



Painting the Picture: The Validity of **Walk Score** in Addressing **Subjective Urban Design Qualities** in the Built Environment

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Cheers,
Dan

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Please enjoy.

Chapter 1 - Hello Walkability

Walkability

In 2015, one would be hard pressed to find a person who would disagree with the notion that walkability is good for us. That it is not only good for our quality of life, but also entails broader health, economic, and social benefits that can be found at the individual and citywide level. This has resulted in a growing need for knowledge about the walkability of the built environment that has contributed to walkability becoming one of the planning discipline's buzzwords over the last couple of decades (Choi, 2013).

What *exactly* is walkability, then? Numerous definitions exist. Various scholars have defined walkability in terms of accessibility, proximity, and suitability factors among other concepts (Gilderbloom, 2015). Such suitability factors include street and sidewalk width, presence of trees, and presence of pedestrian facilities in the built environment among others. In my opinion, Ariffin and Zahari (2013), provide the clearest and most approachable definition of walkability. They define it as “a measure of how friendly an area is to walking. It takes into account the quality of pedestrian facilities, roadway conditions, land use patterns, community support, security and comfort for walking” (Ariffin and Zahari, 2013).

Conceptually, for walking to take place, at a bare minimum the environment needs to be supportive for walking. Following this, it needs to be comfortable, and finally, enticing. This conceptual framework for what affects walkability addresses the comprehensive nature of the phenomenon and will be discussed in more detail in the following chapter.

Why Are We Interested In It?

Extensive research has been carried out into three main perspectives that walkability has been proven to have a positive influence on. These are environmental benefits - including benefits to physical health; social capital; and economics - including those of the city, neighbourhood, and individuals themselves (Litman, 2004).

Walkability, Health, and the Environment

In recent decades there has been a clear trend that has witnessed increasing levels of obesity and its related diseases, such as heart disease, cancer, asthma, and hypertension among American adults (Frumkin,

Frank & Jackson, 2004; Speck, 2012). Now the US Center for Disease Control and Prevention states that one in three Americans - up from one in ten in the 1970s are obese (Frumkin et al., 2004). What is more, this hits us where it hurts the most – the wallet! Asthma alone has associated annual costs estimated at \$18.2billion annually (Frumkin et al., 2004).

A number of studies have attributed these trends to a crisis in urban design with walkability seen as the cure. Cities have become more car-centric - think wide roads, fast moving traffic, vast car parks, a lack of trees, and concrete. The demise of walkability and our increased reliance on the car that limits the use of our legs and contributes the most to pollution is at the root of this problem (Frumkin et al., 2004; Speck, 2012). Quantifying this is a study in San Diego, which reported that 60 per cent of residents in a low-rated walkable neighbourhood were overweight compared to only 35 per cent in a high-rated walkable neighbourhood (Frumkin et al., 2004).

The benefits of walking and more walkable areas on our health have been empirically established. Walking has been associated with fewer weight problems (Griew, Hillsdon, Foster, Coombes, Jones & Wilkinson, 2013; Smith, Zick, Kowaleski-Jones, Brown, Fan & Yamada, 2008), and more walkable environments have been correlated with higher levels of physical activity and lower BMIs (Giles-Corti & Donovan, 2002; Smith, et al., 2008). In more walkable communities people are found to drive less and walk more. Shorter distances to destinations are a key feature of walkable communities and are positively correlated with less Vehicle Miles Travelled (Ewing & Cervero, 2001). In turn, high land-use diversity, residential and employment density, and greater street connectivity are associated with lower per capita emissions of Volatile Organic Compounds (VOCs) and Nitrogen Oxide - the pollutants that create ground-level ozone that cause asthma (Frumkin et al., 2004). Reductions in VMT and in turn Nitrogen Oxide and VOCs, results in higher air quality and thus, a higher quality of life.

Walkability and Social Capital

Social capital has been defined as the value of networks and the norms of reciprocity that arise within those networks (Rogers, 2013). In more simple terms, it refers to the features of social organisation, such as

trust, norms, and networks that can improve the efficiency of society of facilitating coordinated actions (Rogers, 2013).

Social capital is believed by some scholars to have declined over the last few decades (Putnam, 2000). In *Bowling Alone*, Putnam attributes the decline of social capital to increased long commutes, television usage, time and money pressures on families, and generational change. Putnam places the blame for those attributes at the door of suburbanisation that has increased more rapidly with each passing decade. According to him, social capital is important because it has been empirically linked to good health, the proper functioning of democracy, the prevention of crime, and economic development (Putnam, 2000).

Walkability has a long association with helping to build social capital in neighbourhoods. This stretches back to Jane Jacobs' idea that "sidewalk contacts are the small change from which a city's wealth of public life may grow" (Jacobs, 1961). In much the same vein echoing Jacobs, Rogers claims that walkability specifically enhances social capital because it provides the means and locations for individuals to connect, share information and interact with those that they might not have met in less walkable neighbourhoods (Rogers, Halstead, Gardner & Carlson, 2010). Walkability, being characterised by mixed-use pedestrian-oriented neighbourhoods in which daily activities are tenable are theoretically thought to promote the spontaneous encounters of neighbours meeting that can help to encourage a sense of trust and sense of connection between people and the places that they live in (Leyden, 2003).

A number of empirical studies have found a correlation between walkability and social capital (Rogers, 2013; Leyden, 2003). In a random survey of 700 homes in varying neighbourhoods, Rogers collected data on participant perceptions of social capital within their neighbourhood. The results were statistically significant. Higher levels of social capital were found in more walkable neighbourhoods than in those that were considered less walkable. This prompted Rogers to conclude that improved walkability can increase social capital due to the reasons above that more walkable neighbourhoods make it possible for higher levels of social interactions that can lead to social ties being enhanced leading to greater levels of social capital and positive social outcomes. Similarly, an earlier study by Leyden examined the relationship between neighbourhood typology and social capital in Galway, Ireland (Leyden, 2003). Leyden's analysis indicated that participants living in more walkable neighbourhoods were more likely to know their neighbours, participate politically, trust others, and be socially engaged.

Walkability and Economics

General consensus among scholars is that more walkable neighbourhoods have intrinsic economic value that is brought about by encouraging economic transactions and social exchanges (Leinberger & Alfonso, 2012). It is thought to affect economic development by helping to create lively and friendly

pedestrian areas that are important for attracting visitors and residents and contribute to urban revitalisation. Improved walkability according to Litman can promote or boost local economic growth by enticing consumers to spend more time in the local area and shift consumer expenditures towards more locally produced goods, and in turn building greater economic resilience in the local community (Litman, 2014).

Walkability is also believed to lead to higher levels of future economic growth (Speck, 2012). Speck states that walkability is important for retaining and attracting talent, particularly creative-class citizens (Speck, 2012). According to Speck, recent surveys show that creative-class citizens vastly favour communities with an active street life and pedestrian culture that can only come from walkability. Three factors contribute to the economic advantage that accumulates in walkable cities. First, as mentioned above, urban living is more desirable for the young creative segments of the population. Second, demographic shifts currently taking place among younger and older retirement age groups are resulting in pro-urban populations becoming dominant leading to a demand for walkable neighbourhoods. Third, the choice to live in walkable places generates considerable savings for households, consider the need to not own a car, and much of these savings are spent locally (Speck, 2012.)

The economic benefits of walkability have been quantified in various ways, including in terms of land and housing value (Leinberger, 2008; Cortright, 2009; Pivo & Fisher, 2010; Rauterkus & Miller, 2011; Gilderbloom, 2015). For example, in a study of real estate performance that divided the built environment into walkable urbanism and drivable sub-urbanism, Leinberger found that houses and offices in walkable urbanism fetch higher prices than drivable sub-urbanism and resulted in less vacancy rates (Leinberger, 2008). For example, houses in walkable urbanism fetched price premiums of 51 per cent, 150 per cent, and 200 per cent in Seattle, Denver, and New York, respectively, over similar housing types in sub-urbanism. This led Leinberger to conclude that metropolitan areas are likely to lose economic development opportunities if they do not offer walkable urbanism with creative classes gravitating to metropolitan areas as they do.

In another study, Cortright looked at 90,000 home sales in 15 national markets and found that homes that are in more walkable neighbourhoods resulted in higher home values (Cortright, 2009). Cortright used walkability as measured by Walk Score to define more and less walkable areas. He found a positive correlation between walkability and housing prices in 13 of the 15 markets and that controlling for other influencing factors on home value, a one unit increase in Walk Score was associated with between a \$500 and \$3,000 increase in home values in the typical market.

The economic benefits of walkability have also been empirically proven in terms of savings. For example, focusing on Portland, Oregon a city that drives 20 per cent less than other major cities, Cortright quantified that this 20 per cent results in approximate savings of \$1.1 billion each year whilst ignores additional benefits (Cortright, 2007). Litman also identified several areas where savings are made as a

result of walkability (Litman, 2014). These include savings on household transportation costs (often the highest cost for households) and infrastructure maintenance. Litman found that households in car-dependent communities devote more than \$8,500 annually to surface transportation compared to less than \$5,500 annually in more multi-modal communities. Additionally, walkability can result in reduced transportation externalities as fewer cars using the roads will result in less required maintenance.

Chapter 2 - Field of Study

What do we know about what influences walkability?

A variety of aspects of the built environment have been found to influence walkability that in turn have led to the development of numerous tools and methods for measuring walkability (Saelens & Handy, 2008). Additionally, people walk for different purposes. Therefore, it is important to distinguish between leisure walking (primarily for exercise) and utilitarian walking (primarily for transport and running errands), as each type of walking has been correlated with different factors that influence walkability (Forsyth, Hearst, Oakes & Schmitz, 2008).

To borrow a term from Alfonzo, a 'hierarchy of walking needs' exists that influences an individual's decision to choose walking over other modes of transportation (Alfonzo, 2005). Alfonzo developed the Hierarchy of Walking Needs Model, a model that fits within a social-ecological framework to provide a conceptual framework for understanding how different factors may work together to affect walking behaviour and the walking decision making process. The Hierarchy of Walking Needs Model organises five levels of need hierarchically and presents them as precursors within the walking decision making process (*figure 1*). These levels are:

- **Feasibility** – is a walking trip feasible in relation to mobility, time, or other responsibilities;
- **Accessibility** – are there actual or perceived barriers to walking, are sidewalks, paths, or features present, and are destinations within a reasonable distance;
- **Safety** – does a person feel safe from the threat of crime;
- **Comfort** – is it convenient, easy, does it provide satisfaction or contentment; and
- **Pleasurability** – is there a level of appeal, is an area enjoyable or interesting to walk in, is it diverse, complex, and lively (Alfonzo, 2005).

Within the model the lower needs are more fundamental than others and an individual must satisfy the more basic needs before considering higher needs, such as pleasurability. However, not all needs must be fully satisfied to proceed to the next level with partial satisfaction sufficing.

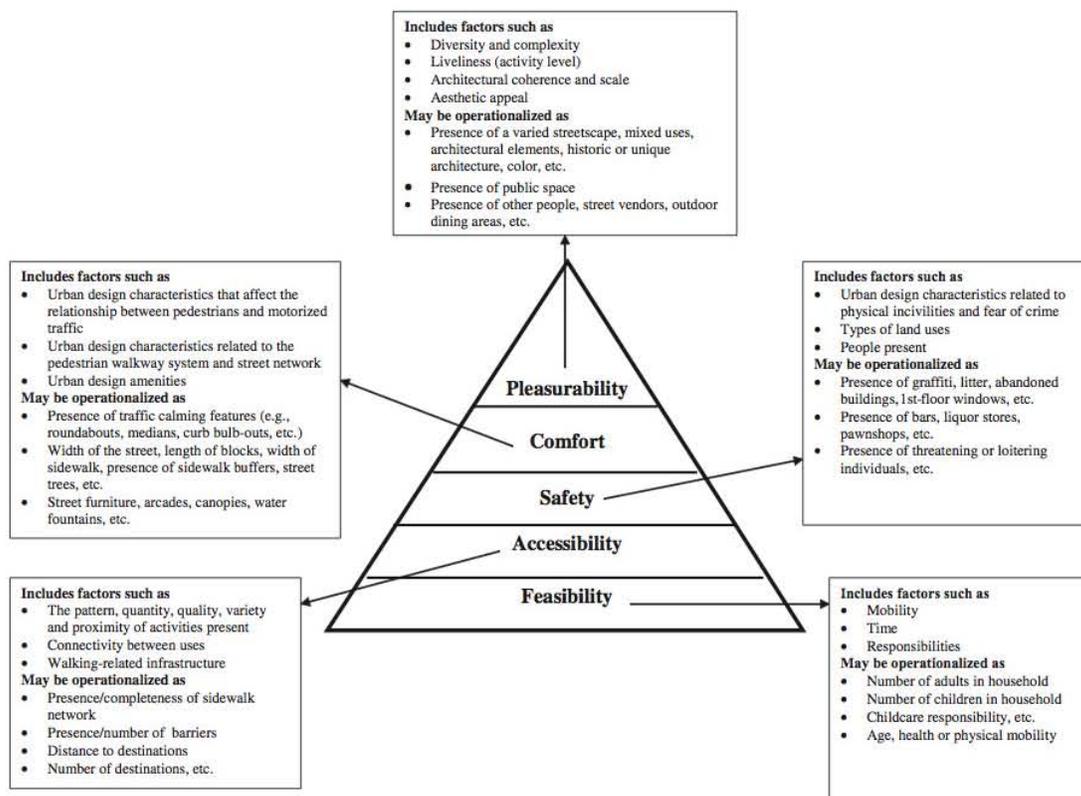


Figure 1. Hierarchy of Walking Needs Model, from Alfonzo (2005)

Alfonzo’s Hierarchy of Walking Needs Model will be revisited in the methodology chapter, as it is from Alfonzo’s model that my conceptual framework that applies to this study was developed.

Review of Methods of Measuring Walkability

Despite the progress made in understanding characteristics of the built environment that influence walkability, the important factors that contribute the most are still in contention (Clifton, Livi Smith & Rodriguez, 2006). Additionally, Clifton et al note that the very nature of the measures themselves can cause complications as some aspects of the built environment can be measured objectively with relative ease, while other measures are more subjective and thus, more difficult in nature to measure.

Earlier studies of walkability consisted mainly of objective measures, such as residential density and land use diversity that can be acquired from the census or from field visits, as well as utilising GIS databases (Sallis, 2009). Since then, other studies have relied on self-reported measures of walkability, as it is believed that residents can provide relatively accurate data on their own neighbourhoods. In this section, I will focus on some of the more common methods of measuring walkability that are prominent in the walkability literature.

Street Connectivity

Together with advancements in GIS, street connectivity has become a standard measurement when trying to understand the walkability of a neighbourhood (Schlossberg, Johnson-Shelton, Evers & Moreno-Black, 2014). Greater street connectivity has been found to result in shorter distances to destinations and more direct routes that encourage walkability (Dill, 2004). A wide range of research suggests that street connectivity plays an influential role in supporting walking. For example, in a study by Hess and Moudon that controlled for population density, land-use mix, intensity, and income, the role of pedestrian trips was three times higher in urban sites with small street blocks (Hess & Moudon, 1999). Table 1 presents an overview of some of the many street connectivity metrics developed to understand walkability derived from the street network.

Measure	Literature
Block length (mean)	Cervero & Kockelman (1997)
Block size (mean area)	Hess et al (1999) Reilly (2002)
Block density	Cervero & Kockelman (1997)
Intersection density	Cervero & Radisch (1995) Cervero & Kockelman (1997) (no. of dead ends and cul-de-sacs per developed acre)
Metric Reach	Peponis et al. (2007)
Directional Distance	Peponis et al. (2007)
Percentage of four-way intersections	Cervero & Kockelman (1997)
Pedestrian route directness	Hess (1997)
Walking distance	Aultman-Hall et al. (1997) (mean, maximum, percentage of homes meeting minimum standard)

Table 1. Measures of Connectivity used in research literature updated from Dill (2004)

An early connectivity metric was **mean block length** (Cervero & Kockleman, 1997). The rationale behind using mean block length is that shorter blocks mean more intersections and therefore shorter distances between destinations and greater number of route choices. Cervero and Kockleman have also utilised **block density** and **intersection density**. Both connectivity metrics approach street connectivity with much the same rationale as mean block length, as higher block density and intersection density translate to shorter distances and more route options and thus higher connectivity. Both connectivity metrics sum the number of blocks and intersections per unit area, such as a square mile. Another key connectivity metric is **Pedestrian Route Directness** (Hess, 1997). Pedestrian Route Directness measures the straight-line distance from two selected points (Hess, 1997). The best value achieved in this metric is 1.00, equal to the same distance the crow flies or a perfect straight direct path. Numbers closer to one indicate a more direct route and therefore a more connected network.

Connectivity metrics have become increasingly sophisticated over time. John Peponis, a leading scholar in space syntax has developed a number of metrics for measuring street connectivity. These include **Metric Reach** and **Directional Distance** (Peponis, Allen, Haynie, Scoppa & Zhang, 2007). Metric Reach is essentially a measure of density. It “measures the total street length that can be reached from a point on the street system if one moved along all available streets taking all available directions until a given distance is reached counting each line segment only once” (Peponis et al., 2007). A typical threshold is usually one mile, a distance that can be walked within 15 minutes. It measures how much street network is available within a range of movement. Directional Distance on the other hand, is more directly linked to the shaping of streets and not density. It is a measure of the average number of directional changes needed to cover the set of spaces that can be reached from a particular point (Peponis et al., 2007). Peponis defines directional change as a turn that exceeds a threshold angle.

Walkability Audits

Walkability audits have emerged over recent years to measure the quality of the walking environment in relation to physical features such as building height, street width, sidewalk quality, and presence of active uses (Ewing & Handy, 2009). Walkability audits have proven popular due to their ability to capture micro-features of the built environment that largely shape how accommodating an area is for walking because they allow assessors to move at a pedestrian pace allowing them to be more aware of their surroundings (Clifton et al., 2006). They can also be both objective and subjective in nature, but tend to sway more towards the objective side due to the relative ease of recording objective characteristics.

Walkability audits are robust because they contain a high level of inter-rater and intra-rater reliability increasing the validity of the tools. They are usually conducted by trained raters for street segments and are useful for operationalizing walkability concepts enabling planners to identify specific sites for walkability improvements (Gallimore, Brown & Werner, 2011). Three of the most commonly referenced walkability audits include the Irvine Minnesota Inventory, the Systematic Pedestrian and Cycling Environmental Scan (SPACES), and the Pedestrian Environmental Data Scan (PEDS).

The first to set the benchmark was the Irvine Minnesota Inventory (Day, Boarnet, & Alfonzo, 2006). It is the most comprehensive in nature assessing 160 variables in the built environment including architectural features, tree cover, street design, and sidewalk quality. As well as a tool for measuring walkability it is also one of the most comprehensive collections of potential variables related to walkability (Schlossberg et al., 2014).

SPACES (Pikora, Giles-Corti, Knuiman, Bull, Jamrozik & Donovan, 2006) developed in Australia, includes 37 variables related to the pedestrian environment, a number of which are subjective evaluations.

PEDS (Clifton et al., 2006) builds on the work of SPACES by retaining a number of subjective evaluations of attractiveness and the degree of physical difficulty reflected in the built environment. It includes 37 variables with additional questions added in sections on pedestrian facilities (buffer type, sidewalk width, etc.), road attributes (posted speed limit, kerb cuts, etc.), and the walking environment (degree of enclosure, presence of power lines, adjacent land uses, etc.). Overall, PEDS was designed to efficiently balance essential information about the environment, limiting itself to one page (Clifton et al., 2006).

Density and Land-Use Mix Diversity

Measuring the walkability of an area based on density has proven popular due to the accessibility of census data and the relative ease of the method (Clifton et al., 2006). Density is always measured per unit of area, for example per square mile, and can be either gross or net. Common measures of density consist of population, dwelling units, employment, floor area, and so on (Ewing & Cervero, 2010). Population density is one of the most consistent influencing factors of walkability as it increases convenience (Frank & Pivo 1994; Cervero, 1996; Ross & Dunning, 1997; Cervero & Kockleman, 1997; Ewing & Cervero 2001; 2010).

Ross and Dunning stated that in the 1995 *Nationwide Personal Transportation Study*, walking and cycling for transportation purposes was approximately five times higher in the highest versus lowest density areas (Ross & Dunning, 1997). Furthermore, Frank and Pivo found that when controlling for vehicle ownership and age, population and employment density were independent positive correlates of walking rates for commuting and shopping purposes (Frank & Pivo, 1994). In the same study, walking rates were also found to be higher in areas with higher levels of land-use mix diversity. Higher land-use mix diversity implies that more destinations are accessible the more mixed-use an area is. Additionally, Ewing and Cervero found that transit mode choice varied primarily with local densities and secondarily with the degree of land use mixing including walking for transportation (Cervero & Ewing, 2001.)

Proximity and Walk Score

Accessibility or proximity to destinations is a key factor in determining the feasibility of walking. The consensus is that increasing proximity to destinations increases the likelihood of walking due to the fact that there will be more places nearby that people want/need to go to and subsequently, convenience is increased.

In recent times, Walk Score has become the most common and popular tool to measure walkability based on proximity to destinations within both academic and professional circles. Importantly, a number of studies have validated the usefulness and validity of utilising Walk Score to measure walkability in neighbourhoods (Carr & Dunsinger, 2010; Duncan, Aldstadt, Whalen, Melly & Gortmaker, 2011). In their study of Walk Score, for example, Carl and Dunsinger found it to be a valid measure of estimating access to

walkable amenities (Carr & Dunsinger, 2010). I discuss Walk Score in more depth in the tools section in the following chapter.

Subjective Urban Design Qualities

As described above, walkability audits that address environmental qualities tend to focus on objective measures, rather than on subjective perceptions of the built environment (Pikora et al., 2002; Day et al., 2006; Clifton et al., 2006). Collecting objective data is a time consuming and expensive effort with some scholars stating that perceptions of features of the built environment, including the diversity and interest of architectural designs within a neighbourhood may play as much of a role in influencing walkability (King, Cynthia, Wilcox, Eyler, Sallis & Brownson, 2000; Ball, Bauman, Leslie & Owen, 2001; Pikora, Giles-Corti, Bull, Jamrozik & Donovan, 2003; Saelens, Sallis, Black & Chen, 2003 1; Gebel et al., 2011).

In a study of the influence of perceived and objective measures of environmental attributes of walkability, Gebel found that about a third of those living in objectively determined high walkable neighbourhoods perceived their local environment to actually be low in walkability, while a third of those living in neighbourhoods with objectively determined low walkability perceived them to be high in walkability (Gebel, Bauman & Owen, 2009). Gebel then identified improving the perceptions of the built environment in that study as having the potential to increase walkability.

Perception has been defined as the “process of attaining awareness or understanding of sensory information... that is a result of interplays between past experiences, one’s culture and the interpretation of the perceived” (Ewing & Handy, 2009). They and others believe that physical features influence both the quality of the walking environment both directly and indirectly through the perceptions and sensitivities of individuals that may produce different interactions in different people (Ewing, Clemente, Handy, Brownson & Winston, 2005 1).

Although objective observations of physical features in the built environment have been correlated with walkability, they do not tell us much about what it is like to walk down a street. They do not capture an individual’s overall perception of the street environment, perceptions that according to Ewing and Handy “may have complex or subtle relationships to physical features” (Ewing & Handy, 2009). They believe that perceptions can be assessed with a degree of objectivity by outside observers. Furthermore, they believe that physical features, urban design qualities, and individual reactions may influence how an individual feels about the street environment as a place to walk and by measuring intervening variables we can better articulate the relationship between physical features of the street environment and walking behaviour.

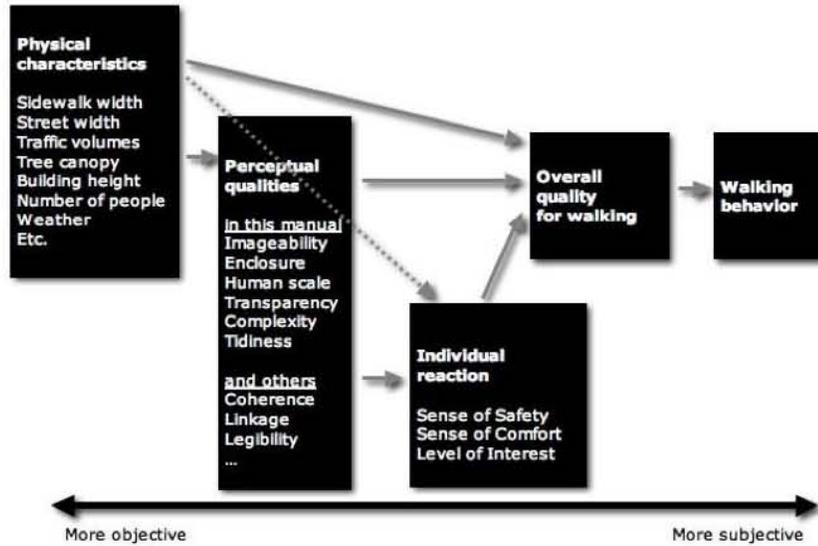


Figure 2. Where subjective urban design qualities slot in to influencing walkability, from Ewing et al. (2005 1)

Ewing and Clemente describe how the urban design literature points to subtler qualities that may influence choices about active travel (Ewing & Clemente, 2013). These qualities have been referred to as perceptual or subjective urban design qualities, and they are believed to intervene between physical features and behaviour encouraging people to walk. According to Ewing and Handy, urban design qualities have not been attempted to be measured and have simply only had their importance asserted (Ewing & Handy, 2009).

Arguably the leading figure in the urban design literature for identifying subjective urban design qualities is Kevin Lynch. In his most important works, *The Image of the City* and *Theory of Good City Form*, Lynch details several key concepts or variables of subjective urban design qualities that are essential in creating a sense of place and communities that are more desirable to spend time in (Lynch, 1960; 1981). Ewing et al successfully operationalized the following qualities of imageability, enclosure, human scale, transparency, and complexity for their Urban Environmental Quality Assessment Tool (UQAT), a tool developed to identify and measure subjective urban design qualities identified in the literature and related to walkability in a bid to better understand how those qualities influence walkability in the built environment (Ewing et al., 2005 1). I will explain each of these qualities in the following section and detail how they relate to walkability in the built environment.

Imageability

The first subjective urban design quality is *Imageability*, which can be seen as the pinnacle of urban design qualities with other qualities being closely related. Ewing and Clemente point out that places that rate high in other qualities generally rate high in imageability (Ewing & Clemente, 2013).

Ewing and Clemente define Imageability as “the quality of a place that makes it distinct, recognisable, and memorable” (Ewing et al., 2005 2). A highly imageable city, therefore, is one that is well formed, containing distinct parts, and is easily recognisable to those who have lived or visited it (Ewing & Handy, 2009). It contributes to a sense of place that makes a place unique, helps people to orient themselves, and makes a place more comfortable and rewarding to walk in, thus increasing walkability (Ewing & Clemente, 2013).

Imageability is also closely related to *Sense*, one of the five basic dimensions identified by Lynch in *Theory of Good City Form* for determining settlement quality. Sense is the degree to which the form of a settlement can be clearly perceived and identified by the user and mentally differentiated and structured in time and space by its residents (Lynch, 1981). Sense consists of concepts including *Identity* and *Legibility*, both of which are closely related to making a place highly imageable and pleasant to walk in. In narrow terms, Identity can be associated with sense of space, which engages the perceptions of its inhabitants, while Legibility is the “degree to which the inhabitants of a settlement are able to communicate accurately with each other via its symbolic physical features” (Lynch, 1981). Contributing to the Legibility of places are symbols of communication such as signs, coloured roofs, spires, gates, lawns, and so on. They are important for informing people about the use of space as well as ownership, goods and services, behaviours and many other things.

Enclosure

Enclosure is about defining spaces with the use of vertical elements to make outdoor spaces seem more room-like (Ewing & Handy, 2009). More concretely, enclosure is defined by Ewing and Handy and other experts as referring to “the degree to which streets and other public spaces are visually defined by buildings, walls, trees, and other vertical elements.”

Enclosure is important to instil a sense of position and identity with one’s surroundings (Cullen, 1961). It can be further construed to creating a sense of comfort in the built environment and is therefore important for influencing walkability. A high level of enclosure is synonymous with a continuous building line along a street or open space of similar heights to create a ‘street wall’ (Ewing & Handy, 2009). Trees and landscaping elements can also contribute to creating a street wall. Breaks in the building line or street wall

with vacant lots, inactive uses, large set backs, and car parks discourage walkability lowering the aesthetic quality of the environment.

Enclosure, like imageability, is closely related to Lynch's dimension of Sense for determining settlement quality. The concept of *Structure* within Sense, is the sense of how parts fit together, how one can orient themselves, know where one is, and know how other places are connected to this place (Lynch, 1981). Lynch states that paths or edge continuities, activity in areas, sequential linkages, and panoramas among other means, establish structure.

Human Scale

Human Scale, refers to how well the built environment relates to the human experience and the ability of humans to go about their daily lives in a comfortable and pleasant manner. The consensus definition by experts is that Human Scale refers to size, texture, and articulation of physical elements that match the size and proportions of humans and correspond to the pace at which humans move about the built environment (Ewing & Handy, 2009). Pavement patterns, building details such as depth of setbacks and ornamentation, street trees, and street furniture are all physical elements that contribute to Human Scale (Alexander, Ishikawa & Silverstein, 1977; Lennard & Lennard, 1987).

Vitality is one of the five basic dimensions identified by Lynch for contributing to settlement quality and is the degree to which “the form of the settlement supports the vital functions, the biological requirements and the capabilities of human beings” (Lynch, 1981). *Consonance* is one of three features of Vitality and refers to the spatial environment in a city being in agreement with the basic biological structure of the human being. Lynch asserts that a city should support “natural rhythms providing a sensory input that neither overloads a person nor depriving them of adequate stimulus” (Lynch, 1981). In short, people should be able to see and hear well. This leans very well to the urban design quality of Human Scale. Lynch states that elements in the built environment should all be fitted to human size and powers including height, reach, vision, and lifting power. Above all else Lynch states that a “setting should encourage the active use of the body” (Lynch, 1981).

Transparency

Transparency is defined as the “degree to which people can see or perceive what lies beyond the edge of a street, and more specifically, the degree to which people can see or perceive human activity beyond the edge of a street” (Ewing & Handy, 2009). Ewing and Handy provide a classic example of transparency as a shopping street with windows that is inviting to customers to look in and shop.

Design elements that sharply reduce an environment's transparency are highly reflected mirror-like glass surfaces and blank walls that lack an ability to define space or impart a sense of scale that according to Hedman, inhibits sense of activity creating an inhospitable setting (Hedman, 1984). Physical elements that influence Transparency include walls, windows, doors, fences, landscaping, and openings into mid-block spaces such as street with many entryways aid Transparency contribute to the perception of human activity beyond a street (Jacobs, 1993; Ewing & Handy, 2009).

Transparency relates directly to Lynch's concept of *Transparency* - a construct of the dimension of Sense for contributing to settlement quality discussed above (Lynch, 1981). According to Lynch, high levels of Transparency communicate to the person in the street a "sense of life" (Lynch, 1981). Lynch states that the ability to sense daily life, from people running errands, doing work in the garden, the evidence of care, control, conflict, cooperation and so on, leads to fundamental satisfaction; satisfaction that can influence people wanting to take to the streets on foot rather than by car to run errands or go about their business or leisure.

Complexity

Complexity is the visual richness of a place (Ewing & Handy, 2009). The level of Complexity in a place depends on the variety in the physical environment. In particular, it depends on variety in the number and types of buildings, architectural diversity, ornamentation, landscape elements, street furniture, signage, different surfaces and patterns, changing light patterns, human activity, and signs of habitation (Ewing & Handy, 2009). An example of Complexity provided by Jacobs and Appleyard, is how narrower buildings in varying arrangements add to Complexity while wider ones do not (Appleyard & Jacobs, 1987).

Complexity is important because as Jan Gehl notes, an interesting or more complex walking network can have the psychological effect of making walking distances seem shorter (Gehl, 1987). The impact of that effect, is that an interesting walking environment where how much time spent walking is less noticeable to the individual is likely to influence a person's willingness to choose walking over other transportation means. Additionally, Rapoport explains how humans are most comfortable receiving information at useable rates and that too little information results in sensory deprivation, while too many results in a sensory overload (Rapoport, 1990).

Complexity is closely related to Lynch's dimension of *Access* for determining settlement quality. Access is the "ability to reach other persons, activities, resources, services, information, or places, including the *quantity and diversity of the elements*, which can be reached" (Lynch, 1981). Access relating to subjective urban design qualities in this sense can be thought of as access to other people, whether they are relatives, friends, acquaintances, or potential partners. Lynch states, "human beings are social animals, and frequent contact, at least between members of a primary social group are fundamental to their wellbeing" (Lynch, 1981).

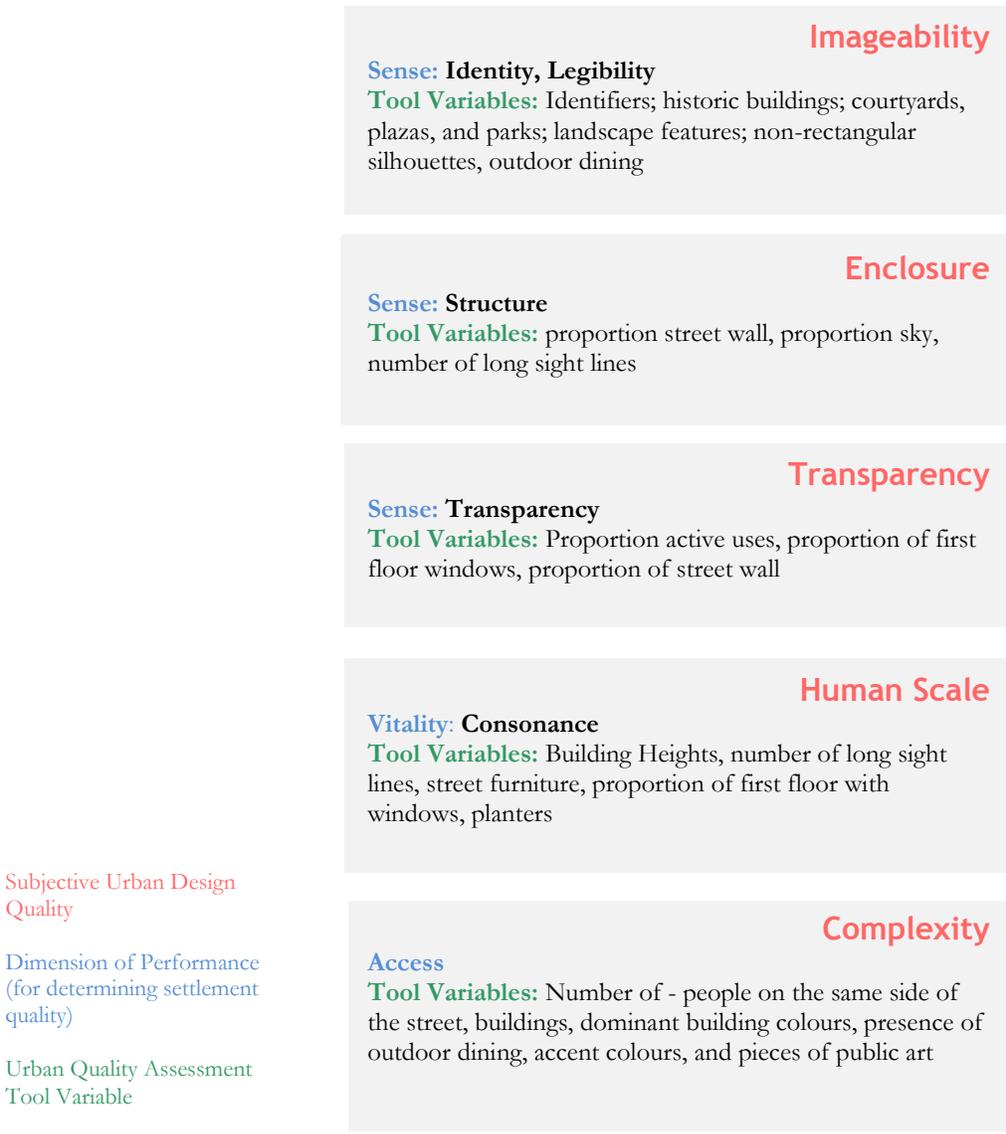


Figure 3. Connections between subjective urban design qualities, Lynch’s Dimensions of Performance for assessing settlement quality, and Urban Quality Assessment Tool variables.

This Study

This study builds on the research invested in understanding walkability and acknowledges the progress made, particularly in the development of tools designed to measure walkability. The main focus of this study is the use of Walk Score as the go to measure of walkability by scholars and practitioners despite not addressing subjective urban design qualities that have been found to influence walkability as discussed above. This is illustrated by figures 4 and 5. The below street address in figure 4 has a Walk Score of 73. This

classifies it as being very walkable. But a closer look reveals a location that I would argue is low in walkability, as it not welcoming to pedestrians and is low in terms of subjective urban design qualities (figure 5).

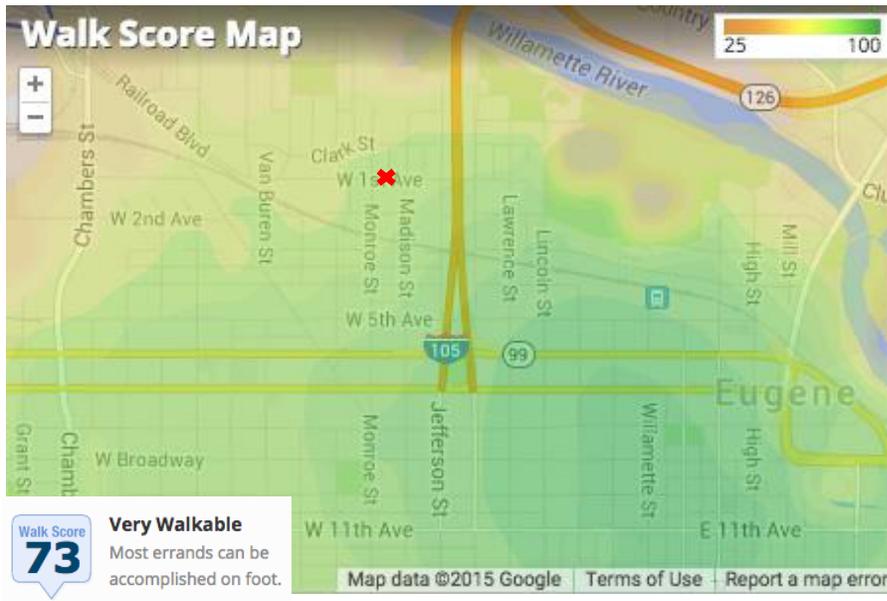


Figure 4 (top). Walk Score of address marked by red x.
Figure 5 (bottom). Google Street View of same address.

Figures 4 and 5, demonstrate my belief that relying solely on Walk Score alone paints an incomplete picture of walkability, as it is unable to measure walkability at a fine grain. Therefore, I argue that Walk Score's place as the go to tool for measuring walkability needs to be reviewed.

The need for exploring the relationship between Walk Score and subjective urban design qualities has been highlighted in the literature (Ewing & Handy, 2009; Carr & Dunsinger, 2010). This study seeks to fill that gap to understand if a relationship exists between walkability as measured by Walk Score and subjective urban design qualities, notably Imageability, Enclosure, Human Scale, Transparency, and Complexity measured with the UQAT tool.

Chapter 3 - Methodology

This section details my approach to this study and discusses the conceptual framework that I applied, justification for the selection of study sites, a description of tools used and refined, the development of a measuring guide, and the data collection process.

Conceptual Framework

I developed a conceptual framework based on Alfonzo's Hierarchy of Walking Needs Models discussed in chapter two. I reorganised the model to conceptualise walkability for the purpose of this study in relation to two aspects of the built environment. That is, the built environment needs to be *Supportive* and *Appealing* for people to choose walking over other means of transportation for utilitarian or leisure purposes.

In the same manner as Alfonzo, my framework is organised with the most fundamental component for influencing walkability (*Support*) located at the lowest level of the framework. This establishes it as the most important component for influencing walkability based on the reason that at a bare minimum an environment needs to be supportive for walking to take place. If it is not supportive, how appealing the environment is may have little influence on walkability, especially for utilitarian purposes. Additionally, like in Alfonzo's model, all needs do not need to be fully satisfied to proceed to the upper level.



Figure 6. Conceptual framework for explaining influences on walkability and associated factors.

Supportive Factors

Informed by previous studies, I consider the following elements to be ‘*supportive*’ factors:

- Destinations within close proximity (*Cervero & Kockleman, 1997; Saelens et al., 2003 1; Saelens, Sallis & Frank, 2003 2*)
- Complete and connected street and sidewalk networks (*Handy, 1996; Ewing, 1996; Cervero & Kockleman, 1997; Hess, 1997; Hess & Moudon, 1999; Saelens et al., 2003 1, 2; Frank, Schmid, Sallis, Chapman & Saelens, 2003; Dill, 2004*)
- High employment and population density (*Frank & Pivo 1994; Cervero, 1996; Ross et al, 1997; Cervero & Kockleman, 1997; Ewing & Cervero 2001; Saelens et al., 2003 1, 2; Ewing & Cervero 2010; Glazier et al., 2014*)
- High land-use mix diversity (*Frank & Pivo 1994; Cervero, 1996; Ross et al, 1997; Cervero & Kockleman, 1997; Ewing & Cervero 2001; Saelens et al., 2003 1, 2; Ewing & Cervero 2010; Glazier et al., 2014*)

Appealing Factors

Informed by previous studies, I consider the following elements to be ‘*appealing*’ factors:

- Subjective urban design qualities (*Lynch, 1960, 1981; Ewing et al., 2005 1; Ewing & Handy, 2009; Ewing & Clemente, 2013*)
- Aesthetics (*Giles-Corti et al., 1996; King, et al 2000; Ball et al, 2001; Humpel, Owen & Leslie, 2002; Giles-Corti & Donovan, 2003; Saelens et al., 2003 1; Pikora et al, 2003; Lee & Moudon, 2004; Gebel et al, 2011*)
- Diversity (*Gehl, 1987*)
- Liveliness and Activeness (*Lynch, 1981; Jacobs, 1993*)
- Comfort (*Cullen, 1961; Alexander et al, 1977; Lennard & Lennard, 1987; Rapoport, 1990*)

In this study, however, I am interested solely in subjective urban design qualities. This study focuses on the following subjective urban design qualities for representing ‘*appealing*’ factors with accompanying definitions from the Urban Quality Assessment Tool (UQAT):

- ***Imageability***: The quality of a place that makes it distinct, recognisable, and memorable.
- ***Enclosure***: The degree to which streets and other public spaces are visually defined by buildings, walls, trees, and other elements.
- ***Human Scale***: The size, texture, and articulation of physical elements that match the size and proportions of humans, and equally important, correspond to the speed at which humans walk.
- ***Transparency***: The degree to which people can see or perceive what lies beyond the edge of a street or other public space and, more specifically, the degree to which people can see or perceive human activity beyond the edge of a street or other public space.
- ***Complexity***: The visual richness of a place.

These subjective urban design qualities to a certain extent broadly address all of the above appealing factors. For example, Imageability is closely related to aesthetics; Enclosure and Human Scale are both closely related to comfort and safety; Transparency is closely related to human activity, comfort and safety; and Complexity is closely related to diversity and aesthetic appeal.

Study Sites

The base unit of analysis in this study are addresses and street segments. Addresses were inputted into Walk Score for generating scores of walkability and street segments were used to measure subjective urban design qualities with the UQAT tool.

The general study area consists of two neighbourhood types within two different cities. The two cities chosen were Detroit and San Francisco. Detroit was chosen to represent a car-oriented city with segregated land uses, spread out development, and limited transportation alternatives. These are all things that are associated with cities that have low levels of walkability. Conversely, San Francisco was chosen to represent a pedestrian-oriented city with high levels of walkability with higher land-use diversity, compact

development, and more transportation alternatives. The rationale for the using different neighbourhood types in two vastly different cities is to account for how different environments affect Walk Score and subjective urban design qualities.

The two neighbourhood types in which data were collected were the downtown cores and an outer suburban neighbourhood. This typology builds on Leyden's neighbourhood typology that consisted of City Centre neighbourhoods – that are mixed-used, pedestrian-oriented, with numerous amenities accessible on foot; and Modern Automobile-Dependent Suburbs – that are characterised by strip mall development with car parks in front of stores and very few destinations that cannot be accessed without the use of a car (Leyden, 2003).

To determine which neighbourhoods could be classed as outer suburban three criteria were established. The first criterion was that each neighbourhood type had to have a certain range of Walk Scores. Second it had to be within a certain distance or location from the downtown. Third, it had to have certain defining physical characteristics. Downtown neighbourhoods, for obvious reasons were easy to delineate.

The neighbourhood criteria is as follows:

Downtown Neighbourhood

- Walk Score: 90-100 (walkers paradise)
- Location: City centre
- Defining Characteristics: Pedestrian-oriented, mixed-use, many amenities, tall buildings, good access to a variety of public transit

Outer Suburban Neighbourhood

- Walk Score: <50 (car-dependent)
- Location: >2 miles from city centre
- Defining characteristics: Car-oriented, primarily residential use with commercial and retail uses located at strip or park developments, amenities accessible only by car, minimal transit, single-family homes, strip malls, business parks

For a neighbourhood to be selected it did not have to meet every listed defining characteristic. Precedence, however, is allotted to Walk Score in selecting a neighbourhood and determining its typology. Additionally, neighbourhood boundaries are defined by Walk Score for convenience. Comparable neighbourhoods were chosen in both cities in an effort to control for Walk Score. A range of 5 Walk Score points was set for determining whether two neighbourhoods could be classed as being comparable. However, this did not apply to downtown neighbourhoods.

Within each neighbourhood, street segments were selected at random for carrying out observations with the UQAT tool. An effort was made to make sure that each neighbourhood's central or 'main' street

was chosen, as well making sure to get select segments to represent a broad view of each study site. Finally, approximate addresses located at the centre of each street segment was used to generate Walk Scores for that street segment.

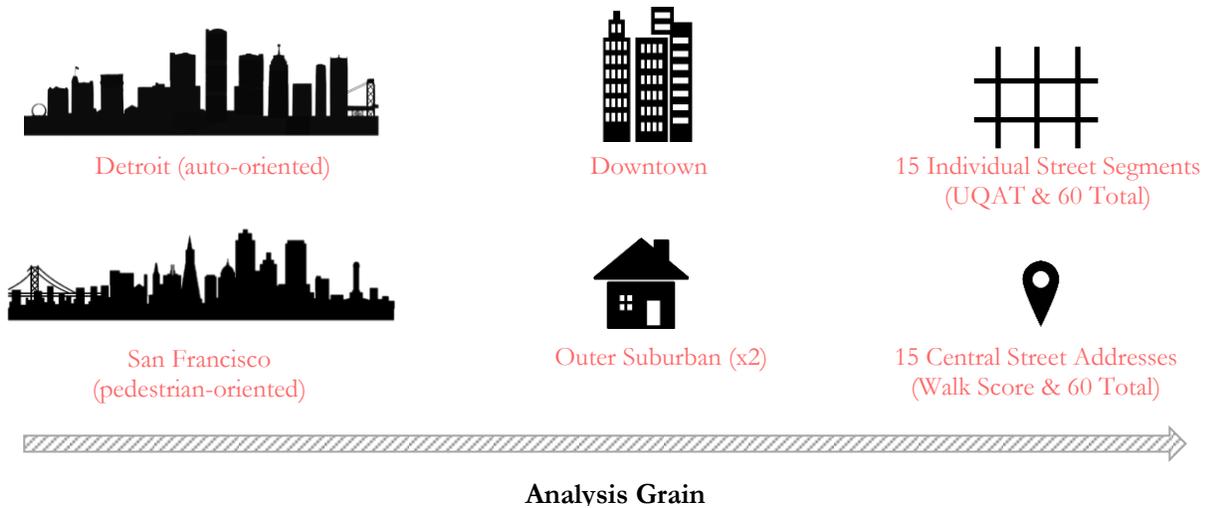


Figure 7. Scale of Analysis for Study Sites.

Data Collection Methods

In this study UQUAT was my primary tool for collecting original data on appealing factors such as imageability, human scale, enclosure, transparency and complexity. UQAT will be administered with the use of Google Street View to virtually visit the study sites. Finally, the third tool that I will use is Walk Score that will provide me with secondary walkability data measured with their methodology directly from Walk Score’s website. A more in depth explanation of these tools follows.

Urban Quality Assessment Tool

UQAT was developed by Ewing et al. with the input of an expert panel drawn from a variety of disciplines including urban planning, landscape architecture, architecture, and sociology among others (Ewing et al., 2005 1). The tool is an index variable that was developed to create a method of objectively measuring subjective urban design qualities that are found to influence walking for utilitarian and leisure purposes (Ewing et al., 2005 1). The tool has been found to be an easily replicable method. An illustrated field manual with step-by-step instructions and a recording sheet are provided as part of the tool.

All of the subjective urban design qualities identified above are variables within the UQAT tool. Those qualities were found to be most important in measuring subjective urban design by the panel and reflect dominant qualities that frequently feature in urban design literature as discussed earlier. Within each variable there are a number of sub-variables that contribute to the overall sense of each subjective urban design quality.

I administered UQAT with Google Street View (GSV). There are several advantages to using GSV, notably the reduced costs, ease of use, and the regular updates to its imagery. It should be noted, however, that it is limited by the fact that cameras are mounted on cars that are higher than eye-level presenting a different view. Other limiting factors include possible image clarity issues, image stitching from different time periods, and the fact that cars tend to go around at quieter times of the day that makes certain variables, such as the level of pedestrian activity difficult to measure (Griew et al., 2013). Additionally, the senses of smell and hearing cannot be recorded with GSV for obvious reasons (Rundle, Bader, Richards, Neckerman & Teitler, 2011). Despite these limitations, the flexibility of GSV and its other advantages far outweigh the limitations and it has been validated as being a reliable and effective alternative for administering desk-based walkability audits with similar levels of inter and intra-rater reliability (Rundle et al., 2011; Griew, et al., 2013).

Due to the nature of this study with observations being recorded virtually, modifications had to be made by omitting or refining certain sub-variables. The need for these modifications came about after two trials were conducted with the tool. The first trial was an in-class trial with my peers and the second trial was a comparison between measures recorded by the tool in-person and those recorded using GSV. Both trials confirmed some of the limitations apparent with GSV.

I modified the tool the in the following areas:

	Omitted	Refined
Sub-variables	Imageability (7): Number of people (both sides, within study area)	Transparency (3): Proportion active uses (your side, within study area) – clarification included in instructions
	Imageability (8): Noise level (both sides, within study area)	
	Human Scale (4): Number of small planters (your side, within study area)	
	Complexity (5): Number of walking pedestrians (your side within study area)	

Figure 8. Omitted and refined UQAT sub-variables.

Imageability (7): Number of people, Imageability (8): Noise level, and Complexity (5): Number of walking pedestrians were omitted, as they could not be effectively measured by GSV. Human Scale (4): Number of small

planters was omitted as part of an effort to streamline the tool and only had minimal impact on the overall Human Scale score. The sub-variable that I refined was *Transparency (3): Proportion active uses*. I refined it by clarifying that the proportion of active uses could be determined for the purpose of this study by the type of land use present and not the number of people entering and exiting buildings. Finally, the tool was streamlined by making the language simpler.

To overcome additional concerns, a measuring guide was created to ensure inter and intra-rater reliability. It is discussed in the following section. Finally, due to the methods employed in this study, namely how I processed the data described below, coefficients for each sub-variable and each subjective urban design quality’s constants were discarded. The modified UQAT can be found in the appendix (*appendix 1*).

Walk Score

Walk Score is an online-based tool that generates a measure of walkability out of 100, based on proximity to amenities within one square mile of any given address. Maximum points are awarded for amenities within a 5-minute walk (0.25 miles) with points decreasing as distance increases. Places that have Walk Scores above 50 are rated as being walkable, while places that have Walk Scores below 50 are considered car-dependent (walkscore.com). Importantly, Walk Score has proven popular with both practitioners and academics for its user-friendly nature, a highlight of which are the heat maps Walk Score generates making it simple to understand levels of walkability in a certain area.

Walk Score®	Description
90-100	Walker's Paradise Daily errands do not require a car.
70-89	Very Walkable Most errands can be accomplished on foot.
50-69	Somewhat Walkable Some errands can be accomplished on foot.
25-49	Car-Dependent Most errands require a car.
0-24	Car-Dependent Almost all errands require a car.

Figure 9. Walk Score scale (walkscore.com).

Walk Score also takes into account a variety of other walkability metrics, including population density and connectivity metrics, such as block length, intersection density, and walking routes into its measure of walkability. It utilises a variety of up to date dynamic data sources including education.com, OpenStreetMap, The U.S. Census, Google, Localeze, and places added by the Walk Score user community. Additionally, it has

started to include crime data for a select number of cities across the USA as of September 2014 (walkscore.com).

Although Walk Score has numerous benefits including using up to date data, affordability, and efficiency in time, it has a few limitations. First of all, it weights all destinations equally. Lee and Moudon found that only destinations such as groceries, schools, banks, bars and restaurants were significantly associated with home-based walking (Lee & Moudon 2006). Its largest flaw, though, in my opinion, is that it does not take into account subjective environmental qualities that are conducive to walkability, therefore does not tell us what it is like to walk down a street.

Data Collection and Processing

This section details the pre and post-data collection.

1) Recruitment and Training of Volunteers

In addition to myself, two volunteers were recruited from an undergraduate planning class. This enabled three sets of data to be collected using the UQAT tool, so that an average could be taken. Using three sets of data from three individuals allowed for individual differences in perception to be accounted for.

Training was necessary to minimise interpersonal differences that occur between raters to increase accuracy. Volunteers were trained to use UQAT by providing an explanation of how the tool works and by completing a guided trial of the tool that also helped familiarise the volunteers with the collection protocol and data collection process. Volunteers were given time to familiarise themselves with UQAT.

2) Data Collection Procedure

This section details the data collection process or steps that I and the other volunteers followed. Volunteers completed only steps one, two and three. This stage took place after all study sites and street segments were determined and explains the data collection process for one study site or neighbourhood.

Data collection took place in the Planning, Public Policy and Management computer lab and involved the following steps:

- 1) Acquaint oneself with provided modified UQAT, the accompanying UQAT Field Manual, Collection Protocol and map of street segments to be assessed in each study site.

- 2) For each observation, using GSV assess the street segment on your right starting at an intersection by heading forward whilst completing the required measures in UQAT. Make sure to follow the instructions in the UQAT Field Manual. Go up and down the street as many times as needed to complete each UQAT measurement.
- 3) Complete street segment assessments denoted on maps for each study site.
- 4) Identify addresses closest to the centre of each observed street segment in each neighbourhood.
- 5) Collect Walk Scores for these addresses.

Collection Protocol:

- Refer to the UQAT Field Manual when necessary.
- Move forward and backwards with keyboard arrow keys (one forward movement equivalent to approximately 15ft).
- When assessing the proportion of sky sub-variable position the camera so that the horizon is just below the centre of the screen.
- On small segments it may be more efficient to centre yourself in the middle of the segment and pan from left to right.

3) Processing and Scaling the Data

This section describes the data processing and scaling process that was carried out solely by myself. The following steps primarily pertain to the collected UQAT data:

- 6) Scale all street segment observations for each individual UQAT measure or sub-variable.
- 7) Sum and scale each street segment's score.
- 8) Average out scaled individual street segments and scale each segment's score so that every street segment has a score out of one hundred. This score will be referred to as the Design Score.
- 9) Gather XY coordinates for the centre of each street segment.

- 10) Create a spreadsheet document that contains each street segment's Design Score, Walk Score, and XY coordinates for uploading to ArcGIS.

Analysis Approach

I employed a four-pronged analysis approach to this study that makes use of heat maps and data tables for easy and comparable analytical comparisons to be made between measuring walkability with Walk Score and in terms of subjective urban design qualities with UQAT. For determining findings for each study site I employed the following analyses:

1) Overall Walk Score and Design Score Comparison

An overall subjective urban design score, what I call a Design Score, was computed for each study site or neighbourhood by dividing the total summed Design Scores by the 15 segments assessed in each neighbourhood. Although Walk Scores and Design Scores cannot strictly be compared, as they do not relate to each other perfectly due their scales and measurements, the purpose of this analysis is to demonstrate broadly the variance in walkability levels between both tools used in this study. This serves as a starting point of further investigation for the reader.

2) Individual Street Segment Walk Score and Design Score Comparison

Each street segment assessed in each neighbourhood was compared to its corresponding Walk Score. The approximate address located at the middle of each segment was input into Walk Score and served as its corresponding Walk Score. The difference between each segment's Walk Score and Design Score was summed to determine how many points difference occurred on average for each neighbourhood and to identify segments that differed wildly in levels of walkability measured by both tools.

3) Visual Walk Score and Design Score Comparison

A visual comparison was conducted for each neighbourhood's Walk Score and Design Score heat map. In this analysis I looked for visual similarities and differences between each tool's heat maps. This helped to identify how fine grained each tool's walkability rating was in relation to each other.

4) Correlational analysis by neighbourhood and city type

A correlational analysis was conducted at the neighbourhood and city scale to determine whether a statistical relationship exists between walkability measured by Walk Score and subjective urban design qualities measured by UQAT across different scales.

Study Site 1: Downtown Detroit

1) Overall Walk Score and Design Score Comparison



Walk Score
93

Downtown Detroit is classified as a “Walkers Paradise”

Design Score
57

Downtown Detroit ranks is relatively average in subjective urban design qualities

Comparing overall walkability measured by Walk Score and UQAT reveals a huge difference in how walkable Downtown Detroit is considered to be. Downtown Detroit has a Walk Score that is 36 points higher than its Design Score.

2) Individual Street Segment Walk Score and Design Score Comparison

Street Segment	Walk Score	Design Score	Difference
1	98	74	24
2	97	63	34
3	92	77	15
4	97	62	35
5	92	78	14
6	85	40	45
7	98	91	7
8	95	95	0
9	88	0	88
10	89	51	38
11	98	75	23
12	88	46	42
13	94	19	75
14	91	41	50
15	93	46	47
Average Difference			36

Table 2. Difference between Design Scores and Walk Scores for each street segment in Downtown Detroit.

Comparing each street segment’s Design Score to its Walk Score indicates huge discrepancies between the two tools similar to the overall comparison above. The average points difference between the two tools per street segment is 36 points. The highest difference was 88 points for Segment 9. This segment contained many vacant lots, no active uses, long sight lines, and so on.

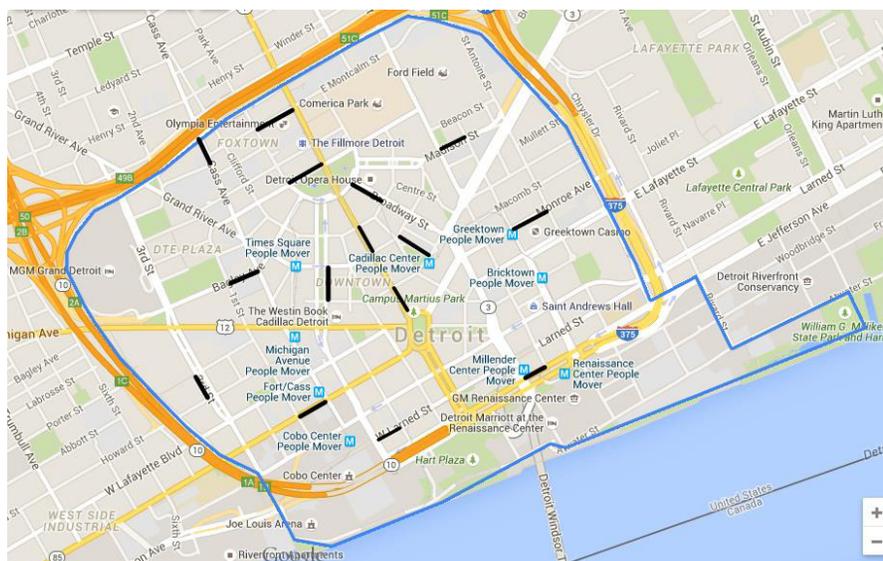


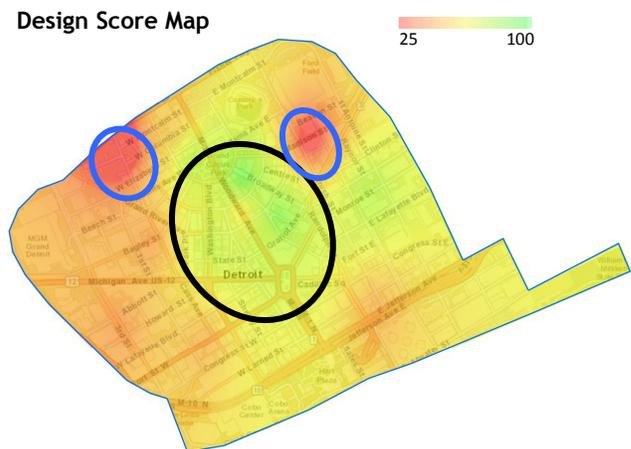
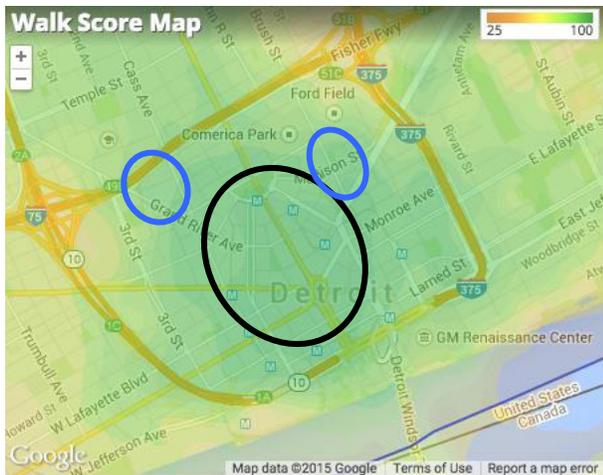
Figure 10. Observed street segments in Downtown Detroit (black lines).



Figure 11. Street Segments 9 in Downtown Detroit (Walk Score = 88 Design Score = 0).

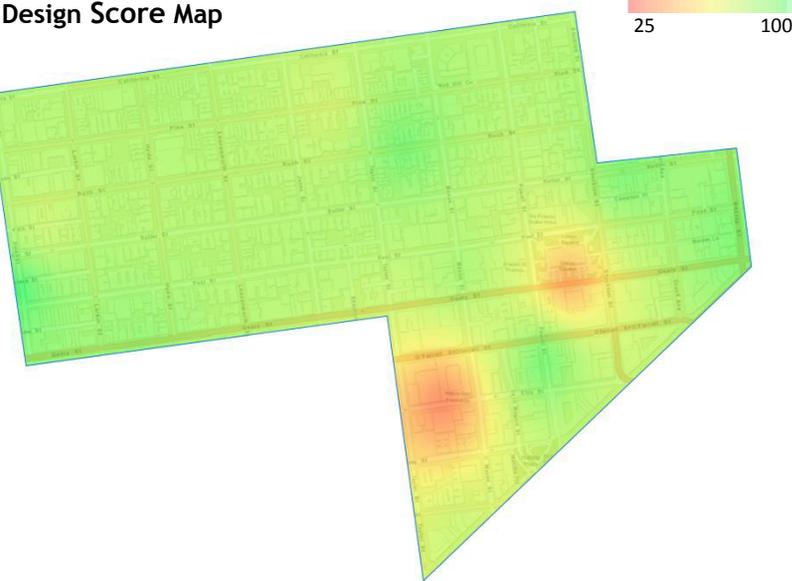
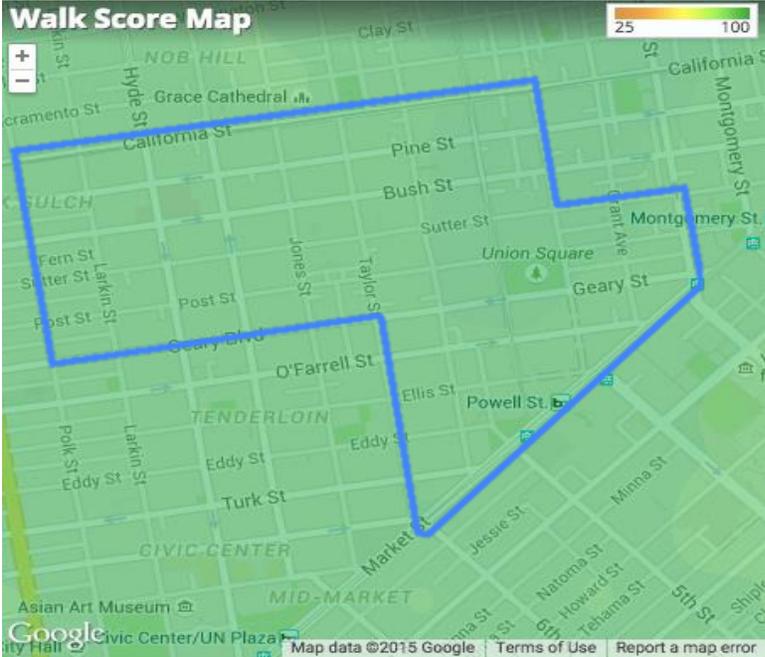
3) Spatial Walk Score and Design Score Comparison

The walkability heat maps reveal some similarities in terms of the spatial variance of the areas that are highest and lowest areas in walkability. Both heat maps indicate that walkability measured is highest in the core of Downtown measured by their respective measures indicated by the black circle on both heat maps. Moving away from this core area, the level of walkability decreases in both maps. However, the Design Score Map reveals dramatic changes in walkability immediately northeast and northwest of the core area (blue circles) in comparison to the Walk Score Map that indicates a more gradual change in walkability.



Study Site 2: Downtown San Francisco

1) Overall Walk Score and Design Score Comparison



Walk Score
99

Downtown San Francisco is classified as a “Walkers Paradise”

Design Score
80

Downtown San Francisco is high in subjective urban qualities

Comparing overall walkability measured by Walk Score and UQAT reveals a fairly significant difference in how walkable Downtown San Francisco is considered to be. However, the difference between the two scores is significantly less for downtown San Francisco (19 point difference) compared to downtown Detroit (36 point difference).

2) Individual Street Segment Walk Score and Design Score Comparison

Street Segment	Walk Score	Design Score	Difference
1	100	45	55
2	99	84	15
3	99	100	1
4	99	84	15
5	99	81	18
6	99	96	3
7	100	95	5
8	99	96	3
9	99	75	24
10	99	75	24
11	99	83	16
12	98	74	24
13	99	32	67
14	98	90	8
15	99	95	4
Average Difference			19

Table 3. Difference between Design Scores and Walk Scores for each street segment in Downtown San Francisco.

Comparing each street segment's Design Score to its Walk Score indicates discrepancies between the two tools. The average points difference between the two tools per street segment is 19 points. The highest difference was 67 points for Segment 13. This segment contained many inactive uses, and few basic and accent building colours. Segment 3 had the lowest difference having a Design Score of 100 compared to a Walk Score of 99. This segment contained a significant proportion of historic buildings, active uses, and street furniture.

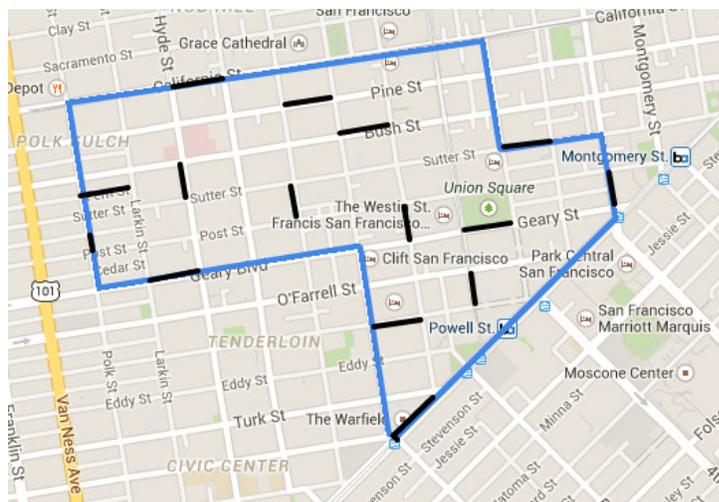


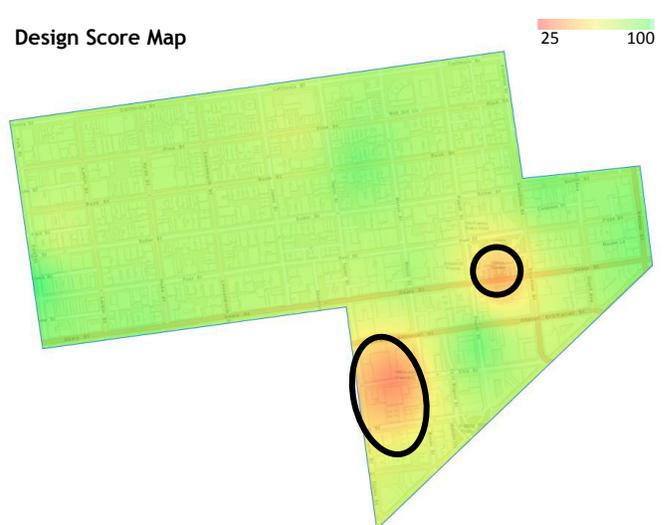
Figure 12. Observed street segments in Downtown San Francisco (black lines).



Figure 13. Street Segment 3 in Downtown San Francisco (Walk Score = 99 Design Score = 100).

3) Spatial Walk Score and Design Score Comparison

The walkability heat maps show only minor differences in the spatial variance of levels of walkability. Both heat maps broadly indicate that walkability is high across most of Downtown San Francisco with the Design Score walkability heat map revealing slightly more fluctuation in colour. One thing worth noting, are the two low walkability areas indicated by the black circles on the Design Score Map. The southwest area was genuinely low in subjective urban design. But the smaller area is a segment next to Union Square, an area certainly very high in subjective urban design qualities, at least to my researchers and I. This low score could be a result of a failing of the tool, or rater error. The sub-variables that caused this low score were the proportion of street wall sub-variables.

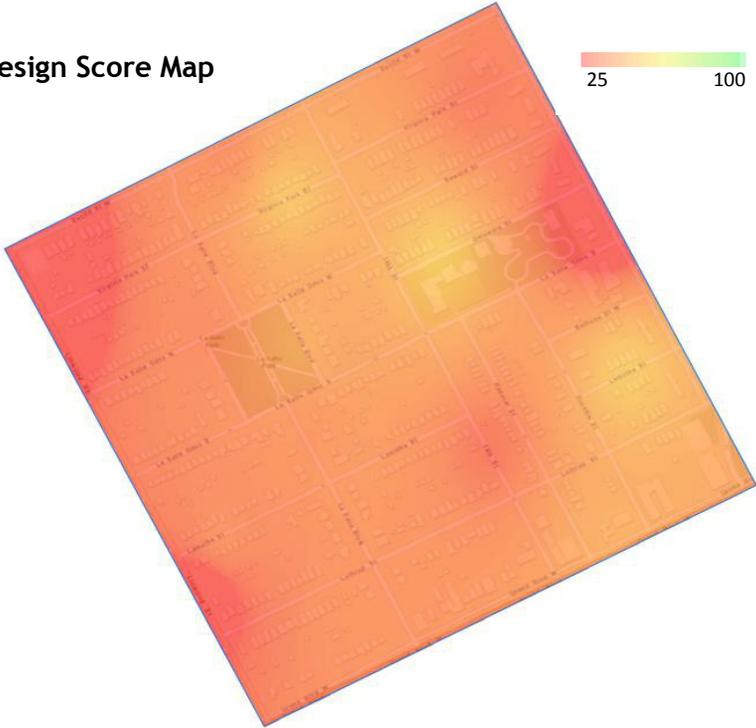


Study Site 3: LaSalle Gardens, Detroit (Outer Suburban)

1) Overall Walk Score and Design Score Comparison



Design Score Map



Walk Score
47

LaSalle Gardens, Detroit is classified as a “Car-dependent neighbourhood”
Most errands require a car

Design Score
32

LaSalle Gardens, Detroit is low in subjective urban design qualities

Comparing overall walkability measured by Walk Score and UQAT reveals a significant difference in how walkable LaSalle Gardens, Detroit is considered to be. LaSalle Gardens has a Walk Score that is 15 points higher than its Design Score.

2) Individual Street Segment Walk Score and Design Score Comparison

Street Segment	Walk Score	Design Score	Difference
1	50	4	46
2	45	31	14
3	69	42	27
4	59	27	32
5	57	51	6
6	46	41	5
7	46	19	27
8	69	50	19
9	59	32	27
10	63	28	35
11	60	34	26
12	48	34	14
13	50	48	2
14	66	12	54
15	53	33	20
Average Difference			24

Table 4. Difference between Design Scores and Walk Scores for each street segment in Downtown San Francisco.

Comparing each street segment’s Design Score to its Walk Score reveals that the average difference is 24 points between the two tools. The highest difference was 54 points for Segment 14. Segment 14 was non-descript containing the presence of two buildings, one notably a church, but little else. However, the segment scores relatively high on Walk Score due to its proximity to a large shopping centre a few blocks north. This highlights the inadequacy of Walk Score’s methodology.

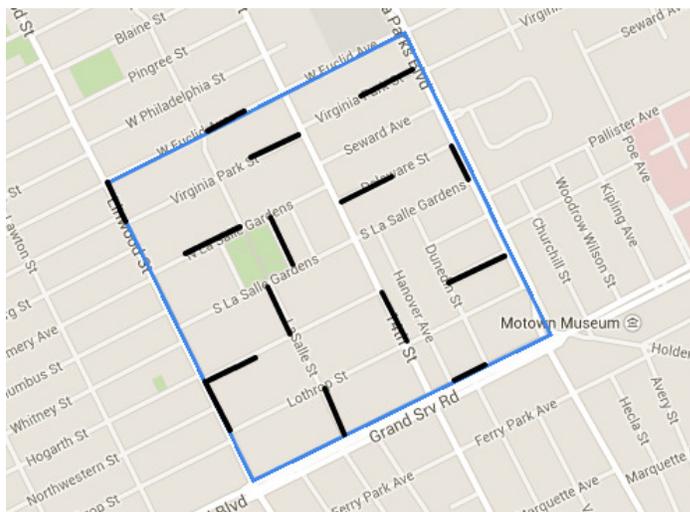


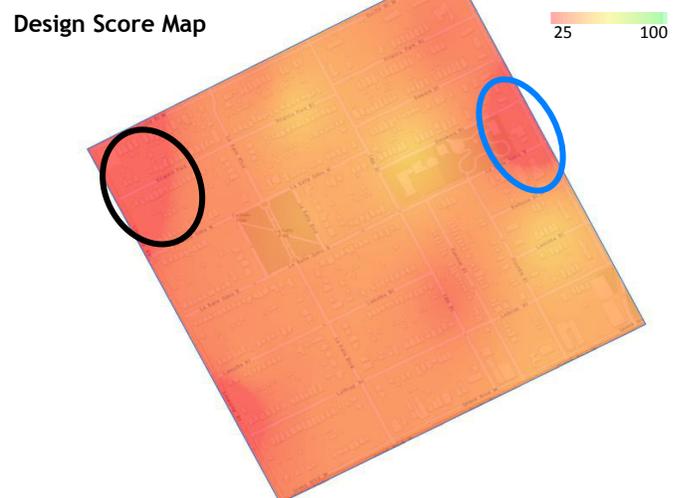
Figure 13. Observed street segments in LaSalle Gardens, Detroit (black lines).



Figure 14. Street Segment 14 in LaSalle Gardens, Detroit (Walk Score = 66 Design Score = 12).

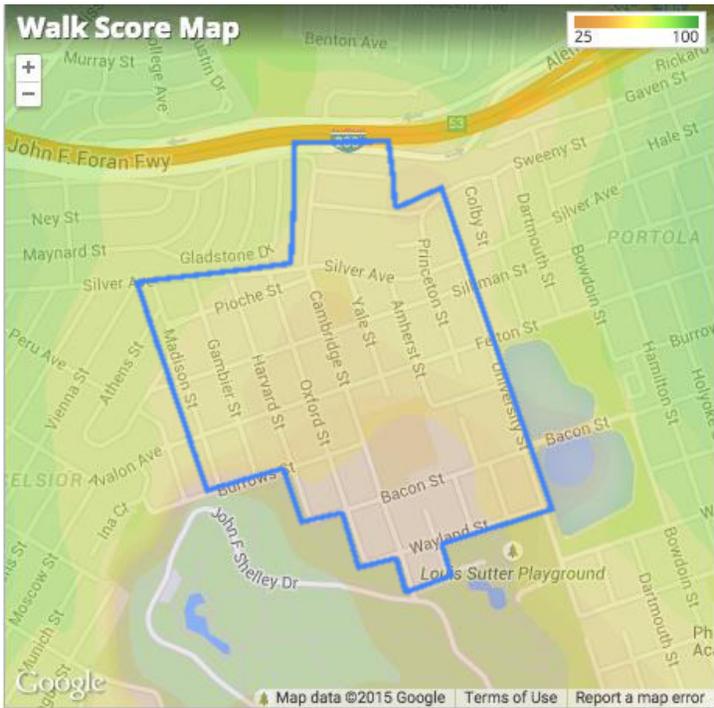
3) Spatial Walk Score and Design Score Comparison

The walkability heat maps show minor similarities in the spatial variance of levels of walkability. Both walkability heat maps have low walkability values at the northwest corner of the neighbourhood indicated by the black circle with the Design Score Map indicating more areas that are lower in walkability in general. Nonetheless, there the similarities end. The blue circle located at the east of the neighbourhood scored low in walkability in the Design Score Map and relatively high for the neighbourhood in the Walk Score Map. This location is the site of Segment 14 described above.



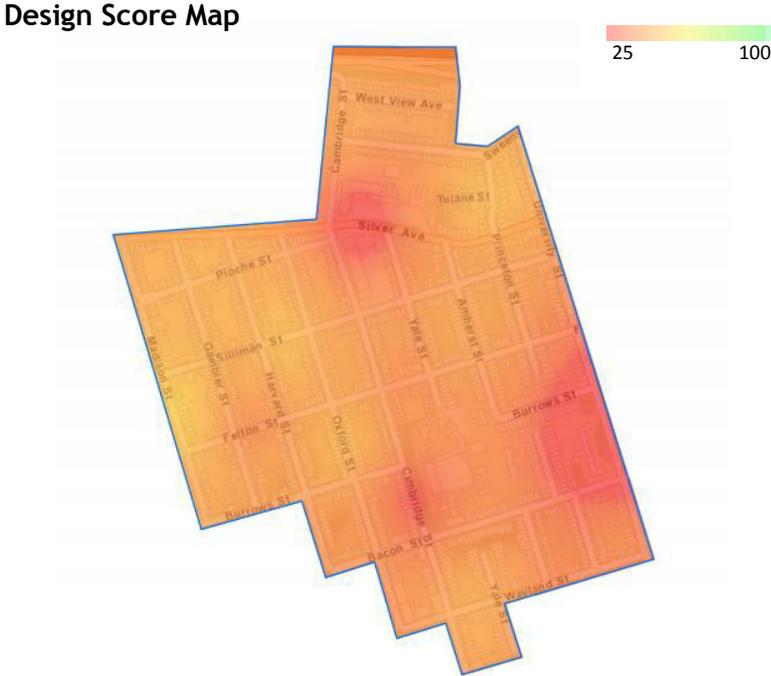
Study Site 4: University Mound, San Francisco (Outer Suburban)

1) Overall Walk Score and Design Score Comparison



Walk Score
48

University Mound, San Francisco is classified as a “Car-dependent neighbourhood” Most errands require a car



Design Score
33

University Mound, San Francisco is low in subjective urban design qualities

Comparing overall walkability measured by Walk Score and UQAT reveals a significant difference in how walkable University Mound, San Francisco is considered to be. University Mound has a Walk Score that is 15 points higher than its Design Score, the same difference as LaSalle Gardens, Detroit.

2) Individual Street Segment Walk Score and Design Score Comparison

Street Segment	Walk Score	Design Score	Difference
1	57	50	7
2	50	34	16
3	40	25	15
4	57	20	37
5	37	35	2
6	54	39	15
7	44	11	33
8	50	45	5
9	61	39	22
10	44	32	12
11	42	34	8
12	34	41	7
13	45	43	2
14	53	44	9
15	56	42	14
Average Difference			13

Table 5. Difference between Design Scores and Walk Scores for each street segment in University Mound, San Francisco.

Comparing each street segment’s Design Score to its Walk Score reveals that the average difference is 13 points between the two tools. The highest difference was 37 points for Segment 4. Segment 4 has a Walk Score of 57, which classes it as being somewhat walkable with some errands being accomplishable on foot. It has a low Design Score of only 20. This is mainly due to the fact that the buildings there are functional. Either side of the street is a church and a school. These buildings are set back so the segment scores low on street wall, have few building colours, as well as few windows at street level. However, despite scoring low for those sub-variables the street was not that unwalkable in terms of how inviting it is to walk down, in my opinion.

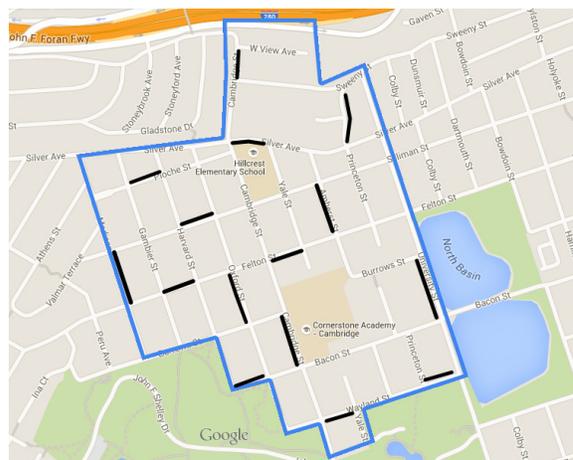


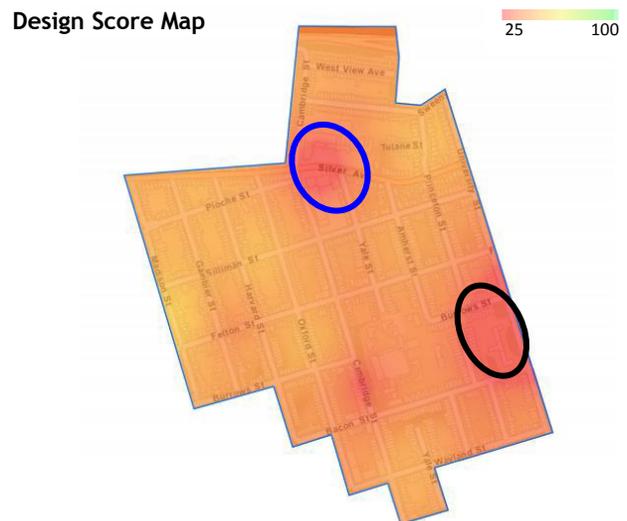
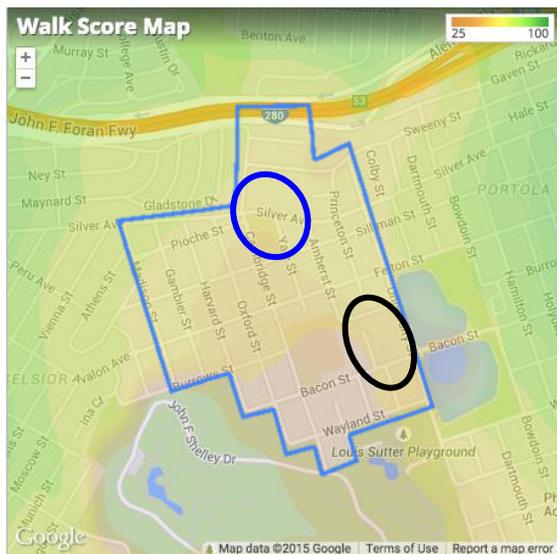
Figure 15. Observed street segments in University Mound, San Francisco (black lines).



Figure 16. Street Segment 4 in University Mound, San Francisco (Walk Score = 57 Design Score = 20).

3) Spatial Walk Score and Design Score Comparison

The walkability heat maps show only one minor similarity in the spatial variance of levels of walkability indicated by the black circles. This segment contained far set backs resulting in little street wall and no active uses that brought its walkability level down. The blue circle however, indicates the notable difference, between the two maps. The corresponding area in the Walk Score Map scored relatively well, whereas it scored low on the Design Score Map. This location is the site of Segment 4 described above.



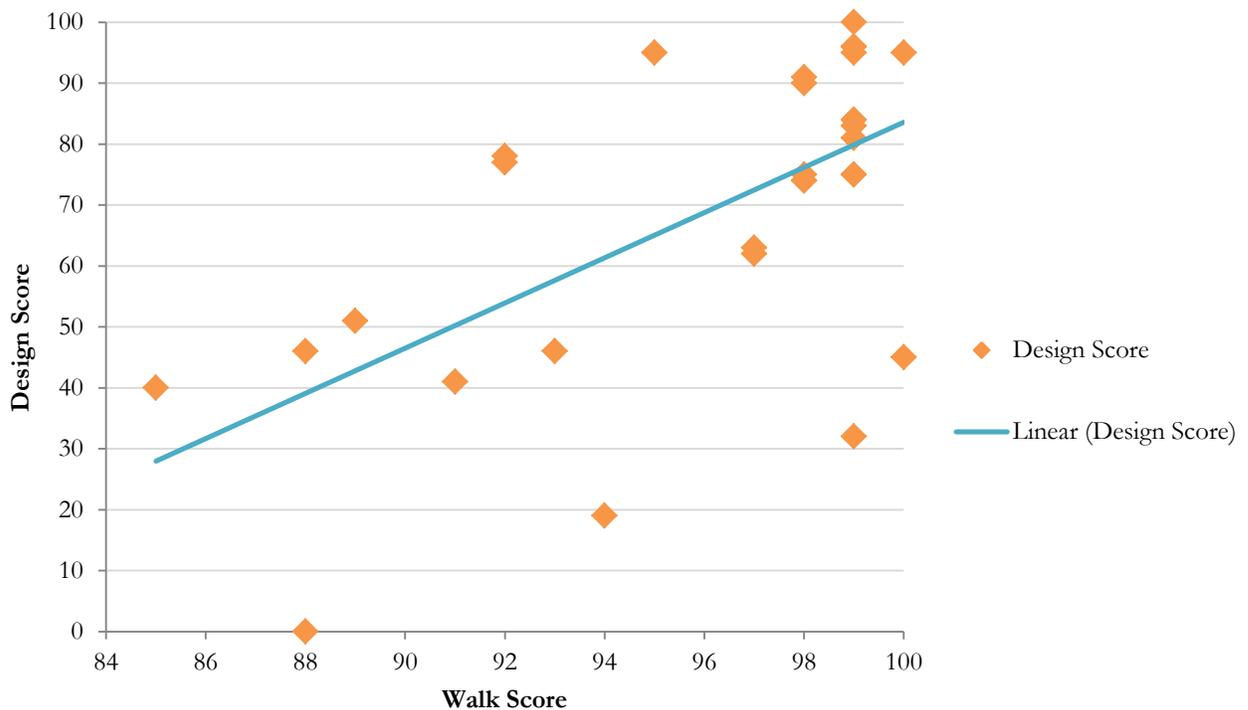
Correlational Analysis: Neighbourhood Scale

Conducting a correlational analysis by neighbourhood type revealed significant differences in the strength of correlation between Walk Score and subjective urban design qualities.

Downtown Neighbourhoods

Conducting a correlational analysis for downtown neighbourhoods in both cities yielded a correlation coefficient of 0.62. This can be interpreted that there is a very strong positive relationship between increases in Walk Score corresponding with increases in the levels of subjective urban design qualities. Additionally, when testing for statistical significance this relationship is statistically significant at the 1% level. Meaning that Walk Score can be determined to be a strong predictor of subjective urban design qualities in the downtown neighbourhoods that were investigated.

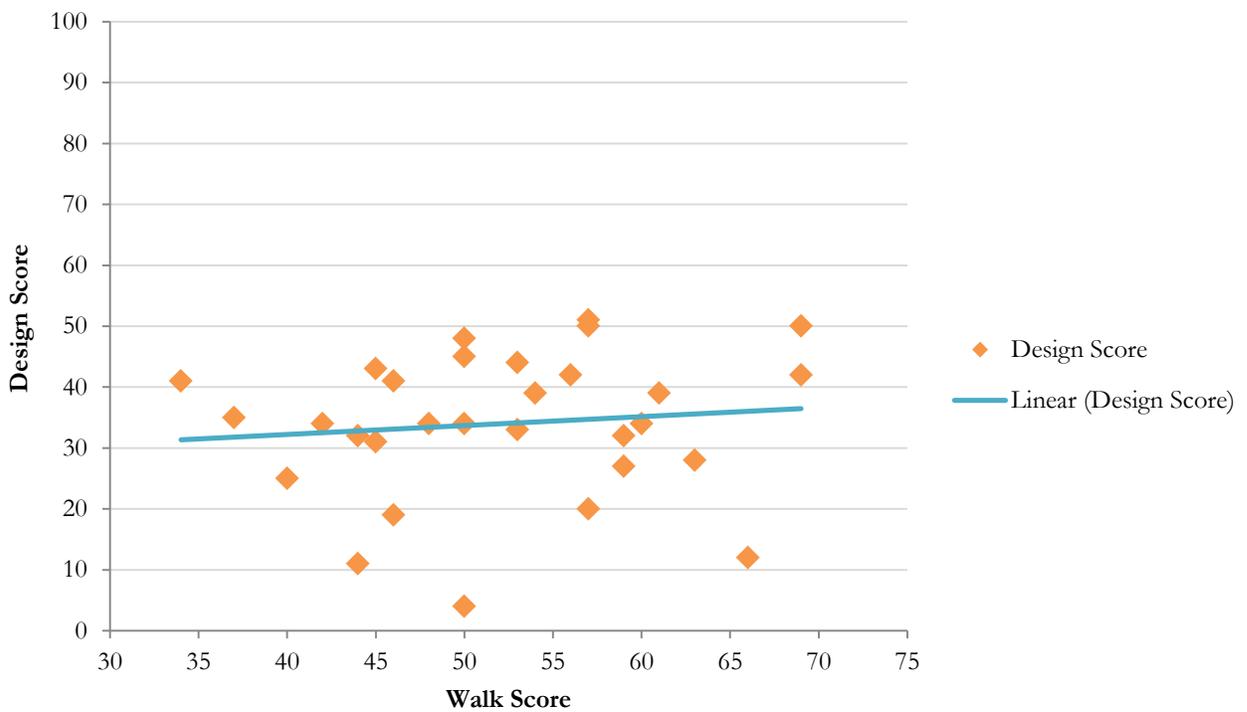
Correlation Coefficient = 0.62



Outer Suburban Neighbourhoods

Conducting a correlational analysis for outer suburban neighbourhoods in both cities yielded a correlation coefficient of 0.11. This can be interpreted that there is a very weak or even negligible relationship between Walk Score and levels of subjective urban design qualities in outer suburban neighbourhoods. This weak or negligible relationship is also statistically significant at the 1% level. Meaning that when Walk Score can be determined not to be a predictor of subjective urban design qualities in the outer suburban neighbourhoods that were investigated.

Correlation Coefficient = **0.11**

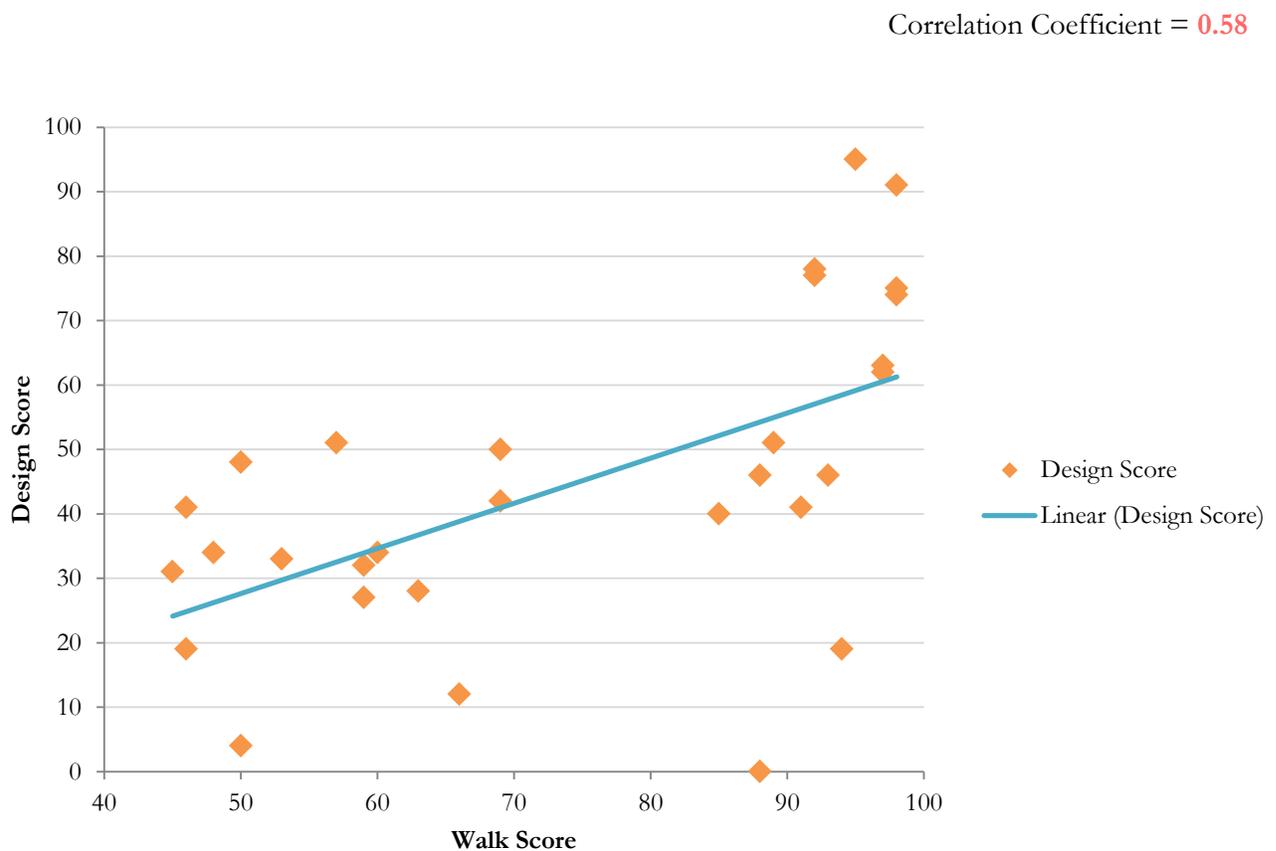


Correlational Analysis: City Scale

Conducting a correlational analysis by city type revealed similarities between the strength of correlation between Walk Score and subjective urban design qualities. City types in this analysis are auto-oriented (Detroit) and pedestrian-oriented (San Francisco).

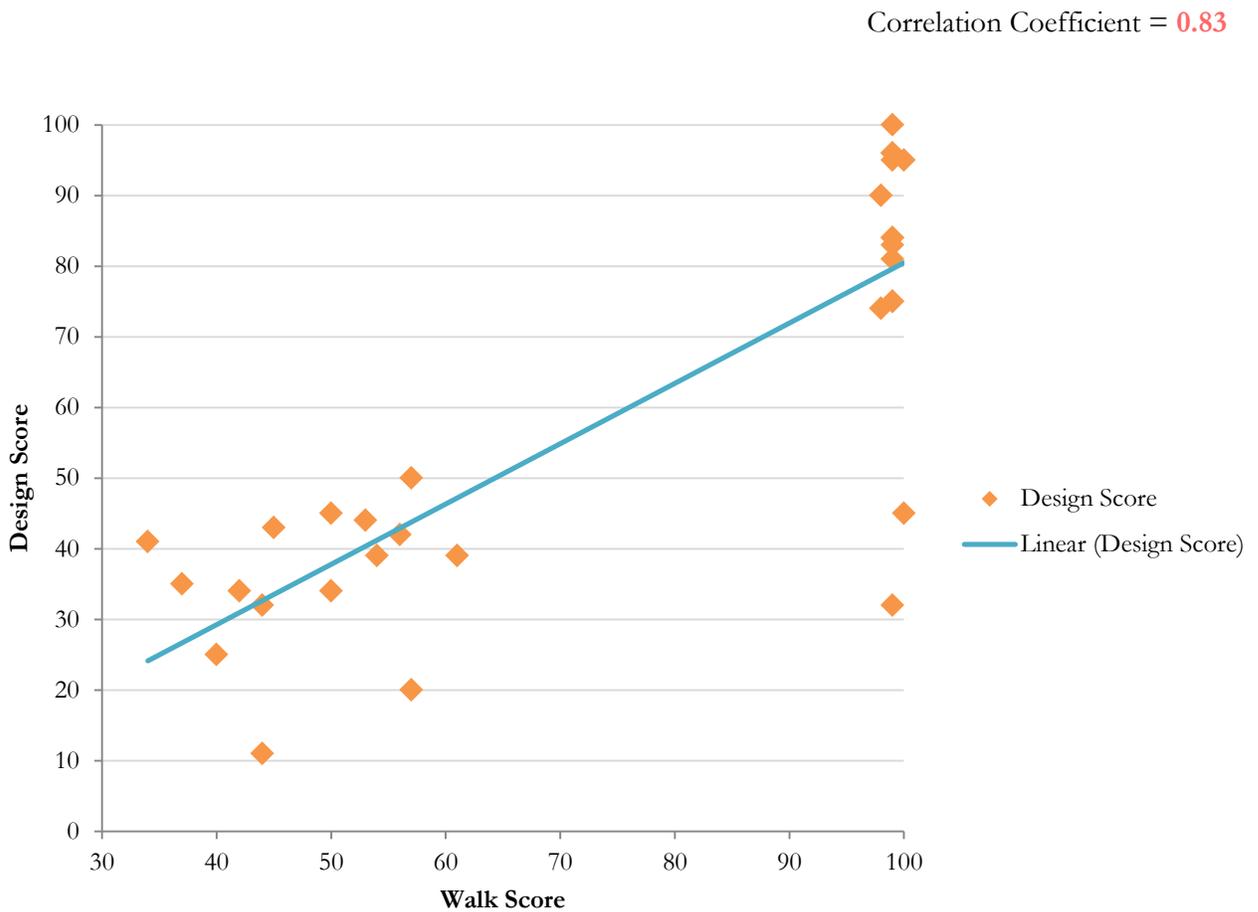
Auto-Oriented: Detroit

Conducting a correlational analysis for both neighbourhoods in Detroit yielded a correlation coefficient of 0.58. This can be interpreted that there is a strong positive correlation between Walk Score and levels of subjective urban design qualities across widely differing neighbourhoods in auto-oriented or car-dependent cities. When testing for statistical significance this relationship is statistically significant at the 1% level. Meaning that Walk Score can be determined to be a strong predictor of subjective urban design qualities in the auto-oriented city investigated.



Pedestrian-Oriented: San Francisco

Conducting a correlational analysis for both neighbourhoods in San Francisco yielded a correlation coefficient of 0.83. This can be interpreted that there is a very strong positive correlation between Walk Score and levels of subjective urban design qualities across widely differing neighbourhoods in pedestrian-oriented cities or cities high in walkability. When testing for statistical significance this relationship is statistically significant at the 1% level. Meaning that Walk Score can be determined to be a very strong predictor of subjective urban design qualities in the pedestrian-oriented city investigated.



Key Findings

A number of key findings that arose from the analyses and indicated clear trends are described in detail below.

1) The difference in Walk Scores and Design Scores were greatest in downtown neighbourhoods than outer suburban neighbourhoods.

Design Scores in downtown neighbourhoods were 27.5 points lower on average compared to their respective Walk Scores. In outer suburban neighbourhoods the difference was just 15 points. As stated earlier it is difficult to make direct comparisons between both methods in this scale but it does, however, suggest that Walk Score is more capable of being a valid measure of walkability in terms of also accounting for subjective design qualities in downtown neighbourhoods more so than in outer suburban neighbourhoods. In reality, the reason may be due to the fact the outer suburban neighbourhoods score lower in Walk Score, as they have fewer amenities compared to downtown areas.

2) Design Score Maps indicate a finer grain of analysis in the level of walkability in the assessed neighbourhoods

Comparing individual street segments' Design Scores to their respective Walk Scores, indicates how Design Scores fluctuate more from segment to segment throughout each neighbourhood assessed. This is also apparent when comparing neighbourhood walkability heat maps and is best shown by the maps for Downtown Detroit. Moving away from the core area, which was high in walkability in both maps, the Walk Score Map gently decreases in walkability, but Walk Scores remain high as indicated by the darkness of the green. However, on the Design Score Map, moving away from that area there are immediately areas that are significantly lower in walkability in terms of subjective urban design qualities. Some of those areas are very close to the downtown core which itself is very strong in terms of aesthetics; contain many vacant lots and vandalised buildings. The Walk Score Map does not pick that up, as it does not take those kinds of things into consideration, but the state of some of those areas and the perception of safety that goes along with them surely would have a large affect on how willing people would be to walk down the street in those areas.

Having just spent time in Detroit this summer, I can corroborate that the downtown core is very nice and is thriving. Certain areas though, just a few blocks or so away particularly to the west and northwest certainly seem less walkable in my opinion in terms of aesthetics and perceived comfort and safety. Those areas certainly would reduce the number of leisurely strolls taken.

3) Walk Score is positively correlated with subjective urban design qualities at the city scale and is statistically significant at the 1% level

Walk Scores were positively correlated with subjective urban design qualities in both city types meaning that that increases in Walk Scores corresponding with an increase in subjective urban design qualities as measured by UQAT. Correlation was slightly stronger in the pedestrian-oriented city type, in this case San Francisco, which had correlation coefficient of 0.83 compared to 0.59 for the auto-oriented city type represented by Detroit. This illustrates that cities that are traditionally considered more walkable like San Francisco are likely to be higher in subjective urban design qualities.

4) Walk Score is positively correlated with subjective urban design qualities in downtown neighbourhoods and not outer suburban neighbourhoods

Walk Scores were positively correlated with subjective urban design qualities in both the downtown neighbourhoods of Detroit and San Francisco and that relationship was statistically significant at the 1% level. Despite that, a relationship was non-existent for the outer suburban neighbourhoods of both cities. Downtown neighbourhoods had a correlation coefficient of 0.62 to compared to 0.11 for outer suburban neighbourhoods. This illustrates that neighbourhoods that are traditionally considered more walkable such as downtown and inner city neighbourhoods are likely to be higher in subjective urban design qualities.

Chapter 5 - Takeaways

What We Can Learn From This Study

It has come apparent from my analysis of comparing Walk Score and subjective urban design qualities measured with UQAT, that in most cases there is a strong positive correlation between areas high in Walk Score also being high in subjective urban design. The strength of this correlation was found to be statistically significant at the 1% level. Despite this correlation suggesting that increases in Walk Scores would result in increases of subjective urban design qualities, it also revealed that measuring walkability in terms of subjective urban design produces a finer grained picture of how walkable an area is from street to street. This confirms what I initially thought – that Walk Score paints an incomplete picture of walkability, as it does not take into account subjective urban design qualities that have been proven in the field of study to be a contributing factor to influencing an individual's willingness to walk.

Street Segment 9 in Downtown Detroit shown earlier and once more below, best illustrates this. This segment had a Walk Score of 88, but a Design Score of only 0. This segment scored 0, because when I scaled all of the UQAT street segment scores to create a 0-100 scale for comparison to Walk Score it was the lowest ranking segment. Nevertheless, in reality looking at the photographs of that segment below does it look like it should have a Walk Score of 88? Would an individual be likely to want to walk down this street for commuting or for leisure? I would argue no. They certainly wouldn't want to walk down a segment that has no active uses, vacant lots, vacant buildings, and no street furniture at night. This is why Walk Score should not be relied on as the go to measure of walkability. It simply does not tell you the truthful story of what it is like on the ground for a person. It is heavily skewed towards proximity to destinations.



Figure 17. Street Segments 9 in Downtown Detroit (Walk Score = 88 Design Score = 0).



Figure 18. Opposite view of Street Segments 9 in Downtown Detroit (Walk Score = 88 Design Score = 0).



Figure 19. Street a couple of blocks over from Segment 9 in Downtown Detroit

Takeaway Messages

I want to leave this study with a few takeaway messages for individuals and groups that I believe have something they could learn from this research in terms of employing similar methods to what I used in this study to their own walkability research.

Message for City Planners and Academics

At this year's American Planning Association's National Conference, a city planner from Philadelphia came up to me whilst I was presenting a poster of this research. He told me how for 2015, Philadelphia was rated the fourth most walkable city in the USA by walkscore.com and he and the rest of the city planning department could not believe it! He told me that even within the city centre of Philadelphia there were many streets that they thought were low in walkability, because of how they looked and the perceptions of safety and comfort that go along with that. He proceeded to tell me that the city planning department were thinking about doing a walkability survey that addressed design to better understand walkability in the city and to forward him my results of this study when I was done.

Considering that conversation, the first message that I have for city planners and academics is that there is great utility in the tools and method that I employed in this study. Firstly, GSV serves as a great tool for efficiently administering walkability audits whilst also being cost effective. Secondly, UQAT is an ideal and easy to use tool for assessing subjective urban design qualities objectively within the built environment that have been found to be conducive to influencing walkability. Thirdly, 15 street segments is a good rule of thumb for observing subjective urban design qualities in neighbourhoods of around 1.5 – 2 acres or less. I found this ideal for giving a good account of the level of subjective urban design qualities in neighbourhoods of that size, but for neighbourhoods larger in size observing more street segments is recommended. Finally, to reiterate and go with the above messages, the framework and methods set out in this study provide an easy to follow and replicable solid base for levelling up if a city planning department wanted to identify areas that are low in walkability in terms of design and aesthetics that could be strategically targeted for improving walkability. Collecting data extensively on neighbourhood streets using UQAT and GSV would be an ideal activity for planning interns to carry out.

Message for Walk Score

Walk Score is great tool that will be continued to be used for many a year to come. The longevity that I see Walk Score having can be attributed not only to how easy the tool is in terms of how user friendly it is and the data it utilises, but because it is always looking to include other metrics into its measure of walkability. The most recent example of this is the inclusion of crime data for certain cities since September 2014. My message for Walk Score is that they should work on including design metrics into their methodology to paint a more realistic picture of how walkable a place is in reality for a person on the street. Design metrics should take some of the precedence away from relying on proximity to destinations too heavily. When that is done Walk Score will fully deserve its spot as the favoured or go to measure of walkability for many people.

Thank you for reading.

Appendix 1 – Modified UQAT Tool

Measuring urban design qualities scoring sheet		Name: Dan Downtown Detroit		Neighbourhood:	
Segment: 1		date & time			
Step	Recorded value	Scaled Value	Multiplier	(multiplier) x scaled value)	
Imageability					
1. number of courtyards, plazas, and parks (both sides, within study area)			0.41		
2. number of major landscape features (both sides, beyond study area)			0.72		
3. proportion historic building frontage (both sides, within study area) (.10)			0.97		
4. number of buildings with identifiers (both sides, within study area)			0.11		
5. number of buildings with non-rectangular shapes (both sides, within study area)			0.08		
6. presence of outdoor dining (your side, within study area)			0.64		
			Imageability score		
Enclosure					
1. number of long sight lines (both sides, beyond study area)			-0.31		
2a. proportion street wall (your side, within study area) (.10)			0.72		
2b. proportion street wall (opposite side, within study area) (.10)			0.94		
3a. proportion sky (ahead, beyond study area) (.05)			-1.42		
3b. proportion sky (across, beyond study area) (.05)			-2.19		
			Enclosure score		
Human scale					
1. number of long sight lines (both sides, beyond study area)			-0.74		
2. proportion windows at street level (your side, within study area) (.10)			1.1		
3. average building height (your side, within study area)			-0.003		
4. number of pieces of street furniture and other street items (your side, within study area)			0.04		
			Human scale score		
Transparency					
1. proportion windows at street level (your side, within study area) (.10)			1.22		
2. proportion street wall (your side, beyond study area) *from above (.10)			0.67		

3. proportion active uses (your side, within study area) (.10)			0.53	
			Transparency score	
Complexity				
1. number of buildings (both sides, beyond study area)			0.05	
2a. number of basic building colours (both sides, beyond study area)			0.23	
2b. number of basic accent colours (both sides, beyond study area)			0.12	
3. presence of outdoor dining (your side, within study area) *from above			0.42	
4. number of pieces of public art (both sides, within study area)			0.29	
			Complexity score	

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