

DOI: 10.12731/2227-930X-2021-11-2-52-64
UDC 72

COMPUTER AIDED SCHEMATIC DESIGN: HOW TO MANAGE LARGE DATA IN THE EARLY STAGES OF URBAN DESIGN PROJECTS

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The study was designed to research and analyse the existing methods used in the industry and propose alternative solutions that would meet the growing project demand. One of the major findings of this paper shows that 65% of interviewed architects and urban designers reported a lack of data accuracy in their concept design solutions, as well as dissatisfaction with the segregated concept design process. Having identified key inefficiencies in pre-design and the schematic design stages of urban design, the study develops a multiplatform web application - a space planning tool that is capable of assisting with data informed design decisions in the early stages of large-scale urban design projects. The alternative solution allows for the execution of concept stage prototyping through UI cell modification by integrating data and generating spatial solutions based on the adjacency requirements.

***Purpose:** the purpose of this study is to understand, improve and eliminate inefficiencies in the early stages of the urban design process.*

***Methodology:** this study will first review existing inefficiencies of the architecture and urban design industry using 2 researched methods: non-participant observations and surveys. Non-participant observations were continuous and were carried out for a period of 9 months. The group that was studied involved 17 people that worked on the early-stage design stage of large-scale architecture and urban design projects. In addition to that, a survey was carried out to examine the identified inefficiencies further and to confirm the hypothesis. The survey involved 370 industry professionals from over 15 countries. Based*

on the developed understanding of project delivery inefficiencies, a classification will be developed to categorize the existing software. Finally, this study will conduct a series of experiments to develop a technical solution to meet current industry demands.

Results: *identification of key pre-design and the schematic design inefficiencies, development of a multiplatform web application.*

Practical implications: *the application is being tested and used in the industry of architecture, urban and spatial design, it has the potential to save companies time and financial resources.*

Keywords: *urban design; data management; architectural design; planning; application*

Introduction

Every urban design project is unique and heavily relies on sets of technical and spatial requirements. Between hand sketches, physical models and long Excel sheets, industry professionals are often lost in the cumbersome early stage design process and seek alternative methods to consolidate their ideation. Not being able to efficiently process ever changing spatial data requirements, work efficiency decreases, forcing urban design industry professionals to spend more time and resources on a given project. Experiencing the problem first hand motivated me to explore this issue further – interview industry professionals, study their methods and perhaps come up with a technical solution to make early-stage design more accurate and efficient.

The purpose of this paper is to identify inefficiencies in pre-design and schematic design phases of large-scale urban design projects, analyse the existing methods and propose alternative tools that can be implemented in architectural offices worldwide to improve the practice of the early-stage design.

Currently, architectural and urban design software solutions are only offered in the later design stages (Fig. 1). However, the pre-design stage, which takes up to 15% of the designer's work, has been overlooked. Having to rely on antiquated methods, like hand sketching and model making, often results in overworked personnel, missed dead-

lines and lost resources (time and money). That causes huge friction as project budgets tend to go over budget by 27% of the intended cost.

Figure 1. Presents the technologically neglected stages of urban and architectural design

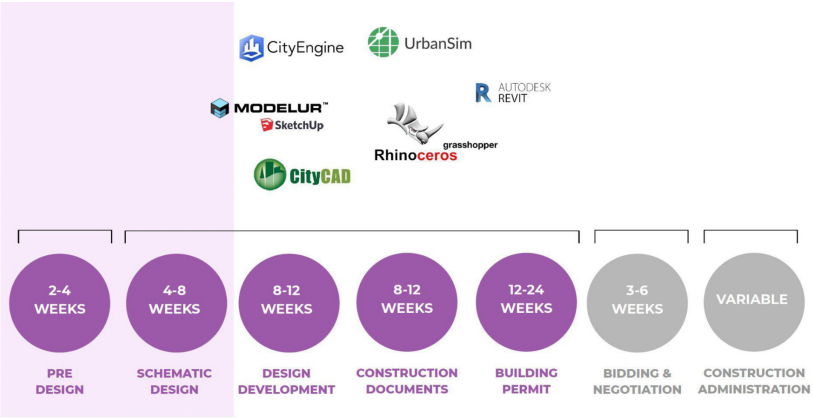

Fig. 1. Architecture phases of design and software that tailors to each of them

With the ongoing development of new cities, regions and re-development of the existing urban fabric, design methods are becoming a highly important topic. Team efficiency does not depend only on the individual talent, but also on the available tools for the execution of the project.

Materials and methods

To contextualize the problem, this paper uses both primary and secondary data. Secondary data was used to present the existing trends and patterns on a large scale. The primary data was accumulated through surveys, observations and experiments.

Observations were conducted in four different locations: London, Hong Kong, Shanghai and Los Angeles. They were made at large scale architectural practices that are highly involved in master planning and urban development projects. Observations were made within small and large teams (4-10), specifically in the early stages of large scale projects. To accumulate additional primary data, a large digital survey was

carried out. It involved 278 industry professionals with at least three years of experience in urban design. The objective of the survey was to understand the difficulties that people experience in their workplace, particularly during the pre-design and schematic design phases. It was focused on finding out the time limitations experienced due to the lack of the needed technology, how frequently these problems were experienced and methods that respondents used to solve them.

To establish cause and effect relationships, as well as to develop a novel solution to existing problems, this paper relied on experimental research. After accumulating data from first hand observations and surveys, an MVP (Minimum Viable Product) of an application was developed and introduced as an additional experimental research tool. MVP was a cloud application named Uflo that allowed users to import their data and generate spatial arrangements online. It was created as a response to the research and allowed users to solve the problems that were most frequently reported through the survey. This experiment was used to determine whether additional tools can substitute the traditional methods of the design practice and improve its overall efficiency.

The application was introduced to the same group of respondents that answered the survey and was used to test the hypothesis. All the tests and feedback were documented in the written form on the forum section of the application. Such format allowed us to facilitate an open discussion about the issues and the desired function of the application.

Results

Having performed observations, surveys and in-depth experiments, four main challenges that decrease efficiency in the early stages of large urban design projects were identified:

1. Lack of data accuracy in concept design solutions
2. Segregated concept design process
3. Complicated software
4. Lack of collaboration tools

Using sketching and modelmaking has always been great for ideation, but when it comes to large scale projects such methods can create inaccuracies, delays and inefficiencies in the design process. While

producing numerous design options and iterations, it is very easy to lose track of data and adjacency requirements, which means designers have to go back, revise and reiterate their proposals. This results in extra time and money being spent on a project. Being able to incorporate data early on in the process would not only improve the speed of the team, but would also help with understanding of the space and hence create better design solutions. Visual representation of the space plays a critical role in designers' understanding of the space and consequent design decisions. (Loomis, Jack M, 2003)

When speaking about the segregated design process, 92% of the interviewed teams use a combination of tools, including hand sketching, physical model making, sketchup, Excel sheets to track data and so on. Having to operate with various tools might seem to make the design process agile, but in reality 75% of people reported having a completely different outcome: the design process becomes more rigid, as so much information and spatial data has to be moved from one medium to another.

There are several technological solutions currently used by industry professionals to accurately inform their design with data: SketchUp, AutoCAD, Rhino, Revit, and a plug-in for Grasshopper – GhExcel to incorporate Excel into 3D modeling. Unfortunately most of the aforementioned tools require specialized software knowledge and that creates significant problems when different team members do not know the same software or are unable to operate it at the same level.

In my survey, 65% of architecture and urban design professionals reported having difficulties with converting and integrating Excel data into their concept design proposals. Having observed existing design approaches and practices within leading architectural firms worldwide also showed that there is a variety of software for later design stages, but no comprehensive tools for the pre-design and schematic design phases. (Fig. 1) It is fair to say that the early stages of architectural and urban design are technologically neglected and are in need of an alternative solution to aid designers in their creative work. My findings confirm this assessment and identify the need for alternative technological advancements to handle the growing project demand.

Creating concept designs is not only about aesthetic proposals, but also about functionality and usability of the space, which requires a lot of spatial data management and consideration. Having the necessary software to aid with the ideation process would significantly improve the urban design practice at its early stages. It could allow architects and urban designers to focus directly on creating narratives and design strategies, without having to worry about losing track of data requirements.

The solution

Having understood the pain points for designers, I developed an alternative solution for data management in the early stages of urban design projects. The web application Uflo translates Excel data to infographics, allows users to juxtapose cells, change parameters and easily identify the mismatch between data and generated geometry. Uflo allows users to import Excel data with spatial and adjacency requirements and generate various possibilities of spatial combinations in one workspace. (Fig. 2) This solution was set to create a digital ecosystem for concept design ideation backed by data.

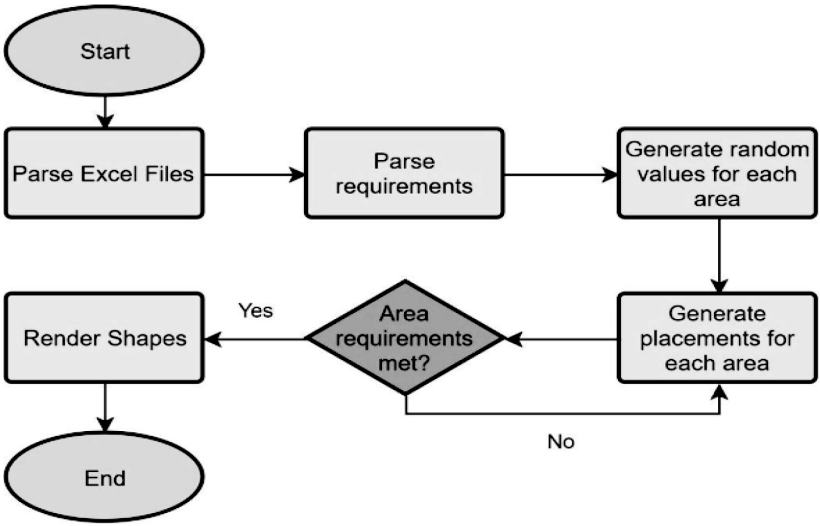

Fig. 2. Flowchart of the developed software - Uflo

The tool was tested by various focus groups: large architecture offices in Hong Kong and Los Angeles, as well as focus groups in the University of the Arts London: Central Saint Martins and the University of Southern California. The tool received positive feedback, indicating its potential to save a lot of time and effort in the early stages of the design process. It consolidated the concept design process, increasing the efficiency and accuracy of project resolution.

The primary mission of Uflo was to tackle the problems architects and urban designers experience in the early stages of their design process. Uflo was created to help urban planners, architectural designers and project managers to work with big data and organize it spatially. It simplifies the process of master planning, and saves time and financial resources. The application streamlines the process and focuses on making the design of large projects user-friendly and efficient. This application can be used in master planning and site drafting, where it is necessary to visualize and manage big data (Fig. 3).

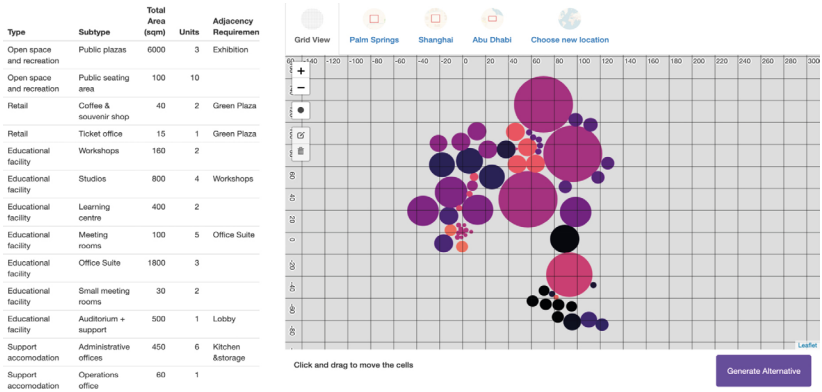

Fig. 3. Conversion of imported Excel data to geometric output.

The developed tool solves four problems:

- Lack of tools necessary for handling complex data in early design stages of large-scale projects.
- Absence of user-friendly data-informed applications for professionals without prior design software experience.

- Lack of software portability (not available on tablets or web).
- Inefficiency of having to use multiple tools and programs to keep track of data in the early stages of large-scale design projects.

Prior to Uflo, the existing problem was solved by using a combination of tools and programs in a sequential and cyclical order. One of such typical processes is described as follows: exporting Excel with spatial requirement to AutoCAD, developing a physical model on the basis of areas generated on AutoCAD, photographing the physical model and recreating it in 3D in SketchUp.

The aforementioned process is highly segregated and has its limitations in terms of data tracking and data management. Using various tools and media requires translating data to 3D and back to Excel multiple times, which is extremely cumbersome when a lot of big data is at stake. It also lacks user-friendly tools – most of the software that is currently used requires a certain level of proficiency, which makes it hard to collaborate with clients and other industry professionals.

The developed application solved that by streamlining the workflow and creating a space for uninterrupted creative process. It provides the designer with an effortless feeling: tech simplifies the conversion of data into 2D, and the front-end design allows users to make all necessary modifications in the same workspace. Uflo has a unique niche in the market – what used to be done by hand sketches, numerous calculations and physical modeling, can now be done digitally. The application is in no way competing with BIM or construction software; it only streamlines the concept design process and works as a bridge between the project brief and the schematic design solution. It also informs the designer whether the proposal meets data requirements, which in turn minimises the number of iterations the designer has to make in the pre-design and schematic design phases.

The MVP of Uflo is based on Bayesian inference and allows an individual to inform design with incoming data on the go. Additional data and programmatic conditions can be added to the file and be seamlessly integrated in the strategy, for example additional requirements from the client. Uflo has a very simple user-friendly interface which makes

it very easy to navigate through the application. It does not require any previous software knowledge and can be used as an efficient tool for collaborating with clients (Fig. 4).

Uflo fills a unique niche in the market and addresses multiple problems, providing users with data informed design solutions, user-friendly design tools and a workspace with digital access for collaboration and presentations.

Innovative characteristics of the invention are based on adding a layer of digital collaboration and allowing users to bring the segregated concept design process online.

Complete example of operating the application (Uflo):

- The invention can be operated online and offline (either accessed as a web application or installed on the computer and accessed offline)
- The first step involves importing the Excel file with all the necessary data for geometry generation. The Excel file should incorporate data classified by type and subtype, as well as identified juxtaposition requirements, if any.
- The user is offered a choice of geometric cell output shape (square / circle) depending on the scale and design intent. The user is also offered a range of color schemes for geometric output. An add-on function allows the customization of color themes.
- Once Excel is imported, one of the geometric outputs is generated (based on the input data and juxtaposition requirements).
- After geometric output is generated, the user has a choice to either generate alternative outputs that meet the requirements or work with the current output to refine spatial arrangement.
- Users can change geometry by increasing, decreasing, separating or merging cells, changing arrangement and juxtaposition. Any change in geometry is reflected on the imported Excel file. If a clash is identified, the user will see a warning window showing the identified clash between geometry and data. When operating in a workspace, the user sees that data informs geometric output and vice versa. Any change either in data or geometry is reflected on the other.

- When collaborating with others (team members, clients, etc.) the user has an option to lock the input data so that changes in geometry are not possible. In such cases the application would only show occurring clashes.
- When a user decides to create a collaborative project workspace, an additional side bar is added, where each member can make notes. Another add-on function of Uflo allows any changes to the geometric output to be recorded per user in the history tab to keep track of design iterations.
- Depending on the project, the user can decide at which stage to import the map, pin and juxtapose geometry on site.
- With or without map geolocation, users can input base height parameters and modify their spatial arrangements. (Fig. 4)
- Any changes that occur in geometry can also be translated to Excel and a warning window with clash identifications would pop up.
- Users have the option to export generated 2D or 3D geometric output in .dwg and .skp to import in architectural software for the following design stages.

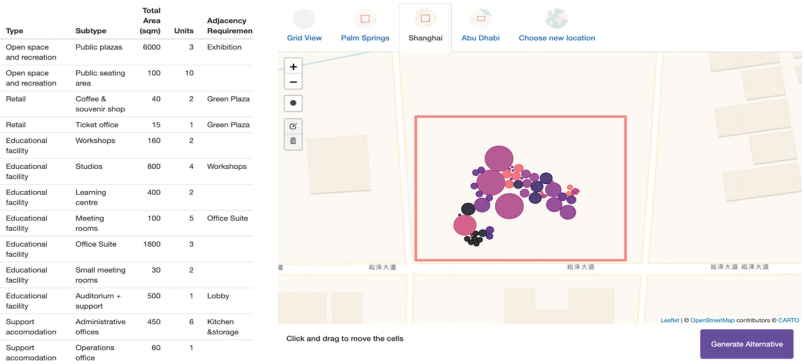

Fig. 4. Locating geometric output on a site, changing its spatial arrangement

Unexpected findings

Having interviewed multiple interdisciplinary professionals who work in architecture, urban exhibition, and installation design, several unexpected discoveries were made.

The study was able to recognise that there are many professionals who curate or design exhibitions who do not have a design background and also struggle with data management in the early stages of their design projects. Having to sequentially arrange spatial data requirements, create narratives and work collaboratively often imposes a challenge, as there is no software or application that could aid the process.

This finding made me realise that Uflo is applicable to spatial design of various scales, be it a large master plan or an exhibition. Data-backed ideation is key when it comes to space-planning: it allows the creation of more precise design solutions and a significant decrease in the number of design iterations.

Focusing on less generally allows people to achieve better results. (Bradley, 2014)

Having technology that aids with data management can allow architects and urban and spatial designers to focus on the creative component of their projects, create more precise design solutions and improve the overall design practice.

Discussion & Conclusion

The aim of this paper was to analyse the existing inefficiencies in the pre-design and schematic design phases of urban design. In addition to this, this paper makes an attempt to solve those inefficiencies of the industry and proposes an alternative software solution to aid the design process.

This study took me on a fascinating journey through the time: it allowed me to understand the traditions of the industry, as well as the needs of the current time and industry demand.

Analysing the inefficiencies made me realise that sometimes we have to leverage macro and micro approaches. Sometimes it is crucial to step outside and analyse industry practices as a whole. As architects and urban designers, we are so busy with the ever-growing project demands, bids and competitions, that we often simply do not have time to reflect upon and change the setup of our practices.

Having a few months off my office architecture job allowed me to dive deeper into this issue, interview people, design the UI of the potential solution and test it with the industry.

The next steps of this work will involve accumulating further in-depth feedback from designers and developing the software further to make it as comprehensive as possible, taking into account the feedback that I received during the initial testing.

I personally do not think that is necessary nor beneficial for creatives to try and attempt to digitalize the whole design process. We think with our bodies, we sense space within, and taking away sketching and physical model making would take away from design practice as a whole. But I do believe that we should be developing more comprehensive solutions to aid us in the design process, especially when large data is involved.

Returning to the introduction, it is now possible to say that inefficiencies in the early-stage design are mostly due to the lack of tools available to architects and urban designers. The development and implementation of new software can improve data management, result in more efficient project delivery and better well-being for industry professionals.

It is to be hoped that this paper will be helpful to designers who have interest in both urban design and technology, serve as a basis for future studies on the relationship between technology and schematic design and eventually lead to further development of technology to support spatial designers in their work.

Declaration of Interest Statement

This declaration confirms that there are no known conflicts of interest associated with this publication and there has been no financial support for this work that could have influenced its outcome.

It confirms that the manuscript has only one named author and that there are no other persons who satisfied the criteria for authorship but are not listed.

It is giving due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property.

The Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications).

References

1. Loomis J.M. Visual space perception: phenomenology and function. *Arq. Bras. Oftalmol.*, 2003, vol. 66, no. 5, suppl., pp. 26-29. https://www.scielo.br/j/abo/a/jZ3fGqx8Vqf8MNJr84WD6rc/?lang=en&format=pdf
2. Bradley S. The Importance Of Focus And The Difficulty Achieving It. *Vanseo Design*. 2014. https://vanseodesign.com/online-business/focus/ (accessed 24 Apr. 2021).
3. Xiaohu J., Xiuming D. *Computer aided design and general planning of urban and rural planning teaching materials*. 1st ed. China Building Materials Industry Press, 2016.
4. Melendez F. *Drawing from the Model: Fundamentals of Digital Drawing, 3D Modeling, and Visual Programming in Architectural Design*. 1st ed. WILEY, 2019.
5. Verebes T. *Masterplanning the Adaptive City: Computational Urbanism in the Twenty-First Century*. 1st ed. Routledge, 2013.

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