Teaching Landscape Spatial Design with Grading Studies: An Experiment Based on High Fidelity DTM

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Abstract: Landscape grading is mostly taught in an independent course of landscape grading, but poorly integrated with the teaching of landscape space design, because the 3D topography of the site is expressed by 2D topographic maps. Applying high fidelity DTM, based on a comparatively flat site, the author explores teaching landscape design by integrating grading in a 3-phase experiments: 1) a step-by-step training on site grading based on Civil 3D, 2) the digital surveying and terrain modelling of the design site, 3) the interaction between spatial conceptualization and grading studies. The results indicate that the students can perceive, operate and conceive the landform as a 3D space throughout the entire process from site surveying to spatial design, and grading studies is well integrated with landscape design.

Keywords: Teaching digital landscape architecture, landscape spatial design, grading, high fidelity DEM, Civil 3D

1 Introduction

Landscape architecture is known as "design of the land", as design always involves making certain changes to the land surface. Therefore, grading is one of the core contents of landscape architecture education. Since the shaping of landscape space is supported by studies on grading, the teaching of landscape spatial design should, in theory, be closely integrated with grading.

1.1 The Separation of Grading Technology and Spatial Design Teaching

However, the teaching of grading studies is usually delivered independently as a technology course focused on the engineering and technical side but seldom integrated into design courses. Since surface undulation, also known as topography, is typically described by 2D-contour maps developed in the 18th century, the spatial operation and conception also rely on the medium of contour. Yet conceiving and operating on 3D topography based on the understanding of 2D contour is a skill set acquired after a period of learning, including skills such as reading contours, reconstructing or adjusting current contours using interpolation techniques, etc.

1.2 The Target and Site of This Pedagogical Experiment

In recent years, with the comprehensive development of contemporary space information technologies such as digitalized date collection and 3D computer simulation, the integration of space information for landscape architecture as well as grading simulation technologies are also reinforced. The digital surveying of topography and the grading analysis of 3D digital terrain model are beginning to be incorporated into traditional landscape grading pedagogy

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at places such as the University of Applied Sciences Rapperswil in Switzerland. However, this training is still unilateral and monistic.

The tenet of this pedagogical design is to reinforce the perception, operation, and conception of the site from a 3D perspective through the application of digital surveying and DTM technology during various phrases of landscape design, in order to integrate landscape spatial design with grading. For the two main reasons below, this experiment selects landscape design sites with horizontal dimensions greatly exceeding vertical dimensions: first of all, traditional contour technology usually expresses these sites as flat ground, therefore its vertical dimension is often overlooked during the spatial conceptualization phrase, and grading studies usually takes place in the detailed design phrase, after the schematic design is created. Secondly, as storm water management is increasingly emphasized today, the ground can be slightly raised to a slope through design for the collection and percolation of rainwater so that the management of surface water and spatial shaping can be organically integrated (PETSCHEK & PANG 2015).

2 Methods and Procedure

2.1 Students, Teachers and Course Duration

The participants in this pedagogy are the first-year graduate students in Landscape Architecture at Southeast University who already possess spatial design skills, software skills including AutoCAD and SketchUp, and grading skills. The two supervising teachers are experienced in landscape spatial design and the application of digital technology in grading, respectively. This pedagogy spans 32 course hours.

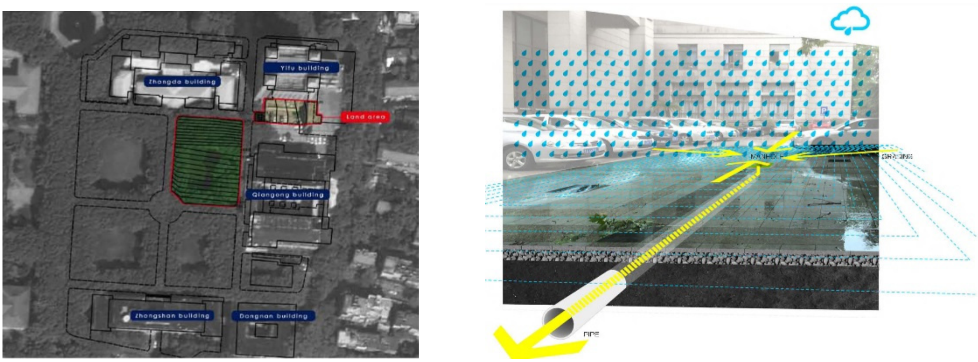


Fig. 1: Left: Aero photos of the site. Right: Design target is to collect rainwater.

2.2 Site and Target

The design site is divided into two areas: one is the hard ground space to the south of an office building on the campus of Southeast University. It is approximately 500 square meters and functions as a parking lot. The other adjacent area is approximately 1,800 square meters of lawn. The two areas are relatively flat and are close in elevation. The design target is to collect rainwater from the hard ground space as well as from the rooftops of nearby buildings to transform the lawn into a rainwater garden (Figure1).

2.3 The Pedagogy Consists of a Three-step Training

a) Step-by-step training on site grading based on Civil 3D

AutoCAD Civil 3D is a 3D civil engineering software specifically used in the field of infrastructure. Its outstanding 3D topography construction function, circuit design function and accurate engineering data allow for the relatively high accuracy and efficiency of 3D terrain model construction and editing. In this pedagogical experiment, teachers selectively teach the various possibilities of Civil 3D software analysis and digital topography editing from the grading perspective of landscape architecture, including terrain modelling, spatial analysis, and surface drainage analysis.

b) The digital surveying and terrain modelling of the design site

The survey task was done by Leica Builder Total Station 502 (Electronic Total Station). Considering the working efficiency of Builder, it is impossible to measure every point, and to take every 1mm of the surface fluctuation into account, the teacher s needs to direct the students to design the survey process and contents beforehand: what kind of height difference could be considered "flat" that could be neglected in survey and what should be taken into account; which landscape elements (vegetation, manhole, open channels.) need to be included in survey and which not; which landscape elements could be put in the same layer of point clouds data, and which in different layers. When the survey is finished, the point clouds data by Builder can be saved as *. ASCII file, and imported directly into Civil 3D to build DTM of the project site (PETSCHEK & PANG 2014).

c) The interaction between spatial conceptualization and grading studies

After conceptualizing the spatial form of the land surface from the draft, the design starts to develop in the DtM-based 3D space simulation: on one hand, students use SketchUp software to study spatial experience of the site; on the other hand, they simultaneously study grading of the site in Civil 3D software. Based on the understanding of the land's 3D form, students repeatedly explore the dimensions of the landform as well as the relationship among slope gradient, surface, appearance and perspective view.

3 Results

In this pedagogical experiment, students integrate the surveying and depiction of the site's topography, terrain model construction, site space design and site grading into a complete design, understanding, operating and conceptualizing the landform as a 3D space throughout the entire process, from site surveying to spatial design. This is reflected in the three phrases of this pedagogy.

3.1 Civil 3D-based Grading Training Allows Students to Establish 3D Perception of Comparatively Flat Sites

The Civil 3D-based grading training is not limited to software operation. It also helps students establish a series of 3D topographical concepts about slightly undulating sites such as roads and parking lots. The movement from point cloud to contour and Delaunay surfaces is the basis for students to turn from 2D to 3D. Slope analysis, elevation analysis, and slope direction analysis further allow students to understand and experience the 3D spatial characteristics of the site. According to the objective law that water will always flow in the steepest direction and eventually run along the valley, students engage in slope arrow analysis and drainage area analysis through simulating and analyzing the activity of water running on terrain surface.

Fig. 2: Left: Applying builder. Right: Site on a rainy day in august.

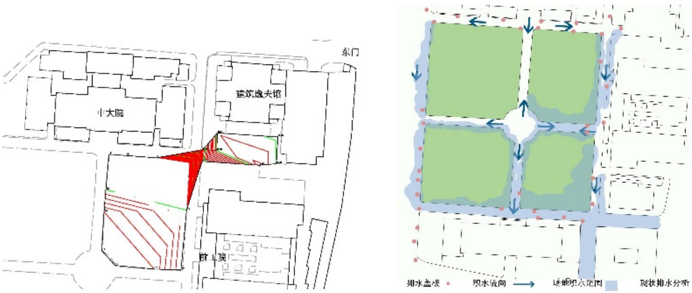


Fig. 3: Left: Plan of site; current situation. Right: Mapping site; runoff in rainy days.

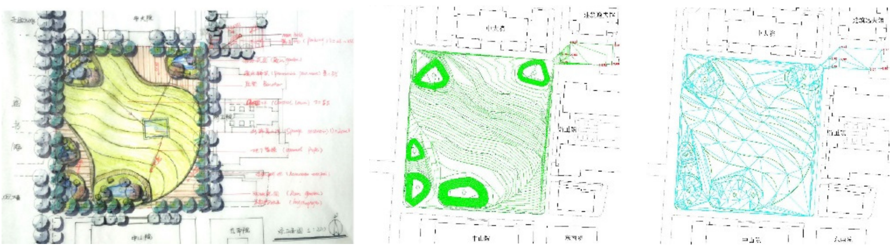


Fig. 4: Left: Draft design of the site. Middle: Contour plan. Right: TIN plan.

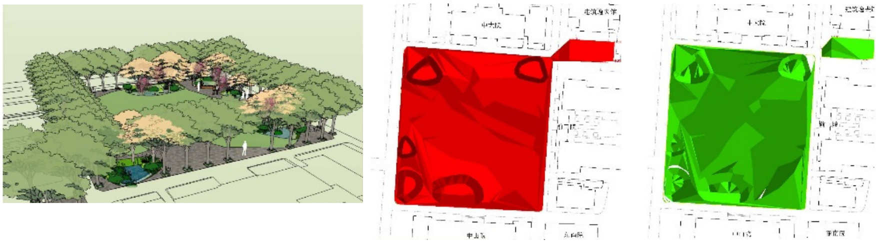


Fig. 5: Left: Bird's-eye view. Middle: Slope analysis. Right: Direction analysis.

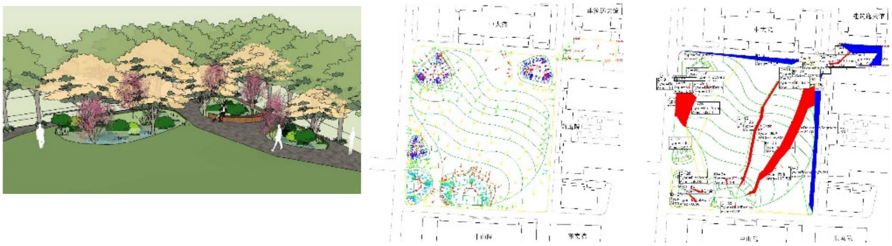
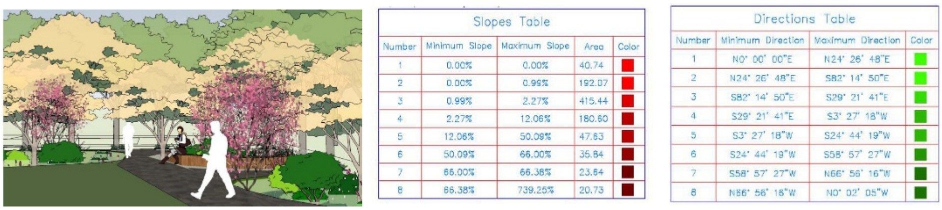


Fig. 6: Left: Bird's-eye view. Middle: Slope arrow. Right: Water shed.



Slopes Table

Number	Minimum Slope	Maximum Slope	Area	Color
1	0.00%	0.00%	40.74	
2	0.00%	0.99%	192.07	
3	0.99%	2.27%	415.44	
4	2.27%	12.06%	180.60	
5	12.06%	50.09%	47.63	
6	50.09%	66.00%	35.84	
7	66.00%	66.38%	23.64	
8	66.38%	739.25%	20.73	

Directions Table

Number	Minimum Direction	Maximum Direction	Color
1	N0° 00' 00"E	N24° 26' 48"E	
2	N24° 26' 48"E	S82° 14' 50"E	
3	S82° 14' 50"E	S29° 21' 41"E	
4	S29° 21' 41"E	S3° 27' 18"W	
5	S3° 27' 18"W	S24° 44' 19"W	
6	S24° 44' 19"W	S58° 57' 27"W	
7	S58° 57' 27"W	N66° 56' 16"W	
8	N66° 56' 16"W	N0° 02' 05"W	

Fig. 7: Left: Perspective of the site. Middle: Slope table. Right: Direction table.

3.2 The Connection between Site Surveying and Modelling Allows Students to Understand and Operate the Design Site Directly in 3D

Students selectively survey points on site by using the Total Station, than create high-fidelity DTM from point clouds, thereby directly perceiving the 3D landform of the site and acquiring the foundation for their subsequent designs. Later, students further reinforce their 3D perception of flat sites through observing the site on rainy days, as well as understanding issues of drainage and water logging of hard roads and soft lawns. They realize that there is no absolutely flat ground in the design of landscape architecture; every site has its inherent spatial 3D structure and surface runoff features (Figure 2 and 3).

3.3 Students Incorporate Grading Studies into Spatial Conceptualization

The high-fidelity 3D parametric model of the site provides an operable platform that can be directly perceived and precisely positioned, qualified and quantified for the landscape design process. It allows students to correct, edit, and evaluate design proposals with greater ease and effectiveness. After generating space conceptualizations that integrate storm water management considerations of the site, high fidelity 3D parametric model leads the students' design development capability – unachievable by traditional contour line plan – comes into play: on one hand, SketchUp software provides direct perception and assessment of the experiential effects of spatial conceptualization. On the other hand, spatial analysis based on high fidelity DTM can improve conceptualization accuracy of 3D space design, while the simulation of surface runoff systematically considers the guidance, collection and percolation of rainwater and gives feedback to optimize spatial conceptualization (Figure 4-7 shows the working process of one student).

4 Conclusion

If grading studies are not integrated with spatial design, it is difficult for students to perceive its significance as the "first phrase design language" during the schematic design phrase. High fidelity DEM technology enables this integration. Sites are always perceived as thickened land, and their irregular, continuous surface runoff as well as the collection and management of rainwater influence students' perception of design site. The inspiration for spatial design concepts are not only based on a 3D understanding of the site, but also integrates quantitative analysis, enhancing the scientific content of site design while manifesting the spatial essence of landscape architecture design.

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