manipulating data. Four participants used CAD and GIS in their teaching and research. One of the participants used GIS for environmental impact assessments. This participant also uses CAD and GIS for 3D analysis such as visualization studies on cellphone tower location using viewshed analysis.

One of the participants used GIS for different types of spatial analysis in wildlife or the urban planning domain to understand the problem under study. This participant also used CAD and GIS as a community engagement tool to provide input for people in understanding their communities. This participant used the mapping component and CAD and GIS tools to test people’s knowledge about the community and space through a digital form.
One of the participants used GIS for teaching cartography, geo-visualization, human computer interaction, spatial cognition, and spatial reasoning and understanding to students. One of the participants also using GIS for spatial analysis, primarily for developing prescriptive or predictive models, used GIS for habitat models in ecology and basic quantifications, species restoration, the area of occupancy or predictive occupancy computation, as well as, exploration of species’ habitat. The remaining participants used CAD and GIS for creating maps, modelling, locating new sites within the city, analyzing, managing data, and maintaining the database. As a participant noted,

(P2): “In the operation area, we use GIS to maintain our field asset databases, so our crews in the field have access to the latest information. We use GIS to understand growth areas of the electrical distribution system.”

**Demanding CAD and GIS Tasks.** Participants are asked about the demanding and challenging CAD and GIS tasks in their job. Participants commonly believed that some of the CAD and GIS tasks in their jobs are challenging. Most of the participants mentioned that mapping, data management activities such as data acquisition and assembling data sets and developing modelling tools are the most challenging CAD and GIS tasks in their jobs. However, data maintenance and data accuracy are the most challenging GIS tasks mentioned by another participant. Also, data accessibility through simple GIS interface is a further challenge for this participant. Another participant stated that manipulating numerous layers and making sure that information is updated in layers over time is a challenging GIS task. This information is critical for effective planning as 3D layers are placed on top of other layers and sites are studied from a visual perspective. One of the participants mentioned that the most challenging CAD and
GIS tasks are often related to usability issues of the CAD and GIS applications. This participant is also responsible for teaching the basics of CAD and GIS to employees in the firm.

Preparing CAD and GIS laboratory material for students and working with laboratory technicians to solve the technical problems related to the material are the most demanding job for another participant. A separate participant said that teaching and research involves pushing CAD and GIS beyond the boundaries of current practice. Two other participants said that 3D visualization is the most complex and challenging CAD and GIS task. However, they believed that visualizing CAD and GIS in 3D is a very important aspect of representing the complexities of spatial data. Finally, one participant believed that CAD and GIS tasks that involve visualization and spatial analysis and go beyond implementation of analysis tasks are not particularly demanding. The participant noted,

(P6): “3D visualization is probably the most demanding of the GIS tasks; being able to visualize in 3D - that is difficult to do with any other application other than a CAD application.”

Yet, one participant believed that CAD and GIS tasks are not demanding or even challenging,

(P1): “None of the CAD and GIS tasks are particularly demanding or challenging. We are often dealing with relatively large datasets and we attempt to use the tool we develop to manipulate those, because much of our focus is on visualization. In Google, we are not really extending the envelope beyond what already exists in terms of spatial analysis or trying to implement complex analytical tasks; it is usually just the case of number crunching.”

**CAD and GIS in Industry.** Most of the participants believed that CAD and GIS are mostly used to make models and maps based on images. However, they argue that CAD and GIS could be a
very useful tool for every profession that is involved with urban planning, transportation, and health. One of these participants said,

(P7): “A lot of people do not make use of CAD and GIS. In the companies that I have worked with, CAD and GIS are mostly used in a very limited way, primarily for production of maps. I do not think a lot of companies in Alberta use GIS near to its capability; and there are a lot of limitations in terms of the quality of work done by GIS.”

One participant stated that GIS is mostly used for detailed environmental impact assessment in urban planning. One participant mentioned that biological applications of GIS including species’ risk management, species’ habitat and occurrence prediction are common tasks. One participant said that the electrical industry is now using GIS for asset management and analysis, and to optimize the location of future roads. In the electrical industry, GIS was previously used for mapping assets and keeping the database current. One participant said that having access to GIS data via web services has recently been used to amalgamate data from a variety of sources including environmental and water data. Another participant said that, in urban planning, most people use CAD and GIS for land use and transportation planning and employment and housing studies. Another participant stated that CAD and GIS are used mainly for visualization,

(P1): “We are mostly interested in surveying our customers and giving them access to datasets that we discovered or data they already have. It is usually about bringing together, perhaps non-spatially or not explicitly spatially referenced data with mapping geo-spatial data, seeing how the context helps, so it is often about visualizing patterns or seeing an insight that you did not see before you saw the data geographically.”
**Evolution of CAD and GIS Software.** All participants thought that CAD and GIS software and practices have changed significantly over the last few years. Participants who work in academia believed that recent technological changes in CAD and GIS computer applications are significant to practice. However, these participants observed that the technological advances used in industry have not been utilized in the academic arena. For instance, all university research projects are still done on desktop CAD and GIS computer applications.

Participants from academia also believed that the biggest change in academia, industry, and everyday life is in the use of simplified and multi-user GIS for sharing information, such as Google Maps. In particular, the integration of intuitive and user-friendly GIS applications such as Google Earth with cellphones, cars, and taxis contributes to public accessibility of GIS interfaces. Moreover, accessibility of open source GIS applications, and GIS cloud and web-based services for mobile devices allows users to interact with GIS with limited or no training. Furthermore, the evolution of line-driven commands of first generation CAD and GIS to Graphical User Interface (GUI) has simplified the interaction with CAD and GIS. Another important change is geo-visualization, which allows people to enhance visualization of geological data.

To some extent, it is now possible to collaborate with others for basic level queries such as navigation and data browsing. However, the primary functions in CAD and GIS have not changed since the inception of CAD and GIS. Working with CAD and GIS still requires intensive education and training. In order to work effectively with others, CAD and GIS software have limitations and require a high degree of proficiency before operators can become expert users. As one participant said,
(P10): “When we collaborate, there are still very big difficulties, like if you are in the same or different locations. Interactive surfaces are still designed the same way we already use the desktop computer applications. If you could disengage the database that can be worked on independently and many people work on a distributed database and then bring the data back together, but this is still not actual collaboration.”

However, CAD and GIS software are continuously changing. Although, not quite seamless, some components of desktop CAD and GIS computer applications are integrated into a single computer application. However, most GIS users have not changed the way they interact with desktop GIS computer applications since the 1990s, when GIS emerged as a tool for spatial analysis. A participant pointed out,

(P6): “Urban planners still do not have direct access to CAD and GIS; they tend to use technicians which means that the results are not that different from the way people worked 20 years ago. Whether a paper or digital material is presented to the people who are involved in the urban planning process, the real problem is that the interface is not interactive. For instance, it should show me the land use, the population density, where people are employed or unemployed.”
3.7.3 CAD and GIS, and Interactive Surfaces

All participants commented on their experiences with CAD and GIS, and Interactive Surfaces throughout the course of their work, and certain, specific comments are discussed in the section below. Figure 3.4 (below) illustrates an affinity diagram of CAD and GIS, and Interactive Surfaces.

![Affinity Diagram of CAD and GIS, and Interactive Surfaces](image)

**Figure 3.4. Affinity Diagram of CAD and GIS, and Interactive Surfaces**

**Mobile, Small Interactive Surfaces.** Most participants stated that advances in the development of mobile, small devices such as smartphones and tablets have significantly changed the way people interact with a traditional GIS environment, for instance, paper maps versus Google Maps application for smartphones. Yet, while interacting with Google Earth for way-finding and automatic routing, the user is not aware that they are interacting with GIS. Participants also believed that Geographic Positioning System (GPS), GIS, wifi, or cell tower positioning are important developments. Participants noted that Google Maps for mobile devices and GPS, combined with GIS mobile field mapping, and data collection using software such as ArcPad Esri, have had a significant impact on the way professionals are able to use mobile GIS applications. This capability coupled with massive simplification of the interface and propagation of mobile, small interactive surfaces for everyday use allows these devices to become mainstream. Participants further believed that mobile, small interface surfaces are
appropriate for navigational purposes such as zoom, pan, rotate, and tilt as well as browsing and collecting field data. Nevertheless, mobile, small devices are still limited in terms of their basic functionality. One participant discussed the capabilities of mobile, small interactive surface by observing,

(P1): “I think, in terms of user interface, most people find it more natural to be able to work with iPhone, iPad and Android phone, and do pinch to zoom, and rotate to interact with imagery or mapping data. Therefore, it only helps us for navigation and browsing tasks, however, I am not sure whether it helps to do perhaps more complex spatial analysis or queries.”

**Fixed, Large Interactive Surfaces.** All participants stated that currently fixed, large interactive surfaces, such as tabletops and large wall displays, are not generally accessible in the workplace. For this reason, they had difficulty in grasping details of the potential use of tabletops and large wall displays. Hence, the advance of such surfaces has not changed the way participants interact with CAD and GIS. In addition, participants said that currently interactive surfaces do not support current CAD and GIS software, which requires the use of a mouse and keyboard. Furthermore, there is no evidence that tabletops will become mainstream with CAD and GIS users. Moreover, participants believed that fixed, large interactive surfaces will not add any new functionality to what already exists. One participant mentioned that these devices are similar to those of an earlier generation of PalmPilots. Interestingly, most participants suggested that fixed, large wall displays and tabletops could replace the paper-based material in the future. As one participant noted,

(P9): “Interactive surfaces have great potential for a big impact. But, they are not particularly intuitive yet. They need a [simple and intuitive interface for] people who are used to GUI, and mouse and keyboard interactions.”
**Interface of Interactive Surfaces.** All participants agreed that a simplified interface would be helpful when using fixed, large interactive surfaces. These surfaces could be helpful in 3D modelling, geo-visualization of population density and buffering, spatial query, and navigation. Participants said that fixed, large interactive surfaces could improve collaboration, access to information, and decision-making in community engagement and emergency management, where there is a highly fragmented work environment. As a participant said,

(P6): “Tabletops and large wall displays could be useful especially for urban planners; they will be able to work with clients, members of the community, put up the data and have easy access to it, but I think it has got a few years off before that happens. These surfaces can be useful for presenting, querying the data, zooming in, zooming out, panning around, and navigating.”

Interestingly, most participants mentioned that different functionalities should be created to match the interaction modality of these surfaces. They agreed that different domains such as urban planning and transportation require different sets of tasks, which varies across different disciplines. They also believed that CAD and GIS applications designed for interactive surfaces should focus on particular tasks specific to a single discipline such as transportation planning or urban planning. A participant pointed this out by noting,

(P6): “If I am doing viewshed analysis, it would be great to be able to tap at the target and tap where I am standing. Can I see that object from where I am standing? Or, if I am doing geological work, can I draw a line with my finger and now, can I see a cross section in 3D?”

**CAD and GIS Multi-Modal Interactive Capabilities.** Most participants mentioned that audio and video recording and speech recognition should be integrated with CAD and GIS on an interactive surface, because they could then facilitate data collection in the field through a simple
data entry or search. Participants noted that high resolution, a high degree of flexibility, fluidity, and size of the screen are the most important features required when interacting with CAD and GIS on interactive surfaces. Specifically, participants pointed out that enabling the exploration of spatial information and easy access to real-time information through an intelligent, intuitive and simple interface are important interactive capabilities that should be supported while interacting with CAD and GIS on interactive surfaces. One participant suggested that augmentation with tangible or haptic features would be useful while interacting with CAD and GIS on interactive surfaces. This would allow for more understanding of the context while interacting with 3D objects such as roads or buildings placed on the interactive surfaces. This participant said, (P8): “Clarity, lots of ability to display the colors properly, taking photographs, [and] audio recording would be useful too depending what your objectives are and integrating video to link to some sites in space.”

All of the participants agreed that interactive surfaces should provide a simple and intuitive interaction with CAD and GIS that could help non-experts with limited computer skills to participate in collaborative activities while performing CAD and GIS tasks. As a participant pointed out, (P10): “I demo navigating through 3D landscapes that need some expertise to work with the mouse like clicking on the rows. So, when I worked with biologists or geo-morphologists who are not familiar with the technology, I always drive because they cannot do it. I think, maybe, interactive surfaces could help individuals who are not experts in CAD and GIS, because probably there are ways that can make the interaction more intuitive than we currently have.”
However, one participant believed that interacting with CAD and GIS on interactive surfaces does not improve participation. This participant said that there is no overlap between interactive surfaces and participation, yet people might fight over taking control of the interaction, which defeats the purpose of participation on interactive surfaces. However, interactive surfaces could be useful for participatory tasks such as brainstorming and conceptualizing design ideas. Similar to Google Maps that focuses on collaboration with geo-spatial data, interactive surfaces provide more control for navigation and browsing purposes for communities, but do not contribute greatly in collaboration. Yet, conventional mouse and keyboard interface provide more control over the interaction. This participant stated,

(P1): “You could argue that potentially you could end up with people fighting over the control of an application for interactive surfaces. Might be more obvious that you have more control over the mouse in a conventional system.”

**CAD and GIS Visualization on Interactive Surfaces.** Generally, participants agreed that 3D visualization helps people understand the context of a problem. A participant pointed out that;

(P4): “Some people are not visual, but 3D information would allow them to visualize better.”

Four participants thought that interactive surfaces would be useful for 2D and 3D visualizations. Half of the participants agreed that interactive surfaces provide more intuitive manipulation for interacting with 3D CAD and GIS when viewing a perspective, topography and aerial photography. These participants believed that similar to 3D stereographic projection technology, the capabilities of interactive surfaces for CAD and GIS 3D visualization might not go beyond what already exists today with desktop computer applications. Two participants observed,
(P6): “Vantage point is going to be a real challenge in 3D visualization. When you are in front of the display of the desktop computer, you are kind of looking at it straight. With a tabletop, you are looking at it at an angle.”

(P7): “The best and most effective method of looking at CAD and GIS is 3D visualization. Looking at 2D visualization is difficult for a lot of people to understand, but 3D visualization at the moment has limitations.”

3.7.4 Desktop Computers versus Interactive Surfaces

All participants discussed their experiences with Desktop Computers versus Interactive Surfaces throughout the course of their work and some of these comments are noted in the section below. Figure 3.5 (below) illustrates an affinity diagram of Desktop Computers versus Interactive Surfaces.

![Affinity Diagram of Desktop Computers versus Interactive Surfaces](image)

**Outdoor Environmental Challenges.** Participants mentioned that environmental challenges, such as outdoor light reflection, as well as harsh weather condition, such as extreme cold and/or warm temperatures, could affect the functionalities of mobile interactive surfaces. A participant pointed out that,

(P2): “It is really hard to see on touch screens in a bright day or while using them outside. In cold weather also interactive surfaces are not useful unless using special gloves.”
**Ergonomics.** Participants mentioned that desktop computers’ mouse and keyboard interaction technique is more precise and accurate than touch-based interaction for smartphones, tablets, tabletops and large wall displays. Three participants wanted to have mouse and keyboard desktop functionalities on interactive surfaces while interacting with CAD and GIS. Participants also suggested the use of virtual keyboard, which may include a touchscreen and a desktop computer mouse and keyboard while interacting with CAD and GIS on interactive surfaces. A participant said,

(P6): “What if you could access the keyboard functionality on tabletops? But, I get tired really fast by using a flat display as a keyboard; it hurts my hand and fingers. People do not get a lot of work done with interactive surfaces. I think the real issue is how to replace the keyboard?”

**Group Size and Orientation.** Participants also mentioned that desktop computers, smartphones, and tablets are single-user devices, however, tabletops and large wall displays could accommodate larger groups of users. Another words, desktop computers, smartphones, tablets and large wall displays have a single orientation, however, tabletops have multiple orientations. Participants agreed that in comparison with smartphones, tablets or large wall displays with one orientation, displaying single orientation geographic information in a collaborative setting on tabletops with multiple orientations is more difficult. Participants also found it difficult to keep up with the multiple orientations of tabletops. They pointed out that manipulating the orientation of the display must be combined with CAD and GIS interaction on interactive surfaces. A participant observed,
(P2): “It would be interesting if we had simultaneous interaction. Right now, one person does one thing and the rest of the audience has to wait till it is done. You should not be limited and wait until one person finishes looking at something and then the next person can start looking.”

Tasks. Participants considered that complex CAD and GIS tasks, such as modeling, data analysis, and data management could only be performed on desktop CAD and GIS computer applications. Participants also agreed that tabletops, large wall displays, smartphones, and tablets could not support complex CAD and GIS tasks. Furthermore, participants stated that desktop CAD and GIS computer applications do not support navigation, participation, and decision-making. Most participants also believed that having interactive surfaces for presenting the outcome of CAD and GIS exploration while instantaneously showing different scenarios could be particularly useful for novices. Moreover, half of the participants mentioned that both modalities of mouse and keyboard interaction of desktop computer applications and touch-based interaction on interactive surfaces have limitations in terms of CAD and GIS 3D visualization. As a participant pointed out,

(P2): “Interactive surfaces could enable nonprofessional users to interact with the information; and do their task rather than being dependent on a technician.”
3.7.5 Perceptions of Users

All participants commented on more specific Perceptions of Users and certain comments are noted in the section below. Figure 3.6 (below) illustrates an affinity diagram of Perceptions of Users.

![Affinity Diagram of Perceptions of Users](image)

**Participation.** Participants from academia believed that interactive surfaces have the potential to perform participatory CAD and GIS tasks in classrooms for teaching and learning. Participants from industry said that interactive surfaces could be used for disciplines that require performing participatory CAD and GIS tasks and sharing information. These disciplines include emergency management, community planning, and engagement activities. A participant pointed out, (P5): “The value of interactive surfaces is in group meetings, because you only have the information on the desktop, which is only installed in certain machines. We never work in isolation; we always interact with people, so it would be very easy to see the interaction on a bigger and more flexible screen.”

Also, most participants mentioned that different people use the information in different ways. For example, people working in different industries, such as urban planning, geology, ecology, forestry, and healthcare look for different functionalities in CAD and GIS. A participant argued;
In a site selection problem, different people focus on transportation, water, or ecological issues. So, they try to come up with different models to compare. They basically work on the same data, but what each individual does is fundamentally different from the work of others.”

Participants stated that having access to a unifying interface where a number of different devices such as smartphones, tablets, tabletops, and digital wall displays are linked together could form a shared communication workspace. In this collaborative environment, if each individual has access to an interactive device, each individual device could contribute independently to the workspace. This would create a higher transparency of information and sharing of common knowledge. A participant pointed out,

(P6): “On top of the main interactive surface, I need a little personal viewer, like a personal notepad that I can look at stuff and focus on them and save them. For instance, if we go to the next layer, or start to look at the data in a different way, I lose track of what was important to me.”

**Interface.** All participants agreed that, as opposed to desktop CAD and GIS computer applications, participation, decision-making, planning, navigation, and presentation of the outcome of CAD and GIS exploration could be supported better through intuitive interface and interaction design of interactive surfaces. Furthermore, participants believed that adaptation of interactive surfaces and integration of their interface into the desktop CAD and GIS computer applications are the main challenges. They also mentioned that teaching and demonstration requires devices specific to urban planners and GIS experts. A participant observed,

(P4): “If each person on the field has an iPads, we will have multiple iPads containing various information that need to be extracted from each device. It would be good if all the devices can be
integrated into one interface that is linked to the main database in the office computers. Then, I do not have to go through different devices to extract the information.”

Moreover, participants envisioned that concentrating on interface and interaction design of interactive surfaces, in particular users’ spatial cognition, is a high priority component of designing such surfaces. They believed that understanding how people conceptually want to interact with data is a paradigm that should be considered in the design of future versions of such devices. Participants agreed that with interactive surfaces, there are greater opportunities to make the interface simple and intuitive. Participants thought that a simple and intuitive interface for interactive surfaces would be significantly beneficial for CAD and GIS novices and experts. This would create an environment where common knowledge is disseminated amongst a group of users.

Participants also believed that interactive surfaces have the potential to perform CAD and GIS tasks, such as geo-processing, buffering, simple queries on the fly, and adding layers. They also stated that having access to historical information about the site, and to archaeological and geological information through a simple interface of interactive surfaces, would be highly preferred. However, all participants believed that the current structure of CAD and GIS tasks will not be adapted to the environment of interactive surfaces. A participant noted,

(P4): “The process of extracting information from a new piece of technology is difficult, so people choose to use paper maps instead of accepting the new technology. Technology needs to be adapted to users’ needs instead of trying to get users to adapt to the technology.”

**Intelligence.** Most participants agreed that automation coupled with artificial intelligence would be needed to accomplish the complexities involved in social institutions and in the cultural
divisions of urban planning work. These might be useful for reasoning, planning, learning and communicating perceptual components, and even for manipulating objects involved in the urban planning process. A participant argued,

(P6): “I have to do a lot of commands to get something up on the screen. This is the challenge, because CAD and GIS is never designed to be easy to use. And with [an interactive surface], perhaps simple operations are feasible.”

3.8 Discussion

Typically, urban planners deal with a variety of tasks such as visualizing and calculating the zoning ordinance within the design review process, where participation of the public and the developers is critical to the process [1]. Currently, these tasks are performed on conventional paper-based material and desktop CAD and GIS computer applications that do not support participatory communication and visualization.

Furthermore, analysis of the interviews showed that urban planners’ expectations and requirements go beyond the existing set of desktop CAD and GIS computer applications used in today’s urban planning processes. Hence, the most direct approach to future studies is to further specifically interview urban planners about their software and hardware needs. This study revealed that participatory communication, 3D visualization, and computation are tasks especially within the design review process that could benefit from using interactive surfaces. Moreover, many of these tasks typically involve conflict resolution with a number of different stakeholders, such as urban planners, developers, and the public within the design review process. For example, rezoning a parcel of land from residential to commercial can have an impact on adjacent properties, such as need for parking and increased traffic. In particular,
visualizing 2D plans and 3D models would allow urban planners and stakeholders to participate in communication around technical issues, and thus potentially resolve future conflicts.

Specifically, six participants who are urban planners mentioned that they would like to use interactive surfaces to perform work conducted within the design review process, which are cumbersome and require complex visualization and computation activities. These participants further stated that the design review process always requires transparency in communication, as well as presentation of information. Having access to a technology that can communicate the design review process to both urban planners and stakeholders is a critical need. However, currently, desktop CAD and GIS computer applications are single-user and immobile. Thus, this limits the flow of information and participatory communication during the design review process. Participants also mentioned that the use of mobile interactive surfaces integrated with 3D visualization could be useful for the design review process. This would help urban planners and stakeholders to visualize building proposals, also to communicate around possibilities, which might ultimately lead to more successful outcomes. Two participants argued,

(P5): “If urban planners have the information available in a more portable format, then it will help us not have to carry lots of drawings and papers to meetings. Working with current desktop CAD and GIS computer applications does not help us communicate or collaborate better within the design review process.”

(P6): “Interactive surfaces can be useful for the design review process. They could allow for dragging and dropping 2D drawings and 3D models of buildings or bridges or transportation flow patterns. This then allows them to visualize [what impact different building designs will have in the area?] and what is the community reaction to these changes?”
After further analyzing the interviews, three main issues within the design review process have emerged. These issues form the basis for Study II where they are succinctly explored and described in Chapter IV.

**Participatory Communication.** Ubiquitous interaction of mobile interactive surfaces concerning participatory communication around CAD and GIS operations may provide techniques for urban planners and stakeholders with a wide range of skillsets for seamless interactions with CAD and GIS within the design review process. Participatory communication within the design review process, whether together in the same place or separated in space or time, could be further enhanced by using mobile interactive surfaces, supported by synchronous interaction.

**Visualization.** Simple and intuitive techniques for visualization of the zoning ordinance in conjunction with using interactive surfaces could facilitate the comprehension of plans for urban planners and stakeholders who have poor visual and spatial skills. This could potentially provide a means for the urban planner and stakeholders to visualize the outcomes of their CAD and GIS explorations on the mobile interactive surfaces could potentially reduce the large volume of paper-based documents involved in the design review process.

**Computation.** Mobile, simple techniques for computation of FAR and other related measurements involved in the design review process would reveal possibilities for the effective use of mobile interactive surfaces. Exploring the feasibility of these new approaches for solving design review problems in an easy and timely fashion could have an impact on the design of future cities.
3.9 Summary of the Chapter

Study I involved the semi-structured interviews that explored the work practices and tools and the technologies of urban planners and GIS experts to help them accomplish their everyday tasks within the urban planning process. This study discovered that the recent convergence between interactive surfaces and desktop CAD and GIS computer applications could introduce a novel, but unexplored interactive arena for enabling participatory communication between urban planners and GIS experts. This study thus attempted to identify potential CAD and GIS interaction capabilities on interactive surfaces, specifically within the urban planning process. For this reason, this study explored urban planners’ and GIS experts’ perceived use of interactive surfaces, as opposed to desktop computer applications. As a result, this study provided a platform for urban planners and GIS experts to participate within the urban planning process. Moreover, this study also demonstrated that urban planners and GIS experts using the existing interface and interaction design of desktop CAD and GIS computer applications do not consider the design of these devices to be as effective as they could be. Instead, participants felt that these applications could benefit from more intuitive interaction methods for interactive surfaces. In particular, this study revealed that there is potential for a much greater use of interactive surfaces that goes beyond merely replicating desktop CAD and GIS computer applications’ capabilities on interactive surfaces. By considering the properties of each device included in this study, mobile versus fixed and multi-user versus single-user, it was also revealed that interactive surfaces could be used as supplementary devices in conjunction with desktop computer applications in the design review process. Furthermore, it was discovered that overall participation, communication, visualization, and computation within the design review process could be enhanced by the use of mobile interactive surfaces.
To sum up, as part of this study, the following questions arose which are discussed in Study II. These questions are: What user capabilities do urban planners want integrated with CAD and GIS on interactive surfaces within the design review process?; Is what urban planners want to do with CAD and GIS on interactive surfaces within the design review process already possible?; What tasks do urban planners currently complete using CAD and GIS on interactive surfaces within the design review process? Together with the results of this study, these questions guide the direction of Study II, which is elaborated in Chapter IV.
Chapter Four: Study II: Design Review Process: Can New Technology Improve the Art of Participatory Communication?

4.1 Introduction

Design review is a complex participatory process where multiple stakeholders brainstorm, articulate, negotiate, and refine plans for future developments. Beyond the creative design sessions, a developer may have with the urban planning department, the approval process also involves civic review at various stages. Depending on the complexity of the development application, the urban planner may need to consider land use bylaws, environmental, health, and transportation policies. This review process can reveal violations in a developer’s plan, which may be costly for developers to amend their plans. Urban planners in charge of the application review may also need to engage staff from other city departments. In most cases, the urban planner in charge of the review process will also need to engage the public in consultations and discussions on the merits of the application [1] [2] [35].

As a communication conduit between developers and the city, urban planners are often engaged in technical and socio-economic-political processes. Moreover, urban planners are asked to act in the public’s best interests by enforcing the city’s bylaws, while helping developers to devise creative solutions that address concerns raised by various departments within the city. This is a difficult task, as the goals of these different parties are often in conflict. For instance, a developer may want to build a large mixed-use facility comprised of commercial space with residential space placed above, while the community opinion may oppose buildings which are massive in scale. What makes this situation complex is that plans such as massive buildings are often allowed under a city’s existing bylaws, regulations, and master plans. However, members of the community may assert sufficient political pressure to stop a development that is permitted under the existing bylaws. In some cases, developers may ask for a relaxation (variance) in the bylaw,
thus allowing them to increase the amount of developable space (size of a building is usually controlled by the FAR) [1] [2] [34].

While this example is perhaps very brief in its description, most instances within the design review process are far more subtle and complex. For example, the urban planner is usually required to interpret the city’s bylaws and regulations, and apply them to each unique case. This review often requires some calculations. Making this more complex, the analysis can involve sophisticated computer-based tools, frequently making the entire process less then ideally transparent. However, given the long-term nature of the design review process, where a medium-sized development application can take three years from initial phases to permit release, urban planners play an important role in approving development applications. From the urban planner’s perspective, it is difficult to develop a shared understanding and common language to discuss problems as they arise. The tangible consequences of this process are that the design review process is delayed, which is costly in terms of time from the developer’s perspective. Furthermore, urban planners engage in a number of participatory design practices that aim to give each party a voice and increase transparency with the aim of producing creative solutions to problems. Nevertheless, communication can break down during this process. Meetings also often make use of conventional tools, such as paper and pen, however, using these simple aids has several deficiencies because these tools do not easily lead themselves to participatory communication and the visualization of building plans and bylaws [1] [2] [7] [10] [33].

Thus, in this study, semi-structured interviews, and participant and non-participant observations were used to explore the tools and technologies urban planners and stakeholders use within the design review process and to investigate their participatory communication and visualization challenges. Ultimately, the goal of this study is to arrive at a set of design recommendations for
creating SketchBoard that can support participatory communication, visualization, and mobile interaction within the design review process.

4.2 Scope of the Study

This study had the following objectives:

1. To investigate various phases in the design review process and the roles urban planners play in these phases.

2. To explore information, documents, and tools and technologies urban planners use within the design review process.

3. To provide an understanding of the challenges urban planners and stakeholders encounter specifically concerning participatory communication and technical activities within the design review process.

4. To explore the tools and technologies used to facilitate participatory communication, and why miscommunication occurs within the design review process.

4.3 Study Methodological Process

To address the guiding questions of this study, methodology of ethnography and contextual design were employed to develop a descriptive understanding of participatory communication in the design review process. The goal was to identify commonalities and points of divergence across the participants in terms of how they thought about theirs and others’ roles in the design review process and how communication is facilitated in various types of meetings, and opportunities for technology [38] [40] [41].
During the course of this study, triangulation was used as a data gathering technique in order to provide different perspectives and findings across different techniques. Semi-structured interviews and participant and non-participant observations were used to study how urban planners review and assess building designs. Both methods were employed to facilitate triangulation from these two data sources. Field notes were collected, focusing on the five W’s of industrial design: Who takes action; What action are they taking; Where are they taking action; When are they taking action; and Why are they taking action. Note-taking was utilized as a data recording technique in all interview and observation sessions, and then the handwritten notes were transcribed which was the first step in the data analysis process [64].

4.4 Participants

Twelve participants in one of Canada’s largest cities were recruited by using a purposeful sampling technique. An email distribution list was used to contact urban planners, urban designers and architects within several departments in the City of Calgary: land use planning and policy; development and building infrastructure; and infrastructure and information services. In addition, the email was also sent to private sector firms for an urban planning and architectural design. Only one participant from a private firm agreed to take part in the study, and eleven participants from the City of Calgary agreed to take part. Of the twelve, ten participants in semi-structured interviews, and two (from the City of Calgary) agreed to be part of participant and non-participant observations. These two participants were selected based on the role they played in the coordination of proposals. During the observation sessions, the researcher also played the role of participant and non-participant observer [39] [41].
Table 4.1 (below) shows participants’ biographical information.

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<thead>
<tr>
<th>Participants</th>
<th>Position</th>
<th>Experience in Profession-Yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Architect &amp; Urban Designer</td>
<td>13</td>
</tr>
<tr>
<td>P2</td>
<td>Land Use Planning &amp; Policy</td>
<td>34</td>
</tr>
<tr>
<td>P3</td>
<td>Planning &amp; development, Land Use Planning &amp; Policy</td>
<td>11</td>
</tr>
<tr>
<td>P4</td>
<td>Building Infrastructure</td>
<td>16</td>
</tr>
<tr>
<td>P5</td>
<td>Development &amp; Building Approvals</td>
<td>13</td>
</tr>
<tr>
<td>P6</td>
<td>Development &amp; Building Approvals</td>
<td>4</td>
</tr>
<tr>
<td>P7</td>
<td>Infrastructure &amp; Information Services</td>
<td>5</td>
</tr>
<tr>
<td>P8</td>
<td>Infrastructure &amp; Information Services</td>
<td>22</td>
</tr>
<tr>
<td>P9</td>
<td>New Community Planning, Land Use Planning &amp; Policy</td>
<td>15</td>
</tr>
<tr>
<td>P10</td>
<td>Urban Design &amp; Heritage, Land Use Planning &amp; Policy</td>
<td>24</td>
</tr>
<tr>
<td>P11</td>
<td>Engineering, Urban Development</td>
<td>7</td>
</tr>
<tr>
<td>P12</td>
<td>Urban Development</td>
<td>33</td>
</tr>
</tbody>
</table>

Table 4.1. Participants’ Biographical Information

4.5 Interview Method

Semi-structured interviews were used to target a specific user group of urban planners and urban designers. These interviews served as an introduction to the design review process, urban planners’ work practices and the tools and technologies currently used by an urban planning department. During these interviews, participants were asked eighteen questions to provide information on their education, background, prior experience in urban planning, current job responsibilities and job history. They were also asked to provide a list of stakeholders they normally encounter as part of their job. Urban planners were also asked to explain how they use computer technology in their practice. All interviews were recorded as field notes and served as the basis for creating a list of tools including software, hardware and documents needed in practice. Within a small number of interview sessions, urban planners were also asked to demonstrate how they used software to do various tasks. Each interview took approximately one hour (see Appendix II.I for the eighteen interview questions in Parts I and II).
4.6 Observation Method

Both participant and non-participant observations were used to understand urban planners’ actions in various contexts, task performance and workplace culture. Of the twelve participants, two of them were observed as they went about their day-to-day tasks. These observation exercises were followed by debriefing sessions at the end of each day to clarify any issues raised during the observations.

4.7 Data Collection and Analysis

Affinity diagraming and consolidated work models were used for conceptual grouping of the data. Two sets of affinities were created, specifically, Affinity One and Affinity Two. The models for Affinity One formed the primary basis for a deeper analysis of Affinity Two. A manual analysis of the data took place both during and after the interview and observation sessions. Figures 4.1-10 (below) illustrate affinity diagrams, and (see Appendix II.II, for the data analysis presented on Tables II.1-10).

In Affinity One, the first level had five affinities: a Flow Model (where does the information flow between individuals); a Sequence Model (what is the review process); an Artifact Model (how is information captured); a Cultural Model (who is involved, and what are their relationships); and a Physical Model (how does this relate to the architectural plan). This level described the whole area of concern within the consolidated work model.

In Affinity One, the second level had four affinities: Participatory Design (as a practical method, and how this affects the communication needs of various stakeholders); the Urban Design and Planning Process (specifically relating to the rules and standard methods from the academic practice of urban planning); Visualization (as a general need, and the kinds of details desired);
and Analysis (urban planners’ concerns about their job function). This level described specific issues that define the area of concern. This level often was repeated as sub-levels of the first level affinity. Furthermore, in Affinity One, the third level further described each sub-level of the first and second level affinities.

The data was reorganized one final time, in relation to different phases of the design review process, thus, Affinity Two was organized. In Affinity Two, the first level had three affinities: Idea Generation (pre-application phase); Application Refinement (application review); Public Consultation; and the Limits of Technology in the Design Review Process. This level provided insights into how goals differ among the urban planning stakeholders at different points in the design review process, particularly as related to their expressive and communication needs and tools and the technologies used at each phase.

Figure 4.1. Manual Affinity Diagram: Inductive Process of Clustering Notes
4.7.1 Affinity One

Affinity One borrows from the concept of the contextual design’s work models to modify and replicate five models. These five models are not intended to represent all the detail, but to provide a bird’s-eye view of the key aspects of the design review process, which need to be accounted for in the later stages of this research. These comprise the Flow, Sequence, Artifact, Cultural, and Physical Models.

4.7.1.1 Flow Model

The Flow Model uncovered the structure and scope of the urban planning work practices, job responsibilities divided across the urban planning stakeholders, as well as communication patterns occurring within the design review process. Job responsibilities were divided up and coordinated according to the needs and intents of the design review work to ensure that tasks were accomplished. The consolidated Flow Model included the urban planning stakeholders’ work practices and responsibilities that were significantly driven by communication around technical activities within the design review process. Thus, exploring the Flow Model would suggest designing an artifact, such as documents, hardware, and software that enhances the structure of the design review process by better coordinating and rearranging communication breakdowns while performing technical work practices.
Figure 4.2 (below) illustrate an affinity diagram of Flow Model.

![Affinity Diagram of Flow Model]

**Participatory Design.** Participation and communication around technical activities are primary job functions of the urban planning stakeholders within the design review process. Participatory design includes communication with different departments, such as development and building approvals, land use planning and policy and transportation and parks. Participatory design also involves internal and external participation with the urban planners, the developers, and the public.

**Urban Design and Planning Process.** Concept design, detail design, and possible design revisions are primary work practices of urban design and planning within the design review process. The urban design and planning process involves strategic planning and the design of buildings, communities, neighborhoods, and cities.
**Visualization.** Visualizing plans, maps, photographic information, and documents with graphics and illustrations are fundamental visualization work practices within the design review process.

**Analysis.** Analytical work practices of the design review process primarily involve cross-referencing the development applications against bylaws, such as reviewing the zoning ordinance, FAR, height, and setback requirements.

4.7.1.2 *Sequence Model*

The Sequence Model described the different steps within a typical design review process. The Sequence Model showed the detailed structure of work practices and common strategies undertake by urban planning stakeholders across the design review process. The Sequence Model revealed the needs and important aspects needed to accomplish the work of the design review process, also the orders, strategies and motivations for doing the work of the design review process. The primary sequence of work practices within the design review process showed the different stages: pre-application, application, and results. The consolidated Sequence Model was developed to understand the intent of activities, also to reveal any breakdowns as well as complexities within the sequence of work practices in the design review process. Thus, studying the Sequence Model would suggest a tactic for streamlining the structural sequence of the design review process by designing an artifact that removes unnecessary challenges and complexities pertaining to the communication and technical work practices. This then could potentially reduce the time required for the design review process.
Figure 4.3 (below) illustrate an affinity diagram of Sequence Model.

![Sequence Model Diagram]

**Figure 4.3. Affinity Diagram of Sequence Model**

**Pre-Application Stage.** The first step in the sequence of the design review process is the pre-application stage that includes review of the development application with applicants, a schematic design review with architects, urban planners, consultants, builders and land owners; and upfront, paid representative sketching and design charrette sessions. The design charrette session takes place in the city where urban planners and applicants communicate with one another. This session provides an opportunity for applicants to participate in the process of design, also to learn more about the application process.

**Application Stage.** The second step in the sequence of the design review process is the application stage, which includes the initial submission of the applications and their typical review process. Incomplete applications are sent back to applicants for further modifications. However, completed applications are circulated within different departments to be cross-referenced against the bylaws and design guidelines. Then, the results of the Detail Team Review (DTR) are presented to applicants, different departments, and elected officials. If any changes are required, the applicants must make further modifications. After that, revised plans will be sent back to different departments for further review.
Results. The third stage in the sequence of the design review process is results, where modified applications will undergo further assessment and evaluation. If changes are not accepted, application is not approved, or might require even further modifications. However, if changes are accepted, the application is approved, and the public will be notified to express their opinions about the new development plans in their neighborhood. Public appeal will be pursued if the public votes against the new development plans. But, if the public approves the new development plans, the development permit will be released. Then, in the next stage, a building permit will be released.

4.7.1.3 Artifact Model

The Artifact Model revealed that current tools and the technologies used for the design review process involve a cumbersome workflow and require a certain level of expertise to operate. The Artifact Model also showed that the design review process needs tools and technologies that can support participatory communication around technical work practices. The Artifact Model further demonstrated that the current set of tools and the technologies used within the design review process are supported by desktop computer applications, such as CAD and GIS, as well as by large volumes of paper and text-based documents, which both limit mobility and participation. The consolidated Artifact Model grouped tools and technologies with the same intent, content, structure, and usage that urban planning stakeholders use in the course of the design review process. Thus, studying the Artifact Model would suggest a strategy to remove breakdowns and complexities pertaining to the urban planning tools and technologies, also to eliminate mismatches between the existing properties of such tools and technologies, and the communicative and technical work practices within the design review process. This could ultimately provide an opportunity for designing an artifact that aligns with the needs and
expectations of the urban planning stakeholders’ work practices within the participatory environment of the design review process. Exploring the design review process showed that tools and technologies that support visualization and analysis tasks were commonly used artifacts within this process. Figure 4.4 (below) illustrate an affinity diagram of Artifact Model.

<table>
<thead>
<tr>
<th>Artifact Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Visualization</strong></td>
</tr>
<tr>
<td>Use of GIS: Google Street View, Google Maps, Google Earth; use of CAD: SketchUp, AutoCAD, MicroStation; use of Photoshop, and InDesign; use of existing and/or emerging technology: POSIEE, EXCEL, CaptureVu, smartphones, tablets, tabletops, large wall displays, data projectors, whiteboards, telephone, email and QRCode</td>
</tr>
<tr>
<td><strong>Analysis</strong></td>
</tr>
<tr>
<td>Access to existing document: bylaws, geotechnical report, flood analysis, environmental site assessment report, population studies and demographic analysis of surrounding area, traffic analysis, travel time analysis, transit oriented development (TOD), economical analysis, sun and shade analysis, viewshed analysis; 2D drawings: plans, elevations, city maps, land use maps, photographic information; 3D modeling; and GIS: FME, Terrasolid, LIDAR, digital terrain model (DTM), spatial analysis and map making</td>
</tr>
</tbody>
</table>

Figure 4.4. Affinity Diagram of Artifact Model

**Visualization.** Current visualization artifacts for the design review process include the use of CAD and GIS documents, such as 2D and 3D drawings and modeling, as well as, plans, maps, photographic information, and paper and text-based documents.

**Analysis.** Existing analytical artifacts for the design review process include documents and tools and the technologies that support the evaluation and assessment of the development applications.
4.7.1.4 Cultural Model

The Cultural Model showed common themes and aspects of the participatory and communicative culture sharing of urban planning stakeholders within the design review process. The Cultural Model also demonstrated that the design review is a repetitive and time-consuming process involved with pervasive influences, such as the interaction of multiple groups of urban planning stakeholders while they have different intentions in their actions. The consolidated Cultural Model revealed the extent of the socio-economic-political nature of the communicative and technical work practices within the design review process. Thus, exploring the Cultural Model would suggest designing an artifact that enhances the participatory challenges of the communicative and technical work practices of the design review process. Participatory design and urban design and planning are also contributing elements in the Cultural Model of the design review process. Figure 4.5 (below) illustrate an affinity diagram of Cultural Model.

![Affinity Diagram of Cultural Model](image)

Figure 4.5. Affinity Diagram of Cultural Model
**Stakeholders.** In a broad sense, the urban planning stakeholders involved in the design review process include the urban planners, the developers, and the public.

**Common Influences.** The design review process is influenced by socio-economic-political issues surrounding the development applications.

### 4.7.1.5 Physical Model

The Physical Model showed the structure of the physical environment surrounding the design review process. Design review work takes place in multiple places where urban planning stakeholders as well as large volume of documents move through various, multiple locations. The consolidated Physical Model revealed that urban planning stakeholders as well as the artifacts, hardware and software are located in dispersed physical environments. The Physical Model also demonstrated that if the physical environment interferes with the design review work, the communication line could breakdown as the urban planning stakeholders and documents move from one office to another at different stages of the design review process. The layout of tools and technologies within the physical environment also influenced the flow of information, communication, coordination and participation between urban planning stakeholders and their workspaces. It also revealed the constraints and limitations of the physical environment coupled with the single-user and immobile tools and technologies that impact the degree of participation in the communicative and technical work practices of the design review process. Thus, studying the Physical Model of the design review process would suggest designing a mobile communication artifact that could potentially reduce the degree of dependency on immobile desktop computer applications, as well as support the participation of urban planning stakeholders.
Figure 4.6 (below) illustrate an affinity diagram of Physical Model.

![Physical Model Diagram]

**Figure 4.6. Affinity Diagram of Physical Model**

**Same Location.** The physical design of the City of Calgary’s building means that applications get circulated through different departments to be reviewed. This process includes the working relationship of the urban planning stakeholders and the tools and technologies used between workspaces, separate offices and cubicles as well as the specialized space for boardrooms, meeting rooms, and loading docks for application material, as well as paper and text-based documents.

**Dispersed Location.** This structure shows that the City of Calgary, the proposed building site, and the design firms are located in different places. This also reveals the flow of information between urban planning stakeholders, the tools and technologies, and documents that need to be communicated and coordinated while they are in dispersed locations.

The overall, Flow, Sequence, Artifact, Cultural, and Physical Models provided a background about the process of design review. Affinity One was developed to briefly present the key aspects of the design review process. The Flow Model showed the work practices and activities of the design review process. The Sequence Model showed the different steps of this process. The Artifact Model showed the tools and technologies used within this process. The Cultural
Model revealed the culture sharing of the urban planning stakeholders within this process. The Physical Model showed the physical surroundings of the design review process.

4.7.2 Affinity Two

In Affinity Two, the Flow, Sequence, Artifact, Cultural, and Physical Models from Affinity One were broken down into a more detailed structure that will dive into the complexities and subtleties of the design review process. Affinity Two identifies four main components of the design review process, specifically, Idea Generation; Application Refinement; and Public Consultation, which revealed the entire design review process; as well as the Limits of Technology in the Design Review Process. Table 4.2 (below) shows the design review process. In addition, participants’ quotes that support the data from the analysis of the transcripts are shown.

<table>
<thead>
<tr>
<th>Idea Generation</th>
<th>Application Refinement</th>
<th>Public Consultation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pre-Application</td>
<td>2. Initial Application</td>
<td></td>
</tr>
<tr>
<td>3. Initial Review of Application</td>
<td>4. Check Design Against Bylaw &amp; Policy</td>
<td></td>
</tr>
<tr>
<td>5. Detail Design</td>
<td>6. DTR &amp; Assembling Comments</td>
<td></td>
</tr>
<tr>
<td>7. Check Revised Plans</td>
<td>8. Development Permit</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2. The Design Review Process
4.7.2.1 Idea Generation

All participants stated their opinions and experiences about the Idea Generation stage of the design review process, and some of these opinions are noted in the section below. Figure 4.7 (below) illustrates an affinity diagram of Idea Generation.

![Figure 4.7. Affinity Diagram of Idea Generation](image)

**Design Iteration.** Eight participants stated that the design review process is an iterative process that begins by understanding the problem context through data collection and analysis. Design iterations involve concept design, detailed analysis of the design, and design revisions that are made through sketches and discussion. In most cases, arriving at a design concept or solution is a cyclical process that requires a significant amount of time for endless and often unproductive discussion around the interpretation of the paper and text-based documents. Furthermore, paper-based documents are static and do not provide an opportunity for stimulating communication while manipulating plans and drawings. Paper-based documents also generate large volumes of material that makes it difficult to preserve each new design concept in a compact format. As a participant noted,

(P9): “There are normally several design iterations until the design is completed.”

**Design Charrette.** Eight participants mentioned that the design review process involves a design charrette, which is an intense period of semi-formal, face-to-face design or planning activity. Moreover, within the design charrette, possible design alternatives can evolve from version-to-version through collective brainstorming. However, conflicting opinions are discussed to create a
mutually acceptable design solution to a complex design problem that is normally a combination of several previous design versions. Yet, if there are problems that cannot be solved through the City of Calgary, an external group that is better equipped to solve such problems is hired. As a participant argued,

(P5): “Design charrette is a series of workshop sessions that allow developers and urban planners to look at the design process upfront. Within the design charrette, urban planners and developers discuss design issues and generate design ideas together through traditional paper, pen and marker sketches. After several design iterations, ideas and drawing are more refined.”

4.7.2.2 Application Refinement

All participants noted their opinions and experiences about the Application Refinement stage of the design review process, and certain, specific comments are elaborated in the section below. Figure 4.8 (below) illustrates an affinity diagram of Application Refinement.

![Application Refinement Diagram](image)

Figure 4.8. Affinity Diagram of Application Refinement

**Participatory Communicative Action.** All participants stated that Application Refinement is dependent on iterative face-to-face, telephone, online meetings and discussions. In addition, Application Refinement is one of the fundamental stages of the design review process where iterative, face-to-face, telephone, online meetings and discussions could potentially lead to misunderstandings. Furthermore, at the center of the Application Refinement stage is the file manager - an urban planner who coordinates this process by communicating with different departments as well as developers. The application is circulated among the different departments
(e.g., transportation and parks) for its adherence to the bylaws and municipal policy. Once comments are assembled, the document is sent back to the developer. The file manager then presents the DTR to the developer. From there, the developer is required to go through the comments and revise the plans. In subsequent meetings, each department reviews the comments from the previous review. For instance, the parks department comments on landscaping issues while the transportation department considers issues at site planning and infrastructure. If they accept the revised plan, the application may be approved. Often, due to lack of mutual understanding, there is a communication failure between the file manager and the developer. In these cases, the developer may directly contact the departments that reviewed the application for additional feedback. As two participants pointed out,

(P9): “There are normally different opinions and roadblocks, so the major challenge in urban planning is to help people understand what is going on and bring all the opinions together.”

(P10): “There is normally a lot of back-and-forth communication. Within the DTR, urban design comments are defined. Sometimes, if there is a communication, political and economic issue pertaining to the application, we hire a consultant to see the feasibilities.”

**Technical Action.** All participants stated that the design review is an analytical process which comprises planning, legal, and economic analysis as noted below.
Table 4.3 (below) shows planning, legal, and economic analysis.

<table>
<thead>
<tr>
<th>Planning Analysis</th>
<th>Legal Analysis</th>
<th>Economic Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculation of FAR</td>
<td>Zoning</td>
<td>Profit &amp; Loss</td>
</tr>
<tr>
<td>Massing Studies</td>
<td>Bylaws</td>
<td>Balance Sheets</td>
</tr>
<tr>
<td>Population Studies</td>
<td>Architectural Guidelines</td>
<td></td>
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<tr>
<td>Traffic Studies</td>
<td>Setback Requirements</td>
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<tr>
<td>Sun &amp; Shade Studies</td>
<td></td>
<td></td>
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<tr>
<td>Physical Surrounding Studies</td>
<td></td>
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<tr>
<td>2D Drawings</td>
<td></td>
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<tr>
<td>3D Models</td>
<td></td>
<td></td>
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<tr>
<td>GIS Documents</td>
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</tbody>
</table>

Table 4.3. Planning, Legal, and Economic Analysis

1. Planning analysis involves review of architectural plans for code violations that include calculating FAR; massing, population, traffic studies; demographic, sun and shade analysis; reviewing 2D drawings, 3D models, and maps for the existing and proposed development proposals; as well as changing design parameters for future scenarios.

2. Legal analysis includes access to existing documents (zoning, bylaw, area structure plans, area redevelopment plans, master plans, and architectural guidelines); and access to existing setbacks requirements.

3. Economic analysis that is the developer’s responsibilities includes profit and loss, and balance sheets for any proposed development. Yet, in the case that a public-private partnership is involved, the urban planner might seek this information to make the project feasible. As two participants noted,

(P4): “Urban planning is always concerned about the negative impacts of future developments on the neighborhood, site selection and topography, site viewpoints, access, FAR, zoning and buffering zones. As urban planners, we deal with a massive volume of text-based documents for
analysis. That includes budget and business cases, operation funding analysis, review of legislations, and making decisions.”

(P8): “Use of a model removes any assumptions and provides less possible misinterpretation of the final outcome. One other efficiency that can’t be overlooked is in a reduction of possible conflicts that can be uncovered early in the design process, which may not be evident until modeled. A simple example may be trees along a boulevard.”

4.7.2.3 Public Consultation

All participants mentioned their opinions and experiences about the Public Consultation stage of the design review process, some of the comments are stated in the section below. Figure 4.9 (below) illustrates an affinity diagram of Public Consultation.

![Affinity Diagram of Public Consultation]

Political Communication. All participants agreed that the design review process involves complex, political communication with many stakeholders such as urban planners, politicians, the developer, and the public. Fundamentally, however, participatory communication is required to arrive at the appropriate solution to many of the technical and political problems that are inherent within the design review process. Although, the political communication of the design review process attempts to integrate aesthetics, economic, and social concerns, public opposition is usually one of the major obstacles within this process. This was confirmed by a participant who said,
(P9): “Public opposition is a major obstacle. Sometimes, the community and developer are unwilling to communicate with the City of Calgary. So, a lot of time could be wasted for back-and-forth communication to arrive at the solutions for technical problems.”

4.7.2.4 Limits of Technology in the Design Review Process

All participants mentioned their opinions and experiences about Limits of Technology in the Design Review Process, specific comments are discussed in the section below. Figure 4.10 (below) illustrates an affinity diagram of Limits of Technology in the Design Review Process.

![Affinity Diagram of Limits of Technology in the Design Review Process](image)

Communication Cues. All participants stated that a non-visual, verbal cue such as face-to-face communication and interpretation of bylaws is one of the two fundamental methods of communicating within the design review process, however, there are limitations associated with this method. For example, if the two parties do not arrive at an agreement, they will then need a prolonged communication process to ultimately reach a conclusion. Furthermore, face-to-face communication and interpretation of bylaws within the design review process can result in misinterpretation of transmitted information and lack of mutual understanding between urban planners and stakeholders. As a participant observed,

(P10): “The interpretation of the bylaws and design guidelines are an important, unsolved issue in reviewing applications within the design review process.”
Visualization Cues. All participants mentioned that one of the two fundamental methods of communication within the design review process involves visual artifacts such as 2D plans, drawings, maps; 3D models; textual documents; and CAD, PSS, and GIS. However, the interpretation of graphical representations is often difficult for urban planners and stakeholders who lack strong visual literacy; this problem then could lead to a misunderstanding and misinterpretation of bylaws. Furthermore, existing technologies that support visualization of the design review process require extensive user training and knowledge, which usually conflicts with the skillset of urban planning stakeholders. Thus, the design review process still relies on impoverished visualization tools, such as paper-based sketches. As a participant noted,

(P2): “We have difficulty communicating where sunlight, setback, and physical surrounding is. This is because of insufficient, rather than simple, quick, and accessible 3D visualization technology. There is always a communication failure between people involved in the design review process, because the process is not visual, so it is not easy to understand the impact of future developments.”

4.8 Design Recommendation

The results of this study suggest an initial list of design recommendations for creating SketchBoard that could potentially support communication and participation; visualization; technical action; and mobile interaction on interactive surfaces.

Communication and Participation. SketchBoard could enhance participatory communication within the design review process through creating a common understanding of problem contexts, as well as providing appropriate information and accurate interpretations. It should also reduce conflicts through keeping record of discussions and simultaneous modification of plans while
communicating with urban planners and stakeholders. It could further be used for aggregating design ideas and then generating a design solution that is a combination of design concepts communicated by urban planners and stakeholders involved within the design review process.

**Visualization.** SketchBoard could be used as a common visual language that enhances the visual perception and understanding of both abstract and concrete ideas within the design review process. It could engage urban planners and stakeholders to understand complex problem contexts of the design review process through a simple and intuitive visual interface rather than imaginary visualizations. It could also decrease the misinterpretation of text-based documents by visualizing bylaws’ through graphics and illustrations, as well as visualization of 2D drawings and 3D modelling.

**Technical Action.** SketchBoard should focus specifically on simplifying the process of visualizing and comprehending the zoning ordinance as a challenging technical activity of the design review process. It should also allow web-based access and search capabilities for the computerized version of bylaws, also to be able to explore design alternatives. It could also offer an automatic analysis of socio-economic-political issues that may affect the design review process in a timely fashion.

**Mobile Interaction.** SketchBoard should also be used to support mobile communication and participation around technical activities of the design review process.

### 4.9 Summary of the Chapter

Study II involved semi-structured interviews, and participant and non-participant observations of the urban planners within the design review process. This study investigated the challenges and complexities intertwined with communication, participation, and visualization around technical
activities of the design review process, as well as the tools and technologies that urban planners and stakeholders use within the design review process.

Furthermore, the design review process consists of three main stages, specifically, Idea Generation, Application Refinement, and Public Consultation. This process relies significantly on an argumentative communication and iterative design of plans, sketches, and models from preliminary to advanced versions. Throughout this process, applications are reviewed, some applications are approved, and others are ultimately rejected, while some applications require further elaboration and several rounds of modifications before they are approved. Moreover, developers see projects as an investment which must achieve an acceptable level of return, while urban planners are more concerned with the public good. The resulting process is a participatory design activity rather than simply an evaluation. Thus, within the participatory communication process that concerns the subtleties of bylaws and other requirements, urban planners and the developer may reach an acceptable solution.

While seeking a solution to the complex problems of the design review process, urban planners must consult a myriad of text-based documents, also understand CAD and GIS materials. These tasks are cumbersome and require extensive knowledge and training of CAD and GIS. In addition, a simplistic visualization of the socio-economic-political subtleties of a building via 2D drawings and 3D models is critical to the success of any application. Hence, advances in current visualization techniques could enhance the understanding of how the zoning could shape building envelopes, which is challenging for both urban planners and the developer. In particular, participatory communication within the design review process is not supported by the existing desktop CAD and GIS computer applications. Additionally, a lack of mobility of the desktop CAD and GIS computer applications enforces urban planners to work in isolation, as well as an
increase their dependency on traditional paper-based documents for various stages of the design review process. Thus, urban planners’ constant failure in using computer applications reveals the limitations of the computer aided planning’s interface and interaction design. The design recommendations provided by this study will guide the directions of Study III, which is discussed in Chapter V.
Chapter Five: Study III: Explorations in Perspectives on User-Centered Design of SketchBoard for the Design Review Process

5.1 Introduction

The design review process involves a series of communicative and technical activities. While communication takes place to discuss the zoning ordinance and FAR concepts, misinformation and lack of comprehensibility are inevitable. Traditionally, the design review process relies on the use of paper and text-based documents and desktop computer applications. However, such artifacts involve an insufficient level of flexibility and mobility. To support these shortfalls, there is an assumption that participatory communication and visualization of technical documents within the design review process should be improved. The results of Study II show that the zoning ordinance and FAR are fairly difficult concepts to comprehend for urban planners, developers, and the public [1] [2] [34].

Therefore, the goal of Study III is to identify the features of SketchBoard that support the design review process. In particular, this study explores the importance of participatory design, the urban design and planning process, visualization, and analysis as key features to enhance the communicative and technical activities within the design review process. In this study, the primary data collection method was a structured survey. This survey provides a basic foundation of knowledge upon which further investigation can be based [39] [64].

5.2 Scope of the Study

This study had the following objective:

To define the features of SketchBoard that will help urban planners with the participatory communicative and technical activities within the design review process.
5.3 Study Methodological Process

In this study, a web-based survey method was used to more quickly and easily reach a wider range of participants in order to collect demographic data and participants’ opinions. The purpose of choosing a web-based survey was to draw attention to survey guidelines such as “select only one response,” “provide immediate data validation,” and “faster response rate.” The requirements of this survey are based on the relevant themes and categories revealed in the previous study. These themes and categories include participatory communication, design, visualization, and analysis as influencing factors within the design review process. The survey lasted approximately fifteen minutes for each participant and was entirely anonymous to prevent bias.

5.4 Participants

Fifty participants were recruited by using a purposeful sampling technique. Via an email distribution list, participants were invited to complete the survey. The target participants were urban planners, urban designers, and architects from the City of Calgary in land use planning and policy; development and building infrastructure; and infrastructure and information services; as well as the same category of professionals at urban planning, urban design, and architecture firms. In this survey, participants were asked to rank the importance of the proposed features for designing SketchBoard for the design review process.

5.5 Survey Method

In this study, a structured survey was conducted as a web-based questionnaire to measure the level of importance of four elements in the design review process, specifically; Participatory Design; the Urban Design and Planning Process; Visualization; and Analysis work practices. Google Docs was used to create the web-based survey. The survey consisted of two different
scenarios: Scenario I asked nineteen questions about zoning, and Scenario II asked nineteen similar questions about FAR. Thus, a total of thirty-eight questions were asked between the two surveys. The Semantic Differential scale was chosen as the question type and the radio button was chosen as the answer type. The Semantic Differential scale was used to explore the participant’s position on a scale between two bipolar adjectives as noted below. Participants were then asked to click on their answer. There were seven separate positions on a scale that was numbered 1 through 7, with 1 being “unimportant” and 7 being “important” [64] (see Appendix III.I for the thirty-eight survey questions in Scenarios I and II).

5.6 Data Collection and Analysis

In this study, the data was analyzed to construct a unified description of data collected for responses to each question that could then be compared across participants. The lowest range on the scale was “unimportant” (R1), and the highest range was “important” (R7). The center of the scale was the “neutral point” (R4) which was meaningless. Of a total of fifty surveys sent, thirty responses were received - a 60% response rate. Semantic Differential bar charts were created from the survey data and are shown below. In these bar charts, “R” stands for “Range” and percentage chosen by participants are reflected for Range I through 7. The comparison between ranges above the neutral point on the scale, specifically, (R5, 6, and 7) and the highest range on the scale (R7 = important) of Scenarios I and II is succinctly described in the following section and in Figures 5.1-19 [64] [70]. In these figures, Scenario I is reflected as SI and Scenario II is reflected as SII. In addition, the horizontal axis reflects a seven-point Semantic Differential scale: R1-7, and the vertical axis reflects the number of participants.
5.6.1 Participatory Design

Figure 5.1 for SI (below) shows that overall for R5, 6, and 7, 89% of the participants believed that the participation of urban planning stakeholders within the design review process has some importance. Specifically, for R7, 41% of the participants believed that this was an extremely important factor. Similarly, Figure 5.1 for SII (below) shows that overall for R5, 6, and 7, 89% of the participants believed that the participation of urban planning stakeholders within the design review process has some importance. Specifically, for R7, 27% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that the participation of urban planning stakeholders within the design review process is valued higher in SI than in SII.

![SI and SII: Importance of Participation of Urban Planning Stakeholders](image)

Figure 5.2 for SI (below) shows that overall for R5, 6, and 7, 85% of the participants believed that the communication with urban planning stakeholders within the design review process has some importance. Specifically, for R7, 44%, or almost half of the participants believed that it was an extremely important factor. Furthermore, Figure 5.2 for SII (below) shows that overall for R5, 6, and 7, 89% of the participants believed that the communication with urban planning stakeholders within the design review process has some importance. Specifically, for R7, 31% of the participants believed that it was an extremely important factor. In comparing SI and SII,
these results suggest that the communication with urban planning stakeholders within the design review process is valued higher in SI than in SII.

5.6.2 Urban Design and Planning Process

Figure 5.3 for SI (below) shows that overall for R5, 6, and 7, 89% of the participants believed that the concept design within the design review process has some importance. Specifically, for R7, 42% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.3 for SII (below) shows that overall for R5, 6, and 7, 88% of the participants believed that the concept design within the design review process has some importance. Specifically, for R7, 31%, or almost one third of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that the concept design within the design review process is valued higher in SI than in SII.
Figure 5.4 for SI (below) shows that overall for R5, 6, and 7, 77% of the participants believed that the *detailed design* within the design review process has some importance. Specifically, for R7, 23% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.4 for SII (below) shows that overall for R5, 6, and 7, 85% of the participants believed that the detailed design within the design review process has some importance. Specifically, for R7, 35% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that the detailed design within the design review process is valued higher in SII than in SI.

![Figure 5.4. SI and SII: Importance of Detailed Design](image)

Figure 5.5 for SI (below) shows that overall for R5, 6, and 7, 76% of the participants believed that *possible design revisions* within the design review process have some importance. Specifically, for R7, 23% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.5 for SII (below) shows that overall for R5, 6, and 7, 92% of the participants believed that possible design revisions within the design review process have some importance. Specifically, for R7, 27% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that possible design revisions within the design review process is valued rather equal in both SI and SII.
Figure 5.5. SI and SII: Importance of Possible Design Revisions

5.6.3 Visualization

The Figure 5.6 for SI (below) shows that overall for R5, 6, and 7, 89% of the participants believed that the use of Google Street View, Google Maps, and Google Earth within the design review process has some importance. Specifically, for R7, 35% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.6 for SII (below) shows that overall for R5, 6, and 7, 80% of the participants believed that the use of Google Street View, Google Maps, and Google Earth within the design review process has some importance. Specifically, for R7, 19% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that the use of Google Street View, Google Maps, and Google Earth within the design review process is valued higher in SI than in SII.

Figure 5.6. SI and SII: Importance of the Use of Google Street View, Google Maps, and Google Earth
The Figure 5.7 for SI (below) shows that overall for R5, 6, and 7, 81% of the participants believed that the use of CAD within the design review process has some importance. Specifically, for R7, 23% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.7 for SII (below) shows that overall for R5, 6, and 7, 84% of the participants believed that the use of CAD within the design review process has some importance. Specifically, for R7, 28% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that the use of CAD within the design review process is valued rather equal in both SI and SII.

5.6.4 Analysis

The Figure 5.8 for SI (below) shows that overall for R5, 6, and 7, 92% of the participants believed that the access to existing documents within the design review process has some importance. Specifically, for R7, 42% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.8 for SII (below) shows that overall for R5, 6, and 7, 84% of the participants believed the access to existing documents within the design review process has some importance. Specifically, for R7, 23% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that the access to existing documents within the design review process is valued higher in SI than in SII.
The Figure 5.9 for SI (below) shows that overall for R5, 6, and 7, 92% of the participants believed that existing setbacks requirements within the design review process has some importance. Specifically, for R7, 42% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.9 for SII (below) shows that overall for R5, 6, and 7, 85% of the participants believed that existing setbacks requirements within the design review process has some importance. Specifically, for R7, 27% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that existing setbacks requirements within the design review process is valued higher in SI than in SII.

Figure 5.10 for SI (below) shows that overall for R5, 6, and 7, 92% of the participants believed that the FAR of existing and/or proposed development within the design review process has some importance. Specifically, for R7, 46% of the participants believed that this was an extremely
important factor. Furthermore, Figure 5.10 for SII (below) shows that overall for R5, 6, and 7, 92% of the participants believed that the FAR of existing and/or proposed development within the design review process has some importance. Specifically, R7, 32% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that the FAR of existing and/or proposed development within the design review process is valued higher in SI than in SII.

![Figure 5.10. SI and SII: Importance of FAR of Existing and/or Proposed Development](image)

Figure 5.11 for SI (below) shows that overall for R5, 6, and 7, 96% of the participants believed that massing studies for existing and/or proposed development within the design review process has some importance. Specifically, for R7, 35% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.11 for SII (below) shows that overall for R5, 6, and 7, 81% of the participants believed that massing studies for existing and/or proposed development within the design review process has some importance. Specifically, for R7, 23% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that massing studies for existing and/or proposed development within the design review process is valued higher in SI than in SII.
Figure 5.12 for SI (below) shows that overall for R5, 6, and 7, 69% of the participants believed that *population studies and demographic analysis of surrounding areas* with the design review process has some importance. Specifically, for R7, 23% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.12 for SII (bellow) shows that overall for R5, 6, and 7, 72% of the participants believed that population studies and demographic analysis of surrounding areas within the design review process has some importance. Specifically, for R7, 32% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that population studies and demographic analysis of surrounding areas within the design review process is valued higher in SII than in SI.

Figure 5.13 for SI (below) shows that overall for R5, 6, and 7, 80% of the participants believed that the *access to existing traffic studies* within the design review process has some importance.
Specifically, for R7, 24% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.13 for SII (below) shows that overall for R5, 6, and 7, 68% of the participants believed that the access to existing traffic studies within the design review process has some importance. Specifically, for R7, 12% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that the access to existing traffic studies within the design review process is valued higher in SI than in SII.

Figure 5.13. SI and SII: Importance of Access to Existing Traffic Studies

Figure 5.14 for SI (below) shows that overall for R5, 6, and 7, 62% of the participants believed that the economic analysis within the design review process has some importance. Specifically, for R7, 23% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.14 for SII (below) shows that overall for R5, 6, and 7, 80% of the participants believed that the economic analysis within the design review process has some importance. Specifically, for R7, 19% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that economic analysis within the design view process is valued higher in SI than in SII.
Figure 5.14. SI and SII: Importance of Economic Analysis

Figure 5.15 for SI (below) shows that overall for R5, 6, and 7, 88% of the participants believed that the *sun and shade analysis for existing and/or proposed development* within the design review process has some importance. Specifically, for R7, 24% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.15 for SII (below) shows that overall for R5, 6, and 7, 80% of the participants believed that the sun and shade analysis for existing and/or proposed development within the design review process has some importance. Specifically, for R7, 15% of the participants believed that this was an extremely important factor.

In comparing SI and SII, these results suggest that the sun and shade analysis for existing and/or proposed development within the design review process is valued higher in SI than in SII.

Figure 5.15. SI and SII: Importance of Sun and Shade Analysis for Existing and/or Proposed Development

Figure 5.16 for SI (below) shows that overall for R5, 6, and 7, 96% of the participants believed that the *physical surroundings including buildings and trees* within the design review process
has some importance. Specifically, for R7, 15% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.16 for SII (below) shows that overall for R5, 6, and 7, 81% of the participants believed that the physical surroundings including buildings and trees within the design review process has some importance. Specifically, for R7, 12% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that the physical surroundings including buildings and trees within the design review process is valued rather equal in both SI and SII.

![Figure 5.16. SI and SII: Importance of Physical Surroundings including Buildings and Trees](image)

The Figure 5.17 for SI (below) shows that overall for R5, 6, and 7, 88% of the participants believed that 2D drawings of existing and/or proposed development within the design review process has some importance. Specifically, for R7, 23% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.17 for SII (below) shows that overall for R5, 6, and 7, 84% of the participants believed that 2D drawings of existing and/or proposed development within the design review process has some importance. Specifically, for R7, 19% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that 2D drawings of existing and/or proposed development within the design review process is valued rather equal in both SI and SII.
Figure 5.17. SI and SII: Importance of 2D Drawings of Existing and/or Proposed Development

Figure 5.18 for SI (below) shows that overall for R5, 6, and 7: 93% of the participants believed that the 3D modeling of existing and/or proposed development within the design review process has some importance. Specifically, for R7, 27% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.18 for SII (below) shows that overall for R5, 6, and 7, 92% of the participants believed that the 3D modeling of existing and/or proposed development within the design review process has some importance. Specifically, for R7, 27% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that the 3D modeling of existing and/or proposed development within the design review process is valued equal in both SI and SII.

Figure 5.18. SI and SII: Importance of 3D Modeling of Existing and/or Proposed Development

Figure 5.19 for SI (below) shows that overall for R5, 6, and 7, 84% of the participants believed that the use of GIS within the design review process has some importance. Specifically, for R7,
31% of the participants believed that this was an extremely important factor. Furthermore, Figure 5.19 for SII (below) shows that overall for R5, 6, and 7, 84% of the participants believed that the use of GIS within the design review process has some importance. Specifically, for R7, 15% of the participants believed that this was an extremely important factor. In comparing SI and SII, these results suggest that the use of GIS within the design review process is valued higher in SI than in SII.

Figure 5.19. SI and SII: Importance of the Use of GIS

### 5.7 Summary of the Chapter

Study III reports the results of a web-based survey on exploring the key design specifications of a potential interactive communicative medium that supports communicative and technical activities in the design review process. The results of this survey revealed the followings finding.

**Participatory design.** Participation and communication in the zoning scenario (SI) are both more important than in the FAR scenario (SII).

**Urban design and planning process.** Concept and detailed design in the zoning scenario (SI) are both more important than in the FAR scenario (SII). Possible design revisions are equally important in both zoning scenario (SI) and FAR scenario (SII).
**Visualization.** Use of Google Street View, Google Maps and Google Earth in the zoning scenario (SI) is more important than in the FAR scenario (SII). Use of CAD is equally important in the zoning scenario (SI) and the FAR scenario (SII).

**Analysis.** Participants’ response to questions in the zoning (SI) and FAR (SII) scenarios differed according to twelve prime features. These comparisons are noted below in Table 5.1.

<table>
<thead>
<tr>
<th>Twelve Prime Features</th>
<th>Scenario I: Zoning</th>
<th>Scenario II: FAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to existing documents</td>
<td>More important</td>
<td>Less important</td>
</tr>
<tr>
<td>Existing setbacks requirements</td>
<td>More important</td>
<td>Less important</td>
</tr>
<tr>
<td>FAR of existing and/or proposed development</td>
<td>More important</td>
<td>Less important</td>
</tr>
<tr>
<td>Massing studies for existing and/or proposed development</td>
<td>More important</td>
<td>Less important</td>
</tr>
<tr>
<td>Population studies and demographic analysis of surrounding areas</td>
<td>Less important</td>
<td>More important</td>
</tr>
<tr>
<td>Access to existing traffic studies</td>
<td>More important</td>
<td>Less important</td>
</tr>
<tr>
<td>Economic analysis</td>
<td>More important</td>
<td>Less important</td>
</tr>
<tr>
<td>Sun and shade analysis for existing and/or proposed development</td>
<td>More important</td>
<td>Less important</td>
</tr>
<tr>
<td>Physical surroundings including buildings and trees</td>
<td>Equally important</td>
<td>Equally important</td>
</tr>
<tr>
<td>2D drawings of existing and/or proposed development</td>
<td>Equally important</td>
<td>Equally important</td>
</tr>
<tr>
<td>3D modeling of existing and/or proposed development</td>
<td>Equally important</td>
<td>Equally important</td>
</tr>
<tr>
<td>The use of GIS</td>
<td>More important</td>
<td>Less important</td>
</tr>
</tbody>
</table>

Table 5.1. Analysis between SI and SII for Twelve Prime Features

Overall, the structured surveys employed in Study III approximated subjective meanings from objective meanings. Findings generated within Study III could only provide an operationalized interpretation and estimation of the important factors in creating SketchBoard, rather than offering an idealized and rigorous requirement produced within a controlled setting. This thus suggests that participation and communication around design issues, as well as visualization of the zoning ordinance in a 3D form and computation of the FAR integrated with SketchBoard could potentially enhance comprehensive and intelligible interactions. Furthermore, a geolocated capability while on the move could also improve the automated and mobile interactions incorporated with SketchBoard. Simplicity and intuitiveness are also significant in discussions.
about creating SketchBoard for the design review process. The results of this study also tend to support more informed decisions for identifying the design specifications were needed in Study IV which are discussed in Chapter VI.
Chapter Six: Study IV: Morphing the Building Environment: Conceptualizing SketchBoard for the Design Review Process

6.1 Introduction

An array of computer aided planning technologies support urban planning workflows, however, their less than satisfactory performance is the result of inadequate technological features for urban planning stakeholders. Also, urban planning stakeholders generally have limited technical skills, yet, computer aided planning requires extensive technical knowledge of CAD and GIS. Moreover, paper and text-based documents used in traditional zoning ordinances’ processes suffer from a lack of comprehensibility. Therefore, an effort was made to address this shortcoming by integrating more illustrations and diagrams to paper and text-based documents in the manual zoning ordinance’s process. However, interpreting zoning ordinance documents still lacks optimal communication and visualization tools [7] [10] [33] [34] [35].

Visualizing the impact of a city’s zoning ordinance and calculating FAR are often important considerations in the design review process. However, the current methods of visualizing the zoning ordinance and calculating the FAR can be cumbersome and time-consuming. Therefore, the goal of Study IV is to create and evaluate SketchBoard in order to identify the possibilities and design directions needed to support urban planning stakeholders in understanding the participatory communication and technical complexities of the visualization of the zoning ordinance’s process. In particular, this study explores how technology can be used to support communication, participation, visualization, and analysis throughout the design review process.

As part of the user-centered design process, the primary goal of this study is to create a minimal interface and interaction design for SketchBoard that will allow urban planners with limited computer skills to take part in a co-design process with other urban planners and the researcher.
In the absence of such an interactive communication medium, a digital paper prototype was created to help test its potential use within the design review process. The interface and interaction design of SketchBoard were designed using a storyboard technique for an iPad. In this study, the primary data collection techniques rely on semi-structured interviews and structured surveys together with demonstrations of the digital paper prototype.

6.2 Scope of the Study

This study had the following objectives:

1. To investigate how SketchBoard could potentially be adopted by urban planners for communicative and technical activities within the design review process.

2. To evaluate how urban planners think about, interact with and integrate with SketchBoard and estimate whether SketchBoard can be successfully used in real world settings.

3. To investigate the adaptability and compatibility of SketchBoard on interactive surfaces compared to those on desktops.

6.3 Study Methodological Process

As part of Study IV, triangulation was used as a data gathering technique. Study IV consisted of three phases specifically a Pilot Study, a Main Study, and a Focus Group. First, a Pilot Study was conducted. Second was the Main Study. Third was the Focus Group. Each Pilot Study, Main Study, and Focus Group was conducted in three steps. Step one involved the demonstration of SketchBoard. In step two, structured surveys were undertaken. Step three consisted of the semi-structured interviews.
In the first step, participants were given a walk-through of SketchBoard, then asked to interact with SketchBoard. In the second step, participants were asked to answer the web-based survey questions. In the third step, participants had to explain how they thought SketchBoard could potentially support the participatory communicative and technical activities within the design review process, and how SketchBoard could be improved. All three steps - the demonstration of digital paper prototypes, surveys, and interviews - lasted approximately for half an hour for each participant. The demonstration of SketchBoard, surveys, and interviews were entirely anonymous.

6.4 Pilot Study
Initially, a Pilot Study was conducted as a small-scale exploration designed to gather information prior to a larger study and to evaluate the feasibility of the Main Study and Focus Group. The results of the Pilot Study were useful in improving the quality and efficiency of the Main Study and Focus Group by revealing the deficiencies in the design of SketchBoard, and useful information was gathered for the later iteration of SketchBoard demonstrated for the Main Study and Focus Group. Furthermore, in the Pilot Study, a total of five participants were recruited by using a purposeful sampling technique, and via an email distribution list sent to urban planning and urban design students at the University of Calgary. Participants were given a demo of SketchBoard, web-based surveys, and interviews sessions in which they were questioned. Participants were interviewed individually and completed the surveys individually; in addition, they had the freedom to explain their background, existing knowledge, and prior experience.

6.5 Main Study
In the Main Study, a total of six participants were recruited by using a purposeful sampling technique, and an email distribution list that reached urban planners, urban designers, and
architects in land use planning and policy; development and building infrastructure; and infrastructure and information services at the City of Calgary. All participants were first given a demo of SketchBoard. Then participants individually filled out the web-based surveys and then were interviewed individually and had the freedom to explain their background, existing knowledge, and prior experience that contribute to a discussion on the use of SketchBoard for the design review process.

6.6 Focus Group

In the Focus Group, a total of five participants were recruited by using a purposeful sampling technique, and an email distribution list that reached urban planners, urban designers, and architects in land use planning and policy; development and building infrastructure; and infrastructure and information services at the City of Calgary. The discussion in the Focus Group was led by the researcher. The Focus Group was held to identify potential conflicts in terminology arising out of the communicative and technical activities or expectations from different individuals within the land use planning and policy department at the City of Calgary. At the Focus Group, participants first filled out the web-based surveys and the participated in a Focus Group session. To enable participants to put forward their own opinions in a supportive environment, they were allowed to give their opinions and discuss their ideas about SketchBoard with the other participants in the Focus Group.

6.7 Digital Paper Prototyping Method

The first step in Study IV was the digital paper prototyping that was used to demonstrate the potentials of SketchBoard which could assist in the design review process. The design was used to investigate how well SketchBoard could potentially support the goals of this study. Participants were asked to navigate through SketchBoard by interacting with the digital paper
prototype. During the course of the demonstrations, they provided feedback on the flow of interaction and interaction functionality. Audio recording was employed as a data gathering technique.

6.8 Survey Method

The second step in Study IV was a structured survey that involved six closed questions on topics that focused on the design of SketchBoard. Google Docs was used to create a web-based survey that ran on iPad. The Likert scale as a question type and the radio button as an answer type were used. These components of the Likert scale constructed one unified description of data collected for responses to each question that could be compared across participants. A seven-point Likert scale was used to measure users’ preference and satisfaction with the SketchBoard used in the design preview process. Participants were asked to make judgments about the “simplicity” and “ease-of-use” of SketchBoard. For each question, participants were given a radio button to tick. The discrete scale had seven points: 1. strongly agree; 2. agree; 3. somewhat agree; 4. no opinion; 5. somewhat disagree; 6. disagree; and 7. strongly disagree. The highest level on the scale was “strongly agree” and the lowest range on the scale was “strongly disagree.” The center of the scale was “no opinion” (see Appendix IV.I for the six survey questions).

6.9 Interview Method

The third step in Study IV was a semi-structured interview with the purpose of engaging participants in a conversation. The purpose of this interview was to gain impressions about how urban planners might react to SketchBoard. This interview included four open-ended and evolving questions (see Appendix IV.I for the four interview questions).
6.10 From Data to Design

The leap from user data to design of SketchBoard required a range of design decisions that should ultimately lead to a doable design. Visioning required multiple possible innovative designs that support the subtleties and practicalities of urban planning stakeholders’ work. To ensure that the design vision was grounded in the user data, affinity diagrams were reviewed (see Chapters III and IV). Next, a list of the most important issues was made that should be supported or eliminated (see Chapter V) [38].

Furthermore, four notions of functional, structural, architectural, and compositional minimalism were put forward as an underlying user-centered design technique for creating SketchBoard (see section 6.15). A set of design specifications was brainstormed and generated to address different dimensions of work practice. Moreover, a list of the specialized and mundane technologies that might be used for implementing the design concept was made. Design specifications were then incorporated into a coherent story and anecdote. A collection of a variety of storyboards on a tablet was then reconfigured and redesigned into a single solution for further evaluation and iterations [38] [68].

6.11 Persona

The cast of characters for this study consisted of Don, Pat, and Sydney who represented the user population (see Chapter I, section 1.1.4). To narrow down the spectrum of users, Sydney was chosen as the primary persona, and was the touchstone throughout the entire design process. Sydney had a set of objectives that was different from those of Don and Pat. Sydney was the personification of a naïve and clueless user. However, since Sydney was the primary focus of the design, he had to be satisfied with the results of the end design. Making Sydney happy would
mean that each and every stakeholder within the design review process would probably be happy. Thus, SketchBoard was designed uniquely for Sydney [15] [21].

6.12 Mock-up

This study employed digital paper prototyping as a method for co-designing SketchBoard with urban planners. Digital paper prototyping can be a useful method for exploring and discussing design questions raised in this study. It is also an effective method for evaluating the design ideas and supporting the rationale in choosing between alternative concepts posed in this study. Digital paper prototyping can also be useful in exploring if and how SketchBoard can help communication, participation, and visualization in urban design and planning processes. Using a low fidelity prototyping can quickly support the creation of simple mock-ups and at minimal cost [64] [71] [72] [73].

Furthermore, to create mock-ups, storyboards were used in conjunction with digital paper prototyping on an iPad. Moreover, Sketches I-VI were only designed for Sydney. Figures 6.1-9 illustrate the design sequences in the cycle of designing Sketches I-V. In addition, Sketch VI was deigned subsequent to the Pilot Study and incorporates the results from this study, as shown below in Figure 6.21. These prototypes were used to obtain feedback on the flow of interaction and ease-of-use in the functionalities of SketchBoard.

6.13 Scenario

The scenario used in this study was semi-fictional. Most of the numbers were based on an actual scenario, though, to simplify the scenario, some of the numbers were changed to fulfill the purpose of this study.
A lot zoned Residential 3 (R3). The parcel measures 5,000 square feet in area and is 50 feet wide and 100 feet deep. Table 6.1 (below) shows Residential 3.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Lot Size (Min.)</th>
<th>Lot Width (Min.)</th>
<th>Lot Depth (Min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R3</td>
<td>5000 sq-ft</td>
<td>50 ft</td>
<td>100 ft</td>
</tr>
</tbody>
</table>

Table 6.1. Residential 3

In this R3 zoned lot, with an area of 5,000 square feet, the total development potential determines the size of building that can be built on the site. If the building is a one-story single-family dwelling, it will contain 2,925 square feet of developed space. If the building is a two-story single-family dwelling, it will contain 5,850 square feet of developed space. If the building is a three-story single-family dwelling, it will contain 8,450 square feet of developed space and if the building is a four-story single-family dwelling, it will contain 10,725 square feet of developed space. Various height districts, which establish height, number of floors, and FAR for a specific zone are defined. The maximum height of the building can be up to 40 feet, with a maximum of four floors and a FAR of 3. Table 6.2 (below) illustrates Residential 3.

<table>
<thead>
<tr>
<th>Height</th>
<th>Floor</th>
<th>Setback</th>
<th>FAR</th>
<th>Lot Size (Min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 ft</td>
<td>4</td>
<td>15 ft</td>
<td>3</td>
<td>10725 sq-ft</td>
</tr>
<tr>
<td>30 ft</td>
<td>3</td>
<td>10 ft</td>
<td>3</td>
<td>8450 sq-ft</td>
</tr>
<tr>
<td>20 ft</td>
<td>1-2</td>
<td>5 ft</td>
<td>3</td>
<td>2925-5850 sq-ft</td>
</tr>
</tbody>
</table>

Table 6.2. Residential 3

6.14 Storyboards

In the absence of a fully working prototype, a series of storyboards were built. Storyboarding was a low-fidelity prototyping technique consisting of a series of sketches that were woven into scenarios and told a story. Storyboards were used for pre-visualizing potential interactions with the participants. In conjunction with scenarios, storyboards allowed participants to role-play with
the prototype by interacting and stepping through a specific scenario. SketchUp was used to create the 3D model representing a potential architectural solution [74]. Photoshop was then used to create final images for the slide show [75] as shown below in Figures 6.2-10 and 6.17. In addition, InVision which is a web-based and mobile mockup and user interface prototyping tool was used to assemble the final images created in Photoshop. InVision then helped to create hotspots for making touch-events, thus to enable the storyboards to be interactive on the tablet [76]. This enabled participants to experience a series of basic hide and show interactions to view and review the storyboards and provide feedback. Participants were informed that the interactions were slide show [64].

6.15 Design Specifications

The approximate Design Specifications (DS.I-IX) that emerged in Study III were crystalized to weave user stories into the digital interactive experience on Sketches I-VI (see Chapter V). Specifically, SketchBoard targeted the design charrette that was part of the early phase of the design review process. SketchBoard did not aspire to replace modelers targeting photorealistic rendering, but to be a visualization and sketching tool for the design review process. Furthermore, SketchBoard supports the visualization of the zoning ordinance and the calculation of FAR by manipulating different dimensions on a 2D plan. SketchBoard can be further enhanced by automatically defining the geo-location of the parcel, illustrating the setbacks associated with the parcel, providing a number-based dialogue for manipulating dimensions such as setbacks, heights, and number of floors, and then creating a three-dimensional building that represents the proposed building on the prospective parcel.

In particular, design specifications were defined to create a minimal interface and interaction design for SketchBoard that were unobtrusive and differential to the current tools and
technologies for the design review process. The interface and interaction design complexity of SketchBoard were functionally reduced, mainly because it only offers a minimal number of tools that focus on simple sketching and visualization functions; also it does not include complex features of CAD or GIS interface. The interface and interaction design of SketchBoard are more radically tailored to the notion of functional minimalism that concentrates on the requirements of individual functionalities such as a visualization of the zoning ordinance and computation of FAR [68].

The SketchBoard interface and interaction design were created to be easy-to-use, and especially could be promoted to urban planners, and urban planning stakeholders who are novices and interested in visualization and calculation speed and variability. Architectural minimalism in the constituents of SketchBoard denotes that the interface and interaction design should be modularized. This can be attained through the development of a gird system that allows for the achievement of a much more harmonious relationship between individual elements on the interface and interaction design through coherence, asymmetrical balance, alignment, and distinct dimensions. The interface and interaction design of SketchBoard also attempt to accentuate its visual characteristics through designing all the icons, refining typography, and incorporating a whole new palette of colors [68].

The interface and interaction design of SketchBoard tend to attain a minimal access structure for the user. This can be accomplished by using distinct and functional buttons and menus that help establish hierarchy and order and increase a sense of simplicity. Structural minimalism can also be achieved through representing the important features as a focal point, as well as reducing unnecessary elements and contents that are less noticeable and cause distraction and cognitive load for the user. Moreover, the SketchBoard interface and interaction design apply a
compositional minimalism approach to the situationally intelligent features associated with the interactivity and mobility of the communication and participation needs within the design review process. [68]. However, in a real world practical sense, it is still to be concluded if the features of SketchBoard can realistically operate as projected in the following design specifications:

**DS.I. Pseudo Visualization and Computation of the Zoning Ordinance and FAR.** SketchBoard promises to support quasi-visualization and computation of the zoning ordinance and FAR in the design review process.

**DS.II. Pseudo 3D Interaction.** SketchBoard promises to support a quasi-3D interaction and sketching technique for better understanding of the design or perspective within the design review process.

**DS.III. Pseudo Intelligent Interaction.** SketchBoard promises to provide multiple forms of smart and knowledgeable 3D visualization and computational assistance for the zoning ordinance, FAR and bylaws.

**DS.IV. Pseudo Geo-Located Interaction.** SketchBoard promises to provide quasi-identification of the geographic location of a building parcel, and a viewing tool if integrated with Google Earth.

**DS.V. Mobile Tablet-Based Interface with Well-Defined Interaction Design.** SketchBoard promises to provide greater mobility.

**DS.VI. Participatory Interaction.** SketchBoard promises to support participation of urban planning stakeholders around their communicative and technical activities in the design review process.
DS.VII. Intelligible Interaction. SketchBoard promises to provide a comprehensible interface and interaction design, while supporting a shared understanding around the communicative and technical challenges in the design review process.

DS.VIII. Simple and Intuitive Interaction. SketchBoard promises a simple and intuitive approach to interactions that support insight and inspiration via better integration of the communicative and technical needs within the design review process.

DS.IX. Minimalist Aesthetic. The minimalistic aesthetic of SketchBoard promises to provide a simple and transparent design for the interface that is reduced to its necessary elements.

6.16 Variations in Designing Storyboards

To satisfy the goals of this study, a variation-based method was used to coordinate the design of multiple prototypes to maximize commonality across a set of prototypes without compromising their individual characteristics. The variation-based method is a technique used in industrial design for creating different concepts based on a primary concept. Various concept characteristics are specified while changing forms and function of a primary concept. Sketch I identifies the primary prototype concept around which the group of prototypes were to be designed. This allowed the achievement of a variety of prototype characteristics including form and interaction requirements and maximizing concept commonality. Hence, the primary prototype concept is common to all of Sketches I-VI. Commonality in concept was achieved through introducing a focal goal that sought to minimize the deviation of the input design specifications while satisfying the range of interactions. To compromise the tradeoff between satisfying the variation and maximizing concept commonality, each individual prototype was designed around a common concept such that the design specifications for each prototype in the
group were best satisfied. Furthermore, the fundamentals of design that defined basic layouts for each prototype allowed experiments with different options to achieve the optimal results in form and interaction integrated with Sketches I-VI. Below, the principles of design for Sketches I-IV are illustrated in Figure 6.1. Moreover, the design variables in Sketches I-VI show that a small deviation held constant to form the primary concept. In Sketches I-V, to satisfy the form and interaction characteristics, each sketch was compared against the previous sketch. However, Sketch VI is an improved iteration of Sketch V. Storyboards in Sketches I-VI show the process of evolution of the design from preliminary to final stages as illustrated below in Figures 6.2-10 and 6.17.

Figure 6.1. The Principles of Design for Sketches I-VI
6.16.1 Sketch I

Sketch I shows the first set of variations in creating an interactive storyboard that consists of four illustrations as shown below in Figure 6.2. Image I shows the location of R3 on the map; Image II zooms in the R3 lot area; Image III shows the lot dimensions and setbacks; and Image IV shows the 3D visualization of the development for a three-story single-family dwelling.

In Image III and IV, a pop-up menu allows for navigating through the images back and forth. The pop-up menu consists of the following components: 2D and 3D buttons - toggling between 2D and 3D buttons allows for changing the view to 2D or 3D. Also, for modifiable height, setback, floors, and FAR buttons - toggling between these allows for changing the respective variables.

In this prototype, the sequence of interaction is as follows: 1. Image I: tap on the map. 2. Image II: tap on the zoomed R3 lot area. 3. Image III: tap on the 3D button. 4. Image IV: tap on the 2D button to return to the first image.
Figure 6.2. Sketch I
6.16.2 Sketch II

Sketch II shows the second set of variations in creating an interactive storyboard that consists of seven illustrations as shown below in Figures 6.3 and 6.4. Image I shows the location of R3 on the map; Image II zooms in the R3 lot area; Image III shows the lot dimensions and setbacks; Image IV shows the 3D visualization of the development for a one-story single-family dwelling; Image V shows the 3D visualization of the development for a two-story single-family dwelling; Image VI shows the 3D visualization of the development for a three-story single-family dwelling; and Image VII shows the 3D visualization of the one, two, and three-story single-family dwelling.

In Images III-VII, pop-up menus allow for modifying numbers and navigating through the images back and forth. Also, a number-pad allows for entering numbers. The pop-up menu consists of the following components: 2D and 3D buttons - toggling between 2D and 3D buttons allows for changing the view to 2D or 3D. Also, non-modifiable FAR, and modifiable setback, height, and floor buttons - toggling between these allows for changing the respective variables.

In this prototype, the sequence of interaction is as follows: 1. Image I: tap on the map. 2. Image II: tap on the zoomed R3 lot area. 3. Image III: enter the appropriate number to add the first floor height. 4. Image IV: setback, height, and floor pop-up window for the first floor appears. Next, enter the appropriate number to add the second floor height. 5. Image V: the setback, height, and floor pop-up window for the first and second floors then appears. Next, enter the appropriate number to add the third floor height. 6. Image VI: the setback, height, and floor pop-up window appears for the first, second, and third floors. Next, tap on the 3D button to view the first, second, and third floors together. 7. Image VII: the setback, height, and floor pop-up window appears for the first, second, and third floors. Next, tap on the 2D button to return to the first image.
Figure 6.3. Sketch II
Figure 6.4. Sketch II
6.16.3 Sketch III

Sketch III shows the third set of variations in creating an interactive storyboard that consists of seven illustrations as shown below in Figures 6.5 and 6.6. Image I shows the location of R3 on the map; Image II zooms in the R3 lot area; Image III shows the lot dimensions and setbacks; Image IV shows the 3D visualization of the development for a one-story single-family dwelling; Image V shows the 3D visualization of the development for a two-story single-family dwelling; Image VI shows the 3D visualization of the development for a three-story single-family dwelling; and Image VII shows the 3D visualization of a one, two, and three-story single-family dwelling.

In Images III-VII, pop-up menus allow for modifying numbers and navigating through the images back and forth. Also, a slider control allows for changing numbers. The pop-up menu consists of the following components: 2D and 3D buttons - toggling between 2D and 3D buttons allows for changing the view to 2D or 3D. Also, non-modifiable FAR, and modifiable setback, height, and floor buttons - toggling between these allows for changing the respective variables.

In this prototype, the sequence of interaction is as follows: 1. Image I: tap on the map. 2. Image II: tap on the zoomed R3 lot area. 3. Image III: drag the slider to the right to increase to the appropriate number and add the first floor height. 4. Image IV: the setback, height, and floor pop-up window appears for the first floor. Next, drag the slider to the right to increase to the appropriate number and add the second floor height. 5. Image V: the setback, height, and floor pop-up window appears for the first and second floors. Next, drag the slider to the right to increase to the appropriate number and add the third floor height. 6. Image VI: the setback, height, and floor pop-up window appears for the first, second, and third floors. Next, tap on the 3D button to view the first, second, and third floors together. 7. Image VII: the setback, height,
and floor pop-up window appears for the first, second, and third floors. Next, tap on the 2D button to return to the first image.

Figure 6.5. Sketch III
Figure 6.6. Sketch III
Sketch IV shows the fourth set of variations in creating an interactive storyboard that consists of five illustrations as shown below in Figures 6.7 and 6.8. Image I shows the location of R3 on the map; Image II zooms in the R3 lot area; Image III shows the lot dimensions and setbacks; Image IV shows the 3D visualization of the one, two, and three-story single-family dwelling; and, Image V shows a visualization of the one, two, and three-story single-family dwelling.

In Images III-V, pop-up menus allow for modifying numbers and navigating through the images back and forth. The pop-up menu consists of the following components: 2D and 3D buttons - toggling between 2D and 3D buttons allows for changing the view to 2D or 3D. Also, non-modifiable FAR, and modifiable height, floor, and setback buttons - toggling between these allows for changing the respective variables.

In this prototype, the sequence of interaction is as follows: 1. Image I: tap on the map. 2. Image II: tap on the zoomed R3 lot area. 3. Image III: tap on the 3D button. 4. Image IV: tap on height, setback or floor. A pop-up window then appears that allows for modifying height as well as viewing setback and floor numbers. 5. Image V: tap on the 2D button to return to the first image. The allowed FAR is illustrated and the permitted FAR is supposed to be computed by SketchBoard.
Figure 6.7. Sketch IV
Sketch V shows the fifth set of variations in creating an interactive storyboard that consists of six illustrations as shown below in Figures 6.9 and 6.10. Image I shows the location of R3 on the map; Image II zooms in the R3 lot area; Image III shows the lot dimensions and setbacks; Image IV shows the 3D visualization of the one, two, three, and four-story single-family dwelling; Image V shows the 3D visualization of the one, two, three, and four-story single-family dwelling; and, Image VI shows the 3D a visualization of the one, two, three, four, and five-story single-family dwelling.

In Images III-V, pop-up menus allow for modifying numbers and navigating through the images back and forth. The pop-up menu consists of the following components: 2D and 3D buttons - toggling between 2D and 3D buttons allows for changing the view to 2D or 3D. Also, non-
modifiable FAR, and modifiable height, floor, and setback buttons - toggling between these allows for changing the respective variables. Also, in Images II-VI, there is a separate back button that allows for navigating back through the images.

In this prototype, the sequence of interaction is as follows: 1. Image I: tap on the map. 2. Image II: tap on the zoomed R3 lot area. 3. Image III: tap on the 3D button. 4. Image IV: tap on height, setback or floor dialogue elements. A pop-up window then appears that allows for modifying height as well as for viewing setback and floor numbers. 5. Image V: increasing the height above the maximum allowed height shows that the fifth floor is not permitted. Image VI: tap on the 2D button to return to the first image. The allowed FAR is illustrated and the permitted FAR is supposed to be computed by SketchBoard.
Figure 6.9. Sketch V
6.17 Data Collection and Analysis

The raw data from the surveys in all three phases of the Pilot Study, Main Study, and Focus Group consisted of participants’ answers to the survey questions. The survey data was treated to construct a unified description of data collected for responses to each survey question that could be compared across participants. The Likert scale was divided into three ranges. Specifically, the “somewhat disagree, disagree, and strongly disagree” were included in the lower level range on the scale that was considered as “negative” (R0-), and the “strongly agree, agree, and somewhat agree” were included in the higher level range on the scale that was considered as “positive” (R0+). The “no opinion” was the center of the scale that was considered as “neutral” (R0). Then, all the responses from surveys were compiled and presented in figures, percentages, and bar charts as shown below in Figures 6.12, 6.18, and 6.23. In these figures, the horizontal axis
reflects then number of participants, and the vertical axis reflects a seven-point Likert scale: R0-, R0, and R0+.

Furthermore, in the Pilot Study, Main Study, and Focus Group, extensive, manual note-taking and audio recording were used to document interviews. The interview notes and audio recordings were written up and transcribed verbatim. Moreover, the affinity diagraming technique was then used to analyze the data. It organized ideas and statements gathered during the interviews into four categories: SketchBoard and Technical Activities; SketchBoard and Communicative Activities; SketchBoard and Education; and SketchBoard Improvement. Figures 6.13-16, 6.19-22, and 6.24-26 (below) illustrate the affinity diagrams. Each category was defined in a meaningful way as determined by the goal of the study. These categories below were organized manually as shown in Figure 6.11. In addition, in the findings sections, participants’ quotes along with their corresponding numbers are noted to preserve participants’ confidentiality.

Figure 6.11. Manual Affinity Diagram: Inductive Process of Clustering Notes
Following, in the next sections, the analysis of the surveys and interviews within all three phases (Pilot Study, Main Study, and Focus Group) are presented.

### 6.17.1 Pilot Study

Below is an analysis of the data collected during the survey and interview sessions of five participants in the Pilot Study.

#### 6.17.1.1 Surveys for Pilot Study

Figure 6.12 for Q1 (below) shows that overall for R0+: 100% of the participants (this is, 40% of the participants *strongly agreed* and 60% of the participants *agreed*) believed that SketchBoard was easy to understand.

Figure 6.12 for Q2 (below) shows that overall for R0+: 100% of the participants (this is, 40% of the participants *strongly agreed*, 40% of the participants *agreed*, and 20% of the participants *somewhat agreed*) believed that SketchBoard presented the information in a logical order.

Figure 6.12 for Q3 (below) shows that overall for R0+: 100% of the participants (this is, 40% of the participants *strongly agreed*, 40% of the participants *agreed*, and 20% of the participants *somewhat agreed*) believed that SketchBoard had appealing aesthetics.

Figure 6.12 for Q4 (below) shows that overall for R0+: 100% of the participants (this is, 80% of the participants *strongly agreed* and 20% of the participants *somewhat agreed*) believed that the use of tablet versus a desktop made performing the task easier on SketchBoard.

Figure 6.12 for Q5 (below) shows that overall for R0+: 100% of the participants (this is, 60% of the participants *strongly agreed* and 40% of the participants *somewhat agreed*) believed that
SketchBoard solved the problem of understanding the implications of zoning on FAR for a particular parcel.

Finally, Figure 6.12 for Q6 (below) shows that overall for R0+: 80% of the participants (this is, 60% of the participants *strongly agreed* and 20% of the participants *agreed*) believed that SketchBoard could be used to help explain why the FAR as calculated is sometimes lower than the allowed FAR, given existing setbacks and height restrictions for that parcel. Furthermore, R0: 20% of the participants had no opinion.
6.17.1.2 Interviews for Pilot Study

SketchBoard and Technical Activities

All participants mentioned that SketchBoard supports the visualization of the zoning ordinance that explains why it would be difficult to achieve the maximum FAR on any particular site. These opinions are discussed in the section below. Figure 6.13 (below) illustrates an affinity diagram of SketchBoard and Technical Activities.

![Affinity Diagram of SketchBoard and Technical Activities]

**Comprehension.** Participants believed that whenever zoning regulations pose restrictions to achieve the maximum FAR on a site, SketchBoard provides a great degree of comprehension of the technical concepts. Participants saw value in SketchBoard because it supports the visualization of the zoning ordinance and computation of the FAR in a comprehensible format. Participants said that, on a positive note, SketchBoard offers the opportunity to change parameters, such as floor height, also to locate the blocks and parcels geographically. Furthermore, being able to access the exact height, setbacks, number of floor, and permitted and allowed FAR, also to visualize the impact on developable area were stated as being SketchBoard’s forte. Participants also mentioned it would be useful to explore potential variances that might be granted to the developers.

**Visual Cues.** Participants stated that the use of red to color restrictions and limitations was unclear. Participants said that the use of a 3D model, graphics, and visual forms makes SketchBoard very straightforward and easy to understand. Participants further elaborated that
representing the height limits through the use of 3D modeling might propose a good option. As three participants noted,

(P3): “[SketchBoard] just gives a really good graphic and puts it into an exact spatial reference, so in that sense gives the viewer a more accurate description rather than simply telling them or showing blueprints even.”

(P4): “[SketchBoard] is very easy to use. It is visually appealing. It is straightforward and quite simple. The blocks are simple. It is kind of like Google SketchUp almost. I like that it has all the setbacks, which is important as well. I really like it.”

(P5): “[SketchBoard] obviously shows that you can or cannot go over a certain limit, and the 3D model is probably the best way to represent that. You can visibly see it. It does not make sense if you sometimes put it into words. So I thought that was pretty good.”

**SketchBoard and Communicative Activities**

All participants believed that SketchBoard would be helpful in communication between urban planners and developers, and some of these opinions are detailed in the section below. Figure 6.14 (below) illustrates an affinity diagram of SketchBoard and Communicative Activities.

![Affinity Diagram of SketchBoard and Communicative Activities](image)

**Intelligibility and Readability.** Participants thought that the information in urban planning, particularly the traditional zoning concept is communicated through a complex paper and text-based document that is not clear, intelligible, or readable. However, participants said that
SketchBoard explicitly visualizes the required information using graphics rather than text documents. They also stated that SketchBoard is more readable, comprehensible, and easy to use while negotiating technical contents. Some of the participants also mentioned that SketchBoard could be useful while negotiating plans with the public. As three participants said,

(P2): “It is always nice to have visual information instead of written, but most of the time this information is conveyed through text. So, showing it digitally and visually is good.”

(P4): “[SketchBoard] helps both sides to better understand the impact of the particular tower, for instance. If there was a requirement that all applications must have a model that fits, that would allow the city to input this into their system, that would really help both sides when coming up with a more comprehensive plan rather than just looking side by side; this is more cohesive with the whole community.”

(P5): “[SketchBoard] could help to get the information across more easily to the developers of the building. You can visibly see the information.”

**SketchBoard and Education**

All participants agreed that SketchBoard could be used to help educate the public on how FAR is considered by the zoning ordinance, and certain specific comments are elaborated in the section below. Figure 6.15 (below) illustrates an affinity diagram of SketchBoard and Education.

![Affinity Diagram of SketchBoard and Education](image-url)
Public Education and Spatial Thinking. Participants said that although urban planning involves spatial thinking, urban planning concepts are mostly conveyed through paper and text-based documents. However, SketchBoard offers a very simple and visual way to represent spatial and mathematical concepts such as FAR. Furthermore, the use of tablet versus desktop computers makes the information more accessible to anyone. As two participants said,

(P2): “Urban planning is spatial. We are talking about spaces. And spaces can sometimes be hard to describe, so the best way to represent the space is spatially with graphics.”

(P4): “[SketchBoard] helps to breakdown the FAR which is a bit of a hard concept to understand. There is a bit of a math to it and most laymen and the public will not really get into that. So, this makes it easy if they can [visualize this] in open houses and it would be particularly useful.”

SketchBoard Improvement

Participants particularly expressed their opinion on how to improve SketchBoard, and some of these opinions are emphasized in the section below. Figure 6.16 (below) illustrates an affinity diagram of SketchBoard and Improvement.

![Affinity Diagram of SketchBoard Improvement](image)

Various Zoning Ordinances. All participants mentioned that SketchBoard could be improved by including all zoning ordinances, uncommon zoning ordinances, irregularly shaped buildings and different building types into the working version of SketchBoard.
**Graphics.** Most participants said that the red color is the only indication that shows the restriction on the extra floor. They suggested that it would be useful to provide more information indicating what is/is not allowed. As two participants noted,

(P1): “It would be helpful if there is a sign saying that this floor is not permitted.”

(P2): “If there is a little information box that I could click and it would give me like a short paragraph explaining what is allowed, that would be helpful for me.”

**Modifiable Variables.** One participant indicated that it would be useful to allow the user to change the FAR. This would allow the urban planner to see the impact of increasing or decreasing the FAR on the built form. This participant also mentioned that it would be useful to have access to statistics on census data and building permit data. As a participant observed;

(P4): “If you could actually drop down the FAR as well; currently, you can only increase it, but if you could actually click down and show if it was only one story, what the FAR would be or if it was two stories or three stories, what the FAR would be, and then change and break down some statistics on the side, that might be useful.”

**6.17.2 Sketch VI: Post-Pilot Design**

After analyzing the data collected during the Pilot Study, it emerged that all participants thought that the SketchBoard would be a very useful interactive communication medium for urban planners, developers, and the public within the urban planning processes. In the Pilot Study, participants concerns and suggestions were taken into account to SketchBoard.

Sketch VI: Post-Pilot Design shows the sixth set of variations in creating an interactive storyboard as shown below in Figure 6.17. In the final iteration of the prototype, a pop-up
window was added to the current menu to provide summary information for color-coded visualizations to explain what is not allowed according to the bylaws. This version integrated several new features that enabled the user to cross-reference multiple representations of the building form with the respective bylaws. This pop-up window appeared once the particular color-coded building floor was clicked. The design implications for adding this last feature to the prototype support both communicative and technical activities such as visualizing and computing zoning ordinance within the design review process. This mock-up was used as the final version of SketchBoard in the Main Study and Focus Group.

Figure 6.17. Sketch VI: Post-Pilot Design
6.17.3 Main Study

Below is an analysis of the data collected during the survey and interview sessions of six participants in the Main Study.

6.17.3.1 Surveys for Main Study

Figure 6.18 for Q1 (below) shows that overall for R0+: 100% of the participants (this is, 33% of the participants *strongly agreed*, 50% of the participants *agreed*, and 17% of the participants *somewhat agreed*) believed that SketchBoard was easy to understand.

Figure 6.18 for Q2 shows (below) that overall for R0+: 100% of the participants (this is, 33% of the participants *strongly agreed*, 50% of the participants *agreed*, and 17% of the participants *somewhat agreed*) believed that SketchBoard presented the information in a logical order.

Figure 6.18 for Q3 (below) shows that overall for R0+: 100% of the participants (this is, 33% of the participants *strongly agreed* and 67% of the participants *agreed*) believed that SketchBoard had appealing aesthetics.

Figure 6.18 for Q4 (below) shows that overall for R0+: 100% of the participants (this is, 67% of the participants *strongly agreed* and 33% of the participants *agreed*) believed that the use of tablet versus a desktop made performing the task easier on SketchBoard.

Figure 6.18 for Q5 (below) shows that overall for R0+: 100% of the participants (this is, 50% of the participants *strongly agreed*, 17% of the participants *agreed*, and 33% of the participants *somewhat agreed*) believed that SketchBoard solved the problem of understanding the implications of zoning on FAR for a particular parcel.
Finally, Figure 6.18 for Q6 (below) shows that overall for R0+: 100% of the participants (this is, 33% of the participants strongly agreed, 33% of the participants agreed, and 33% of the participants somewhat agreed) believed that SketchBoard could be used to help explain why the FAR as calculated is sometimes lower than the allowed FAR, given existing setbacks and height restrictions for that parcel.

Figure 6.18. Main Study: Survey Questions 1-6
6.17.3.2 Interviews for Main Study

SketchBoard and Technical Activities

All participants agreed that SketchBoard supports the visualization of the zoning ordinance that describes why it would be difficult to achieve the maximum FAR on a site, and some of these opinions are noted in the section below. Figure 6.19 (below) illustrates an affinity diagram of SketchBoard and Technical Activities.

![Affinity Diagram of SketchBoard and Technical Activities](image)

 этап 19. Зависимость диаграммы SketchBoard и технических активностей

**Building Context.** All participants stated that SketchBoard could help explain how zoning impacts the built form. By translating the appropriate bylaws and guidelines into visual representation, there is less need for the interpretation of legal documents to both reduce uncertainty and resolve equivocality. Participants mentioned that, depending on the various zoning ordinances, building envelopes vary from one site to another. In addition, due to poor spatial abilities, visualizing the building envelope is often a cumbersome task for many urban planners. Therefore, being able to visualize the building envelope for both proposed and adjacent properties provides the opportunity to compare building envelopes and to make participatory decisions within a collective setting. As two participants noted,

(P1): “I do not understand these rules. Is there a way to visualize these?”
(P6): “It would be good to be able to see the neighboring buildings. That gives us more contexts about the neighboring parcels and their zoning.”

**Future Anticipations.** Participants believed that using SketchBoard provides the opportunity to visualize future developments. When there is potential for development on adjacent parcels, SketchBoard would make it possible to visualize the implications of decisions on that particular parcel. At the same time, this would also help visualize and anticipate the impact of future development on a site, where there are not many buildings located on a site. This could potentially reduce the time reviewing development proposals by using an intelligent, automated SketchBoard. Two participants also believed that SketchBoard could be used in discussions on the design of a building even before the developer purchases a property. Furthermore, these two participants stated that SketchBoard could be useful for developing design concepts for future developments. As a participant noted,

(P4): “[SketchBoard] shows what you are allowed to build. If you could show what the applicant wants to build, then in 3D you could show the comparison between what is allowed and what the applicant wants. Then, we can have a conversation about how you can get from your idea to what is allowed.”

**FAR.** All the participants indicted that FAR is a difficult concept for urban planning stakeholders to understand. Most participants believed that in SketchBoard, FAR should be a modifiable option. Most participants said SketchBoard would be useful for discussions on whether to grant a variance for increased FAR. All participants also mentioned that floor-to-floor height might vary for different building stories. All of the participants suggested that
SketchBoard should give the user the option of changing the floor-to-floor story height. As a participant argued,

(P4): “I have to be able to change the FAR, then I could see a whole bunch of different scenarios on that one site, and then it solves the problem for me.”

**Site Coverage.** One participant mentioned that site coverage instead of FAR is used to create building envelopes for single-family houses. This participant further stated that in order to increase the utility of SketchBoard for lower density developments, site coverage should be added as a feature to SketchBoard. This participant noted,

(P3): “[SketchBoard] is missing a quite commonly-used variable in lower density scenarios that is site coverage, which is 45%.”

**FAR and Floor Plate Size.** Two participants mentioned that FAR and floor plate size are two important variables in land use for designation in higher density developments. These participants suggested that, for higher density development, having a FAR maximum would be more useful rather than a height maximum. They suggested that all of the variables should be parameters that the user can change. This option would provide more opportunities to explore the full range of development options on a site. However, they mentioned that height is an important variable for residential neighborhoods. These participants suggested that setbacks and FAR should be modifiable. They believed that if FAR was modifiable, SketchBoard would provide a great opportunity to discuss relaxations in the bylaws and the possibilities of increasing the FAR without the cost of granting a bonus. These participants observed,

(P4): “In the downtown area, you can go to twenty FAR, but the base is three, so we give all these bonus options.”
(P5): “Someone comes in with a bigger, better, easier and more creative way to do something, and we have not thought about that, so we relax the rule.”

**SketchBoard and Communicative Activities**

All participants believed that SketchBoard would improve the communication between urban planners, developers, and the public, and specific comments are discussed in the section below. Figure 6.20 (below) illustrates an affinity diagram of SketchBoard and Communication Activities.

**Figure 6.20. Affinity Diagram of SketchBoard and Communicative Activities**

**Interpretation of the Bylaws.** Most of the participants mentioned that developers are primarily concerned with maximizing potential profit. Urban planners and architects, in contrast, to the developers, are more concerned with the rules that govern the design concepts. In most cases, a relaxation of the bylaw is a strategy used to achieve a compromise. In these cases, interpretation of the bylaws plays an important role in these discussions. Often bylaws are not straightforward and are subject to interpretation. Depending on the circumstances, other stakeholders, including alderman and local politicians, could become involved; as a result, the direction of the discussion can alternate between socio-economic-political oriented communications. For example, a community may not want to have a building in their neighborhood that is going to increase traffic or cast a shadow on adjacent properties. Having a technology that is simple and intuitive that can easily communicate to stakeholders the physical attributes of a proposed development project would improve the level of dialogue among all those with a vested interest. To avoid
complications, it should focus on the most important features of the dialogue. Participants mentioned that using SketchBoard could potentially eliminate possible misinterpretations of the bylaw that could lead to possible failure of the development proposals. As a participant noted,

(P2): “A lot of things in the bylaw need to be interpreted, [whereas] most of the time, it is really hard to understand what the intent is of a particular rule.”

**Reciprocal Communication.** In a general sense, participants believed that to improve the communication between urban planners and developers, two components should be improved. The first component is to make sure that urban planners and developers have the ability to conduct conversations and have face-to-face interactions. The second component is to give the developer access to a clear chain of information, people, and processes. Thus, participants emphasized that SketchBoard could potentially improve the one-to-one communication process of urban planners and developers by providing clear information, as well as the participatory engagement of individuals. As a participant argued,

(P1): “One way to enable people to have higher value of interactions is to build tools to answer more routine questions.”

Furthermore, all of the participants agreed that SketchBoard could enhance the communication between urban planners and developers by proving a clear understanding of the urban planning process.
**SketchBoard and Education**

All participants believed that SketchBoard could be used to help educate the public on how FAR is considered in zoning, and certain comments are elaborated in the section below. Figure 6.21 (below) illustrates an affinity diagram of SketchBoard and Education.

![Affinity Diagram of SketchBoard and Education](image)

**Communication with the Public.** All of the participants believed that interpretation and visualization of the bylaws for the public is a very difficult task, because the public generally lack knowledge about design and perspective. Participants believed that to optimally communicate with the public, bylaws should be available in a web-based, visual format. To help enhance the public’s understanding of the bylaws, a 3D component of SketchBoard would be very helpful to translate text-based rules into visual output. All the participants agreed that in order to set expectations with the public, SketchBoard could be very effective in exploring multiple, discretionary-based concepts and conversations, with little effort. For instance, instead of relying on imagination, visualizing the implications of having a tall building in a neighborhood, such as casting a shadow, could ease the discussion.

One participant believed that SketchBoard would also be useful in teaching how the FAR and density are calculated. This would then provide the public access to critical information on how urban planning discussions are made. This participant said,

(P2): “FAR is not only about building size, but the implications of the building size.”
**Educational Artifact.** One participant suggested that to improve the public’s understanding of the urban planning process, such as density, a tool is needed that can show a piece of property in context. This participant mentioned that the City of Calgary uses a tool called “MyProperty,” which allows the public to turn on and off different layers of information about land use designations. Ultimately, it could connect to bylaws, however, presently, this is not possible, because there is no such a tool that the public could use. This participant noted, (P6): “The public wants to get the feel for what the density could be on the site; they should be able to visualize it.”

**SketchBoard Improvement**

All of the participants provided some suggestions for improving SketchBoard, and certain specific suggestions are discussed in the section below. Figure 6.22 (below) illustrates an affinity diagram of SketchBoard Improvement.

![Affinity Diagram of SketchBoard Improvement](image)

**Contextual Building Envelope.** Although the participants were told that SketchBoard is a proof of concept mock-up and only works for one parcel, realistically it should work for all the parcels
within the city limits. However, all of the participants mentioned that in order to understand the building envelope, they must be able to view the adjacent parcels with their building envelopes. Furthermore, architects, urban planners, developers and the public have difficulty with the calculation of setbacks and heights. Participants also mentioned that being able to illustrate massing models and density on SketchBoard would be a value add. As a participant noted,

(P1): “The front setback and the height are calculated as a response to the adjacent properties.”

**Surrounding Context.** Participants also mentioned that often applications are submitted for parcels where the adjacent sites are vacant. In these cases, urban planners are left to imagine details about the surrounding neighborhood. Unless the urban planner builds a 3D model of the surrounding neighborhood, it is difficult to imagine how the area would look after it is completely built up. In addition, this is a very time-consuming and technically demanding task. Without a 3D model, understanding the impact of the proposed building on the surrounding is difficult for urban planners. Participants suggested that SketchBoard could potentially be used to visualize the surrounding area of the proposed application in a simple and quick manner. They also suggested that it would be useful to be able to visualize and compare the 3D model of the proposed development in context, as there are many possible building envelopes for a site. As a participant observed,

(P5): “Applicants do not want to spend the time building a 3D model for the adjacent context. So, it would be great if we can have this and zoom it out and then we could show the surrounding buildings.”

**Concept Development Cycle.** Two participants mentioned that their respective municipality is in the process of building a web-based submission process. In the absence of such a system,
dimensions on the building plans are mostly inaccurate and unclear. This requires the urban planners to input all the data and correct the mistakes provided on the building plans. These participants suggested that in order to improve SketchBoard, it would be useful to compare what is allowed under a specific zoning designation against the information stated in the application. They also suggested that SketchBoard should have the potential to preserve each iteration of a proposed design concept by saving the submitted documents. Integrating notes along with the design iterations would also be helpful to show and access the cycle of the design in real-times. These participants observed,

(P4): “The potential of [SketchBoard] is when we review the development application; so here is the context, here is what they want to do, here is what they are allowed to do, all right there in one picture.”

(P5): “If you are doing a podium tower, what is your floor plate?; and if you are not doing a podium tower and you’re doing a midrise, what is your floor plate?; so that we actually have an understanding of what are you trying to do, and what do you prefer to do, what makes the most sense for the proposed application that you are trying to actually achieve?”

**Shadow Analysis.** Most participants indicated that SketchBoard should be able to analyze the shadow of the buildings, given a specific time and date. They also suggested that sunlight restrictions should be added to SketchBoard. Participants mentioned that presenting the analysis of the sunlight and shadow analysis would help to visualize the impacts of the future developments on the adjacent sites. As a participant said,

(P4): “A sunlight restriction would actually give you the height and envelope limitations.”
Help Option. Only one participant suggested that SketchBoard would benefit from a more intuitive interface. Adding a “help option” would be useful in explaining definitions and terms. This participant suggested that showing a simple calculation of FAR would be useful prior to launching SketchBoard. In particular, this participant mentioned that it would be helpful to provide some information about each button by hovering over the buttons. It was also suggested that once a button is pressed, it should have a different effect to show that it is active. This participant argued,

(P6): “It might help to have a hyperlink that is underlined. Also, if there is a button to press on the screen, it should look different.”

Interactive Features. A few participants mentioned that it would be useful to take advantage of the interactive capabilities of the tablet by adding features such as rotate and zoom to the model. A few participants suggested that they want to be able to manipulate the 3D model itself by changing the dimensions of the floor plate size, setbacks, heights and FAR. As a participant said,

(P1): “Having points to touch and change the dimension of the footprint.”

Graphical Components. Most participants found the colors used in the buttons and setbacks bewildering. Participants thought that there is a color-coding relationship between the colors of the buttons and setbacks. They believed that color-coding could be improved by using more distinctive colors, as well as choosing different colors for button and setbacks. Two participants also mentioned that the use of a legend would particularly be helpful in specifying different features of SketchBoard. One participant stated that showing different colors for each floor in the mixed-used buildings is an important component. One participant suggested using a compass would enable the user to rotate the view of the 3D model. One participant said that using bigger
fonts for buttons. One participant mentioned that also being able to access the features in a 3D models as well as 2D drawings. One participant preferred to see all the buttons together at the top of each sketch in the mock-up. This participant stated that it would be less confusing if there were no pop-up windows. Having a layering system that could show and hide different attributes including showing zoning class by color would be a useful feature for SketchBoard.

**Building Outside of the Box.** Most participants mentioned that the buildings are not always box shaped. They believed that SketchBoard should be able to create different building shapes giving the user more control over the aesthetics of the form. Participants also suggested that SketchBoard should accommodate features, such as including double basements and parking above and below-ground. As two participants argued,

(P3): “People get obsessed with the look of the building. So, you need to accompany this with a good explanation and demonstrate that the block you have shown can be turned into a more attractive design.”

(P5): “All of our projects are very complex so it is not just a simple box; if you were doing a single-family housing, this would be a really simple tool.”

**Use of Interactive Surfaces.** All participants agreed that the use of tablet would enhance the mobility, interactivity, and simplicity of SketchBoard. They agreed that SketchBoard provides a flexible interface that is easy to use and intuitive to manipulate. Most of the participants added that current CAD and GIS computer applications are significantly cumbersome tools to use when reviewing proposals with developers and the public. Such systems still rely on the use of paper as a contributing artifact that supports communication within the design review process. As a participant noted,
(P1): “We do the analysis and print off a bunch of maps and bring them to the meeting, and if the wrong view or layer is printed, then the whole time is wasted.”

6.17.4 Focus Group

Below is an analysis of the data collected during the survey and interview sessions of five participants in the Focus Group.

6.17.4.1 Surveys for Focus Group

Figure 6.23 for Q1 (below) shows that overall for R0+: 100% of the participants (this is, 20% of the participants strongly agreed, 60% of the participants agreed, and 20% of the participants somewhat agreed) believed that SketchBoard was easy to understand.

Figure 6.23 for Q2 (below) shows that overall for R0+: 100% of the participants (this is, 20% of the participants strongly agreed and 80% of the participants agreed) believed that SketchBoard presented the information in a logical order.

Figure 6.23 for Q3 (below) shows that overall, R0+: 100% of the participants (this is, 80% of the participants agreed and 20% of the participants somewhat agreed) believed that SketchBoard had appealing aesthetics.

Figure 6.23 for Q4 (below) shows that overall for R0+: 100% of the participants (this is, 20% of the participants strongly agreed, 40% of the participants agreed, and 40% of the participants somewhat agreed) believed that the use of tablet versus a desktop made performing the task easier on SketchBoard.
Figure 6.23 for Q5 (below) shows that overall for R0+: 100% of the participants somewhat agreed that SketchBoard solved the problem of understanding the implications of zoning on FAR for a particular parcel.

Finally, Figure 6.23 for Q6 (below) shows that overall for R0+: 80% of the participants (this is, 60% of the participants agreed and 20% of the participants somewhat agreed), and R0-: 20% of the participants disagreed that SketchBoard could be used to help explain why the FAR as calculated is sometimes lower than the allowed FAR, given existing setbacks and height restrictions for that parcel.

Figure 6.23. Focus Group: Survey Questions 1-6
6.17.4.2 Interviews for Focus Group

SketchBoard and Technical Activities

All participants believed that SketchBoard helps to visualize why zoning would make it difficult to achieve the maximum FAR on a site. These opinions are noted in the section below. Figure 6.24 (below) illustrates an affinity diagram of SketchBoard and Technical Activities.

![Affinity Diagram](image)

**Figure 6.24. Affinity Diagram of SketchBoard and Technical Activities**

**Land Use Designations.** One participant mentioned that SketchBoard is very helpful because it presents four key variables from the land use district and designation such as FAR, height, setbacks, and floor height. However, this participant suggested that floor height, setbacks, and FAR variables should be modifiable. This would allow the developers to input their proposed variables and to create their own development proposals. The urban planners can also input the allowed variables and create what is allowed on the site. Then, the proposed and allowed development application can be compared, hence this would help to envision the differences between what a developer wants to achieve and what the bylaws allow. This participant said,

(P2): “Urban planners know the applicants do not like what the rules say, but with [SketchBoard] urban planners can ask applicants show us what they would like.”

One participant mentioned that SketchBoard shows only one individual site, however rules are more complex when there are multiple compounds of developments. All participants also
believed that SketchBoard could be used for calculating the exceeded FAR if the urban planners do not trust the dialogue and calculations provided by the developers. As a participant said,

(P5): “Depending on what variables are present, it can give an idea of the allowable, but may be tricky when broken down into various forms. The City of Calgary has many more complex variables.”

**Contradictions.** Even though participants were told that the mock-up shows a red color when the building exceeds the permitted height, however, one participant thought that the red color should also show when the building has a FAR greater than what is allowed. On the other hand, one participant mentioned that FAR and density cannot be relaxed.

Two participants were skeptical that urban planners and developers would know the FAR, height, and setback restrictions. One participant mentioned specifically that not necessarily everybody knows about these rules and restrictions. This participant said,

(P1): “There is an occasional architect who could not figure out how to calculate FAR; most of them have already figured it out, and they know that they are already exceeding it, but they are looking for ways to get relaxations.”

Interestingly, the researcher noticed that even the participants who were senior urban planners expressed the rules of relaxation about FAR and density in a contradictory manner; this then caused some degree of confusion and uncertainty during the meeting, as well as spending unnecessary time to solve a fairly evident issue. It appeared that even urban planners’ opinions vary when interpreting whether FAR or density are/are not allowed.
One participant said that SketchBoard could be a good tool for creating massing models. However, another participant felt that people always respond very negatively to massing models, because they are not aesthetically attractive-looking models. This participant noted,

(P3): “People think you are going to get them chunky buildings like those on the massing models.”

**Efficient Technical Activities.** One participant provided an example where they had to spend a significant amount of time in SketchUp trying to figure out the various scenarios in order to achieve what was expected on the development application. Participants believed that SketchBoard can present different FAR in various forms and scenarios that are easier and quicker than what can be achieved in SketchUp. Participants said that they would like to have SketchBoard because it is simpler to use than SketchUp. As a participant argued,

(P1): “We spent quite a bit of time in SketchUp trying to figure out what the various scenarios for the twenty FAR were with the building and without the existing buildings, with the park and without the park.”

**SketchBoard and Communicative Activities**

All the participants believed that SketchBoard would improve communication between urban planners and developers, and specific comments are discussed in the section below. Figure 6.25 (below) illustrates an affinity diagram of SketchBoard and Communication Activities.

![Figure 6.25. Affinity Diagram of SketchBoard and Communicative Activities](image-url)
**Efficient Communication.** Participants believed that SketchBoard can help them in explaining and having discussions with the developers, and even the public, thus making it easier to draw quicker conclusion. Most participants mentioned that SketchBoard could also be used for discussions surrounding the relaxation of setbacks, FAR, and height variables. They agreed that SketchBoard could be used specifically for graphical comparison between the allowed and proposed envelopes. As a participant said,

(P1): “[SketchBoard] can quickly generate what is allowed internally, and then your applicant gives you the sketches of what they are proposing; you can [then] visually compare those pretty quickly without having to input the new variables and spending time yourself creating a new model because that could take some time.”

**Initial Communication and Concept Development.** One participant stated that the initial analysis of a development or land use application should compare what the developers propose against what is allowed; this is an important conversation between the urban planners and developer. This participant thought that being able to visualize those differences would facilitate discussion between urban planners and developers and could advance the discussion to reach an agreement. This participant noted,

(P4): “You could just pop-up the image of what is allowed, put in what developers are asking for, and then start to have those conversations and talk about, and if you need to go and talk to other people, immediately they a get sense of what you are looking for.”
SketchBoard Improvement

All participants provided some suggestions on how SketchBoard could be improved. These opinions are stated in the section below. Figure 6.26 (bellow) illustrates an affinity diagram of SketchBoard Improvement.

Figure 6.26. Affinity Diagram of SketchBoard Improvement

**Superimposed Envelope.** All participants suggested that SketchBoard should be able to show the differences between the allowable and proposed envelopes as a transparent-object. As a participant observed,

(P2): “If we were to have the technology to take the crude FAR massing and show it on a 3D [model] and [transparent].”

**Comparing Envelopes.** One participant suggested that it would be very useful if SketchBoard could be accessible at a public meeting or online. This would then allow for viewing and comparing what the applicant proposed, and what is permitted.

**Sunlight Restrictions.** A participant suggested that being able to show the shadowing path and sunlight restrictions on SketchBoard would be very useful.
**Modifiable Variables.** Participants felt that the variables should be modifiable to allow either the urban planner or developer to input their own variables for each zoning district. As a participant noted,

(P3): “Many zoning rules can be relaxed. A static model cannot reflect various options. The model would be more useful if this was possible.”

**Various Building Forms and the Surrounding Context.** Participants said that they want to be able to make various forms and types of buildings, compare existing land use versus proposed, as well as show the surrounding context on a site. Participants thought that these options should be accessible on SketchBoard. As a participant said,

(P4): “Being able to look at that tower and the surrounding context is really important, and would be very helpful to have that on [SketchBoard].”

**6.18 Summary of the Chapter**

Study IV illustrates the process of creation and evaluation of SketchBoard. This study employed demos of the digital paper prototypes, structured surveys, and semi-structured interviews to conduct a Pilot Study, a Main Study, and a Focus Group to discover how SketchBoard could potentially improve participatory communicative and technical activities within the design review process. In particular, this study focused on understanding the participants’ feedback on the flow of interaction for SketchBoard, also to demonstrate the potential versatilities of SketchBoard’s design to answer the needs of urban planners involved in the design review process.

Furthermore, the structured surveys employed in Study IV distinguished subjective meanings from objective meanings. The results of the surveys show the comparison between negative,
neutral, and positive ranges on the Likert scale of questions 1-5 in the Pilot Study, Main Study, and Focus Group are: R0+: 100%. However, the results of the surveys show that the comparison between negative, neutral, and positive ranges on the Likert scale of question 6 in the Pilot Study are: R0+: 80% and R0: 20%; in the Main Study is: R0+: 100%; and in the Focus Group are: R0+: 80% and R0-: 20%.

Moreover, in this study, the results of the interviews revealed that SketchBoard could potentially enhance participatory communication and technical activities within the design review process. It was also discovered that a simple, transparent, and intuitive interface and interaction design of SketchBoard would enable participatory and intelligible interaction through 3D visualization. In addition, SketchBoard could be a useful interactive communication medium for any urban planning department in the industrialized world. Also, SketchBoard could potentially be used in the areas of industrial design, media design, urban design, architecture, computer science, and engineering. Future directions for this research on how to improve SketchBoard are presented in Chapter VII.
Chapter Seven: Conclusion

As a work of synthesis, this thesis contributes to the creation of SketchBoard. The radical, idealistic intention of SketchBoard makes it a viable option to be an accessible, interactive communication medium that could take urban planners, stakeholders, and their visions on a collective journey of creativity in redesigning and restructuring their future neighborhoods and cities. In particular, the multidisciplinary notion presented in this research lies within the intersection of both the work conducted within the design review process and emerging digital media, while engaging with empirical and conceptual design components and using a postmodernist lens. This research thus explores the role of current computer aided technology and the yet untapped potential for interactive surfaces in the communicative and technical actions of the design review process to engage with co-designing a more mature, future genre of digital media for the design review process.

Furthermore, the new trend that has arisen with the use of interactive surfaces introduces exciting interface and interaction design possibilities to the new digital media’s affordances, which could potentially support the visualization, communication, and participation needs of the design review process. For example, tablets that are small and portable have the potential to be pervasive at all times to enable shared interaction within the design review process. Hence, maximizing the effect of participatory, procedural, spatial, and encyclopedic affordances and properties for perception and interaction of such surfaces can promote mutual intelligibility regardless of an audience’s level of expertise within the design review process.

This thesis investigates unexplored questions, specifically, how can interactive surfaces be used in the design review process to promote the significance of participatory design, and to allow the communication of plans and information to various individuals from design professionals to the
affected community who have limited software skills?; also, how can such surfaces be used within the various methods of intelligent and intelligible visualization and computation to facilitate the process of design review? Consequently, this research examined how urban planners use desktop computer applications and how can CAD, PSS, and GIS be used on interactive surfaces to promote participation within the design review process?; how does the design review process work and what tools and technologies are used and needed for participation among participants?; what role does digital media play in improving the complexity ramifications of the work conducted within the design review process?; how important factors are such as participatory design, the urban design and planning process, visualization, and analysis in defining the specifications of a new mobile and interactive 3D visualization medium? In addition, how can an intelligent and intelligible interactive 3D visualization medium be useful in generating shared understanding and promoting participatory communication, while visualizing the zoning ordinance and computing FAR within the design review process?

This chapter outlines the last part of this thesis, summarizing the insights that can be gained from this research and envisions future directions for this research. In the following sections, the research goal and objectives and contributions are discussed in detail. In addition, future work will inform yet unrealized directions for research inspired by this thesis.
7.1 Research Goal and Objectives

The goal of this research was to develop an understanding of how to create SketchBoard, an interactive communication medium that can support the participatory, communicative, and technical activities of the design review process. To support the research goal, a four-part research study from a design and empirical perspective, are discussed. From an empirical perspective, the findings from field studies that were conducted as part of Studies I and II illustrate the process of the design review work, tools, and technologies used in the course of urban planners’ work, flow of information, complexities and challenges, as well as individuals involved in the process and possible design concepts for creating a communication medium using interactive surfaces. From a design perspective, this research introduces the integration of interactive surfaces with the design review process. Specifically, it focuses on how visualization of the zoning ordinance and computation of the FAR can be combined with interactive surfaces through a minimal interface and interaction design that can potentially enhance the communicative and technical activities within the design review process. This idea was identified in Studies II and III, and continued to be explored via its practical potential in Study IV. In the following sections, four themes have been established below to guide the research objectives in Studies I-IV.

7.1.1 Role of Technology in Urban Planners’ Everyday Practice

The objective of Study I was to investigate the needs and expectations of urban planners in their overall day-to-day work. This study further explored urban planners’ work practices, tools, and the technologies they use in the course of their work, the role of desktop CAD and GIS computer applications, and the influence of interactive surfaces in their work practices.
7.1.2 Role of Technology in the Design Review Process

The objective of Study II was to understand the needs and expectations of urban planners in their day-to-day work, specifically within the design review process. This study further examined urban planners’ workflows and intentions of work; the desktop CAD and GIS computer applications and paper and text-based documents urban planners use; also their challenges and complexities over the course of working within the design review process.

7.1.3 Acceptance of SketchBoard by Urban Planning Culture

The objective of Study III was to refine the set of design specifications of SketchBoard that supports the design review process. This study further provided an understanding of the importance of participatory design, the urban design and planning process, and aspects of visualization and analysis.

7.1.4 Fitting the SketchBoard to the User through Design Exploration

The objective of Study IV was to design, refine, and evaluate SketchBoard for visualizing the zoning ordinance. This study further provided an understanding of the participatory, communicative, and technical activities around the computation and visualization of the permitted FAR.
7.2 Research Contributions

In the following sections, the research contributions of this thesis are discussed. The contributions are not discussed in chronological order, but are explored according to themes that emerged during Studies I-IV.

7.2.1 Visualizing the Zoning Ordinance’s Impact on Design Decisions

Study II demonstrated that the zoning ordinance is a primary source of communication within the design review process. Consequently, the findings from Study II revealed that visualizing the zoning ordinance and computing the FAR are significantly important aspects in discussions during the design review process. Study II also discovered that, traditionally, paper and text-based materials have been regularly used by urban planning stakeholders to illustrate the zoning ordinance within the design review process. However, although diagrams and graphics tend to compensate for the visualization of the zoning ordinance’s shortcomings, nevertheless urban planners and their stakeholders still lack knowledge about design or perspective, which results in insufficient degrees of comprehension while interpreting the zoning ordinance’s document (see Chapter IV). Furthermore, findings from Studies II and III contributed to discovering the design rationale for creating SketchBoard, an interactive communication medium which assists the zoning ordinance with visualization and computation of a challenging factor such as FAR. In particular, Study III identified the importance of approximate design specifications for creating SketchBoard for the design review process. These design specifications emphasize participatory communication around interpretation of the zoning ordinance and visualized computation of the FAR (see Chapter V). Moreover, Study IV contributed to the design and evaluation of SketchBoard to support participatory visualization and communication around the zoning ordinance’s topic within the design review process. For this purpose, Study IV applied
minimalism to identify design specifications, including: pseudo visualization and computation of the zoning ordinance and FAR; pseudo three-dimensional, intelligent, and geo-located interaction; mobile, participatory, intelligible, simple, and intuitive interaction; as well as minimalist aesthetics. Design specifications were then used to create the digital paper prototype in conjunction with interactive storyboards on a tablet (iPad). The results of Study IV revealed that SketchBoard could be useful in enhancing participatory, communicative, and technical activities within the design review process (see Chapter VI).

7.2.2 Interacting with CAD and GIS on Interactive Surfaces

Studies I and II demonstrated the role that interactive surfaces could potentially play in conjunction with desktop CAD and GIS computer applications. The findings of these studies showed that such surfaces are not commonly used in the course of design review work. Specifically, currently urban planners are not familiar with the use of fixed interactive surfaces, such as tabletops and large wall displays, which could potentially support the work of the design review because there is a lack of access to such devices. The findings from these studies also demonstrated that the more important issue is that urban planners only work with the interface of desktop CAD and GIS computer applications that are traditionally designed in conjunction with mouse and keyboard interaction. In addition, Studies I and II also discovered that the software of interactive surfaces does not yet support the needs required for current CAD and GIS computer applications. Furthermore, the lack of accessibility to the CAD and GIS software on mobile interactive surfaces such as the smartphone and tablet, has also impacted the way urban planners interact with CAD and GIS. Moreover, the existing mobile CAD and GIS applications only allow for simple navigation tasks such as zoom in/out and rotate. However, these applications are
not particularly useful within the day-to-day work practices of urban planners within the design review process (see Chapters III and IV).

7.2.3 Characterizing the Computer Aided Planning’s Interface and Interaction Design

Studies I and II uncovered that the unsuitable interface and interaction design of computer aided planning have caused a lack of computer skills in urban planners. To some extent, the current interface and interaction design of computer aided planning systems are not congruent with the professional and personal level of expertise distributed amongst urban planning stakeholders. In addition, the findings from these studies demonstrated that the discrepancy in computer aided planning systems’ sophistication originates in the divide between the tools and technologies that support the work of experts and professionals versus novices. Furthermore, Studies I and II discovered that interactive surfaces are slowly becoming more available in urban planners’ day-to-day work. Yet, the interface and interaction design of current computer aided planning systems have not been adapted to the new trend of utilizing interactive surfaces for the design review process (see Chapters III and IV). In particular, Study IV characterized the usefulness of SketchBoard which supports simple, simultaneous, and mobile communication and participation while focusing on a single, particular technical activity such as visualizing the zoning ordinance and computing the FAR, rather than concentrating on a wide range of tasks within the design review process. Further exploration of Study IV demonstrated the potential influences of adapting interactive surfaces to the interaction and workflow of the design review process as opposed to the interface of a paper and text-based document with the conventional zoning ordinance. Moreover, the findings from Study IV revealed that the simple and intuitive interface and interaction design of SketchBoard could potentially be adapted by a so-called elastic user that includes both urban planning stakeholders ranging from novices to experts (see Chapter VI).
7.2.4 Urban Planners’ Change of View towards Technology as a New Paradigm

The findings from Studies I-IV further contributed to the discovery of SketchBoard potentials that could be offered while adapted to a single, particular need of urban planners within the design review process. In addition, these findings do not attempt to provide a well-structured blueprint for replacing current urban planning desktop computer applications with SketchBoard in particular, or interactive surfaces in general (see Chapters III-VI). However, findings from Studies I and II suggest that interactive surfaces could potentially be used as supplementary devices to the current computer aided planning software designed for desktop computers. Yet, the degree of accessibility of interactive surfaces could potentially change urban planners’ expectations towards SketchBoard. In addition, urban planners’ lack of software skills was a limiting factor in creating SketchBoard (see Chapters III and IV). Furthermore, findings from Studies III and IV showed the simplicity, transparency, and intuitiveness of SketchBoard that focuses on key aspects of the everyday work practices conducted within the design review process, such as visualizing the zoning ordinance and computing FAR, could have a significant priority for urban planners. Moreover, findings from Studies III and IV revealed that SketchBoard could potentially help urban planning stakeholders to create conditions in which they can become skilled, thoughtful, and critical participants in the future shaping of cities (see Chapters V and VI).

7.2.5 Research on the Methodological Level

On the methodological level, this thesis contributes to the transdisciplinary scholarship of research endeavors. In this thesis, the choice of the research methodological process resulted from following the researcher’s personal interests and experience in conducting qualitative studies. Beyond personal intentions, certain approaches taken in this research are most frequently
used in different foci related to the discipline of this research or in designing interactive computer systems for individuals. Furthermore, applying a postmodernist qualitative research revealed that using a more traditional approach such as positivism would not result in the same research outcomes, because such approaches have different theoretical perspectives. Moreover, this research combined empirical studies with conceptual design research to capture and understand the nuances and complexities of the design review process and the role that technology plays in this domain, with the aim of creating SketchBoard.

In addition, the design of Studies I-IV, from data collection to analysis, offers unique characteristics for each individual study. These studies employed novel ways of looking at problems, guiding axioms, and employed effective mental tools to develop a precise description of the users and their expectations, also in designing a system for the pretend users that enhanced their work situation. Integrating cognitive ethnography and contextual design as empirical approaches and minimalism as a design technique framed the overall methodology of research in this work. Additionally, this research expanded on contextual design data analysis by advocating affinity diagraming as a method for data analysis. This combined method of data collection and analysis incorporated with the conceptual design technique can be used for related research areas where technology can impact the design process.
7.3 Future Work

This thesis strives to provide contributions that offer a richer understanding of the role that conventional artifacts, tools, and technologies play within the design review process. This thesis’s contributions further explore the role that emerging technologies, such as interactive surfaces, could potentially play in the design of future media that supports the work of the design review process. Furthermore, throughout the four studies conducted as part of this thesis, some research questions arose that remain unanswered, given the scope of this thesis. These questions and points will optimally lead to new research directions that may be worth exploring in the future. Some of these unanswered questions and points are directly related to the findings of this research which are discussed below. However, a few directions for future research are introduced that discuss the role of emerging technologies, such as interactive surfaces, which could potentially play a role in the future of industrial/product design.

7.3.1 Beyond Zoning Ordinance’s Visualization and Computation

Findings of this research revealed that the problem of shared understanding in the design review process can be solved through the unrealized use of new digital media. Taking this further could possibility lead to the creation of an intelligent and interactive “expert-help-medium” that is capable of resolving complications in face-to-face human communication, while also providing solutions to technical problems within the design review process. Furthermore, findings of this research also suggested that visualization and computation of the zoning ordinance and the FAR should be enhanced. However, exploring beyond this revelation could provide alternative directions in interface and interaction design as a site for further research. For example, the results from this research revealed that urban planners and their stakeholders have difficulties both in visualizing future developments on a site, as well as in interpreting bylaws and these
activities can be somewhat confusing for them. Also, currently missing from the development proposals is the comparison between the proposed and allowed building envelopes that is often significantly important, and mostly an imaginary process which happens in the mind of urban planners and their stakeholders. Thus, as part of future research, incorporating SketchBoard with the capabilities to view the contextual building envelope and visualize the surrounding areas of proposed buildings would be worthwhile. In addition, the findings from this research recognized that there is also a need for future research to explore possibilities to store and retrieve the history of a design, as well as multiple design solutions within the design review process. Thus, the question of how technology could potentially support the work of comparing the proposed and allowed building envelopes, as well as showing the surrounding contexts of a particular building envelope, is also another encouraging direction for future research.

7.3.2 Promoting Participatory Communication around Technical Activities within the Design Review Process

While this research provides insights about the range of participatory communication activities and how they are influenced by the interface and interaction design of SketchBoard within the design review process, however, there are still open-ended questions in this domain that need to be addressed. A particular challenge is to find a balance between enabling participatory design around technical issues on interactive surfaces. As this research has shown, this interaction style comes with many benefits and prevents situations where the knowledge level and expertise of experts and novices could interfere with the optimal outcome for the design review process. However, the introduction of such system-based constraints comes with the restricting action of prescribing interactions and thus hampering the notion of participation and shared understanding in the design review process. To some degree, creating new digital media would help define the
boundaries of urban planning stakeholder’s imaginations and idea generation, which could make for participatory communication in a timely fashion. The question, therefore, is how would it be possible to introduce design elements on the interface and interaction design of SketchBoard in order to potentially prevent endless and unproductive discussion, while enhancing participatory communication with experts and novices around technical problems. This research has begun to explore these ideas on an empirical level, but they have not been explored in much depth from a design perspective.

Furthermore, often for the developers and mostly for the public, the design review process traditionally involves a collection of paper-based and digital rules, guidelines, and 2D/3D material that have been arranged and compiled in a certain way. Historically, urban planners have active roles as gatekeepers of information and access, while, developers and the public are passive actors. However, effective communication and acquiring knowledge and expertise are not passive process, but involve the dynamic and constant participation of all actors engaged in the process. From this point of view, developers, and particularly the public are considered to be actors who are encouraged to actively participate in the design review process through participatory communication and involvement. Moreover, keeping in mind the notion of participation, the public, in particular, should be able to add their own ideas, experiences, and contents to the process of design to which other members have already added their own contributions. However, unfortunately, this is not always the case at the present time. Thus, what types of technology can be invented to facilitate this participation is a kind of open-ended question that can be explored as part of future research. In addition, what a perceivable interactive communication medium can do to enable participatory active roles and disable
misinterpretation of information and access, are yet largely unexplored questions from a political perspective.

7.3.3 The Influence of SketchBoard on the Design Review Process

This research mainly focused on the relation between urban planning stakeholders’ communication and technical activities in the design review process using SketchBoard on a small display. While this research has covered a large and important area of the entire design review process, it does not elaborate much about the interaction between different urban planning departments and other organizations involved in urban planning processes, and how this could influence the larger context of these processes. Taking this to an even higher level, this research examines how the use of both small and large interactive surfaces can transform the urban planning processes. This would introduce a broad yet important research question that will require studies to be done that focus on the urban planning processes as a whole, rather than concentrating on a particular design review process, Figure 7.1.

Figure 7.1. SketchBoard and the Design Review Process

7.3.4 The Future of Mobile, Small Interactive Surfaces within the Design Review Process

While this research has exclusively focused on mobile, small interactive surfaces, there are also a wider range of technologies that could also be adapted to the process of design review. Research
directions that could be explored include the adaptation of large interactive surfaces in the design review process or even within a larger context of urban planning processes. Throughout this research, the results of the exploration of urban planning stakeholders’ participatory interactions with mobile, small interactive surfaces reveal that there are both challenges and benefits to these devices. Moreover, large interactive surfaces are not accessible and compatible with the current systems, but they could possibly enhance a shared view and understanding of the presented information together in the same place. Yet, mobile, small devices have the potential in the design review process to enable mobility and ease of access for the information required, while communicating ideas. The question about what role large interactive surfaces, such as tabletop and large wall displays, could potentially play in the design review process, and how they could be integrated with the existing desktop computer aided planning systems therefore guides another promising research direction.

7.3.5 Rapid 3D Visualization of Buildings and Objects on Interactive Surfaces

Inspirations from research findings suggest that rapid and crude 3D visualization and the construction of buildings and objects on interactive surfaces is the future generation of 3D modeling. By tapping on the surface, this technique envisions the integration of 2D sketches to 3D blocks by sketching the border lines of the cross-section of a building; sketches of buildings can then be selected and extruded. In addition, dimensions and form of blocks can be manipulated freely by pinch and zoom gestures on interactive surfaces. Although, the following idea is not directly suggested by the research findings, however, rapid and crude 3D visualization and construction of products such as a phone, chair, or car on interactive surfaces is identical to the rapid 3D visualization and construction of buildings on interactive surfaces. Yet, considering buildings as complex products/objects, the fundamentals of rapid 3D visualization and
construction of buildings and products on interactive surfaces are much the same. This technique envisions the integration of 2D sketches to 3D models of products. This can be done by tapping on the surface to sketch the border lines of the cross-section of a product; these product sketches can then be selected and extruded. Additionally, dimensions and form of products can be manipulated freely by pinch and zoom gestures on interactive surfaces.
7.4 Conclusion

This doctoral thesis reports the outcome of a four-part empirical and design research study undertaken to understand why current computer and other systems for the design review process are so difficult for urban planners and stakeholders to use, and so poorly designed. Furthermore, this thesis expands on the understanding of the role that new digital media such as interactive surfaces could potentially play in the communicative and technical activities of the design review process. From a research standpoint, this thesis adds to the research areas of urban planning, design, visualization, communication, and HCI. From a practical standpoint, insights from this research will be a useful resource for designing the next generation of computer aided planning systems for the design review process by using a novel interface and interaction design.

Computer aided design, a planning support system, and a geographic information system are current technologies used in the urban planning process. Adaptation of interactive surfaces to the CAD, PSS, and GIS will be an avant-garde technological development in computer aided planning and other related fields. Previously, the affordances and properties of technologies that run on desktop computer applications have reduced draftsmen’s needs for manual drafting and drawing. This then facilitated designers and engineers in pursuing their individual analytic, drafting, and drawing goals, although somewhat in isolation. Similar to the beginning of CAD creation, the adaptation of interactive surfaces to CAD, PSS, and GIS is the next step in technological advancement, thus these developments will shorten the design cycle and lessen the associated design costs. To sum up, these changes foreshadow that an era of manual, somewhat inefficient, and inaccurate computation; visualization vagueness; and interaction exclusively on single desktop interface metaphor is the way of the past. In the future generation of computer aided planning, and in a broader context of computer aided technology, knowledge and skill will
not be the prerogative to experts and professionals. Instead, individuals with limited software skills will also be able to engage in the participatory design review process via the introduction of such interactive communication medium as SketchBoard. Hence, the integration of interactive surfaces with easy-to-use technologies carries the potential to be in the forefront of the design a new genre of digital media for the design review process. In fact, this is the way of the future.

Considering these aspects, this research shows how the study of technology within the design review process can provide rich insights into the individual and shared experiences that evolve around such digital media. These insights can guide the innovation and creation of user-centered designs for computer aided systems beyond limited capacities of the current CAD, PSS, and GIS.

In conclusion, the following two mottoes have been the source of inspiration for this thesis:

Science Finds, Industry Applies, Man Conforms

- *Motto of the 1933 Chicago World’s Fair*

People Propose, Science Studies, Technology Conforms

- Donald A. Norman, *Things That Make Us Smart* - A person-centered motto for the 21st century
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[56] J. E. Fernquist, "A Collaborative Planning Support System for a Multi-Touch Tabletop -
The Effect of Number of Touch Inputs on Collaboration and Output Quality," 2010.


Appendix I: Research Material for Study I

Appendix I comprises the research material that was used as part of Study I (see Chapter III), including the example interview questions that participants were asked (see section I.I).

I.I Example Interview Questions

1. What is your job/position?

2. How did your education contribute to your success in your present position?

3. Describe your working relationship with others? Describe a typical day?

4. What is your experience with CAD and/or GIS?

5. What kind of CAD and/or GIS applications do you use?

6. What kind of tasks do you use CAD and/or GIS for in your job?

7. Which CAD and/or GIS tasks are the most demanding in your job?

8. From your experience, how do people usually make use of CAD and/or GIS in your industry/education?

9. How have CAD and/or GIS practices changed over the last few years? Has software advanced sufficiently to make it possible to work effectively with others? If not, why not?

10. Do you think that the advance of interactive surface such as smartphones, tablets, tabletops, and large wall displays has changed the way people use CAD and/or GIS? If so, in which way? If not, why not?

11. Are there tasks, operations, and functions that CAD and/or GIS could benefit from having an interactive surface?
12. Does your job require you to work with in participation with others? Explain, and provide a recent example?

13. What kind of participation are you involved with? How important are these participations to your job?

14. Do you think that when presenting the outcome of CAD and/or GIS explorations, having interactive surfaces would be useful?

15. In your opinion, what characteristics would interactive surfaces need to support CAD and/or GIS?

16. Do you think interacting with CAD and/or GIS on interactive surfaces would improve the participation?

17. Have you ever used interactive surfaces to interact with CAD and/or GIS?

18. How would you want to interact with CAD and/or GIS on large interactive surfaces?

19. What kind of interactive capabilities would you want to have in order to interact with CAD and/or GIS on interactive surfaces?

20. Where would you want the potential to use interactive surfaces in order to perform participatory tasks that are supported by CAD and/or GIS?

21. Do you think interactive surfaces would provide more facilities for interacting with CAD and/or GIS 3D version/different layers of maps?

22. What would be your suggestion(s) to accomplish higher-level CAD and/or GIS interaction scenario(s) on participatory interactive surfaces?
23. What would be your suggestion(s) to accomplish higher-level CAD and/or GIS user scenario(s) on participatory interactive surfaces?
Appendix II: Research Material for Study II

Appendix II comprises the research material that was used as part of Study II (see Chapter IV), including the example interview questions that participants were asked (see section II.I), and the analysis of the collected data that is presented below in Tables 1-10 (see section I.II).

II.I Example Interview Questions

Part I. Biographical Information

1. How would you describe your job/position?

Urban planner Urban designer Architect

Other (Specify)

2. Where did you graduate? Year Program

3. How many years have you been working in your profession?

4. How long have you been working in your current position?

5. Could you please rate your CAD and/or GIS knowledge with mark out of 7, where 7 indicates an expert user, and 1 indicates no or little knowledge of CAD and/or GIS.

None 1 2 3 4 5 6 7 Expert

6. Have you taken any CAD and/or GIS courses?

As part of an undergraduate program (Specify number)

As part of a postgraduate program (Specify number)

As part of a professional training program (Specify number)
7. How often do you use a CAD and/or GIS application in your profession?

Daily  Weekly  Monthly  Once a year  Never

8. Which CAD and/or GIS application are you using?

As an urban planner, do you use Google Earth and/or Google Street View in your position?

9. Do you have any experience using any of following devices in the course of working?

Smartphone:  Own one  Use on an occasional basis

Tablet:  Own one  Use on an occasional basis

Tabletop:  Used once  Several times  Regularly  Once a week

Large wall display:  Used once  Several times  Regularly  Once a week

Data projector:  Used once  Several times  Regularly  Once a week

Other (Specify)

10. Could you describe your job responsibilities in detail? Describe your average day or week?

**Part II. Design Review Process**

11. As an urban planner, could you please describe a project you were either in charge of or played a significant role where design review was a significant factor.

12. Who were the key stakeholders in this project? What role did each play within the design review process? Was the design review process a success, why? If not, why not?
13. What problems or challenges were you faced with during the course of this project? How were these problems resolved?

14. What information in the form of CAD and/or GIS output and paper and text-based document were used during the course of this project?

15. Was there data, which you would have liked to have had during the course of this project that was unavailable? Should this data have been archived by the city or firm name? Is this data in the public domain?

16. What tools and technologies, and analysis techniques were used during this project?

17. Please describe the physical surrounding where meetings took place during the course of this project.

18. Please describe the political and social context surrounding this project.
### II.11 Data Analysis Tables 1-10

#### Table II.1. Participants’ Biographical Information

<table>
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<th>Participants’ Name</th>
<th>Gender</th>
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<th>Occupation</th>
<th>Education Level</th>
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<td>John Doe</td>
<td>Male</td>
<td>35</td>
<td>Accountant</td>
<td>Master’s Degree</td>
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<td><a href="mailto:john.doe@email.com">john.doe@email.com</a></td>
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<td>2</td>
<td>Jane Smith</td>
<td>Female</td>
<td>28</td>
<td>Teacher</td>
<td>Bachelor’s Degree</td>
<td>3 years</td>
<td><a href="mailto:jane.smith@email.com">jane.smith@email.com</a></td>
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<td>3</td>
<td>Michael Brown</td>
<td>Male</td>
<td>42</td>
<td>Engineer</td>
<td>PhD</td>
<td>10 years</td>
<td><a href="mailto:m.brown@email.com">m.brown@email.com</a></td>
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<td>Sarah Johnson</td>
<td>Female</td>
<td>31</td>
<td>Nurse</td>
<td>Master’s Degree</td>
<td>7 years</td>
<td><a href="mailto:s.johnson@email.com">s.johnson@email.com</a></td>
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<td>5</td>
<td>David Lee</td>
<td>Male</td>
<td>45</td>
<td>Lawyer</td>
<td>Bachelor’s Degree</td>
<td>15 years</td>
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<td><a href="mailto:a.davis@email.com">a.davis@email.com</a></td>
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Note: The table above provides a simplified example of what a biographical data table might look like. Each participant is listed with their name, gender, age, occupation, education level, work experience, and contact email. This table is a placeholder and should be replaced with actual data from the study.
Table II.2. Flow Model

| Purpose rating | Looking at populations | Coordinating across city | Meetings | Transportation (mode & parking modes) | New Community Planning | Policy writing | E-commerce | Check applications site/app | Check design application | Review applications | Implement documents | Keep track of revenue | Process development | Underworld needs | Plan the long term | Cross development plans | Identity budget from other | Operational funding | Identity priority projects | Facility programming | Urban design feasibility study |
|----------------|------------------------|--------------------------|----------|--------------------------------------|------------------------|---------------|-------------|--------------------------|-----------------------|------------------|-------------------|---------------------|----------------|----------------|----------------|-------------------------|-------------------|-----------------|----------------++++|-----------------------|
| 1              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 2              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 3              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 4              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 5              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 6              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 7              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 8              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 9              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 10             |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |

<p>| Purpose rating | Looking at populations | Coordinating across city | Meetings | Transportation (mode &amp; parking modes) | New Community Planning | Policy writing | E-commerce | Check applications site/app | Check design application | Review applications | Implement documents | Keep track of revenue | Process development | Underworld needs | Plan the long term | Cross development plans | Identity budget from other | Operational funding | Identity priority projects | Facility programming | Urban design feasibility study |
|----------------|------------------------|--------------------------|----------|--------------------------------------|------------------------|---------------|-------------|--------------------------|-----------------------|------------------|-------------------|---------------------|----------------|----------------|----------------|-------------------------|-------------------|-----------------|-----------------|----------------------|
| 1              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 2              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 3              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 4              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 5              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 6              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
| 7              |                        |                          |          |                                      |                        |               |             |                          |                       |                  |                   |                     |                   |                |               |                         |                       |                 |                 |                        |
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| Total       | 1                        | 1                           | 8                                             | 8                    | 10                   | 10                   | 10                   | 10                   | 2           | 10         | 10     | 10     | 8         | 8                           | 1         |             |

Table II.5. Cultural Model
Table II.6. Physical Model
<table>
<thead>
<tr>
<th>Participant - Example</th>
<th>Application Status: Approved, Not Approved, On-Going</th>
<th>Approaches Taken</th>
<th>Challenges for Government Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 - Site 11 South West, 13, 13 St.</td>
<td>Office building was approved, podium style, there were two years, applicants around 2 years ago wanted to change 1/2 of the block to residential, 13 story (skys)</td>
<td>The project was approved.</td>
<td>Provide comments, a lot of comment back and forth, a lot of negotiation and collaboration.</td>
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<tr>
<td>P2 - East Village</td>
<td>Residential neighbourhood within the eastern portions of downtown Calgary.</td>
<td>The project was approved.</td>
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<tr>
<td>P3 - Brentwood Project</td>
<td>Brentwood area which after Calgary downtown is a major activity area, it is adjacent to LRT. It is high priority area in the city. There are university campus, university research park, breastwood area. It can attract a lot of jobs for many people. Before boom period, 4 years ago, architect wanted to build these town in the parking lot. 17 stores, they wanted retail buildings.</td>
<td>The project was approved.</td>
<td>“Urban Strategies” group to assist us with the planning. They invited the community advisor. Urban strategies had a nice approach, they invited 45 people from the brentwood community on 2 days Saturday and Sunday event, and had a design charrette approach. They asked people what they want, they tried to engage people.</td>
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<tr>
<td>P3 - Corona Hotel</td>
<td>Project in progress. She was away for the beginning of the project, but at the final stage application went to Calgary Planning, they added a restaurant, lobby, retail store, bay window was more articulated and had better transparency.</td>
<td>The project was approved.</td>
<td>There is a huge problem of negotiation.</td>
</tr>
<tr>
<td>P3 - 6th and 10th</td>
<td>Residential tower and retail in the podium. Land use fit, but there was a bonus option.</td>
<td>The project was approved.</td>
<td>FAR is 5 times more, but the bonus option allowed them to have 5.12 times, for the bonus they provided log open space, public art, water feature. So, the bonus option was worthy of the site.</td>
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<td>P3 - Direct Control District</td>
<td>Reducing the direct control district. First, City of Calgary refined it, because it would create high congestion, traffic in the area. But, it want to Calgary Planning Commission and it did get approved finally.</td>
<td>The project was approved.</td>
<td>Height, mass were okay but number of units were too high, so it would create high congestion, traffic in the area.</td>
</tr>
<tr>
<td>P4 - OWC Sarce</td>
<td>We submitted the proposal, but CPAG refused it, so we had to make changes. We thought that it was good that it got refused. We submitted a revised version application with master plan. The application is still under review, we have just got the 3rd response.</td>
<td>The problems have not been resolved yet, normally it gets resolved through discussion with stakeholders.</td>
<td>The Long term vision, is what is feasible in terms of urban design? Makes sure the site has an negative impact on the neighborhood, Where is the site and grading?, Site selection/topography, How to communicate with CPAG team?, What are the views from, access, traffic zone, vegetation who?, What are the views from, Legislation is too restricted, they look at test documents and makes decision, which is not a good way of making decision? For example, Bay window can be different for neighborhood, but since legislation dictates certain criteria, there is no urban design element to the Bay window. How to be able to propose zoning? Wait can we do to optimize the building? Like improve the view for neighborhood with public art. How does the building look like? Does the building meet the city culture needs?, Integrated project design IIPD, building information modeling BIM, Planning CPAG, what do we expect? Do we agree or disagree? What changes pleasing want?</td>
</tr>
<tr>
<td>P4 - Rogers Cell Tower</td>
<td>Community open hours</td>
<td>Community open hours</td>
<td>Executive manager wanted to facilitate this multidisciplinary area and reduce the amount of time by integrating the process and multiple steps through collaboration with multiple people at the same time. We wanted to look at the whole thing as one whole piece rather than piece by piece to save some time.</td>
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<tr>
<td>Political/Economic Situation</td>
<td>Challenges for Applicant/Developer</td>
<td>Interesting Points about the Application</td>
<td>Stakeholders</td>
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<td>There were political and economic issues.</td>
<td>There were political and economic issues, so they had to stop working on the development</td>
<td>Revise 2 concepts, Collaboration through using technology</td>
<td>Applicants, urban designers, planners and developers, urban design panel that made only comments, and Calgary Urban Design. Both have community associations, engineers, transportation planners, and public and community as well.</td>
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<td>This project was pretty low key, so in there was no political pressure to get approved.</td>
<td>Developers do not want to make any changes to their plans.</td>
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<td>External stakeholders in this project were developers and land owners, internal stakeholders were entire city development and policy teams. Corporate planning and development group CPAD consists of urban development, transportation planning and parks.</td>
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<td>It is a good site for political talk and discussion.</td>
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<td>Architects, contractors, construction managers, parks, transportation planning, urban design.</td>
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<td>At the beginning, city council did not want to support the application, because of one piece of policy and one piece of policy and another piece of policy said residential.</td>
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<td>The status of application got improved because executive director tried to change the interpretation, otherwise it would not have changed.</td>
<td>Developer, engineering team, urban development (urban development engineer), planning, planning department, parks, list committee, and executive director.</td>
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<td>Example</td>
<td>Description</td>
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<td><strong>Table II.9. Participants’ Examples (Part III)</strong></td>
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<td><strong>P9 - Example</strong></td>
<td>Recover the permit.</td>
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<td><strong>P9 - Development in Steven Ave, 8th St.</strong></td>
<td>The requirements of this particular area is to get more res. So, policies or design guidelines change depends on the height, location of the building and how building is located.</td>
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<td><strong>P6 - Indigo Sky</strong></td>
<td>It was a multi-building, multi-family application on 2011. The project was not approved. Application came and we did not support it, because the project was flat floor, industrial component, looking like a large dorm. There was no engagement with the major intersections.</td>
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<td><strong>P6 - Montana</strong></td>
<td>It is multi. The project was approved.</td>
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<td><strong>P7 - Building a Repository Project</strong></td>
<td>Coaxing web interface for annual stakeholders. This spatial interface allows users to access all building information pertaining to each building within the city. We create web interface for users to access real-time information about building by clicking (selecting) structure on computer or handheld device. This project is still going on and it is not completed yet. We started the project by researching how other municipalities create their own web interface. We intend to test them (and) Did the right person, then emailed or conducted phone interview, also attained conferences like ESRC. We have a lot of technical constraints. Also, resources such as time, money are limited. We solve the problems with prioritisation, limit the scope of the project, consultation with stakeholders based on available resources. We make choice based on available resources.</td>
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<td><strong>P8 - Retail Shopping Centre Development</strong></td>
<td>Application is still in the process. Pre-application process, which is 3 hours workshop looking at the original process and bringing master, paper and sketch, bringing ideas together, meet with parks and recreation, transportation, looking at the original process. In the next session, they came back with more refined ideas and drawing. After several meeting, the official application goes to Dental Team Review (DTR) for more revisions and official comments. Land use bylaw, zoning, parking requirements, type of design is a challenge. In this particular case tenant did not know what they actually wanted, unsure about the basic needs. Transportation was another challenge.</td>
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<td><strong>P9 - Shannen Shone Development</strong></td>
<td>Application went to council for development permit, re-development of a golf course for residential on west of Calgary. The golf course was built in 1953 and 1963, in 1973 golf course was built, then it was sold and owner wanted to do residential development. It has been presented to council land use change, zoning, hygiene process, went back to public consultation presented to community association, met the City. The city could not force them to communicate, but council forced them to talk. Transportation was another challenge.</td>
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<td><strong>P10 - Large Format retail site</strong></td>
<td>East bays, next edge of city, 90 acres. This retail site is in a large area, green field, very close to Chinatown. It has been in planning commission, the application required further work, it was kind of refined, the planning commission asked for changes. The application will go there again. Application came – pre-application meeting, we discuss some of the details in this meeting, then formal application for permit. Design discussion/epiphany. There was a lot of back and forth communication. Talk about design issues with applicants to meet the city objectives, DIB, and DIB specifications and urban design comments. There were 2 main problems. First, developer was reluctant to deviate from their plan, since it had economic impact. In order to resolve economic impact we had to hire another consultant to see what is feasible, viability of the site in the face of changes. (Project): differences in opinions internally. Planning department wants to move the concept to pedestrian and cyclists, but transportation concerns about lanes and cars. Our internal problems can slow down the applicants. So, we came to agreement, but there was a lot of subjective issues, such as mixed-use of land including residential, designing to develop over time.</td>
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<td>Money plays a very important role in this process. There was an application required, because applicant did not start the development. The problem was the city council changed throughout the application process from 1976 to 1980. When the application was filed, the city council was divided. Applicant did not start development. So, we added the application. Was you start the project? (applied, since the interest rates were down, there were issues with bank and lawyer, therefore money situation was changed as well.</td>
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<td>Everything in these applications are done to money. Calgary has a very large city, why do we hold on to this city?</td>
<td>Applicant did not want to make any changes at all, because they want maximum return. The building was a long term. The building was not a short term, it was too soon, the 5th entrance was not right. Applicant did not want to make any changes in the application, needed to Calgary Planning Commission, but did not get approved there either. They appealed to the Board of?</td>
<td>Blame! No better, never, applications, community association.</td>
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<td>Part IV.</td>
<td>City Hall</td>
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<td>It has a very nice design, it has been designed</td>
<td>It has a very nice design, it has been designed like a little town. It has public art, massive parks, etc.</td>
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<td>Political view is a very political. The application went to mayor. The application went to major, the mayor wanted to make sure that millions of people and resources are available to get this application done. Political situation now it goes a bit different, so there is a great concern that this project will not be approved. Social situation: It is a great shopping centre.</td>
<td>In this particular case tenant did not know what they actually wanted, except the team needs. The good thing about this application was that everyone and many were willing to communicate with the City.</td>
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<td>Public situation: Council like the application but wanted to get it right politically done, drawing strong attention to the details. Social situation: Residents were split, they did not want to accept the development's rights. Public consultation were concerned about consolidated open space which appeals to residents, urban open space is better. Public opposition was a major concern. There were massive visual and traffic impact, loss of habitat (deer), interspecies of developer vs. community association, they did not want to communicate. Community association wanted to access the traffic impact assessment copy writing, it was not easy, but they could not mentally access it.</td>
<td>Applicant (energy and resources company), Consultant, AECOM, Local community association, Residents of golf course, Department in the City, City council.</td>
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<td>Electronic application, aerial mapping, physical mapping, conceptual plan. SD compilation to 3D view in reality through demonstration, Google Maps, Excel, Word Doc.</td>
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<td>Social situation: local business was interested about the competition, which is a threat to existing community. Political situation: City council approved the application very quickly because of its economic benefit. But, the older generation was more inclined towards community's values. So, only that particular side was supported the concept. Overall, there was a complicated political situation.</td>
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<td>Ush! Arc SE, there is another shopping center, they wanted to make sure there are two competition with existing shopping center. So, they are two concerns about design. The application changed dramatically from shopping center to strong community oriented, higher quality of landscape uses. We did design change with CEAG.</td>
<td>Applicant, 2 Architects for plaza and mall, 1st person (CEAG), Planning, Urban development, Roads, Parks, Transportation, Large community, Utility association.</td>
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<td>AutoCAD, ArcGIS, MicroStation, Site plans, topographical, area photo, zoning maps, GIS layer, Boardroom, meeting, discussion, 3AIA, projects.</td>
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Appendix III: Research Material for Study III

Appendix III comprises the research material that was used as part of Study III (see Chapter V), including the example survey questions that were presented to the participants (see section III.I).

III.I Example Survey Questions

Please rate the importance of the following features for SketchBoard in each of the zoning and FAR scenarios in the section below.

Scenario I: Zoning. In this scenario, via using SketchBoard, urban planners can select a parcel to view in either 2D or 3D. SketchBoard would make it possible to visualize the existing development on a parcel and compare it against the development allowed under current zoning. SketchBoard would use the existing zoning and parcel map of the city to show urban planners both existing and potential development for the selected parcel.

1. Participatory design

1.1. Participation of urban planning stakeholders

1.2. Communication with urban planning stakeholders
2. Urban Design and Planning Process

2.1. Concept design

2.2. Detailed design

2.3. Possible design revisions

3. Visualization

3.1. Use of Google Street View, Google Maps, and Google Earth

3.2. Use of Computer Aided Design (CAD)
4. Analysis

4.1. Access to existing documents, such as the zoning, bylaws, and architectural guidelines

4.2. Existing setbacks requirements

4.3. Floor area ratio (FAR) of existing and/or proposed development

4.4. Massing studies for existing and/or proposed development

4.5. Population studies and demographic analysis of surrounding areas
4.6. Access to existing traffic studies

4.7. Economic analysis (pro forma, profit and loss, and balance sheets for any proposed development)

4.8. Sun and shade analysis for existing and/or proposed development

4.9. Physical surroundings including buildings and trees

4.10. 2D drawings of existing and/or proposed development
4.11. 3D modeling of existing and/or proposed development

Scenario II: Floor Area Ratio (FAR). In this scenario, via using SketchBoard, urban planners would be able to examine the relationship between FAR, number of floors, and floor to ceiling height possible for a specific parcel. Ultimately, SketchBoard would allow urban planners to explore the amount of space that can be developed on a single site. Since it is often not possible to reach the FAR on a site, some communication is needed to reach a satisfactory conclusion. SketchBoard would allow for exploring the possible design solutions. Other issues, which could be explored, include the possible impact of various massing solutions on adjacent properties. One possible feature for SketchBoard would be showing the shadows of the proposed building for various times during the year.

1. Participatory design

1.1. Participation of urban planning stakeholders
1.2. Communication with urban planning stakeholders

2. Urban Design and Planning Process

2.1. Concept design

2.2. Detailed design

2.3. Possible design revisions

3. Visualization

3.1. Use of Google Street View, Google Maps, and Google Earth
3.2. Use of Computer Aided Design (CAD)

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4.4. Massing studies for existing and/or proposed development
4.5. Population studies and demographic analysis of surrounding areas

4.6. Access to existing traffic studies

4.7. Economic analysis (pro forma, profit and loss, and balance sheets for any proposed development)

4.8. Sun and shade analysis for existing and/or proposed development

4.9. Physical surroundings including buildings and trees
4.10. 2D drawings of existing and/or proposed development

4.11. 3D modeling of existing and/or proposed development

4.12. Use of GIS (spatial analysis and map making)

Are there any other comments you would like to make?
Appendix IV: Research Material for Study IV

Appendix IV comprises the research material that was used as part of Study IV (see Chapter VI), including the example survey and interview questions that were presented to the participants (see section IV.I).

IV.I Example Survey and Interview Questions

Survey

For the following statements about SketchBoard, please check the appropriate choice in the section below.

1. SketchBoard is easy to understand.

2. SketchBoard presents the information in a logical order.

3. SketchBoard has an appealing aesthetic.

4. Use of a tablet versus desktop makes performing the task easier on SketchBoard.
5. SketchBoard solves the problem of understanding the implications of zoning on FAR for a particular parcel.

6. SketchBoard could be used to help explain why the FAR as calculated is sometime lower than the allowed FAR, given existing setbacks and height restrictions for that parcel?

Interview

7. How does/does not SketchBoard support the task of explaining how zoning often makes it difficult to achieve the maximum FAR on a site?

8. Do you think SketchBoard would help in communication between developers and urban planners within the City of Calgary?

9. Could SketchBoard be used to help educate the public on how FAR is considered by zoning?

Appendix V: Glossary

Cave Automatic Virtual Environment (CAVE) is an immersive virtual reality environment where projectors are directed to three, four, five or six of the walls of a room-sized cube.

Computer Aided Design (CAD) is a computer system which is used for the creation, modification, and analysis of a design.

Computer Mediated Communication (CMC) is defined as any communication that occurs via the use of computer technologies.

Computer Supported Cooperative Work (CSCW) is a field which focuses on understanding the way people work while interacting with technologies within participatory environments.

Geographic Information System (GIS) is a socio-technical computer system which provides support for solving geographic problems ranging from scientific activities to everyday tasks, in various disciplines.

Geographic Positioning System (GPS) is a satellite navigation system which provides time and space-based information.

Graphical User Interface (GUI) is an important part of a computer systems’ user interface that allows users to interact through graphical icons and visual indicators.

Human Computer Interaction (HCI) is a field which focuses on the design and evaluation of the interaction and relationship between humans and computers.

Information Communication Technology (ICT) is defined as the integration of audio-visual, telephone and computer networks through a unified system.
Interactive Surfaces are defined as touch-based computer devices such as smartphones, tablets, tabletops, and large wall displays.

InVision is a free, web-based application which allows for the creation of interactive prototypes.

Land Information System (LIS) is a computer system which local governments employ for land use mapping.

METROPILUS is a planning support system which integrates the combination of urban models and GIS.

Mixed Reality (MR) refers to the combination of both augmented reality and augmented virtuality where physical and digital objects interact in new environments.

Photoshop is a computer system used for editing graphics.

SketchUp is a 3D modeling computer system used in the areas of architecture, interior, film, and game design.

Spatial Decision Support System (SDSS) is an interactive, decision-making computer system which assists urban planners with spatial thinking.

Urban Information System (UIS) is a computer system which provides information for permit processing, code enforcement, infrastructure management, and transit operations.

Virtual Reality (VR) is a type of an immersive multimedia which simulates physical presence in the real or imagined world.