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Analyzing Lynch's City Imageability in the Digital Age

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Abstract
This paper explores the role of virtual mapping environments in analyzing people's perception of spaces and their implications in planning. We examine how people interpret Kevin Lynch's "city imageability" in the digital age by asking two questions: (1) how can we create mental images of city elements by using virtual versus physical environments? (2) What are the strengths and weaknesses of each method? We studied sixty-eight mental maps—created by thirty-four participants—identifying five factors for disagreements on city elements: scale, eye level, details, accuracy/timeliness, and sensory/movement. We conclude by suggesting how practitioners can take a balanced approach for city imageability analysis.

Keywords
Kevin Lynch, city imageability, city elements, virtual mapping environments, mental maps

Introduction

In this paper, we examine the role of virtual mapping environments in analyzing people's perception of spaces and places and the implication of using these environments to advance field observation methods in urban planning and design. Based on Kevin Lynch's (1960) city imageability concept, our goal is to explore the ways people understand and interpret Lynch's five city elements—paths, edges, districts, nodes, and landmarks—in the digital age. We also want to understand how using virtual mapping environments can help planners conduct Lynchian analysis and identify Lynchian city elements. City imageability is the quality of the city elements that trigger lucid images in an observer, while city image is defined as a public image of any given city, which is the overlap of many individual images (Lynch 1960). A legible city image is necessary if an individual is to feel engaged by their city. Lynchian techniques are useful in understanding public images of the city for creating memorable and legible places that possibly advance residents' sense of attachment to urban areas (Larice and Macdonald 2013).

Lynch devised his mental mapping technique in the 1960s (Lynch 1960), prior to the invention of digital technologies such as the Internet, smartphones, Google Maps, and GPS. Scholars and practitioners have widely discussed Lynchian imageability analysis and its role in affecting planning and design. Their focus, however, has been mainly on ways in which practitioners can explore cities' imageability through field observations (Southworth 1985). Virtual mapping technologies are becoming more advanced and increasingly available to urban planners (see Koziatek and Dragićević 2017; Mandarano and Meenar 2015; Portman, Natapov, and Fisher-Gewirtzman 2015). Due to such advancements, there is a need to understand technology's role in assisting planners conduct city imageability analysis. These contemporary approaches would likely influence the applications of Lynch's method in two ways: their impact on the public perception on cities and their influence on collecting and creating the city image in a planning project.

Today's virtual mapping environments can help us explore city elements at various levels (e.g., eye levels and bird's-eye view), scales, and times (see Jiao, Holmes, and Griffin 2017; Kepper et al. 2017; Morello and Ratti 2009; Park and Ewing 2017). Urban planners are increasingly pairing physical environment exploration methods with virtual explorations (e.g., using Google Map/Earth/Street View) for performing site analysis or understanding urban environments (Christman et al. 2018; Li, Zhang, and Li 2017; Li et al. 2015; Odgers et al. 2012; Richards and Edwards 2017). The literature, however, is thin in identifying the differences in our perception of city elements when

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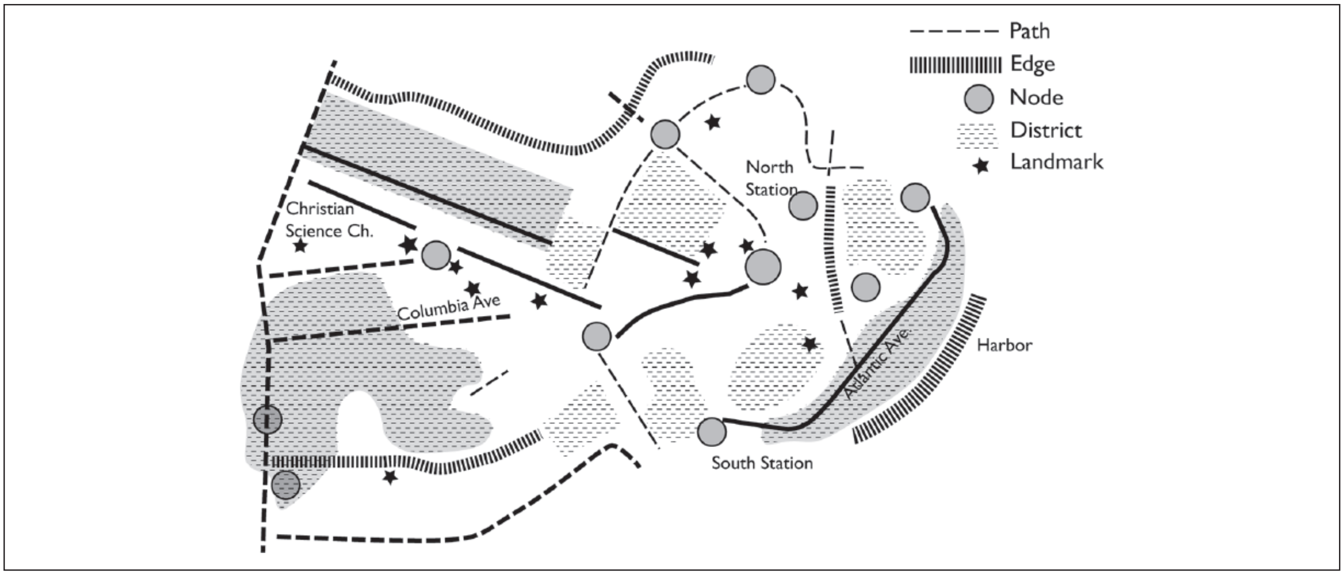

Figure 1. Lynch's "visual form of Boston as seen in the field."
Source: Adapted and simplified from Lynch (1960, 19, 147).

we experience them through physical versus virtual exploration. Our study addresses two broader questions: (1) How can we create mental images of city elements through today's virtual mapping environments and compare them with the images created through field observations completed in physical environments? (2) What are the strengths and weaknesses of each type of exploration?

We open this discussion, first, by connecting observational methods—including mental maps—with virtual mapping environments, explaining the application of digital technologies and virtual mapping environments in collecting objective and perceived data for planners, and summarizing the literature on the benefits and shortcomings of these new technologies. Then, we present our methodology to explore five Lynchian city elements using two methods: physical environment exploration using field observation and virtual exploration using Google Map/Earth/Street View. The results and comparison between two types of exploration methods provide insight for planners and urban designers on the application of Google Map/Earth/Street View to explore city imageability and the potential influences of these technologies on people's mental images of urban spaces.

Literature Review

Urban Experience and Application of Lynchian City Elements in Planning

An aspect of urban design that has always received intense scrutiny is how and to what extent the physical urban environment affects people, their well-being, and their experience (Carmona 2010; Jacobs and Appleyard 1987; Rapoport 2016). Any progress in this understanding can help urban designers assess the consequences of their design, and the way people see, use, and experience their physical environment. Urban designers need validated toolkits to bridge "objective" urban environments to its "subjective" urban experiences, in different phases of design. A popular toolkit is Lynch's (1960) city image method. Lynchian techniques have proven valuable in environmental design research and in many types of urban design projects (Larice and Macdonald 2013).

Lynch—whose 100th birthday we celebrated in 2018—was a pioneer in the application of environmental perception and cognitive science in planning and urban design. He argued that by understanding how people perceive the city, we could create more imageable and psychologically satisfying environments. A central notion in his method is legibility, or the extent to which people read the streetscape in a comprehensible and coherent way. Despite individual differences, a "public image" of the city—the everyday mental pictures carried by a large number of people—can be conceived. He classified the elements of city image into five types: (1) paths: the channels along which the observer moves, the most significant organizing feature of cityscape, and the predominant element in the city image for many people; (2) edges: the boundaries between two regions; (3) districts: areas identified by common characteristics; (4) nodes: focus points for activities and/or orientation, which an observer can enter; and (5) landmarks: external points of reference. These elements are the raw materials of a city image (Figure 1), and the interactions of them may reinforce one another and provide a satisfying city image (Lynch 1960).

City image elements are rooted in public perception, and not just experts' opinions. In one research study, for example, Jiao et al. (2017) investigated people's communication around Lynchian city elements through social media (Twitter) during the 2012 Super Bowl event. They found instances of all Lynchian city elements in the tweets. District, landmark, and node references were most common in the tweets.

More than two decades after the publication of the *Image of the City*, Southworth (1985) discussed the impact of Lynch's imageability concept on planning and urban design. Southworth (1985, 52) concluded "imageability research has proved to be a rewarding area for investigation and has made substantial contributions to techniques for environmental analysis and citizen involvement in the planning process." He urged planners to explore ways to connect theories and techniques to actual designs. Today, examples of the use of Lynch's methodology in urban planning practice are countless. Using Lynch's concept of place legibility, for example, a mental map of an area was developed and used to lay out a neighborhood in San Luis Obispo, CA (City of San Luis Obispo, Community Development Department 2004). City of Arroyo Grande, CA, used its existing "image" to illustrate its problems and potentials (City of Arroyo Grande, Community Development Department 2016). Designers and decision makers considered those city image elements and determined how they would be affected by development projects. The City of Menifee, CA, used this method to analyze its unique physical setting as part of its community design efforts to create a "positive climate" for business and a "good impression" on visitors (City of Menifee, Community Development Department 2017). Some plans, such as Diridon Station Area Art Master Plan in San Jose, CA, may not have used Lynch's methodology, but have embraced its terminology and main concepts (San Jose Office of Cultural Affairs and Public Art 2010). Another example is the downtown master plan of South Salt Lake City, UT (City of South Salt Lake, Community Development Department 2015). The broad concepts of imageability and legibility were used as one of the "big ideas" behind the master plan, without much elaboration on the implementation of the technique or the assessment of the final proposal. Irvine, CA, also relied heavily on the "imageability" concept and techniques (Forsyth 2005). They received criticisms, however, for not addressing other qualities such as diversity, human scale, or vitality (Lynch 1981). Forsyth and Crewe (2009, 420) argue that "Lynch's 1960 work provides a clear vision that is easy to apply, providing a potential alternative to the harsher forms of modernist design." The use of Lynch's method as a design tool, however, is less clear than its application in the analysis phase. Despite the countless examples of the use of concept and methodology (although relatively few large-scale planned communities), further research is needed to predict the image impact of proposed developments (Forsyth and Crewe 2009). As the manifestation of design is mostly possible in the virtual environment, predicting the image impact is also (more likely) possible in the virtual environment.

Observational Methods, Mental Maps, and Virtual Mapping Environments

Direct observation is a traditional method to objectively measure built environment characteristics and human activities (Cohen et al. 2011; McKenzie et al. 2006). Human perception, preferences, and opinions are mainly collected through subjective tools such as mental maps, self-reporting assessments, questionnaires, and interviews (Byrne 2012; Loukaitou-Sideris and Sideris 2009; Wendel, Zarger, and Mihelcic 2012). Mental mapping—a technique used in the social sciences, public health, and humanities—refers to the exploration of people's mental constructs or processes, as well as the tangible map products they create (Curtis 2016). Mental maps relate geographical settings to human perception and, ultimately, to human action. Mental maps can be created by asking a participant to sketch a rapid description of the city, covering all the main elements (Lynch 1960). Therefore, they are products of mental images—images of the city created through experiencing cities' multiple elements (e.g., edges, nodes, paths).

Lynch's city image technique is unique. It is a subjective method; however, an expert can "directly observe" the built environment and anticipate the public's mental map. This technique considerably reduces the cost and time of collecting a large number of mental map samples from the public. The method, however, entails limitations like other observational methods (McKenzie and van der Mars 2015; Park and Ewing 2017), such as requiring multitrained observers, increased budget, and extended project schedule.

Virtual mapping environments such as Google Earth, Google Map, or Google Street View may overcome some of these limitations. In this paper, we refer to virtual mapping technologies as web- and geographic information systems (GIS)-based applications or tools that allow sharing and combining various experiences and information (Flanagin and Metzger 2008; Gouveia and Fonseca 2008). Google Earth is an example of these tools that allow people to use mapping and geospatial services in the online environment. These technologies also provide an opportunity for planners and urban designers to learn from geospatial content (e.g., location-based pictures and videos) shared by a crowd voluntarily (Bishr and Kuhn 2007; Goodchild 2007). Virtual mapping technologies, therefore, allow planners to access both formal data (e.g., census data) and citizen-generated data and explore their use in decision-making processes (Sui and Goodchild 2011).

Previous studies have supported using Google Street View for observational methods. Christman et al. (2018) and Rundle et al. (2011) used Google Street View to validate GIS-model generated suitable sites for green stormwater infrastructure and examine the walkability of a physically built environment, respectively. Odgers et al. (2012) supported the use of Google Street View as a reliable and cost-effective tool for measuring both the negative and positive features of local neighborhoods. Using a virtual systematic social observation (SSO) and resident surveys, high levels of observed agreements were documented for signs of physical disorder, physical decay, dangerousness, and street safety. Kepper et al. (2017) developed a parcel-level SSO methodology using Google Street View. They also found Google Street View as a reliable tool for performing SSO. Ewing et al. (2016) also compared Google Street View, Bing StreetSide, and EveryScape to explore their ability in providing reliable information about the number of pedestrian counts of five hundred eighty-eight urban blocks in New York City. Comparing the results with the manual pedestrian count deemed two of these websites reliable.

Using other methods such as time-lapse video cameras (Arnberger, Haider, and Brandenburg 2005; Guillén et al. 2008) or unmanned aerial vehicles (UAVs; Getzin, Wiegand, and Schöning 2012; Park and Ewing 2017) for monitoring human activity, such as walking and cycling, have become popular in environmental studies. The main advantages of these methods are the (1) possibility of using them in inaccessible or dangerous areas, (2) availability of postdata collection and validation, and (3) possibility of covering large target areas (Park and Ewing 2017). Using free websites such as Google Street View compared with using technologies such as UAVs, however, requires less training, is easier to conduct, and requires less additional time for data analysis through reviewing captured videos.

New technologies and virtual mapping environments have eased the collection of perceived data for planning organizations. In the era of the Internet and smartphones, using virtual tools to engage citizens in map creation and community participation has increased. Pánek (2016, 300) argues that "there is a visible shift in the (map) power structures, from maps created by experts and state administration representatives towards maps created by people and their users." This shift includes mental maps and public's perceptions and preferences. Several organizations have also started using web-based crowdsourcing technologies to explore people's interests or ideas about the urban areas. Crowdsourcing is a method for outsourcing problem solving through the engagement of a large crowd (Brabham 2009). There are various examples of web-based crowdsourcing tools being widely used by cities to engage a large number of people in solving urban issues, for example, by reporting pothole or graffiti issues (e.g., http://www.citysourced.com and https://seeclickfix.com). Some of these tools are being used directly for planning purposes. Various cities such as Philadelphia, Chicago, and Cincinnati, for example, have used web-GIS tools to ask people about their desired locations for installing new bike-share stations. The tools allowed people to suggest locations for new stations on a map and explain why they perceive this location as a suitable one. These tools helped cities learn about people's perception of suitability of urban areas for implementing bike-sharing systems (Afzalan and Sanchez 2017).

The advancements in new virtual technologies have augmented strong interest among planners and urban designers to explore and implement data-driven decision-making processes (Goodspeed 2014). The current literature points to the frequent use of open data portals and new data sources by planning organizations for exploring urban environments in greater detail or making complex models for objective planning or app development. The City of Los Angeles, for example, has collaborated with Environmental Systems Research Institute (ESRI) to develop a comprehensive open data portal (http://geohub.lacity.org) to allow private organizations or groups to build applications that are useful for the city and its residents. Planning organizations are now commonly adopting such data-driven approaches to advance their objective decision making; it is, however, not clear whether they are also active in using new digital technologies to enrich their qualitative analyses such as Lynchian explorations.

In recent years, many researchers have studied Lynch's five city elements using different methods and addressed different questions. Morello and Ratti (2009), for example, argued that the digital image of the city was based on 3D visual fields; they presented the visible spaces from a vantage point in 3D and examined how they could provide a quantifiable basis for Lynch's urban analysis. They proposed a reinterpretation of Lynch's urban analysis on visual elements, highlighting how the use of 3D visual fields could provide a new tool for identifying the elements. Their technique could potentially be developed as software for environmental prediction by quantifying Lynch elements objectively. Their attempt was part of other scholarly attempts to use Space Syntax techniques (see Hillier and Vaughan 2007) to link the morphological characteristics of street network to the perceptual and behavioral dimensions of urban life.

Using Lynch's method with other urban design techniques is a common practice. Topcu and Topcu (2012), for example, engaged thirty undergraduate students to examine their perceptions (using Nasar's (1997) "evaluative urban image" elements) along with their mental images (Lynch's city image elements) to identify important design clues to produce successful campus spaces. They found that in Selcuk University's campus area (Konya, Turkey), there were a lot of undefined and vacant spaces between buildings. Therefore, the campus imageability was low and few city image elements were identified on campus. In this case, Nasar's "evaluative urban image" technique complemented Lynch's "city image elements" to provide a more comprehensive assessment of campus image.

In another example, Jiang (2012) argued that by using computer technology and increasing the availability of geographic information of urban environments at very fine scales, the image of the city could be quantitatively derived using an automated process. Liu, Zhou, Zhao, and Ryan (2016) analyzed the interaction between city elements and human perception through geotagged photos taken in twenty-six different cities. They showed some gaps between subjective perceptions (processed through photos) and Lynch's city image elements.

People are now learning about urban environments through both direct field observation and virtual exploration; how they create an image of their city, therefore, is not only based on their physical environment explorations. In addition, practitioners can be more deliberate in their exploration of cities' legibility through more effective technology use. We have not seen any study that has focused on a comparative analysis of the exploration of Lynch's city elements using two types of environmental observations: virtual and physical. Our study—as presented in the next few sections—focuses on this topic.

Method

We have addressed our two research questions through an exploratory study. The primary author led the original study in 2016 with twenty-two participants and then repeated in 2017 with another twenty-two participants. The participants were upper level undergraduate students in planning and related social-science programs with an age group ranging from 22 years to 33 years. They were 64 percent male and 36 percent female. All participants were required to read Lynch's articles on city elements and imageability and participate in a group discussion on the definitions of the elements and the ways we can identify them, regardless of the methods we choose—virtual or physical exploration.

Based on Lynch's five elements, each participant created one mental map of a neighborhood (based on virtual exploration) and one mental map of another neighborhood (based on physical environment exploration through fieldwork). To compare results, two participants worked on the same neighborhood, but worked individually. In other words, each neighborhood had one map done by one participant using virtual exploration, and another map done by a different participant using field observation. Overall, forty-four participants created eighty-eight mental maps of forty-four neighborhoods, 80 percent of which were in Philadelphia, Pennsylvania, and the rest were in Southern New Jersey.

Participants chose their study areas (neighborhoods) following a two-hour-long group discussion, which was facilitated by the primary author, making sure that each group of two participants—while working on the same neighborhood—had a similar level of familiarity or experience about the neighborhood prior to this study. Two participants, for example, chose Philadelphia's Gayborhood neighborhood, because they both visited the area a few times, had a general understanding of the socioeconomic characteristics of the area, and neither of them ever lived in the neighborhood.

In both years, this was a three-week-long exercise. The process can be further explained by giving an example involving two participants. In week 1, participant 1 and participant 2 virtually explored neighborhood 1 and neighborhood 2, respectively, using Google Map/Earth/Street View, and then each created a mental map and reported how they perceived Lynch's five elements. The maps were either hand sketched or computer-assisted using visualization software. Whenever applicable, participants identified major and minor versions of each element (e.g., major node, minor node) on the map. In week 2, Participant 1 worked on neighborhood 2—explored by participant 2 virtually in week 1—and observed those five elements in the physical world, on foot, and submitted a map and a report. Participant 2 in week 2 worked on neighborhood 1 exploring the physical environment. In week 3, both participants exchanged their findings, compared maps, and wrote a brief report each based on key findings, focusing on the two broad research questions of this study.

As expected, some mental maps or reports were either incomplete or did not offer much details for further analysis. After careful consideration, we selected the work of thirty-four participants, representing sixty-eight mental maps (see Figure 2 as an example). We used these maps as references to our qualitative content analysis, which focused primarily on the reports submitted by participants. Considering comments as the unit of analysis, we implemented qualitative content analysis to "interpret meaning from the content of text data" (Hsieh and Shannon 2005, 1277). For research question 1—comparing city elements through virtual versus physical environment exploration—we calculated the percentages of agreement versus disagreement between two participants working on the same neighborhood, but using two different methods. Based on qualitative interpretation of the participants' comments, we also identified key factors that might be responsible for any discrepancies in the findings due to the use of different methods. In the next section, we present and discuss only the factors that were reported by more than half of the participants. For question 2—finding strengths and weaknesses of both methods—we compile and contrast key arguments reported by participants.

Findings and Discussion

Consistency in Perception of City Elements through Virtual versus Physical Environment Exploration

Participants did not always identify the same city elements through their virtual or physical environment exploration of the same neighborhood. Eighty-six percent of the total participants in the 2016 study and 89 percent participants in the 2017 study agreed that they identified the same paths using both methods. The pattern, however, was not consistent in all categories; only 33 percent participants in 2016 and 36 percent in 2017, for example, agreed that they identified the same edges from both types of exploration. In both the 2016 and 2017 studies, the majority of participants identified the same paths, nodes, and districts in their assigned neighborhoods; about

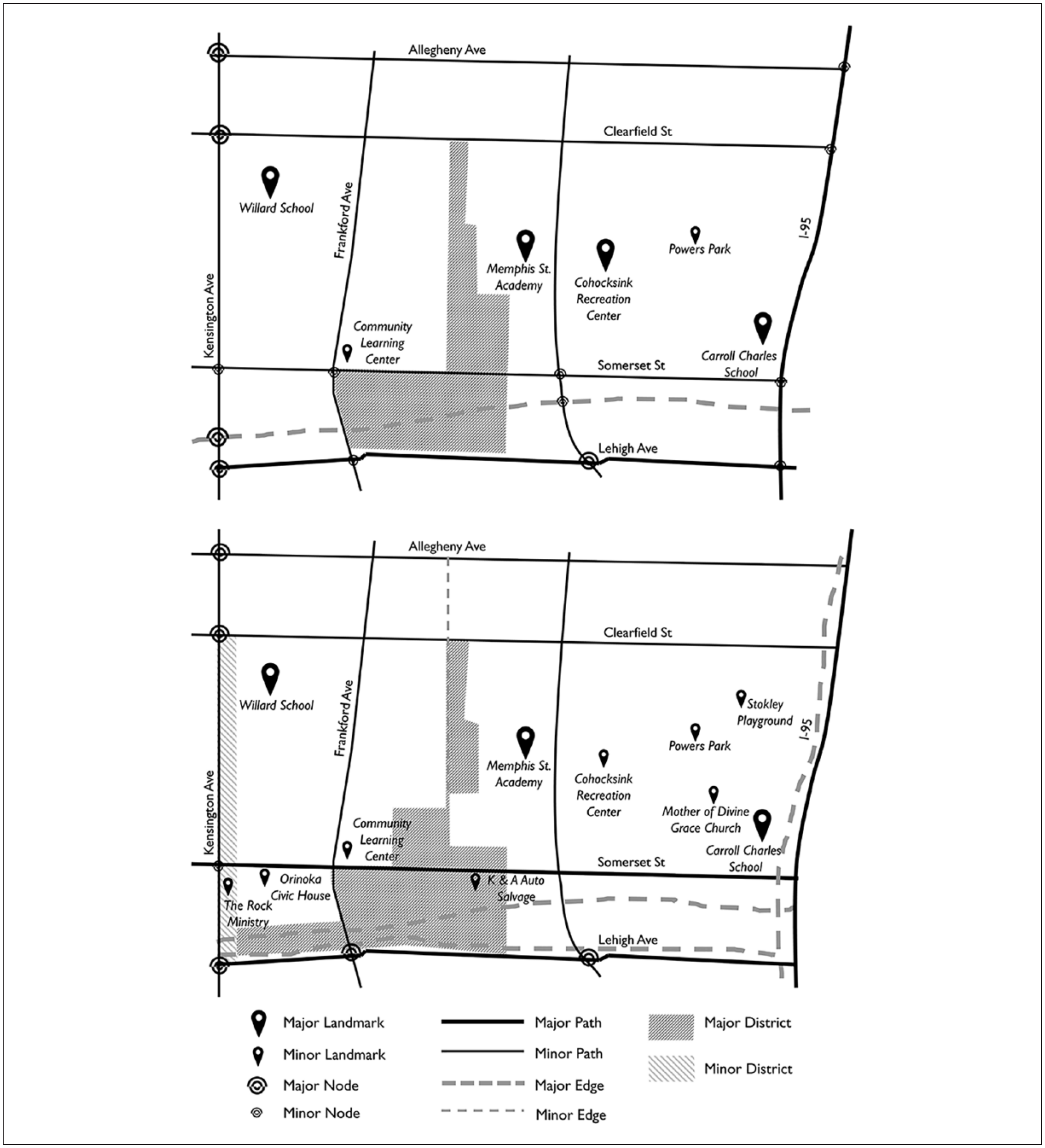

Figure 2. Examples of mental maps created by a participant through virtual (top) and physical (bottom) environment explorations.
Note. Location: North of Lehigh Neighborhood, Philadelphia.

half of all participants agreed or disagreed about landmarks; and the majority of participants disagreed about edges when they used different methods. See Table 1 for the percentages of disagreements in all categories in both years.

Through a qualitative content analysis of participants' comments, we have identified five major factors: (1) scale, (2) eye level, (3) details, (4) accuracy and timeliness, and (5) sensory/movement, based on which participants interpreted

Table 1. Disagreement about City Elements through Participants' Virtual or Physical Environment Exploration of the Same Neighborhood.

Study groups	Paths	Edges	Districts	Nodes	Landmarks
2016 study	14% disagree	67% disagree	29% disagree	19% disagree	48% disagree
2017 study	11% disagree	44% disagree	32% disagree	22% disagree	51% disagree

five city elements differently and disagreed with their peers who followed different methods of exploration.

Factor 1—scale. The perception of scale was a prominent difference between virtual and physical environment explorations. Participants who viewed neighborhoods virtually oftentimes underestimated the size, presence, or importance of particular path, edge, or landmark when compared with the physical environment analysis. For example,

> (Edge) "The 3D platform for built environments really skews the sense of scale . . . the convention center was a massive structure and determining factor in how I perceived the edges of Chinatown, whereas in the virtual exploration it wasn't included in the boundary of the neighborhood."

> (Path) "[My peer] did virtual exploration and identified an elevated highway as a major Path in the neighborhood. I didn't consider it as a Path during my walk, as it was physically disconnected with local roads."

Factor 2—eye level. All participants using the physical environment exploration method did a walking tour, so their eye levels varied from 5 to 6 ft from the ground. The virtual explorations, on the contrary, offered the capability of viewing a neighborhood both at the street level and bird's-eye level. Using the bird's-eye view and fly through capability of Google Earth/Map, participants were able to identify city elements that might be really close to the street, but somewhat obstructed or hidden from the street view. For example,

> (Edge) "During my [walking] tour, I did not notice this [nearby big industrial area], perhaps because of trees or buildings obstructing the view."

Factor 3—details. The varying degrees of detail between the virtual and physical environment exploration also led to considerable differences in perceptions of neighborhoods. Generally, the virtual exploration provided fewer details than the physical environment exploration. The virtual exploration gave a general overview of the environment, but lacked the specificity and detail gained from a physical environment exploration. Some participants, however, mentioned that they identified specific details in the virtual mapping environment, which their peers could not see in the physical environment. For example,

> (Edge) "[My peer] indicated that there was a gate and fence along the boundary of Bartram's Garden which formed an edge from the river, creating open space amenities for low-income populations. This gated and fenced area was not evident in [my] virtual survey of the area."

> (Landmark) " . . . it is easy to pick out [large] green spaces the way they are depicted in digital aerials, whereas large monumental architecture isn't done justice by street view photographs."

Factor 4—accuracy and timeliness. The accuracy and timeliness of the virtual environment resulted in substantially different interpretations of neighborhoods, due to both rapidly changing urban environment (e.g., a neighborhood undergoing significant redevelopment) and/or the timeliness of the virtual environment (e.g., the date/time at which it was recorded). For example,

> (District) "The recent developments in the entertainment district were missing in outdated virtual maps, so I could not properly identify a District."

Factor 5—sensory/movement. The lack of movement and limited sensorial experiences (e.g., sound, smell) in virtual exploration led to a less-than-complete observation when compared with physical environment exploration. On the contrary, due to situational incidences (e.g., road accidents, protests, concerts, rallies, inclement weather, road construction), some participants reported that their physical environment exploration did not go as planned. Most participants, however, agreed that physical environment exploration allowed observers to view the neighborhood in motion and how people interacted with the built environment. Although virtual exploration allowed for a general overview of the environment, it did not allow for a full understanding of how it functions in the physical environment. For example,

> (Node) "In the [physical environment] visit people could be seen transferring from buses, [stopping] at [corner] stores, and using the intersection as a meeting point . . . In the digital world this intersection did not feel like a [N]ode at all."

> (District) "Through a walking tour, I was able to see smoke from tire burning, smell the smoke, hear sounds from activities in a scrapyard, and I could identify a semi-industrial district. [My peer] missed all these sensorial experiences in his virtual exploration."

In summary, the majority of participants in this study identified different edges and half of them identified different landmarks when they used virtual versus physical environment exploration methods. Some participants did not perceive the same paths, nodes, and districts, while using these two methods. They identified five major factors for the inconsistency in perception of city elements: (1) scale—virtual environments often undermined the size, presence, or importance of certain paths, edges, or landmarks; (2) eye level—virtual environments offered bird's-eye view and fly-through capabilities to explore edges that were obstructed or hidden at the street level; (3) details—virtual environments often lacked the specificity and detail gained from a physical environment exploration through field observation; (4) accuracy and timeliness—virtual platforms were often outdated and misrepresented the rapidly changing built environments; and (5) sensory/movement—virtual environments lacked real movement and sensory experiences, leading to incomplete observations.

Comparing the Strengths and Weaknesses: Virtual versus Physical Environment Exploration

Virtual environment exploration—strength. One of the primary strengths of the virtual exploration is the ability to glean a basic overview and understanding of the urban environment. The virtual exploration platforms—primarily Google Earth/Map/Street View—allow the user to generally understand the area because of the relatively detailed set of images and information, available at different angles and eye levels (e.g., street view, bird's-eye view). For example,

> Virtual environments are a wonderfully accessible tool for exploring an area one has never visited, and getting a general idea of what to expect before visiting in person.

In addition to a general overview and understanding of an environment, virtual exploration also allows users to access a repository of web-based information, such as business information, bus lines, and time-series images, among others. In particular, the presence of old images captured in Google Street View over many years can add a temporal dimension to the virtual exploration, that is, inaccessible while walking around the neighborhood. For example,

> You can get an idea of what businesses are around, how people live, what housing is available, what the streets look like, if it has the facilities to be a walkable neighborhood, etc.

Finally, a virtual exploration is resource efficient despite the requirement for Internet accessibility. It takes less time and money, for example, to conduct a virtual exploration. It is not affected by weather or street conditions (e.g., construction, accidents), and it also allows for the ability to revisit particular areas or landmarks easily. For example,

> Sometimes it's cost effective and less time consuming to use these 3D platforms instead of visiting each area needed for a GIS analysis.

Virtual environment exploration—weakness. Although virtual exploration has its strengths, it also has several drawbacks. First, the qualitative aspect of the area—or, how the neighborhood "feels"—might be missing. Because virtual exploration relies on static images and/or maps, the atmospheric or sensorial aspects of neighborhoods cannot be fully understood—how the area functions, smells, sounds, moves, or feels like. Even videos may not be able to capture some of these. For example,

> I feel like actually being in a place gives you a better feel for the way people interact with their environment.

> The attributes like traffic speed, walkability, and crime safety cannot be [experienced] on Google Earth.

> You are not able to experience the culture, sounds, and immersion in a virtual environment.

Second, the virtual exploration offers a snapshot in time of a place. Because the imagery can only be updated periodically, the virtual exploration is likely somewhat out of date, particularly in areas undergoing rapid redevelopment. In addition, the quality of the imagery/technology also affects the quality of the analysis. For example,

> The 3D digital environment is a lot more static than the [physical environment].

> The quality of LiDAR 3D data is not good enough for this type of micro-level analysis. They fall short of the real experience of actually visiting an area.

Finally, the virtual exploration oftentimes misses specific details about a place and is more conducive to giving a general overview and understanding of an urban environment. For example,

> What you don't see are the features that might be important to your reason for going somewhere. This includes aesthetics, architecture, vegetation, murals, and traffic. It is easy to miss little things . . . when you are looking at a virtual map. I don't believe that viewing a virtual map gives you the full extent of the actual neighborhood image.

Physical environment exploration—strength. One of the primary strengths of physical environment exploration is the ability for a comprehensive analysis and observation. By being physically present in the urban environment, the observer can use all of their senses, feel the neighborhood live, and cover the entire area. For example,

Table 2. Brief Comparison of Virtual and Physical Environment Exploration Methods.

Type of exploration	Strengths	Weaknesses
Virtual environment	• Facilitates general understanding of the area • Provides access to other web-based resources (e.g., location of bus stops) • Can be resource efficient • Allows exploration from anywhere at anytime • Ability to view old images (both satellite view and street view)	• May not capture qualitative aspects of the area (e.g., smell, noise, traffic) • May not capture as much details as the physical environment and may not be helpful with microanalysis
Physical environment	• Helps with comprehensive exploration and capturing the sense of a place • Can be real time and more accurate	• Can be inefficient or weak in capturing the overall picture of the area • Can be very resource intensive

> The [physical] environment . . . allows for the sense of touch and smell [that can] guide an unrestricted exploration of an environment.

> Perceiving an environment in person will provide the most accuracy in regards to details and understanding the elements that cannot be virtually mapped such as people, [history], and culture.

In addition, a physical environment exploration allows the user to feel the area in real time, under its current conditions. There is no limitation based on technological capacities—whether the accuracy or timeliness. For example,

> Going to the place in person will show a view of the place that is always up to date, as well as allowing the person viewing the place to see things in more detail and from an even greater number of angles.

Physical environment exploration—weakness. Despite the strengths of real-time and comprehensive analyses, physical environment exploration does present a few weaknesses. First, because the user must explore each street or section individually, it can be difficult to get the overall picture of the urban environment. For example,

> The problem with perceiving a place in person is that it creates the possibility of becoming disoriented within the environment.

In addition, conducting field observations can be resource intensive—in terms of time and money—and is partially reliant on acceptable weather conditions. An observer must travel to a neighborhood, spend a considerable amount of time, and summarize their observation, all of which is considerably more time-consuming than conducting a virtual exploration. For example,

> . . . while missing something in a [physical environment] experience, having to go back could be a big deal.

Table 2 summarizes the reported strengths and weaknesses of the methods related to both virtual and physical environment explorations. Participants concluded that following a balanced approach—combining virtual and physical environment explorations of the same neighborhood (study area)—provided them with detailed enough information to analyze their perception of spaces and places and enhanced their overall understanding of the study area. They anticipated that such balanced approach would complement their field observations in future urban planning and design projects.

Implications for Planning Practice and Pedagogy

Our study contributes to planning practice by discussing the role of virtual mapping technologies in Lynchian imageability analysis and assessing the opportunities and constraints of using these technologies. A rich body of literature comments on the role of web-GIS and crowdsourcing applications in collaborative planning and data-driven decision making. In addition, scholars have argued the role of web and GIS-based tools in wayfinding and navigation. The literature, however, lacks an understanding of the pros and cons of using these technologies in Lynchian analysis. Our study has focused on a small sample of participants; however, it provides insights into the applications of virtual mapping tools in qualitative and subjective neighborhood explorations.

This study also contributes to planning pedagogy. In this research, we used students as future planners, designers, or experts who were studying urban spaces to explore our research questions. Virtual mapping technologies can provide pedagogical opportunities to help students explore the application of new technologies in planning and design. In this study, the students were able to think critically about the values of Google Earth, Google Map, and Google Street View in advancing site analysis by comparing these methods with more traditional ones, such as field observations. Such comparative explorations helped students gain a better understanding of the role of new technologies in advancing planning and design practices and the need for their effective implementation.

Our study proposes two types of pedagogical opportunities: (1) complementing field observations with virtual explorations (e.g., checking and complementing field observation data with virtual mapping in an urban design studio course) and (2) replacing field observations with virtual explorations (e.g., analyzing urban form of global cities in an urban design method course). Planning educators teach Lynchian analysis to help students learn how to study urban spaces and explore their legibility. With the increasing use of digital technologies in exploring urban environments, educators can help students learn about the pros and cons of using various methods in determining the elements of urban spaces. Educators can create the following exercises, for example, to assist students to critically examine when and how to use or combine field observation and virtual analysis.

- Exercises to help students compare and contrast the results of various methods of exploring city elements, through conducting field observation and virtual analysis. The focus of these studies would be on exploring the results' accuracy.
- Exercises to allow students to discuss and compare logistical and financial requirements for using various methods for analyzing city elements.
- Exercises to help students identify strategies for responding to legal and privacy issues of using virtual technologies in exploring urban environments.

We identify four types of implications based on our study findings for planning practice and pedagogy: site exploration, resource management, data accessibility, and perceived versus objective environments.

Site exploration. Planners can use virtual technologies for general exploration of the study area at their convenience, when they are located in offices far from the project site or when the project site is not safe for them to enter. An example of this situation is when planners are working on international projects, where conducting field observation is not readily feasible. We also can assume a case in which planners are studying a neighborhood with a high incidence of criminal activity. Another example is the possibility of using these tools for site exploration in areas with severe weather conditions. Using virtual mapping technologies can provide a safer and quicker way of field observation. Their use, however, would have some limitations, as discussed earlier; planners may not get detailed and updated information about qualitative aspects of the environment that we discussed before.

Resource management. Virtual mapping technologies can help planners conduct field observations more efficiently by saving them time and budget. They allow planners to do some parts of their exploration online, by limiting the time they need to spend on resource-extensive field observation processes. Planners, however, need to allocate resources to ensure online tools' effectiveness; for example, they may need to recruit or assign skilled staff who understand the strengths and weaknesses of using these tools.

Data accessibility. Planners can access new data sources while using virtual mapping technologies. Many of the online mapping tools provide information to planners about various aspects of the sites or neighborhoods they are exploring. Google Map or Google Earth, for example, allows planners to see images of places uploaded by citizens at different times of the day or in various seasons. Google Map may even provide information about the real-traffic of the main roads. Some other tools (e.g., ArcGIS Online, Social Explorer, Urban Footprint) also allow planners to make queries about the socioeconomic background of residents or various built-environment-related factors (e.g., street width) related to the study area. Planners and designers, however, should consider issues of data quality in their exploration. Some of these data may be outdated or not as comprehensive as what planners can get through fieldwork.

Perceived versus objective environments. Our imagined city is not the same as the actual city. Planners, therefore, should start their field observation by answering a simple question: does the observation instrument measure the perceived environment or objective environment? The main objective of the city imageability analysis is to document the perceived environment and not necessarily the reality in its full shape and complexity. If pedestrians, for example, do not notice a nearby industrial area because of trees or buildings obstructing the view, that industrial area does not "exist" in their mental image. Online tools can expand and expedite the data collection process, but collected objective data should not be interpreted as perceived data. Planners, for instance, should be cautious in the analysis of a bird's-eye view of Google Earth, and rely more on eye-level street-view photos. This note is a reminder that urban design can choreograph urban life by highlighting some urban form elements and disguising others from pedestrian views and passenger vehicle views.

Concluding Remarks

Planners and urban designers explore urban environments and city elements not only through field observations, but also using various digital methods, including virtual explorations (e.g., using Google Earth/Map or Street View). Use of virtual mapping environments is increasingly becoming popular for site analyses and design proposals. We have explored the ways people can understand and interpret the five city elements—based on Kevin Lynch's city imageability concept—in the digital age. We have also discussed potential strengths and weaknesses in using virtual versus physical explorations in the imageability analysis. Because of such strengths and weaknesses, many participants in our study disagreed with the way they identified Lynchian city elements, while using field observation versus virtual exploration methods. The majority of participants in the 2016 study, for example, disagreed about edges when they used different methods. As discussed earlier, the observed mismatches between findings from the two methods can be explained by the occasional mismatches between the perceived environment and the objective environment. So what are the implications for planners? A mismatch between the perceived and objective environments means that there is an opportunity for planners to reshape the city image by intervening in the physical environment. In a virtual exploration, for example, a creek that is identified as an edge, while it is hidden by a row of buildings or trees, may not be perceived as an edge in a field observation. This finding can encourage planners to make the creek more visible to the public and make it part of the city image. Overall, the results of our study suggest how planners and urban designers can or should take a balanced approach, while understanding an urban environment or performing a neighborhood/site analysis. This balanced approach incorporates virtual and physical environment exploration methods to benefit from the opportunities that each method offers. The traditional field observation of physical environment can be much more effective when used in combination with virtual explorations.

Practitioners still need to understand urban environments through traditional physical environment explorations to get the feeling of the environment or the sense of place. Conducting detailed field observations, however, can be challenging due to several limitations such as lack of time and resources, or sometimes the weakness of physical environment exploration methods in generating a general overview of the site. Practitioners can strongly enrich their exploration by using virtual mapping tools, such as Google Earth/Map or Street View, to quickly and more efficiently understand the overall feeling of the environment and explore cities from a different angle. Based on our study, virtual mapping environments can specifically help planners conduct field observations for Lynchian analysis when dealing with resource limitations. Combining the two methods can advance urban imageability exploration, and therefore, help planners design more legible places in which the users feel attached to and comprehend them.

We have explained the following implications for planning practice and pedagogy: (1) planners can use virtual mapping technologies to explore a study area that is far, unsafe, or with severe weather conditions, although they may miss qualitative aspects of the exploration; (2) by using virtual mapping technologies, planners can save time and budget to explore a project area, although they need to be aware of the strengths and weaknesses of these technologies over real fieldwork; (3) virtual mapping technologies offer additional online data that may be difficult to find during fieldwork, although data quality or accuracy may become an issue; and (4) planners need to be aware of perceived versus objective environments, while using virtual mapping technologies and, therefore, need to focus more on observation at the street-level, not bird's-eye level.

We have identified a couple of limitations of our study. Our analysis and findings were based on a small sample size ($n = 34$) and all our participants were students with a similar academic background and technical skills, and similar abilities to use virtual mapping environment. It needs to be seen how a similar study can use practicing professionals as participants or participants of diverse age groups, technical skills, and expertise. The other limitation is related to the study areas used in our research. Our study areas were all neighborhoods, not cities. Not every neighborhood has a well-defined district; therefore, some participants had to adjust the meaning of a district in their study areas.

Future studies should examine the role of new technologies in facilitating more subjective and effective exploration of urban environments. Eye-tracking tools could be used to compare the differences between the points of interest in a walking tour versus virtual tour. The advances in image processing technologies—using artificial intelligence and machine learning—can advance the interpretation of image data in large scale. These technologies may help with scaling up virtual explorations—e.g., by exploring a massive number of digital images in various cities to explore the legibility of urban areas based on Lynch's approach (Liu et al. 2016). Creating an algorithmic version of Lynch's analytical approach, using image processing technologies, will be a valuable contribution to the urban planning and design fields.

Future research may address the following questions: what is the effect of other types of technologies (e.g., virtual reality or VR glasses, data collection sensors, or cameras installed in public places) in facilitating or distorting Lynchian exploration of urban areas? What systematic methods or strategies can planning organizations take into account when adopting these technologies? Which types of these technologies are more useful? Can these technologies help planners be more efficient and predictive in creating plans or designs with greater feasibility, by providing them novel insights or data? The world of digital tools is evolving at a rapid pace. Planners and planning organizations should not only explore whether and how these tools can enrich their current planning and design methods, but also use them to discover approaches that have not been possible before.

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