

# Using parametric methods to understand place in urban design courses

**ABSTRACT** Today, many urban design studios begin with the data collected and analyzed by others and in their abstraction is experientially distant from the place itself. New digital parametric methods of urban design education today support the inclusion of everyday experience of phenomena through 1) the systematic comparison of urban characteristics; 2) the inclusion of experience as phenomena over time and 3) open formulation by each student of urban characteristics. This article describes the methodology of three courses taught in Eugene, Oregon, Barcelona, Spain and Portland, Oregon. Each course integrated urban design principles and table-based geospatial information (GI) computing techniques that included phenomena of place. Unlike GI planning software such as ESRI ArcGIS (1999) and City Engine (2008), the parametric software Rhino Grasshopper, with open plug-ins for CSV tables and OpenStreetMaps (Coast 2004) and custom scripting, allowed students to formulate their own open tools to understand people and place. This codification of time-based phenomena is especially relevant for the current generation of urban design students but faces new challenges as tools of both analysis and design.

**KEYWORDS** Urban Design, Parametric Design, Phenomena, Place

## Introduction

Traditional urban design studios begin with site visits during which time students gather information that is grounded in their own experiences in an intuitive and rarely systematic manner. Design approaches are informed by trial solutions (Lawson 2006) and more recent computing assisted ideas of ‘design patterns’ (Woodbury 2010). Parametric urban design tools bridge these two realms by (1) drawing upon existing data sets and (2) gathering and analyzing one’s own data both in-situ and off-site. New parametric methods of urban design education today in architecture (Beirão 2011) (Speranza 2014) (Tang 2011), planning (Marshall 2009), landscape architecture (Holzman and Cantrell 2014), ecology (Sattler 2014) and information architecture (Koltsova 2012) focus students’ understanding to the varied phenomena of a place, as defined as the everyday experience and behaviors (Norberg-Schulz 1976), rather than directing them to rely on more abstract and fixed geometric modes of data and analysis such as existing GIS shape files and municipal CAD files.

The new inclusion of phenomena is evident in the software tools used by urban design students as well as everyday users of new software and mobile technology to enhance our understanding of everyday behaviors in time and space (McCullough 2013). Examples of this include everyday recommendations for driving or bike routes based on live-traffic input (Google Maps 2005), Twitter feeds (2006) of urban events based on live feedback from users and more qualitative descriptions of food choices (Yelp 2004) and image feeds (Instagram 2012). These methods ‘attach’ (Latour 2008) people to place over time through the inclusion of observable phenomena and user feedback, encouraging urban design students today to develop their own open tools to formulate the complex and evolving ways people experience urban space. With the idea that static geometric information may no longer be the sole starting point for urban design students today, this research presents methods using parametric Rhino Grasshopper (Rutten 2007) software to include traditional urban design practices of in-situ analysis and the iterative agency of these plugins and sensors in urban design.

Parametric approaches in urban design may now be moving from formal to phenomenal understandings. The iterations of design thinking (Lawson 2006) may now include human and non-human agency in both everyday media (Latour 2005) as well as in architectural design (Delanda 2009) (Latour 2008). Parametric design once

metaphoric and formal may now include 'practical' performance (Allen 2005). A generation of students acclimated to a more digitally connected life engage design processes to observe, codify and systematically relate information from qualitative experience to quantitative measurement, and vice versa. Apps may be a new sketchbook. Workflows using handheld mobile devices with built in sensors and apps along with open professional parametric design software allow students to creatively formulate their own design methods to understand place, sometimes even in real-time (Nabian 2013). Site visits in urban design courses may include traditional notebooks and with accompanied digital online apps that include Microsoft's Quickoffice (2012), Google Docs and other iPhone apps to record and share in-situ observations increased by new legislature unlocking cell phones in Europe (Comision 1998) and the United States (Unlocking 2014). The integration of these new digital tools force students to manage new challenges to balance time, design path understanding and methods to balance the complexity of urban design. This was witnessed in the three projects to be discussed here.

Early parametric urban design work such as 'parametric urbanism' of Patrik Schumaker (2008) and Zaha Hadid include formal contextual features of rivers, roads and topography. 'Swarm urbanism' of Neal Leach (2008) includes the emergent patterns of agent intelligence of individual virtual city inhabitants. These urban computing ideas built upon the systematic urban design approaches of patterns by Christopher Alexander (1977), visual understandings of cities by Kevin Lynch (1960), walkability (Jacobs and Appleyard 1987) and livability (Gehl 1986) as well as later studies of permeability (Stiles et al 2009) and 'imageability' (Ewing and Handy, 2009). More recent urban design and parametric design work addresses these needs for a broader and more complex view of geospatial understanding including integrated ecology and Walkscore (Tang and Anderson 2011), spatial organization (Beirão 2012), the pedestrian scale (Koltsova 2012) and GIS (Reinhart 2013),

Parametric design thinking though is more continuous (Woodbury 2010) (Beirão et al 2011) than previous traditional design thinking. Design thinking of 'see-move-see' (Shon 1983) is now automated. The research presented here attempts to connect off-site and on-site information (Speranza 2014) but acknowledges the danger of automation on the design process. The non-linear and complex design process of urban design (Portugali 2000) including analysis, synthesis and evaluation (Lawson 2006) is clearly affected by this change in parametric design thinking and design agency (Gerber Ibanez 2014). Both the advantages and difficulties integrating off-site and on-site phenomena with geometric and traditional urban design approaches will be discussed with the case study projects and in the conclusion of this paper.

The integration of computing and traditional techniques to measure observed social and natural phenomena to understand place, occurs in two ways: 1) analytically through the use of open interface software Rhino Grasshopper to codify data both off-site and in-situ; and 2) simultaneously integrated analysis and design synthesis methods with dynamic design solutions to 'attach' place and time through phenomena such as transit, weather or people's behavior. The urban design public art work of Ned Kahn may be seen as a precedent to enhances people's understanding of place by visualizing wind in real-time (2004) and interaction designer Aaron Koblin and artist Janet Echelman (2014) add the additional layer of real-time data. Likewise these techniques to integrate analysis and design seek to address early GIS problems to include the need for dynamic modeling, new urban models and a close tie to urban policy (Su 1998).

The methods described here do not only inform analytical decision making but identify the experiential qualities of urban characteristics that design proposals may create in the built environment. At times the analysis leads to direct design input, enhanced by the simultaneous use of Rhino Grasshopper for both analysis and design. At other times the analysis directs the student designer to explore a quality of human experience such as transparency or seating accessibility in both parametric and traditional design approaches. It is important for the work presented here that parametric computing agency is intended to empower student experience and inclusion of site understanding in their design work and not replace traditional methods of site diagramming, sketching and planometric analysis to understand place. Still the integration of these digital parametric approaches introduces new challenges including new design synthesis workflows, the consistency of data collection and the accessibility to use advanced hardware and software. Parametric design methods described here systematize 'see-move-see' (Shon 1983) and qualitative urban design understanding (Ewing Hardy 2009) with unique challenges for off-site and on-site analysis and design approaches.

Three courses that explored the use of parametric methods to understand place in urban design pedagogy were taught in Eugene, Oregon, in Barcelona, Spain and finally in Portland, Oregon. Each course integrated urban design principles and table-based geospatial information, or GI, computing techniques measure phenomena of place. Unlike GI planning software such as ESRI ArcGIS and City Engine, the parametric software Rhino Grasshopper, with open

plug-ins for CSV tables and OpenStreetMaps OSM (Coast 2004) and custom scripting, allows students to use these methods to create customized urban design approaches for application at the human scale of urban space and time to understand people and place.

In the first course Parametric Places, held in the spring of 2014, students developed design tools using Rhino 3D, Grasshopper and custom scripting to analyze existing urban design criteria including minimum requirements of open space, social housing, social services and historic buildings with other qualitative characteristics in Barcelona's "22@" information activities district. The second course, part of Life City Adaptation: Barcelona Urban Design summer program, added on-site measurement of urban characteristics at street front locations and off-site parametric modeling pedagogy. The third course Measured Attachment, in the winter 2014, tested the application of previously developed tools but in Portland, Oregon, at the locations of public space, building envelope and interior building space, most deeply engaging these methods as tools of analysis to tools of design synthesis.

The Parametric Places course and Life, City, Adaptation: Barcelona program, or lcaBCN, both study Barcelona but the first is taught off-site while the second is taught in-situ in Barcelona. The Portland Measured Attachment course used similar in-situ methods as the on-site summer lcaBCN program but unlike the other two courses was an architectural design studio allowing breadth of time for both analysis and design synthesis. The two regular term courses fell within the ten-week term while the summer program was six weeks. The pedagogy of each course responds to the contextual problems of each place while addressing urban design principles, parametric design skills and design strategies when time allowed. The student projects in each course balance two needs—the human experience of place and the challenge to consistently formulate open information using parametric software. The design of these courses and subsequent design of student projects acknowledge both traditional and new digital methods to support people and place over time.

### **“Parametric Places” (Off-Site Analysis)**

This media elective in urban design course title Parametric Places was taught in Eugene, Oregon in the spring quarters of 2012, 2013, and 2014. It uses parametric software Rhino/Grasshopper and associated plug-ins to study open-ended planning relationships in the "22@" information activities district in Barcelona. Formalized in the year 2000, 22@ district guidelines include block-by-block requirements for new developments to include 10% open space, 10% social housing, 10% social services as well as requirements to protect buildings of industrial cultural significance. Students consider these and additional urban relationships while working off-site in Eugene, Oregon collecting data from documentation provided by the 22@ planning office, online mapping resources and general research of the Poblenou neighborhood, Barcelona and Catalunya.

The course began with teaching and writing exercises in urban design principles in the context of the city of Barcelona in parallel with exercises in firstly non-parametric application of Rhino 3D and later with parametric interface Grasshopper. Students learned methods using case studies in urban design and parametric design. Students then worked in groups of two to develop an urban analysis tool with design strategy implications.

#### **I. Barcelona and 22@ Urban Design Background, Weeks 1-2**

- Urban Design Reading and Writing Assignment, general and Barcelona context
- *Example* Study with unit block tiling exercises in 2D and 3D (hand media diagrams)

#### **II. Case Studies in Parametric Urban Design, Weeks 3-5**

- Analog parametric design in Rhino 3D / Illustrator
- Digital parametric design in Grasshopper for individual relationships

#### **III. Student Projects, in parallel with weekly Grasshopper plugin and scripting workshops, Weeks 6-10**

- Background problem and project purpose
- Comparative statistics to Portland, Oregon
- Formulation of urban characteristics to include
- Dataset gathering
- Analog para
- metric drawings, digital parametric drawings in Rhino Grasshopper
- Urban design strategy and drawings using analysis tool

Students first understand a place from an urban design approach identifying an urban problem of their interest and only then consider the use of parametric design to creatively formulate a design solution off-site for a local problem in Barcelona. Secondly students begin with analog tiling exercises to understand parametric design. They use the more open Rhino Grasshopper software rather than ESRI's ArcGIS and new ESRI City Engine to formulate comparative 'definitions' in Grasshopper. Existing datasets such as land use files and new datasets are combined by each student using online information. Projects are conceived as tools for planners, residents and business owners to affect behavioral change of human experience rather than formal design. Students follow the method listed above to observe, analyze and develop an urban analysis tool for use in Barcelona and applicable in other locations.

In their project "Intergenerational Interaction" students Vincent Mai And Ryan Kiesler addressed the needs of Barcelona's aging population as caregivers today. In Barcelona, one in every five people is aged 65 or older, compared to half that percentage in Portland, Oregon (Barcelona 2013-2016). The percentage of population aged 65+ increased from 14% to 20.5% between 1981 and 2010 (Barcelona 2013-2016). One in every four seniors is living alone. One in every four seniors has income lower than 532.51€ / month (Barcelona 2013-2016). Additionally, the current economic crisis has left the elderly as the primary caregivers of some of the youngest generations. These social behaviors have left both generations vulnerable and defined the urban design problem to enhance the quality of open spaces to support the interaction of these two generations. The purpose of this project was to create an analysis and optimization tool to inform the qualitative design of intergenerational spaces in the 22@ district of Barcelona, promoting social cohesion and community connectivity.

Applicable urban characteristics are identified and indicators (seen below in parenthesis) are used to measure and formulaically compare them to each other.

- a. Seniors Accessibility (senior housing; senior services)
- b. Youth Accessibility (kindergarten; elementary schools)
- c. Popularity (third spaces)
- d. Visibility (visibility of third spaces)
- e. Shading (3D geometry and building height)
- f. Safety (street traffic)
- g. Capacity (size)
- h. Feasibility (location of open space)

To gather data base geometry was taken from the 22@ zoning map PDF provided by the City of Barcelona. The primary source of 2D information was Google Map and Satellite. Google Street view was used to confirm street level information and Microsoft Bing Maps were used to supplement locational and descriptive information when views were not available. Google Earth provided 3D building information.

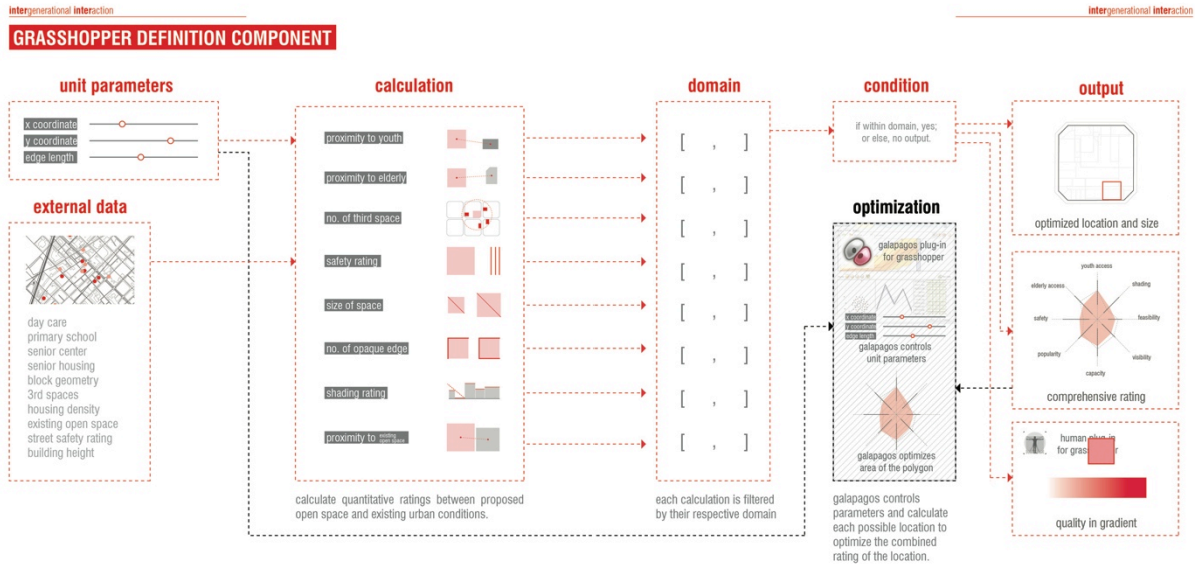
To codify data this project used a method previously developed with another off-site student project City Farm (Speranza 2014) to assign existing input values such as roof material types and building structural type to building lines and points in Rhino 3D, similar to a method using ESRI ArcGIS shape files often collected by municipalities for off-site data management of size, tax, owner and other values for properties and infrastructure. The HUMAN plug-in component "ObjectAttribute" was a key software element newly used in this application to read the attributes of layers and names in Rhino as data inputs in Grasshopper, mirroring the ESRI ArcGIS process.

The Grasshopper plug-in Galapagos was then used to compare the existing and the optimal location of open spaces formulated with other urban design characteristics. The analytical Rhino data set to Grasshopper process was reversed using the "AttributeOutput" component in HUMAN to output a custom designed spider chart that comparatively evaluates the eight urban characteristics of each study block.

- a. Seniors Accessibility (number and location of senior housing and senior services)
- b. Youth Accessibility (number and location of kindergarten and elementary schools)
- c. Popularity (number of location of third spaces)
- d. Visibility (site line and number of 3<sup>rd</sup> spaces or streets within 5m of open space)
- e. Shading (shaded / shaded + exposed = building height /  $\tan 0$  / width of block. 0 is simplified as the 12pm sun angle on June 21<sup>st</sup>.)
- f. Safety (SF 1 = 1 lane of traffic, buffered, wide sidewalk; and SF 8 = 3+ lanes of traffic, unbuffered, narrow sidewalk. Overall safety factor = safety factor / shortest distance.  $0.36 = SF 9/25 \text{ m}$ )

- g. Capacity (Size): Size of open space complies with a minimum of 10% block area requirement; and Size of open space support 35% (youth + elderly percentage) of residents
- h. Feasibility: proximity to existing open space (area of proposed open space to existing open space, 0m-160m)

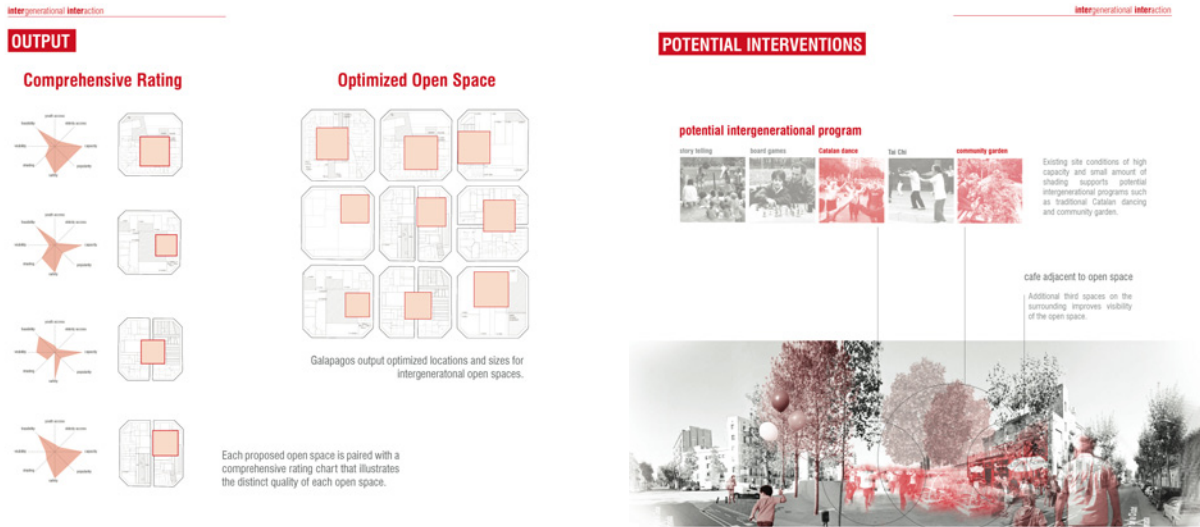
Many of these indicators were measured as distances in meters (a, b, c, d, g and h). Shading, Building Height (e) measured a numerical count and ‘housing’ used the name attribute of each building to list the number of stories. ‘Safety, street line with rating’ (f) was measured using the ‘layer’ attribute as numbers 1, 2, 3 and 4 for the number of traffic lanes, value 7 at the major street Pere IV and value 0.1 at limited access passage streets within example blocks. A protocol was encouraged to increase the data consistency and only one student collected any single data type. Codification was refined through an iterative process.



**Figure 1. Formulation of eight urban characteristic parameters and output.**

The output of final spider charts for each block demonstrates the value of a systematic codification and formulation of various characteristics to qualitatively compare spaces beyond an overall numerical score. A quality of intergenerational space was measured with qualitative, quantitative and geometric analysis. All measurements were also spatially located. The custom selection of characteristics, the custom formulation and the openness of Grasshopper scripting and plug-ins allowed the two students to creatively explore their understanding of place for the elderly and youth in Barcelona. Such a ‘tool’ or project would otherwise be very difficult to achieve in planning software such as ESRI ArcGIS that do not easily allow open formulation. In this case, off-site experience of the site was highly focused via early reading and statistical research, data collection via a familiar source such as Google Maps and Google Street View and processed in the familiar architectural scale software Rhino/Grasshopper with exploration of various plug-ins and custom scripts. The project will be shared with the City of Barcelona and the city of Portland, Oregon.

The project attempts to engage the challenge to measure qualities of urban space using parametric media (Koltava et al 2012) (Ewing and Hardy 2009). The project used limited indicators of important characteristics identified by the students. The instructor, more familiar with the area in person, described each parcel location in the Barcelona study area having lived in the area, noticing errors in understanding and translation. This was especially evident with cultural differences in early Catalan education with guarderías and escola besols for toddlers aged 1-5 and United States early childcare. Both students in this team were already familiar with the use of Rhino Grasshopper. Final design strategies and renderings of a possible future scenario were limited and minimal in their development perhaps by the time needed to understand the technical knowledge of the parametric design method and the short ten-week term.



**Figure 2. Spider charts for each of the nine study blocks.**

### **“Life City Adaptation: Barcelona Urban Design Program” (In-Situ Analysis)**

A second course methodology accredited for urban design and media development took advantage of its place in Barcelona in the summer of 2013. The Life | City | Adaptation: Barcelona Urban Design Program began in 2010 with the direct collaboration with the “22@” information activities district planning office. It builds upon traditional pedagogical methods that understood the ‘genus loci’ of the site (Norberg-Schulz 1976) both in its constructed geometry (Burns 1991) and ‘anchoring’ to the environment of the site (Holl 1996) including air and light (Ando 1991) as well as symbols and cultural rituals (Studio Works 4, Miralles,1997). The program has increasingly used digital media to leverage our understanding to sense the city using both visual (Lynch 1960) and non-visual senses (Vitiello Wilcocks 2006) and folding these into digital workflows through data management software, sensors, Arduino and robotic processors available today. Still the program is grounded in earlier developed in-situ observation, hand diagramming and mulit-media analysis of public spaces in both Barcelona and Granada, Spain.

The program begins with half-day neighborhood site-visits, group lunches in each neighborhood, and systematic mapping exercises using a unit based pre-parametric approach to diagram urban rooms their qualitative experience by hand. This is followed by skill based digital analog and digital parametric techniques off-site in a workspace on computers alongside trace and notebooks. Later, a series of in-situ site mapping exercises, first by hand and later marked digitally from a My Places Google map, records student determined qualities at 108 points across a 3x3 block grid to systematically collect data of urban characteristics on-site that inform their self-initiated urban programs. Traces of pre-digital parametric software from the program begun in 2010 are evident today as students do not bring computers to the four-day comparative visit to Granada, Spain. Since 2012, students use Rhino Grasshopper and other mobile app software to record, formulate, analyze and design tools similar to the Parametric Places course described above. Location in-situ in Barcelona versus off-site in Eugene, Oregon allows these observable field measurements. It allows students to experience everyday life, visits to nearby towns for cultural context and the interaction of local experts in planning, robotics, transit, landscape architecture and architecture.

Similar to the Parametric Places course described above, this program integrates urban design theory and writing skills with digital media skills education. The difference with this course from the Parametric Places course was the opportunity to teach urban design through on-site visits to neighborhoods. Neighborhoods are defined by four morphological types over the first four weeks of the program: maritime metropolis, modernisme, contemporary pluralism and other comparative types in Granada. Like Parametric Places the student slowly buildup an analysis

project but begin earlier in week two of this compressed five-week timeline to define that project. Design of an app and urban installation are aspects of this pedagogy not present in the previous Parametric Places course in Eugene.

I. Neighborhood Studies, Weeks 1-4: 1) Maritime Metropolis, 1329; 2) Modernisme (Art Nouveau), 1859; 3) Granada, Cultural Comparison; and 4) Contemporary Planning, 1992

- Urban room diagrams: wall, edge and tree / urban furniture; 60 second timed diagrams in series (hand media)
- Collage diagrams: time, material, vector and real-time database from online sources (mixed-media)
- Analog parametric design: Tiling Exercise of Plan Cerda (patterning in Rhino and Illustrator)
- Digital parametric design: Grasshopper unit relationships (digital parametric design in Grasshopper)

II. Student Urban Design Projects, Weeks 2-5

- Theory reading and writing assignment of project definition
- Mapping I, BCN: 108 point 'heat map' of indicators, table entries with mobile smart phones (hand and mixed-media)
- Group project definition
- Mapping II, GRX: Neighborhood diagrams of Albaicin, historic center and other neighborhoods in Granada. (hand media)
- Mapping III, BCN: Sample block and 3 x 3 and neighborhood (digital media)
- Infographics: Diagramming Statistics + Comparative Data (digital media)
- Grasshopper Urban Analysis Tool Definition
- Geomapping: Grasshopper + Elk, alternative to GIS
- Interface Design I: Mobile Application Interface Design
- Interface Design II: Urban Design Intervention in selected open space.

In-situ experience is unique to individual students. It empowers their critical thinking to discover how to abstract and codify information as designers. Open design tools such as Grasshopper plug-ins and scripting offer more specific opportunities for comparative formulation than ESRI ArcGIS planning software. Students systematically codify their experience first-hand. Aggregation of the data as a class, for example two indicators of relevant urban qualities each, encourages the students to follow and embed a clear data dictionary of their work shared with all eight colleagues. The consistent observation, codification, recording and communication of this data translation into numerical and typological data is a major source of unfamiliarity and inconsistency that is improved through iterative data collection both in Barcelona and Granada. The overall experience by students to live in a place for six weeks and visit comparative locations to modestly understand a culture and everyday life, to have a passionate urban problem to investigate and confronts with the difficult challenge to measure social behaviors and urban qualities both directly over various times to make the data more representative and through recording of indirect indicators of those qualities including traces (Gray 2010) or patterns (Johnson 2007) of their existence.

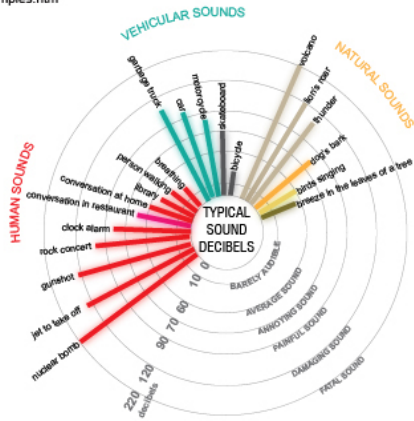
In the student project "Interactive Sound Tool" by Pedro Peralta, Eleazar Racoma and Alexandra Lambrechts, the sensory experience of sound is combined with other indicators of urban design characteristics to provide a tool for citizens to understand place and sound in real-time. The tool measures both quantitative decibel and qualitative types of sound qualities in-situ in Spain such as human sounds, natural sounds and natural sounds. Personas such as young families looking to buy a first apartment, people looking for street activity on a weekend evening or an individual looking for a quiet place to read on a Sunday afternoon might use the tool.

The following initial urban design characteristics were measured and geospatially located using latitude and longitude numbers in CSV tables (codification in parenthesis): zoning use (type), sensitivity to noise (rated 1-5), fenestration operability (open/closed), density of people (count), construction (yes/no), noise source (type) and decibel level (number). A mobile app and urban kiosk were designed as ways to collect live data and for people to interact with this analysis and make informed behavioral decisions.

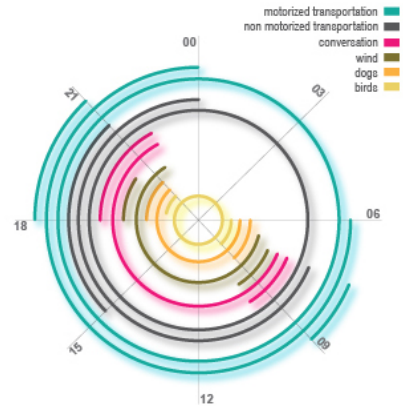
### Background Data

#### Average dB Levels

<http://www.industrialnoisecontrol.com/comparative-noise-examples.htm>



### Sound Timeline



<http://pickanalysis.com/how-hearing-loss-and-your-work-are-related/>

**Figure 3. Interactive Sound Tool, Background data of quantitative and qualitative measurement of sound.**

Zoning Use (particularly measuring residential and ground floor commercial activities)

Noise Source + (type of noise source)

Decibel Level + (measurement of decibels at location and time)

Sound Output (type of sound)

User Persona +

Sensitivity to Noise, rated 1-5 (not used)

Fenestration Operability {Open/Close} (not used)

Density of People (not used)

Construction {Yes/No} (not used)

+ indicates in-situ measurement necessary

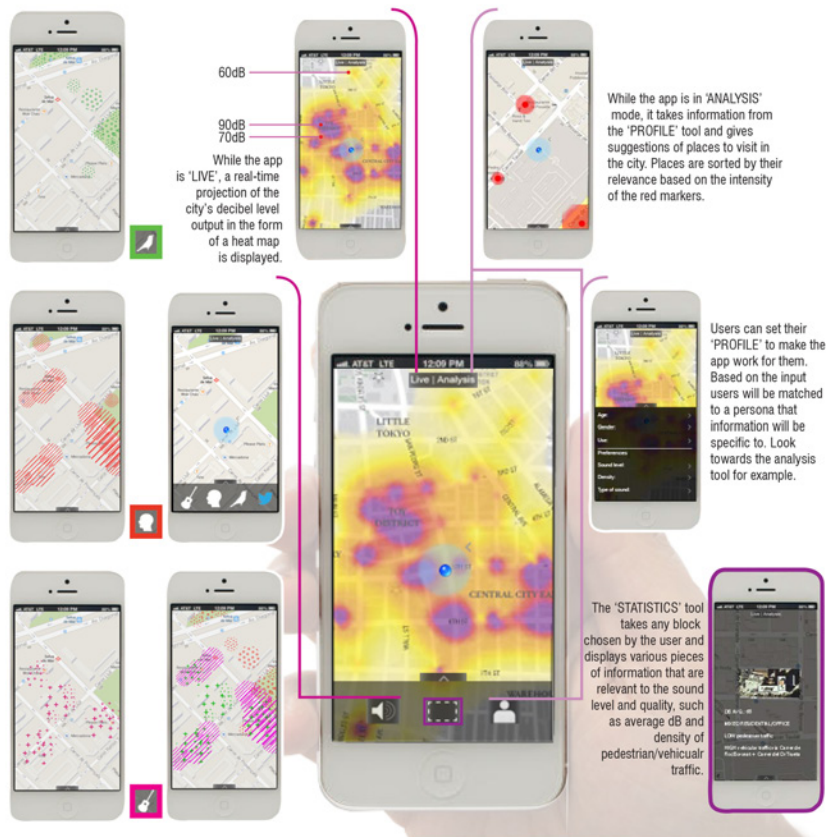
Data was gathered with all indicators observed first-hand including verification of zoning use with existing off-site data. Decibel levels were measured with mobile phone app Decibel Ultra (Schafer 2007). Data was recorded and mapped with 108 points over a 3 x 3 grid of Blocks in the Poblenou area of the 22@ district in Barcelona and later comparatively in small placetas in the Albaicin and avenues neighborhood in Granada, Spain. Data mapping was done iteratively over a 24 hours period. Again, the Human plug-in for Rhinoceros Grasshopper was used to visualize data into colors. An important differentiation of data occurred when students realized that sound data was not only quantitative but qualitative. This led to the differentiation of sound in types as human sounds, vehicular sounds, and natural sounds against an abstract scale of human tolerance of sound (Figure 3).





**Figure 4. Interactive Sound Tool, Qualitative conditions codified to types**

Data was codified with sound quality types cataloged and differentiated for use by a 0 to 5 rating system for use as inputs in Rhino Grasshopper using CSV tables with location based latitude and longitude information like ESRI ArcGIS. GI locations were brought to the CSV via custom Google My Map pin, exported as KML and converted to CSV format. The Grasshopper Human plug-in is then used for custom indicator formulation, analysis and visualization of the information using color outputs over neighborhood maps.



**Figure 5. Sound Pollution, Mobile App Interface**

This project, like other in-situ projects, benefitted from measuring both observable use of space by people and the physical indicators of these behaviors. A challenge to this observation by students both seen in the first 108 point 3 x 3 test area in Barcelona, the more diverse test areas of various sizes in Granada and in final case study areas in Barcelona, was the interest to measure people's behaviors directly over time. An observation at any single time, for example, around 4pm in summer months of July or August in these locations, would reveal very little use of public space. Some of these spaces, especially those in the everyday spaces of the city, come to life late at night. Temperatures reaching 45 degrees Celsius could explain this behavior by local residents. This revealed the value to record fixed indicators such as benches, waste or operable windows of more transient behaviors. Observations over time occurred but posed the challenge of other environmental variables being different. This posed a danger of data analysis if the students failed to recognize that the data may not be representative of everyday human experience.

The output for this tool is an interactive visualization (Figure 5) of sound quality and type for a given neighborhood and urban room location. The interface would provide a feedback loop with users as a mobile phone app or located at situated technology such as a kiosk. The intermediate step of designing a mobile app interface between time-based design drawings and final urban intervention was particularly facile for this generation of students accustomed to mobile app interfaces through their daily lives. Should design work focus on traditional long-term resilient elements of urban design such as paving materials, permitted street-level uses, service vehicle access and serene park space or should design work focus on the public access of information (McCullough 2012) for each city user to make decisions about their use of space? The final review of the project in Barcelona sparked an intense discussion between invited urban design professionals, academics and city agent representatives whether a physical intervention in public space and without a fixed infrastructure is urban design.

#### **“Measured Attachment- Big Data Meets Urban Design: (In-Situ Analysis and Synthesis)**

The third course titled “Measured Attachment- Big Data Meets Urban Design” was an architectural studio in Portland, Oregon in the winter of 2014, and provided greater opportunity for digital analysis and design synthesis in an integrated workflow where the Rhino Grasshopper software/file as a tool achieves an agency as a tool to be used in various locations over time. Previous digital parametric software such as Maya in the 1990's were closely related to theories of time and ‘event architecture’ (Tschumi 1996) acknowledging philosophers Jaques Derrida, Theodor Adorno, Paul Virillio and Gilles Deleuze as new ways to approach site and context using digital media. Parametric inputs of existing formal site conditions of rivers, streets and topography used Maya MEL (Alias/Autodesk 1998) scripting to acknowledge place (Schumaker 2008). Later ideas of agents (Allen 1999) and mapping of materials, ecology and time (McHarg 1969) (Corner 2004) led to more recent seamless process of analysis and synthesis of design (de Landa 2011) (Latour 2005) evident in this studio project.

The building program for this project called for an approximate 60,000 square feet of industrial office, or ‘maker’ space, and complementary third-spaces for Portland transit agency TriMet's forthcoming Milwaukie Alignment light-rail corridor. The ten-week studio was divided into three parts. The studio began with two parallel site analysis studies: 1) a traditional site analysis done as a class; and 2) students working in groups of two or three to each identify and measure two on-site indicators of urban design characteristics for a 3 x 3 study area within the project's Brooklyn neighborhood located between Division Avenue and Powell Boulevard in Southeast Portland. The students then repurposed existing Rhino Grasshopper based ‘tools’ from previous Parametric Places and IcaBCN Program coursework. In a second part of the course students tested the application of these reworked analytical tools for design synthesis with one student each focusing on urban space, the urban envelope and extension into the interior building space. The last third and final part of the term was devoted to design development also using parametric design. Similar to in-situ work in Barcelona, but to a greater extent, the studio worked closely with local stakeholders including the property owner Stacy Witbeck and its development team of urban design consultant John Spencer and DECA Architects, Portland's Department of Planning and Sustainability and Portland's transit agency TriMet.

The course approach here took advantage of the case study approach of the Parametric Places course but began from urban analysis tools developed in previous iterations of the courses described here. The development of individual tools was similar especially by week three of this ten-week studio course but by week four students were already deeply investigating the application of these analysis tools as tools for the synthesis of design at the scale of architectural building and urban design spaces rather than the smaller urban installations such as kiosks seen in the

previous Parametric Plaes and lcaBCN Program. Students worked on-site and off-site according to the following outline:

I. Analysis, repurpose existing Parametric Places or lcaBCN Program tools, Weeks 1-3

- Problem and Purpose statements
- Traditional site analysis: city, neighborhood, district plans; 3 x 3 test area plan and 3D model; existing city and academic planning analysis of the site; site material and time maps; transit analysis; district scale physical model
- Parametric analysis tool using existing tools but reformulated with new urban design characteristic indicators.

II. Application to Design Synthesis, Weeks 4-6

- Application of analysis tool as tool for design synthesis at three scales of urban space, urban envelope and urban architecture

III. Design Development, Weeks 7-10

- Parametric design tool at three scales
- Scaled drawings and 3D modeling

Approach

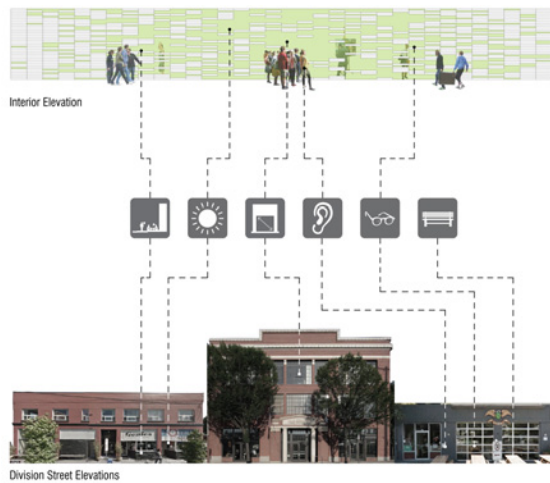


Successful Area

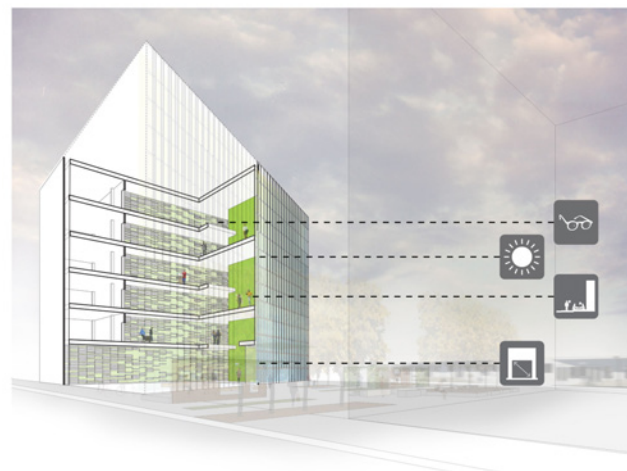


While there are many aspects and elements that go into creating a third space, the interaction between the third space and its urban approach is vital to establishing its quality and activeness. The quality of the streetscape and the third spaces are both improved by the effectiveness of each other. Measuring both of these categories and laying them over one another displays graphically that an active third space is directly related to the activity present along the streetscape. This tool has taken measurements at existing geo-locations and does not measure the entire fabric of a street. However, the amount of data points measured sufficiently represents the overall quality of the streetscape.

Elevation Study



Sectional Perspective



**Figures 6a, 6b, 6c and 6d. Active Third Space, site analysis of indicators. Listed clockwise.**

Previous courses described here were either off-site or on-site but lacking a significant depth of design engagement. This architectural studio allowed in-situ data collection, critical design understanding from analysis to design synthesis, and design development. Projects were ultimately self-formulated. Rhino Grasshopper software was used to both analyze and synthesize creative solutions that followed the on-site understanding gained by students in the immediate 3 x 3 test. The design development allowed a simultaneous use of parametric design from input to design output to recreate not immediate formal relationships in traditional design methods but ways to support a qualitative experience from existing urbanism understood by each student on-site. Still, the shortened ten-week term provided a challenge to develop small-scale architectural scaled resolution, compensated by working in groups of three students, encouraging simple building form via maximum build-out of the building envelope, weekly evening media tutorials outside of class and the participation of outside stakeholders.

The two student designers Dan Davis and Ryan Dirks of this project “Intersecting Locality” based their project on the question if the design of the built environment could be linked to urban conditions based on a heightened understanding of selected experiential qualities. The studio method provided them with a way to sift through the aspects of a building that determine its sense of place and identity, allowing a targeted design response at social intersections on the site. Careful repurposing of existing Rhino Grasshopper tools allowed the observation off-site and the in-situ adjacent 3 x 3 study area of seven urban design characteristics listed below. Three characteristics were especially informative on-site for the later project and recorded to a CSV table as follows: numerically counting seating, the depth measurement in feet of space from the sidewalk into storefronts and the measurement of the material diversity of façades.

*Urban Design Characteristic Parametric Indicators List*

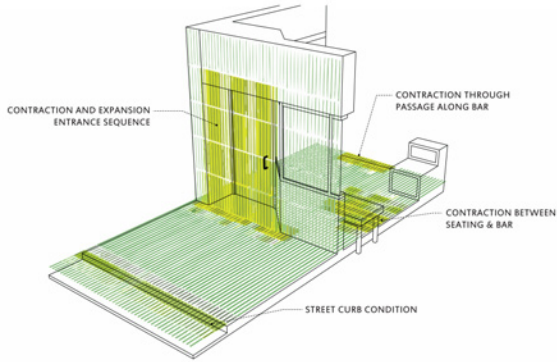
- a. Seating + (including accessible interior spaces)
  - b. Planting
  - c. Spatial expansion +
  - d. Material variation +
  - e. Façade transparency
  - f. Lighting effects / shadows
- + *indicates in-situ measurement necessary*

Data was gathered in the test area using observation and ratings based on the codification above. The one exception is material variation, which was defined as the number and percentage variation of materials on the façade (not counting small areas like flashing, coping, etc). Google maps and Google Street View was used before and after in-situ observations to help focus indicator selection and ways to record and confirm the data. Underlying geometry was imported to Rhino Grasshopper via the Elk plugin using crowd-sourced OpenStreetMap (OSM) file downloaded online from openstreetmap.org (Steve Coast 2004). On-site measurements taken in iterations throughout the term rather than the traditional single remote studio site visit, were important to this analysis and design process. They helped ensure a more representative understanding of the street-level neighborhood identity (Jacobs 2000) which is normally a significant difficulty for measuring social behaviors on-site directly.

**DATA ANALYSIS: EXPANSION & CONTRACTION**  
 DIVISION ST. SOUTH FACING ELEVATION: GENIE'S CAFE



**INTERIOR ARCHITECTURE:  
 EXPANSION & CONTRACTION**



**DATA ANALYSIS: FACADE TRANSPARENCY**  
 DIVISION ST. SOUTH FACING ELEVATION: GENIE'S CAFE

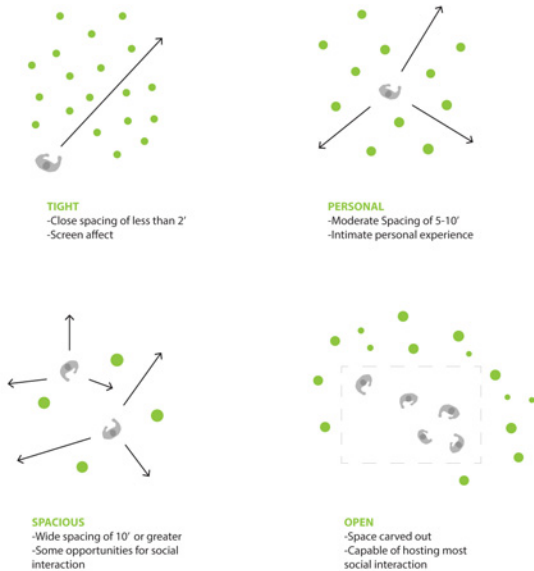


HIGH: STOREFRONT GLAZING  
 LOW: PUNCHED WINDOW  
 MODERATE: GLAZED ENTRANCE

**Figure 7a and 7b. Analysis of neighborhood test area elevation indicators.**

Data was codified with image bitmaps used to analyze storefront elevations in the neighborhood test area and to rate patterns of indicators for consideration in the new design proposal. Although some directional inputs were on the new site proper, measurements of urban qualities of the immediately adjacent neighborhood were used for critical design decisions for types of urban experiences including various qualities of spatial expansion in the new site, seating and material use. The exploration of ‘third spaces,’ (Oldenburg 2001) defined as places for people to meet in public space demonstrated a difference in United States conception of public meeting space versus ideas for meeting space in Europe via the original repurposed tool’s use in Barcelona.

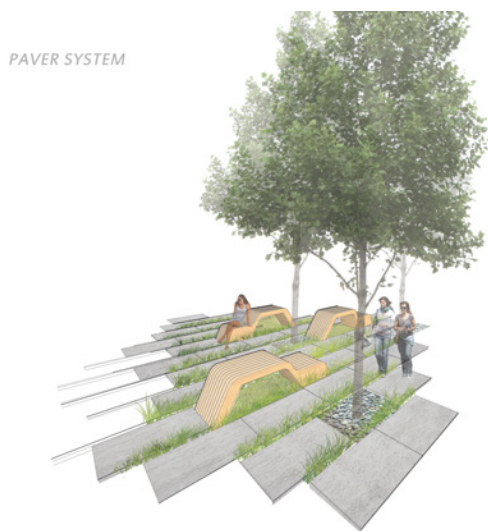
**PLANTING SPACING CONDITIONS**



**SITE PLAN: GROUND LEVEL**



**Figures 8a and 8b. Design synthesis studies of spatial expansion and seating in the immediate design site.**



**Figures 9a and 9b. Design synthesis studies of spatial expansion and seating in the immediate design site.**

This project revealed the usefulness of these open methods to measure unique qualities and translate to output of various landscape urbanism and architectural scales. These parameters are not available in ESRI ArcGIS software nor easily found in existing database files by municipal or private sources. As seen in the other in-situ project in Barcelona the use of table based CSV files of point locations in occupiable sidewalk right-of-ways were preferred to object attribute assigned values from the Parametric Places projects including INTERgenerational INTERactions.

The challenge of integrating a parametric analysis and design process into one design approach was revealed with this process. An important outcome was the understanding that on-site measurement of urban qualities need not be direct. For example, the site in this project was slated to be mostly demolished and the current built fabric did not represent the current nor future identity of the neighborhood along Division Avenue near 12<sup>th</sup> Street. Thusly deriving flows and forces currently across the site would not be relevant. Instead the intersection of Division and 12<sup>th</sup> Avenue was used to qualitatively understand the neighborhood and develop a quantifiable way to measure that understanding. This provided an indirect way to then apply these same analysis tools as synthesis tools for the design project. Some force lines such as views to downtown Portland, approach directions from the forthcoming light rail station stop, personal space and other local flows were used as inputs for the design, façade and urban space approaches.

Important to success of the design process were: 1) group work of three students not only to disperse the work load but also to discuss this new design method and necessary skills; 2) beginning with preexisting Grasshopper tools to later take ownership and repurpose; and 3) all of these Master of Architecture students had a previous undergraduate background in architecture, albeit from varying backgrounds especially with regard to traditional urban design and digital parametric media.

## Conclusion

Place and time are important aspects of phenomena that may be included in urban design education with the use of new digital methods. New methods of urban design education today support the measurement of everyday phenomena through: 1) systematic comparison of urban qualities; 2) the measurement of phenomena as experienced by students over time and 3) open formulation of urban characteristics by each student using digital methods. The three courses described here use off-site and in-situ learning to test these ideas. The study of codification of time-based phenomena is important in a world of ever increasing integration of everyday digital connectivity. The way people experience cities has changed. The way we gather data and later integrate that into design has changed leaving us with the task of understanding how to fold together accepted traditional urban design methods with these new methods.

GIS planning software first seen in geography and planning education courses taught by Edward Horwood at Northwest University in 1963 and Howard Fisher at Harvard (Chrisman, 2006) did not initially achieve these three goals of experience, open and formulaic methods possibly available today via new tools for on-site and off-site analysis. GIS first initiated a shift in pedagogy and practice from geometry-based CAD files to ESRI 'shape files,' geospatially relating non-spatial information in table-based format including latitude and longitude with zoning use, number of stories, tax records and other parametric values. Early GIS did not broadly address dynamic modeling, new urban models and a closer tie to urban policy (Su 1998). The pedagogical methods of parametric urban design currently researched by others and discussed in this paper seek to extend this non-spatial integration into analysis and design. Professional urban design agencies such as Metro planning, Barcelona's 22@ agency, and the Barcelona Agency of Ecological Urbanism (Rueda 2012) and others have actively used tools such ESRI City Engine and custom digital simulation tools to integrate both qualitative and quantitative information together.

As described in the projects above, the inclusion of qualitative urban characteristics in analysis requires a deep understanding of Grasshopper, plugins such as HUMAN and CSV components as well as sensors and careful codification protocols on-site. The greatest danger and source of future research was the distinction between measuring human social behaviors directly or indirectly via either traces of human occupation or the ability of the built environment to support the interested urban quality. In either case the design student inherently faces the challenges of quantifiably measuring experience such as numerical decibel levels or codifying through a rating system such as 1 through 5 for the ability to sit. These analysis challenges were met with other challenges to then synthesize design. Digital parametric design skills are not yet widespread. Still, the acceptance of parametric design in the related architectural, landscape architectural, ecological, planning and policy fields of urban design suggest that the application of parametric design to geographic information systems is forthcoming. The following concluding points may facilitate the use of parametric design in urban design.

### *Systematic Abstraction of Information*

The traditional use of existing ESRI ArcGIS planning data off-site in urban design often removes students from their individual approach to abstract the phenomena they experienced with their own language of design. While the codification of qualitative experience into quantitative measurements and types is a careful one to limit subjectivity, it also generates an important individualistic understanding of design formulation in urban design by each student. Examples of GI tools that assisted in the objective codification of urban information include the software Space Syntax by Bill Hillier (1976) and the subsequent criticism of its inconsistency by Carlo Ratti (2004) at once points out the value of a broad system of comparative data and the danger to flatten individual understanding by codifying very complex understandings of urban design.

One of the challenges but keys to the methods described in this paper is systematic consistency, especially between students. Collaboration is important in the complex direct and indirect (Heath, Oc and Tiesdell 2010) processes of urban design. Collaboration may occur between consultants professionally and between students when Grasshopper scripts and partial scripts are passed from person to person. Collaboration was essential in the Portland studio between the three-team members of exterior space, envelope and building design. It was also essential between all the course members who shared the first in-situ data as individuals would use other students' recorded data as their design intentions clarified. In Eugene's Parametric Places class Grasshopper scripts were exchanged between years of students. In Barcelona collaboration of data occurred both within the program and with other programs. In all three courses repeating data gathering and codification was essential. Clear protocol and communication in the form of data dictionaries was helpful. This problem of understanding types of data including that made from scratch is well documented by MIT's SENSEable City lab (Nabian 2013).

Courses taught off-site, for example the Parametric Places course were the most geometric for students- assigning attributes to building curves in Rhino using Rhino Grasshopper plug-ins HUMAN. This method is more visual for students connecting geospatial information with codified qualitative information. Off-site, or virtual site visits with Google Street View, did create errors in translation and cultural did occur such as the children's daycare and kindergarten uses described in the Parametric Places project Intergenerational Integration. Students today have such a comfort with off-site information that the risk exists to make clear presumptions about being in one's own cultural location- less likely when on-site in a different environment. On the contrary, the students with off-site projects were able to devote more effort to carefully codify and develop complex Grasshopper parametric tools than student on-site in Barcelona who spent more time in-situ away from their computers. Those students were more deeply engaged with observing or 'seeing' (Larson 2006) than analyzing it. The Portland studio students who has both the Grasshopper software support and in-door computing space as well as local proximity to the site to visit frequently and live in the place, had the most successful 'see-move-see' (Lawson 2006) design projects.

Projects conducted on-site used Rhino Grasshopper but the more abstract CSV workflow with latitude and longitude based qualities to sense sound, smell, feeling and taste to complement existing GI data such as tax information, lot size, last sale, address of current owner, zoning use, etc. Attributes of qualities were not assigned visually to a building curve in Rhino 3D but relied on the spreadsheet workflow- not directly visual nor in the same design environment of Rhino 3D but relying on linked CSV and OSM files. The on-site project "Interactive Sound" for example related CSV decibel levels, noise source, sound type and user persona with existing residential zoning use and ground floor use assigned in Rhino 3D first observed in person and confined with Google Street View.

Urban design projects are complex. In the profession they utilize analysis and design members across disciplines and locations. The differences working on-site and off-site using both native Rhino 3D attribute information versus CSV and OSM table based spreadsheet information suggests a need to have a clear protocol between team members. While the parametric urban design methods are complex relating various types of information across software, and thusly the need for systematic abstraction of information, it mirrors the real-world professional challenges of urban design.

#### *Inclusion of Experience Over Time*

The projects presented in this article were intended to interject the experience of student site visits, both virtual and physical, in the use of parametric design to understand place. Off-site projects in Eugene, Oregon demonstrated an extraordinary creativity to experience the site virtually from 5,637 miles away beginning with existing data, the exploration of possible new data and the formulation of integrated analytical and design synthesis tools (de Landa 2011). Ten years ago this was not possible in the same way. The current generations of students understand how to 'attachment' their projects to place despite great distances (Latour 2008, Seamon 2011). In fact, the use of datasets generated from real-time information sources such as Google, Bing and the City of Barcelona suggests that students are quite comfortable today to design not a singularity of design for their project but allow the agency of the information and tool itself connect their projects to place over time. Thusly the projects in all of these courses accept new approaches to design (Woodbury): that the agency (Latour 2008) of an analysis/design tool is an effective form of design today to design not singularities but design that adapts over time and location.

Clear limits are present with parametric urban design in-situ to include the experience of student designers. These challenges could be described in three ways: 1) presumptions; 2) technically challenging and 3) not comprehensive. Presumptions are made in the need to simplify experience into quantitative numbers as seen in the flattening of experience into 1 to 5 ratings to CSV tables. Technical needs to understand the software and possess sensors are more tedious than the traditional hand media to record observations quickly and in the hand of the designer. Lastly, design projects with parametric urban design projects are noticeably less comprehensive and more focused on small differences in experience given the technical needs to master the digital methodology. This is apparent in the focused efforts of Zaha Hadid and Patrik Schumacher in formal study- perhaps necessary to master that technique at its inception ten years ago. Designs are less holistic but seemingly more technically objective than traditional urban design.

Regarding this last point of focus of each project and lack of comprehensive design in parametric urban design, projects executed in-situ in Barcelona and Portland measured a smaller scale of effective phenomena. Data of experience was gathered at the human scale in person, such as spatial extension measured in Portland and sound qualities recorded and categorized in Barcelona and Granada, Spain. This acknowledgement of human scale in-situ often resulted in the identification and measurement of urban characteristics and design solutions at the small human scale- deeply grounded in the students' experience of place, and the project's connection to its environment, rather than geometric formal design (Franck 2007). The project Intersecting Locality in Portland demonstrated this by



investigating the qualities of space, seating, material diversity and shading not immediately evident in the site but found in the local neighborhood. In this was, parametric urban design offers new ways to understand place on-site (virtually or physically) that may complement traditional methods of urban design.

### *Open Urban Characteristic Formulation by Each Student*

The third emergent point from these three projects and the pedagogical methods described here is the power of open formulation of urban characteristics to measure place. Traditional zoning and planning data found in existing municipal CAD, shape files and pdfs's do not unlock the creative minds of students. Likewise more closed software such as ESRI ArcGIS while refined in their development are not as open as the free and open files constantly being updating Grasshopper Forum ([www.grasshopper3d.com/forum](http://www.grasshopper3d.com/forum)) community of users. Traditional methods often assume impersonal ways to understand place that are not necessarily connected to the individual constructed experience of each student (Wiggins 1998). Traditional software limits the ways in which urban characteristics maybe compared. The new methods to formulate unique tools for formulate selected urban relationships using Rhino Grasshopper suggest a different approach to site analysis that provides a greater richness of data to methodologically include the experience of a place in urban design projects more than traditional GIS planning approaches.

The value of open software will play an important role in the emerging trends of media methods in urban design pedagogy. Social media critic Evgeny Morozov 'solutionism' (2013) reminds us to question data, "Recasting all complex social situations either as neat problems with definite, computable solutions or as transparent and self-evident processes that can be easily optimized--if only the right algorithms are in place!" Morozov is a proponent of open software that empowers the everyday users instead of concealing these algorithms in the hands of large corporate and government interests seen with closed proprietary software.

Open formulation has it challenges. While open files such as those found on OpenStreetMaps, may be free to download (a recent studio request for a Detroit district ESRI shape file was responded to with a \$1200 price) the information is not consistent. Data may be missing. Data may be inaccurate. Data fields within the same city such as building outlines within the cities of Barcelona or Portland are present in some neighborhoods but not in others. OSM is also a unique coding language. Grasshopper plugin Elk currently only provides access to streets, rail, bikes and waterways without custom scripting to access the many other data types within OSM files. Likewise, while Grasshopper and these plugins are free, the base software Rhino, or Rhinoceros, by McNeal is not.

While the interests of the methods described in this paper are more focused on the education on urban design students and professional application rather than broader socio-political contextualization, Evgeny Morozov's ideas of the creative empowerment of open solutions frames the parametric urban design methods presented here to embrace these new approaches that explore ways to integration our first-hand experience to observe, understand and design the urban environment. Student work in urban design today needs to integrate traditional urban design approaches with parametric software and everyday mobile computing devices such as smartphone apps and sensors if it intends to engage design thinking that is part of the everyday lives of urban designers both in the academy and the profession. Such methods allows students to connect their everyday digital world with established and emerging urban design practices. The ways to measure observable experiences are different today than in the past in the way they empower students to personally codified and creatively explore design solutions to connect people with the places they live.

Future directions of the research include application of these methods to broadly measure the social interaction and cohesion of neighborhoods. The ability to measure GPS and parcel scaled information first-hand will comprehensively include social indicators of space, housing, services and work in the lens of both public and private spaces. Demographic indicators will include age, income and cultural background. Infrastructural indicators will include indicators of access to transit and information technology, also through the lens of public and private access. Custom scripting in C++ will be needed to develop Grasshopper components to measure existing OSM files and new datasets gathered on-site. Urban morphological comparisons will be done in comparative neighborhoods in Barcelona and Portland.

Other research projects with investigate patterns PM particulate matter air quality and high resolution urban design characteristics for the healthy development of children in cities. These studies include on-site testing in neighborhoods in Barcelona, Spain and Portland and Eugene, Oregon. Likewise the methods are being used to study a 17 acre riverfront development and related 60,000 square foot maker space and possible public market integrating

data of water flow along an adjacent river, electric use across neighborhoods of a city, air pollution and sound pollution.

These examples of future research around the area of parametric urban design demonstrates the need to test these new methods to understand this understand of smaller-scaled and time-based phenomena information of place over time. Future research will attempt to develop protocols for data gathering and processing. It will also address the need to integrate analysis and design in the agency of one tool to make this analytically information applicable to design solutions that improve the life of city habitants in our communities.

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### Figure captions list

- Figure 1. Formulation of eight urban characteristic parameters and output.
- Figure 2. Spider charts for each of the nine study blocks.
- Figure 3. Interactive Sound Tool, Background data of quantitative and qualitative measurement of sound.
- Figure 4. Interactive Sound Tool, Qualitative conditions codified to types
- Figure 5. Sound Pollution, Mobile App Interface
- Figure 6. Active Third Space, site analysis of indicators.
- Figure 7. Analysis of neighborhood test area elevation indicators.
- Figure 8. Design synthesis studies of spatial expansion and seating in the immediate design site.
- Figure 9. Design synthesis studies of spatial expansion and seating in the immediate design site.