Evaluating a web based urban design reference tool

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The research presented here examines how a web-based urban design reference tool called elementsdb was used in four landscape architecture, urban planning, and environmental design courses. Using a sequence of questionnaires, focus groups, interviews and content analysis, the research tested the hypothesis that interactive use of the database would enhance student learning by providing students with spatial data-rich precedents of well-designed buildings, streets and sites. This paper introduces elementsdb, which provides high quality project specific urban design precedents, presents its structure and contents, and illustrates how students utilized it. The findings reveal that many of the students acquired some basic urban design knowledge, and we found three categories of student use: i) as a passive reference medium to look up information; ii) as a mechanism to assist with critically evaluating existing urban development; iii) in the a form-making process to assist in the creation of designs; and iv) as an evaluation of urban redevelopment propositions. We conclude with a discussion of issues related to incorporating web-based precedent cases into studio pedagogy to meet the growing needs of design education and professional practice.

Responding to the needs of today’s urban design students

Planning and design education helps students attain literacy and familiarity with abstract, empirical and three-dimensional information about the forms and systems that make up cities, particularly sustainable buildings, sites, and neighbourhoods in a relatively short time-frame (Al-Kodmany 2001, Gaber 2007). Many students in graduate-level professional programs in landscape architecture and urban design come from non-design backgrounds,
thus their facility with understanding and envisioning three-dimensional built form is limited, as is their knowledge of the wider implications of the different alternatives they might imagine (eg. environmental, construction methods, costs, marketing). Tools that help them to quickly spatialize and envision propositions are valuable. Those that also provide deep content with visual, textual and numerical information add depth to the educational experience. Since today’s students are inclined to look for precedents and other references on the web, we set out to test the application of a set of web-based urban design reference tools.

The design studio, in which knowledge is learned through experience, is the dominant pedagogical environment in architecture, landscape architecture and urban design (Akin, 2002). Acknowledging that, in the strictest sense, design experience demands the actual production of a design, Heylighen and Neukermans (2000) argue that designers also gain important experience from visiting building projects and by interpreting secondary images and pictures. Ultimately, they contend, “What all these interpretations of experience have in common, is that there is a concrete design project at stake” (Heylighen and Neukermans, 2000, p. 87). Thus, concrete design projects, which are more commonly called ‘design precedents’ or ‘design cases’, are widely accepted as core experiential learning tools in the design studio environment (Miranda and Park, 1998; Akin, 2002; Oxman, 2003; 2010).

Akin (2002) describes precedents as: “specific designs or buildings, which are exemplary in some sense, so that what architects and students glean from these examples can support their own designs” (p. 409). As an experiential learning tool, precedents act as a first step in the design process, and allow beginning designers to give form to their ideas without ‘reinventing the wheel’ (Akin et al, 1997). The dominance of precedents and design cases in the design studio environment, explains Boling (2010), stems from the custom of referring to examples of built projects over the utilization of robust principles in design practice. This form of instruction separates design education from more traditional academic disciplines, because: “students are directed to a corpus of desirable outcomes rather than principles and theories. Based on this, they are expected to produce similar results with novel features” (Akin, 2002, p. 409).

From as early as 1997, Akin et al. (1997) linked case and precedent based design to digital technology. They argued that “…a principal role of current design instruction is to expose students to a rich repertoire of outside precedents. We believe this can be done effectively in a computer medium” (Akin et al.,1997, p. 266). Computerized databases have been hailed as a logical and formidable forum to house episodic memories, or precedents. The principal advantage of storing case-based designs in a computerized system is the accessibility afforded to designers, and the multiple forms of data that can be seamlessly collected and disseminated from one integrated platform. These data sources include: text, two-dimensional graphics and multiple CAD files, including three-dimensional visualizations and urban simulations (Oxman and Shabo, 2002). While there are plenty of detractors from the idea of exclusive use of computers in design (Andia, 2002, Fraser and Bjornsson 2004) and evidence that students who no longer design by hand are missing an important learning block (Turkle 2009), the potential for computers to provide high quality models and data on built projects is vast. The challenge, then, is in employing the use of visualization in ways
that would capitalize on its efficiencies in the experiential learning environment of the studio but without detracting from the creative explorations of design students (Tai, 2003; Fraser and Bjornsson, 2004).

**elementsdb**

The web-based reference tool we tested for this research is a database of parcel-scaled precedents of contemporary urban land uses called *elementsdb* (*elementsdb.sala.ubc.ca*). The database contents were designed to provide tools and examples to assist urban designers and members of the public engaged in urban design decisions to develop sustainable urban design solutions at a neighborhood scale. Data collected is fundamentally urban planning and urban design-oriented — attempting to capture the qualitative and quantitative dimensions of informative, replicable examples and practices of sustainable urbanism. We made an assumption in this research that this database of precedents would also be instructive in the classroom setting. Central to *elementsdb* is the understanding that the urban environment is divisible into parts, primarily parcels of land and rights of way. This resource catalogues examples of urban development and provides tools for organizing, sorting, sifting and gathering information on individual cases. Cases are built from field-measured examples of the land use elements of urban form — parks and open spaces, streets, residential, commercial, civic and industrial parcels and buildings. *elementsdb* is in an early stage of development and included 123 cases at the time of this research. Three dimensional digital models associated with each case are downloadable, and the data is exportable. *elementsdb* was designed to have four distinct purposes for progressively demanding tasks: i) as an urban design literacy aid, ii) as a passive reference tool to look up information; iii) as a form-making tool to visualize measured urban design propositions in context; and iv) as a tool for creating comparable, measured scenarios of urban design proposals.

Measured visualization demands that cases be comparable. Each case is therefore rigorously measured and illustrated using easily comparable data standards and graphic conventions. Illustrations of each case include a three-dimensional (3D) model, a site plan, an aerial photograph, and street level photographs. Each case also includes basic information about the site, density, buildings and uses, occupancy, land cover, and environmental features. Raw data is exclusively about each case and is primarily physical information. Time-sensitive or location specific information, such as cost of construction is not included. This source data is designed to be useful on its own or in external modeling to evaluate performance against indicators of sustainable development such as housing and population density, access to transit and services and general building efficiency (Figure 1). Any user of *elementsdb* can download a PDF document summarizing key information. Users with log-in permissions can download 3D models, photos and numerical data.
Learning tool for basic urban design facility

The main goal of elementsdb is to provide a mechanism for communicating the basic characteristics of urban design and accelerate spatial learning in public engagement exercises. The intent is not to replace a deep engagement of the substantive attributes and critical analysis of urban design with fast superficial understanding, but to facilitate dialogue and discussion when rapid familiarity with the basic elements of urban design is needed. We also imagined elementsdb to be useful in teaching beginning design students or non-designers in courses that emphasize critical analysis of urban environments. For the purposes of this paper we tested the application of elementsdb in classroom settings with students in both design and non-design classes.

The second goal of elementsdb is to provide a catalogue of built examples of contemporary urban development. Cases are selected to be instructive, and they fulfill morphological categories. For such reference purposes, students can browse or search the database with searching functions. The database is organized at the highest level by land use, then within each land use, morphologically (see Figure 2). Within all land uses that typically include buildings such as “residential” or “civic,” the morphological categories are detached, attached and stacked. In the case of streets and parks, the morphological categories are
according to industry standards for levels/types of use, such as local, collector and arterial streets. Once cases have been sorted, a “roster” or list of those fulfilling the search is created. This can then be sorted by intensity factors, such as density.

The third goal of elementsdb is to enable measured 3-D visualizations, that are accessible to diverse audiences. Urban design in many instances is a public exercise where professionals are often challenged with communicating complex urban form information to lay audiences. Professional design students are likewise encouraged to practice strategies for effective public engagement. Imagery and three-dimensional models are often used to communicate with diverse public audiences. elementsdb is intended to help people to visualize urban design propositions in context through the inclusion of 3D models with each case. The 3D models shown in figure 3 were created in Google SketchUp, specifically to be user-friendly and to allow quick and easy importation into Google Earth. This software is downloadable for free and relatively easy to learn, particularly for students of planning, urban design, landscape architecture and architecture. Because the cases in the database are built, field-measured examples, they can be viewed in their real built context or can be used as proxies for urban design proposals in other locations. Numerous case models from the database can be assembled to create propositional neighborhoods, (see Figure 3) assisting a variety of users to envision three-dimensional spatial implications of urban form. These 3D visualizations might be considered step one of the scenario-building application described below.
The final goal of *elementsdb* is to assist with the quick and easy creations of comparable, measured scenarios of urban design options. Besides visualizing and qualitatively evaluating proposals, today’s urban designers and professional design students must understand and provide evidence of the impact of designs on the larger city and region, typically in the form of performance measures. For example, in early stages of discussing land use change, simple massing models from the database showing only land use might be placed on aerial photos of areas under discussion. Assemblies of cases would provide the source data for the numerical accounting of these proposals, for example, to estimate population or proposed dwelling density. When linked to Google Earth, or any other open access mapping, the database allows low-cost, accessible, user-friendly scenario modeling. It is quick and easy to create 3D visualizations in SketchUp, Google Earth or other vector-based computer graphics environments. Data can be accessed on line or exported to spreadsheets where it can be manipulated by users to track key quantitative indicators (Figure 4). The availability of simple data that can be aggregated for a single scenario and compared across multiple scenarios allows for quick visual and quantitative analysis of different urban design options.
Classroom application in multiple disciplines

Three core faculty worked with a team of four additional faculty, six teaching assistants and four research assistants to develop the program of testing elementsdb in planning and urban design classes. The study included 113 students (46 undergraduate and 67 graduate) studying landscape architecture, environmental design, urban design, planning, geography, civil engineering, architecture, global resource systems, commerce, biogeosciences and sociology.

The core faculty designed a tutorial that was then customized for each class in consultation with course instructors to directly complement existing curricula in each of the classes. The classes were Introduction to Urban Planning (undergraduate), Environment and Urban Form (undergraduate and graduate), Theory and Methods of Urban Design (graduate) and an Interdisciplinary Design Studio with graduate students from Urban Planning and Landscape Architecture. For the first three courses students completed two surveys each, one survey before a tutorial and presentation of the database, and one survey a week later. The before-and-after questionnaire was intended to test basic knowledge of urban design principles. Questions included definitions and associations requiring choosing from available responses and filling out short answers. By testing this knowledge early in the semester immediately before and after a presentation and exercise using the database we intended to determine whether there is any evidence of improved understanding as a result of using the database.

Students were given access to the database and invited to use it in any way they chose in fulfilling the requirements of course assignments. At the end of the semester, after all course work was completed, students were invited to attend focus groups to discuss their use of the database. Eight students from 3 courses participated in the focus groups. Course instructors were not present during any of the research activities related to their respective students and they did not know the identities and participation of students in their courses. Student output
in the form of assignments and final projects was additionally used by the authors as part of our examination of student use.

Prior to the start of the academic year, the team of faculty, and research and teaching assistants, met to discuss possible applications of the database in the classrooms and determined what types of support would be needed to implement the program. All faculty and teaching assistants attended a training session in the weeks prior to the start of the term. This was a test of the tutorial that would be held in each classroom during the term. In parallel, research assistants were trained on the protocols of case creation and assisted with expanding the content of the database. These students then continued to serve as a resource for everyone else involved in the project.

The in-class tutorial included a lecture by one of the authors (Girling) covering the theories, rationale and intended long-term applications of the database in practice. The lecture included a presentation of the conception and organization the database as well as examples of how it had been applied in practice by two of the authors (Girling and Kellett). A teaching assistant then led a tutorial explaining the basics of using the database web site. An exercise followed in which students were asked to solve a very basic urban design exercise of finding two specified cases in the database and importing them into Google Earth (Figures 5, 6).

Figure 5: Photos of a tutorial session.
The most instructive source of data for the purposes of this paper was the focus groups at the end of the semester. We employed qualitative methods with open-ended questions about the students’ use of the database and allowed them to lead the discussion. Total discussion time was 64 minutes with one group and 87 minutes with another. Three researchers were present at each session, one facilitating discussion and ensuring equal participation by all members of the group, another was taking notes and performing back-up facilitation and a third was operating equipment. Discussions were audio and video taped and the student responses were used as a textual database for analysis and coding of themes and patterns. We also interviewed course instructors at the conclusion of the course to elicit their general impressions on how students used the database.

Student work was the final object of analysis. The team employed critical systematic appraisals of the work using the following questions about the work: is there evidence of the database being used to support this work; is there evidence that the substantive content was improved as a result of using the database; and is there evidence that the presentation of the content was improved as a result of this work? While this kind of analysis is necessarily subjective, it is grounded in a deep knowledge of student capacities and capabilities in different types of assignments through decades of teaching experience by members of the research team. It is in the combination of data sources that we achieve rigor and critical analysis. We also minimized the effect of the speculative nature of this analysis, in terms of the significance we may ascribe to the relative role of the database in affecting student work, by assuming there was no evidence when evidence was marginal.

**Reflections on student use of database**

We produced basic descriptive statistics from the results of the questionnaires administered before and after the *elementsdb* tutorial. Results showed that students understanding of basic urban design concepts improved in the second questionnaire: 68.2% (58/85) of all students scored better in the second questionnaire than the first. While we cannot attribute causality, correlation suggests that either the use of *elementsdb* or discussions of the content and
attributes of *elementsdb*, appeared to have the greatest affect in the undergraduate planning class, with 75% (15/20) showing improved understanding. Student understanding was not correlated with prior design experience: 67.4% percentage (29/43) of new design students showing improved understanding (undergraduate and graduate planning classes), and 67.7% percentage (21/31) of students who had prior design experience. In the case of many of these students, prior design experience did not necessarily include knowledge of urban design concepts.

Discussions of *elementsdb* appeared to be most correlated with improved understanding in the *Introduction to Planning* course with an 11% average increase in correct answers to questions about urban design (3.3 average increase in points out of a possible 30). Students in the *Environment and Urban Form*, and the *Theory and Methods of Urban Design* courses, improved by 9.5% and 5.9% respectively. When we tested students in the planning classes, which are open to students with no prior urban design knowledge, 76% of those who showed improved understanding of urban design were new to design. This suggests that the database may have helped achieve improved understanding. However, without further research with the possible use of a control, it is impossible to rule out that a similar amount of time spent discussing urban design principles with no reference to *elementsdb* could have yielded the same or greater improvement in understanding. Deeper analysis including larger sample sizes of students new to design would be needed to suggest that the use of *elementsdb* does in fact improve or enhance urban design learning.

In the following sections we report preliminary findings on how students used the database. The discussion covers both positive and negative findings about the use and usability of the database.

Early evidence of database as a tool for urban design literacy

The interdisciplinary urban design studio instructor said the following:

*[elementsdb] made it possible for students to very easily work with the basic units of urban design: building types and block arrangements... it was very easy to use the building types in the library. Given that our students had little urban design experience it very radically accelerated their ability to deal with the basic building blocks of urban design. I like how the buildings essentialize the fundamental urban typology. It would have taken many weeks for me to teach them these types.*

Students in the introductory planning course also produced a level of spatial development that is not customary for their level. In examining completed assignments, we found that students in the introductory planning course achieved a level of understanding that was unusual given that there was very little time devoted to urban design principles (total of one hour lecture). We did not monitor student use of *elementsdb* in terms of number of visits, duration of visits, and detailed reporting on time spent on each page, but such a study would help reveal some of the subtleties of both usability and efficacy as a pedagogical tool. For example, did students visit the database website for only brief visits, once or twice for targeted needs, or were they longer visits exploring different types of cases and data outputs that fostered deeper learning?
Students in the introductory planning class required more background and context setting for the database and more information about the intent and functionality of its various features. The course instructor found that only those students who took the initiative to ask detailed questions after class benefited from the database to the point where their understanding of the complexities of urban design improved in their assignments. Students in the interdisciplinary design studio, on the other hand, seemed to have benefitted in terms of accelerated learning by using the database.

**Reference feature limited by number of cases**

Students reported frequent use of the database as a reference for urban design examples. They spoke of using it as a starting point for any precedent search and it was most useful for students who were looking for generic building types to populate neighborhoods as part of a larger scheme. The database was least useful for students looking for unique or specific examples that would either be featured prominently in a design or contributing substantially to specific desirable qualities of public realm and aesthetic character. With only 123 cases in the database at the time they used it, students found the range of types and the number of cases within each type to limit their capacity to use it as a reference tool. Course instructors, on the other hand found that this limitation required students to think more critically about those attributes that they did require in a case and to have to creatively adapt the available cases to suit their needs.

Students additionally found it difficult to use the open space cases as precedents. The uniqueness of the specific site conditions for which students were seeking precedents mattered more for parks and open spaces than it did for buildings. Students found it much more difficult to ignore site-specific topography, orientation and adjacent uses when viewing open space cases as precedents.

**3D Models as building-block for neighborhood design**

Students used the SketchUp models directly in their presentations (Figure 7) and indirectly as a backdrop for generating perspective drawings (Figure 8). A number of students used the digital models for generating the general massing of buildings and city blocks but then chose to detail the buildings differently (Figure 8). In other instances students constructed depictions of design visions using 3D models imported directly from the database (Figure 7). These students expressed the value of seeing planning proposals in three dimensions to increase their understandings of the spatial implications of their designs.

As the examples of student work show (Figures 7, 8) the database functions as a building block for neighborhood scale visualization. Students aggregated downloaded 3D models to simulate urban design visions. Some students reported that this is a “fast and easy” task that can provide quick visualizations of their urban design ideas from multiple perspectives. Other students struggled with including more than one or two buildings in a SketchUp model. They found that when several models were assembled, the aggregate file sizes were too large for the processing and graphic capacity of their personal computers.
One of the reasons the models were memory intensive was the amount of detail built into the fully rendered exterior architectural expression. This detail was sometimes a barrier. On a number of occasions students were reluctant to use the cases for visualization purposes because they did not capture the kind of architectural quality the students were after. In one of the studio design reviews an external critic faulted the students for populating their urban designs with architecturally detailed buildings in a way that implied they were undertaking architectural designs.

![Figure 7: Student proposals for urban infill using "massing" models downloaded from the database. Left: James Godwin, Right: Breanna Bishop, Thomas Daley and Tamara White](image)

![Figure 8: Bird's eye perspective (right) drawn from 3D computer models (left). Sam Mohamad Khany](image)

**Evaluating urban design propositions**

This intended purpose of *elementsdb* showed least evidence of use. Two students reported using the embedded information on density, permeable surfaces and window to wall ratios, number of units and, in turn, the number of inhabitants. However, most students reported not accessing this part of the model. The results were somewhat surprising at first since one of the courses required students to develop population and job projections as well as density calculations. After closer examination we found that the instructors for that course provided their own rules of thumb, which differed from those in *elementsdb*, for calculating density values in order to harmonize the students’ figures with those of the municipality for which they were developing design proposals.

We found no evidence of the widespread use of the data features of the database except in *Introduction to Planning* where it was explicitly part of the assignment. The class
undertook an explicit precedent study assignment in one afternoon session. These students were asked to compare two different land use/building types found in a neighborhood they were studying by locating “proxies” in the database. They were asked to compare these precedents against factors of site size, density, land cover, building use, floor areas, number of bedrooms as well as to comment on factors of aesthetics, fit, environmental and energy impacts (Figure 9). Each group then reflected upon how they might use the database and this type of exercise in a community planning process. Students were asked to imagine how the database could be embedded in a community planning process and how their data and analysis might contribute to closing the gap between planners’ knowledge and the knowledge of the community.

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<td>average bedroom</td>
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Figure 9: Precedent comparison using content from the database.

The students’ descriptive comparison of the cases showed insights beyond the basic information provided. For example, they demonstrated basic understandings of the energy differences between low-rise detached buildings and high-rise stacked buildings. They also commented on the differences in roof areas and impervious coverage, suggesting they understood that large expanses of impervious surfaces have significant watershed implications. In other words, although unexplained, the presence of certain data seemed to initiate discussion and peer learning. Some of their comments indicate that they have also understood the purpose and potential applications of the database:

This data is useful for planners, the city, and community groups. All groups should be aware of the buildings’ environmental impact, especially on the habitat and aquifer of the bioregion, and ways that they could potential improve their footprint. For people using the buildings, or interested in using them, it is helpful to know some of the structures’ benefits and challenges, such as energy consumption.
In our analysis, the use of Google SketchUp helped to provide a visual representation of the neighborhood where alternative buildings, found in the database, could be used. The use of visual tools becomes increasingly important when trying to communicate ideas with the community due to their lack of technical knowledge on the subject. Furthermore, the database (if available to the community) is a good way to close the gap between the planner’s knowledge and the knowledge of the community by making specific information about development possibilities available.

In commenting on the utility of the database, one student group wrote:

*Using the data gathered through the database it is easy to compare many similar developments at once. By conducting a comparative analysis of this data across different buildings of a similar type, use, and structure, numbers that don’t fit the norm are extremely easy to pick out.*

Student comments about the use of the data revealed some potential problems of interpretation. The instructor for the course indicated to students that the conditioned floor space value for each case could be used to indicate how much energy is used to heat or cool a building. However, in conducting their comparative analysis of cases one student group used the value as a direct measure of energy use and not as a proxy.

Our findings confirm that the measurements associated with each case in the database are useful for some degree of comparative analysis. However, imprecise use of the data associated with each case could lead to errors in comparative analysis and suggests more careful contextualization of the data and its potential utility is necessary. The data were mostly used when students were specifically instructed to do so or to help to find cases in elementsdb. While a few focus group participants spoke of finding the data useful, others spoke about the difficulty of generating summary outputs of the data. Numerous students seemed to only have a vague awareness that the cases included numeric data. This suggests that the data or utility of the data may not be explicit or accessible enough in the current iteration of the database. More training is likely needed on the calculation capabilities of the database as well as further study with more advanced students who are explicitly seeking quantitative comparisons between different urban design options.

**Discussion**

This exploratory evaluation indicated to us that data-rich, visually-oriented on line references for urban design education have the potential to elevate learning and enrich urban design processes and rigor. On the whole the general receptiveness to the interface by students and the speed with which they began to navigate its features and create visualizations suggests that it provides a useful mode of precedent research.

The most evident potential for on line data rich urban design references such as elementsdb is the ability to encourage and enhance students’ abilities to develop 3D visualizations and
then to critically evaluate them. Intermediate design students who had some background in the basic concepts, principles and theories of urban design, but limited experience in designing at the neighborhood scale were quick to employ the tool in this way. Even beginning students quickly learned how to download and use the models for visualizations. Compiling a design from several cases to create a “neighborhood” was clearly a relatively straightforward and popular task amongst the students. Early evidence suggesting that the database can accelerate knowledge of urban design typologies and facilitate visualization is compelling.

Teaching students to go the next level and employ performance measurements of aggregated designs is a greater challenge. This built-in potential in elementsdb was not realized. While some students reported searching for cases by floor area ratio, numbers of floors, green roofs etc., the majority of students did not attempt to use the data to estimate metrics such as commercial and residential built areas, numbers of dwellings or population. We are concluding that: a) we did not provide adequate instruction about how to do this and b) in most cases metrics beyond the basics such as density were not required by instructors. At the time of this experiment, the methodology was clumsy and required use of Excel spreadsheets. Direct student commentary as well as the lack of use subsequently led us to develop a more user-friendly interface. On the teaching side, crafting assignments that would require students to directly use the measurement tools of elementsdb would create the kind of integrated approach to measured visualizations that elementsdb was designed to address.

For case bases such as this to function as a rich online reference for students of urban design, the numbers and variety of documented cases must be significant. Having a broader range of typologies and a greater variety of cases within each type would add to the contribution and functionality of the database in the classroom or studio. Increasing the number of cases would not just add that number of possible design propositions, but would increase by orders of magnitude the different combinations of design features and characteristics that can inform an emerging new design. A major challenge, of course, is the task of growing these kinds of databases. As Akin (2002) found, adding cases takes enormous resources. Maintaining the quality and consistency of the visual and numeric data associated with each case is particularly difficult (Akin 2002). Students’ frustration with the limited number and variety of cases, which limited its usability, did not dampen their enthusiasm for the interface. They were brimming with ideas and suggestions for cases that the database would ideally include. As discussions of a growing database unfolded, however, the logistical impediments of growth aside, the challenge of keeping the data sets organized and accessible became increasingly evident even to the students. Our team found that student use of the database— their needs for content and the kinds of precedents they ultimately found to be useful— indicate opportunities for strategic rather than comprehensive growth.

The issue of the level of detail of architectural expression in the 3D models is worthy of additional research. Too little visual information, can render the cases too generic and therefore less believable. Too much information, particularly architectural information, can mislead or mis-inform, as was experienced by some of these urban design students.
Ultimately it is up to the designer to make these difficult visualization decisions. This is clearly one area where explicit instruction about issues of representation is warranted. Detail also adds to file size, which can lead to processing problems. An immediate outcome for elementsdb was the introduction of a new version of the 3D model for each case in the database that depicts building massing without the detail that creates large file sizes and triggers reactions to specific architectural attributes.

All students reported that elementsdb was user-friendly and easy to navigate, with no significant problems. However, the underutilization of the reference resource and scenario performance categories of use suggest that important lessons can be drawn for the development of this type of web based tool. Identifying more explicitly the categories of target audiences that the database is intended to serve is an important precursor to improving its functionality. Having explicit pathways of use for each category of user, perhaps with specific categories of views and information for each category of user, may allow the database to grow without being cumbersome.

We began by suggesting that the demands placed on designers have grown and that a complex array of variables or metrics, is becoming increasingly integral to the creation of sustainable urban design. Our observation of limited use of the measurement capacity of elementsdb suggests that beyond the interface problems, perhaps more attention should be paid to the development of curricular and course-specific learning objectives to demand quantitative comparisons of urban design options. It is in that context of sustainable design pedagogy that the full potential of data rich on line urban design references can be both realized and tested.
BIBLIOGRAPHY


