Shaper2D

Visual Software for Learning Shape Grammars

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Shaper2D is a Java applet and application for assisting in the learning of shape grammars. This software is examined as a facilitator for designing with shape grammars through analysis of computation in a workshop setting.

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Introduction

Shaper2D is a platform-independent Java applet and application for assisting in the learning of shape grammars. It aims to take into account the needs of designers by retaining a transparency of process in computational design and creating an engaging environment where the designer is encouraged to explore basic shape grammars.

Previously developed software for exploring two-dimensional and three-dimensional shape grammars provide powerful tools to learn fundamental concepts, but are not conducive to experimenting or playing (Resnick *et. al.*, 1996) with shape grammars. *Shaper2D* encourages this by providing the user with instant feedback and a purely visual, designer-friendly interface.

Three studies of *Shaper2D* examined the role of process-specific computer programs for facilitating the Constructionist learning and understanding of shape grammars. All three studies were located at the MIT Department of Architecture: the first and third studies took place as part of a regular MIT class, while the second was a follow-up study that took place independent from any formal teaching environment.

Shaper2D and Constructionist Theory

Shaper2D provides a situated (Lave & Wenger, 1991), constructive approach to learning about computational design using shape grammars. By using it to tackle a design problem, the user has the opportunity to construct both an advanced understanding of what shape grammars are and how they can be utilized in real life.

Shaper2D is intended for experimentation with computational design in correspondence with the Constructionist philosophy of "learning by doing". It was born out of a need for a tool to encourage and facilitate experimentation with basic, two-dimensional shape grammars (Knight, 1998b) through situated, real-time experimentation. *Shaper2D* provides the means to create and explore new ideas about shape grammar theory; it is playful, and engages the user in a meaningful, supportive learning environment. *Shaper2D* is a localized shape grammar "microworld" (Papert, 1993) for generating designs using very restricted kinds of shape grammars. Limitations are deliberately built into the system in order to constrain the user to the exploration of a small sub-section of this computational design methodology.

With shape grammars, a designer can reproduce a design using a given spatial relation or rule, but by generating or analyzing new or unfamiliar designs she verifies that the knowledge is "owned". By using *Shaper2D*, designers are encouraged to conduct educated experiments with shape grammars rather than regurgitate shape grammar concepts.

The Development of *Shaper2D*

Previous programs have been developed to expedite the process of design using shape grammars (such as *GEdit*, Tapia 1999; *3D Shaper*, Wang 1999). These software applications have been used on occasion for classroom teaching; however, their roles in the design studio have been less successful. Various reasons have been cited for this, including a completely unrestricted workspace that is only truly useful to more advanced uses of shape grammars, delayed feedback, and a designer-unfriendly interface. These are not criticisms of the software, as each application has some audience in current shape grammar pedagogy and research. However, the deficiencies listed above are those that *Shaper2D* seeks to address.

Shaper2D was also written to overcome the platform-specific limitations imposed by previous shape grammar interpreters. The application has been run successfully under several major operating systems (Windows, Mac OSX and Linux), and the applet runs under any web browser capable of running Java™ 2. The application has the further advantage of allowing the user to save a design in the DXF file format for importing into another CAD application (such as *AutoCAD* and *Microstation*).

The *Shaper2D* Studies

The first study, study A, took place during the spring 2001 semester as part of the MIT/University of Miyagi Remote Collaborative Workshop. This was the first time that *Shaper2D* had been used in a practical studio situation. The aim of the study was to determine whether *Shaper2D* could be utilized as a tool for learning.

Study B, a formal, stand-alone follow-up study, was set up in response to the findings from study A. Its objective was to test whether hand computation is a necessary prerequisite to using computers for learning shape grammars.

The third study, study C, was in response to studies A and B. This more informal study tested *Shaper2D* as a design rather than pedagogical tool. It sought to investigate how a pre-conceived design intention could be implemented for a site development problem using basic shape grammar concepts. *Shaper2D* was used as the principal design resource. This study took place during two sessions of the spring 2001 MIT Design Inquiry seminar.

All participants in the studies were graduate or undergraduate MIT architecture students. The students were required to synthesize and assimilate the new shape grammar concepts presented to them with previous knowledge acquired during their architectural education and training. With this in mind, an attempt was made to situate the exercises in authentic design activities, as far as was feasible and relevant to the particular study. The studies were all located in typical architecture studios augmented by computers and other technological equipment. Exercises were devised to assess and develop the student's comprehension of shape grammar theory.

Study A

The aim of this workshop was to design the layout and massing for family townhouses, using shape grammars as the generative design methodology. Two sites were given—Long Island, Boston Bay, Massachusetts, and Izumi Park Town, Sendai City, Miyagi Prefecture, Japan. (see Celani, 2001) *Shaper2D* was used to generate the site layout for the houses.

The students were expected to produce several designs for housing layouts using *Shaper2D* as the principle design resource. This expectation

was fulfilled, although the Miyagi students presented one design rather than the two alternatives presented by the MIT teams. It was decided that this was probably due to a miscommunication about the assignment requirements. The designs presented by the students for the *Shaper2D* assignment demonstrated a varying degree of aptitude for designing with shape grammars. Later in the project, two teams explicitly stated that *Shaper2D* contributed to their final designs. They also commented that the program was useful for the site plan, although scale and the lack of site context in the design panel made it difficult to immediately associate the designs generated with the site.

Study A included a non-anonymous, post-assignment software evaluation questionnaire. Informal conversations were also held with both MIT and Miyagi students (in person and via *NetMeeting* respectively) after the workshop, in order to gain a more in-depth insight into the advantages and limitations of the *Shaper2D* software and collaborative learning experience.

The workshop revealed a key aspect of *Shaper2D* that had been overlooked—that *Shaper2D* is a design tool as well as educational software.

Study B

The purpose of this follow-up study was to test the necessity of learning shape grammar concepts through hand computation before moving on to using computers for further exploration of these concepts. It was a condensed version of the first two sessions of the remote collaborative workshop (Study A) and began with a short presentation of shape grammar. After the presentation, the subjects were asked to complete two short shape grammar exercises: the first using *Shaper2D*, and the second using hand computation.

The experiment involved two MIT S. M. Arch. S. students. Selection criteria for the participants included design, preferably architectural, training and no previous exposure to shape grammars in a studio environment.

The subjects were able to complete the first exercise, using *Shaper2D*, with little difficulty, although their descriptions of how they derived the designs varied in terms of precision and accuracy. Subject A demonstrated a good understanding of the spatial transformations involved in the rule applications and was able to elucidate the procedures to Subject B who took longer to perceive what was happening. In the second exercise, using hand computation, the situation was reversed. This time, subject B quickly completed all the set problems, while subject A struggled with the rule applications and found it difficult to understand the spatial transformations being performed. Subject B explained the solutions to subject A, who eventually claimed to have an understanding of the processes involved.

After the exercises, the students and the author talked about the session and the strengths and limitations of hand and computer computation.

Due to the limited number of participants, conclusions could not be drawn as to whether hand computation is necessary as a precursor to using the computer in order to fully understand shape grammar concepts. Also, although the study did not consider *Shaper2D* in a design context, comments made about constraints of rule application and using the design as a base for concept development suggested the need to explore the use of *Shaper2D* as a design tool.

Study C

This study investigated how a pre-conceived design intention could be implemented, if at all, for a site development problem using basic shape grammar concepts. *Shaper2D* was used as the principal design resource.

The students were provided with a short introduction to shape grammars, *Shaper2D*, and the homework assignment, the design brief of which

was the same as that for Study A, except for the site. During the following session, the students were required to present an overview of the design process that led them to the proposed site layout, and a summary of their experience using *Shaper2D*.

Ten students in total completed and presented their designs to the class. Out of these students, seven used *Shaper2D* for part of the design process and three students elected to use a different program for the assignment. Data was collected during the post-assignment presentation and round table discussion.

In the post-study discussion, which took place during the following Design Inquiry session, one student commented that, "... designing is the process of deciding what's best out of an array of possibilities. " The conclusion made as a result of this discussion was that a designer develops a unique relationship with a design tool, leading to an individual belief in that tool's capabilities. However, a designer's fluency with a preferred design tool or method is usually not vocalized. With reference to shape grammars, and their place in the design process, it was commented that when a designer becomes fluent in using a particular tool she is able to better consider all the possibilities available to her.

Conclusion

The conclusions drawn from the studies are that *Shaper2D* cannot stand alone when solving a design problem and that different exploratory tools are needed to derive a better understanding of the objects being created.

Since the studies took place other students at MIT have used *Shaper2D* of their own volition when designing with shape grammars, due to its ease of use when searching through a design space.

It is hoped that by capitalizing on the advantages of computer power over hand computation, especially when it comes to more complex design generation, *Shaper2D* will help to foster enthusiasm amongst designers for exploring the possibilities available with computational design.

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