

Designing a Craft Computing Environment for Non-Industrial Settings

by

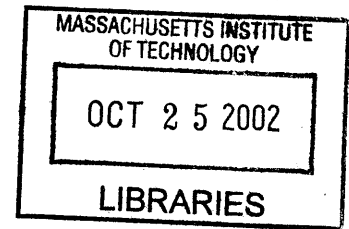
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Submitted to the Program in Media Arts and Sciences,
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Master of Science
at the
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Abstract

This thesis studies the design and introduction of relevant computer-based design tools for non-industrial locations in developing settings. To this end, a programmable environment for combining motifs into patterns was developed named Estampa (**E**nvironment for **S**tamping **P**atterns). Estampa was developed for the community of Santa Clara del Cobre, a copper craft artisan town located Mexico, where they already used Computer Aided Design (CAD) tools for their craftwork.

Estampa is a visual programming language environment for applying transformations to primitive motifs to create ornamental patterns. Estampa seeks to recreate the motifs and patterns in the Best Maugard drawing method, a drawing technique for creating authentic Mexican drawings.

The design and implementation of Estampa seeks to fulfill the economic, cultural and artisanal requirements of this specific location. The evaluation of Estampa, through initial user trials in the community, presents other possible approaches for introducing programming in a relevant way to non-industrial locations in developing countries. Drawing from this example, a series of guidelines are presented for designing and introducing relevant computer-based applications for these communities.

Thesis Advisor - **Mitchel Resnick**
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
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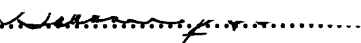
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Chapter 1

Introduction

The research in this thesis combines three topics:

- The description of a successful introduction of a computer aided design (CAD) tool in a non-industrial, non-developed location. I studied how James Metcalf introduced a CAD tool in Santa Clara del Cobre, an artisan community in Michoacan, Mexico.
- The design and implementation, based on the above-mentioned study, of a programmable drawing tool called Estampa (Environment for Stamping Patterns). Building on the Best Maugard technique (Adolfo Best Maugard, 1927), Estampa provides programming constructs and commands for generating patterns of primitive motifs. The programmability of the environment allows the artisan and children to explore the design of patterns in new ways, not possible existing CAD tools.
- The evaluation of Estampa through user trials with children and artisans of Santa Clara del Cobre. I then developed a set of design guidelines for the creation of specialized applications relevant for non-industrialized settings.

1.1 Motivation: Digital Design Divide

Computers are being introduced into developing locations by regional, national, and international agencies. To create software relevant for these locations, it is essential to have software design criteria that meets the cultural, social, and economic requirements of these settings. To have a deeper understanding of these design requirements, I studied how a successful CAD/CAM application was introduced in a craft school located in the small artisan community of Santa Clara del Cobre. Based on my findings, I then created a programmable drawing tool, specifically tailored for the artisan's economic and cultural needs.

While the desire to “bridge the digital divide” has reached the agenda of many international and government agencies, there is still much discussion of what the “digital

divide” means and how it might be diminished. Some initiatives consider it is enough to provide Internet access and productivity suites, but I contend that it is not. The computer can have a broader role than being just a communication and information medium; it can be used for simulation, control, sensing/acquisition or design.

The use of the computer as a digital design tool might seem too sophisticated for non-industrialized settings, but in Santa Clara del Cobre, CAD/CAM tools are currently being used to conceive and manufacture copper crafts. I aim to provide these artisans with an environment where they can use the computer as a programming tool. I believe that if the artisan is presented with an appropriate tool, he will use the power of computer languages to create new designs for his crafts. In the short term, artisans could program these new designs using Estampa. Furthermore, learning to program can teach debugging skills to the artisan, useful for solving daily computer problems such as configuring hardware, installing software, or locating a malfunction.

I hope that in the long term, artisans will be sufficiently acquainted with the programming skills required to design and implement their own custom environments. Artisans have traditionally manufactured their tools (Rolt, 1965) and in Santa Clara del Cobre, the artisans are presently creating their own crafting tools such as custom iron tools and lathes. Consequently, I see no reason why they could not create their own software in the future, given the necessary training.

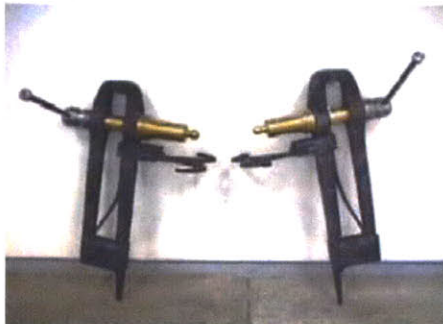


Figure 1 Tail vice forged in iron for an ironsmith



Figure 2 Lathes created for artisans by artisans

My choice to work in Santa Clara del Cobre was not motivated by pity or philanthropy but rather by this town’s, crafting culture, small size, rural location, and educational philosophy. As far as my research is concerned, these elements translated into simple logistics and straightforward politics, along with a creative and technical background ideal for introducing new digital technologies.

1.2 Approach: Craft Computing

While investigating pilot educational programs in Mexico with professor David Cavallo¹, I visited an artisan craft school, the CECATI 166 (Centro de Capacitacion Tecnica e Industrial), located in Santa Clara del Cobre. This school is exceptional, since it uses the computer as more than an information and communication technology. It uses the computer as a digital design tool, for the creation of non-industrial crafts. Each craft is unique and created with a wide range of modern and ancient techniques. The artisans of the CECATI also take an active role in teaching CAD to the community of Santa Clara by giving courses in the Salvador Escalante elementary school.

Thus, Santa Clara del Cobre provided an ideal environment for the research and development of new digital design technologies. In the CECATI, James Metcalf adapted a method for designing authentic Mexican drawings to be used with a CAD application. This technique, the Best Maugard method, lends itself to computational environments since it describes in detail how to combine motifs repetitively to create patterns. Since the patterns generated by the artisans for decorating their copper plates are quite symmetric and seem programmable the following question arises:

Is it possible to create a programmable tool for motif and pattern exploration for the artisans and children of Santa Clara del Cobre?



Figure 3 Hand-made artisan plates from Santa Clara del Cobre

¹ Principal investigator of the Future of Learning Group at the MIT Media Laboratories

In order to investigate this question I created an environment for stamping patterns, Estampa, which is based on the motifs and pattern arrangements described in Best Maugard method.

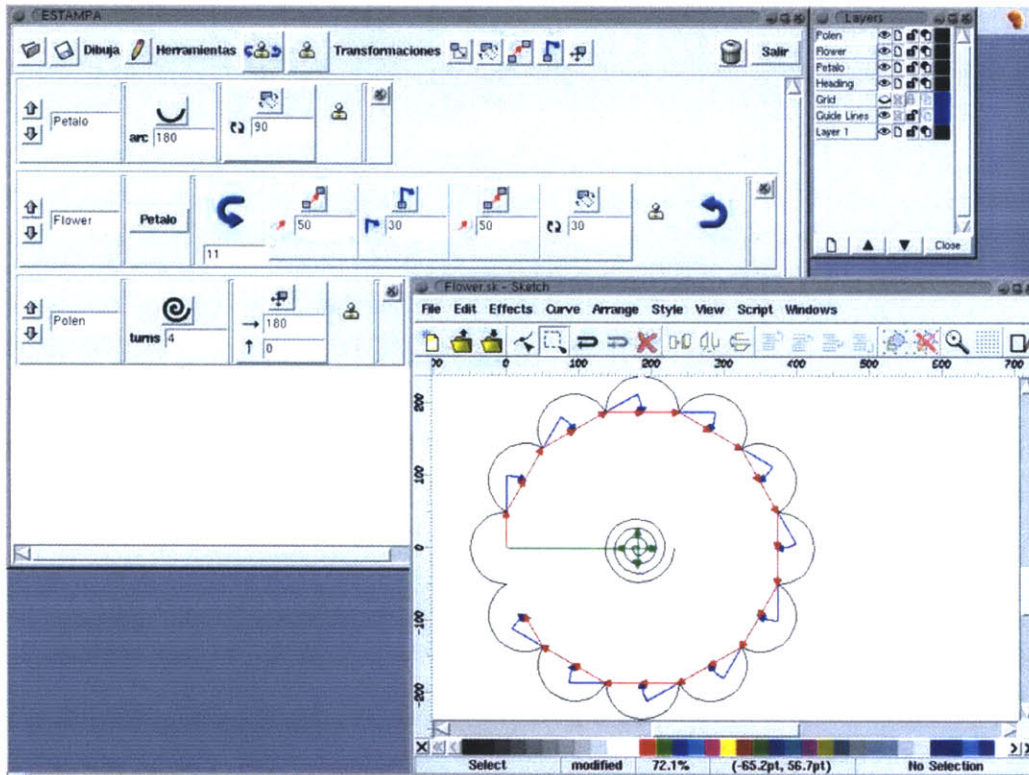


Figure 4 Estampa: Environment for Stamping Patterns

Patterns can be drawn with Estampa by programming “stamping rows” in an iconic visual language. These “stamping rows” apply transforms (translation, rotation and scaling) to pre-selected motifs (spiral, circle, half-circle, s-form, line, zigzag, wavy-line) or groups of motifs.

Estampa is based on the Best Maugard technique for creating Mexican drawings. It is a craft-computing environment in which patterns can be programmed to be later incorporated in the creation of a craft.

1.3 Overview

In the second chapter, I will introduce the concepts and historical background related to the creation of Estampa. I will present the concept of Craft Computing in the third chapter, describing existing educational crafting software and the requirements necessary for the design and development of a Craft Computing application. In the fourth chapter, I will

describe the design and implementation of Estampa, and in the fifth chapter, I will evaluate Estampa by analyzing the user trials and other field observations.

Chapter 2

Historical and Methodological Background

This chapter describes the underlying concepts and historical background surrounding Estampa. I first relate a brief historical account of Santa Clara del Cobre, the CECATI craft school and the introduction of computers in the CECATI. Then I present the learning and fieldwork approaches that I used for the design of Estampa. Finally, I present other related work, previous educational languages created for drawing and related Media Laboratories projects

2.1 Santa Clara del Cobre and CECATI

2.1.1 Santa Clara



Figure 5 A view of Santa Clara del Cobre Landscape

Forged and hammered copper objects have traditionally been produced in Santa Clara del Cobre. The first artisans were the Purepechas, a local indigenous culture. When the Spaniards arrived, Santa Clara continued to play an important role in the smelting and production of

copper objects during the Colonial period and the Independence. In the 1860's, as a result of a decline in the working of mines and Mexico's economic condition, the town became impoverished. Handcraft production decreased until the 1940's when artisans concerned about the dying copper tradition organized the first copper fair reinvigorating the forging activity. For more Information, refer to "Artisans of the Future Santa Clara del Cobre" (Jorge Pellicer, 1996).



Figure 6 Santa Clara del Cobre location in Mexico

2.1.2 CECATI Background



Figure 7 The CECATI Adolfo Best Maugard

In 1968 James Metcalf and Ana Pellicer settled in Santa Clara del Cobre. Since their arrival, they have exchanged metal working techniques with the local artisans and have taught other crafts. They founded and direct the local crafts school, the CECATI (The Technological and Industry Training Center). Anna Pellicer the director of the CECATI describes the school as follows:

The principal workshops, of the school are metalworking and jewelry-making in copper and silver. Obviously, the former is the most important because it is the principal industry of the region., and is subdivided into two specialties: the forging technique of Santa Clara, and the European tradition which is now disappearing in many industrialized countries. The craft jewelry-making introduced by the school is one of the most unique contributions for the development of women and the community. The supporting practices, which also produce their own objects, are: blacksmithing, casting in lost wax and sand casting, machine tools, metal turning machines (lathes), enamelwork, stone cutting, and electroplating in copper and silver... The possibilities for integrating all these different specialties exceed one's imagination, and the fact that students move freely from one shop to another gives this new generation of artisans an inexhaustible vocabulary of concepts which augments their perspectives for a fruitful and successful career. (Jorge Pellicer 1996)

The CECATI is autonomous in many aspects as they manufacture their own materials, tools and develop new techniques. One distinctive creative aspect of the center is their non-industrial production: that is, each handcraft produced is unique and created with a wide range of ancient or modern techniques. These techniques are rooted in local ancient techniques to forge the copper or have been introduced or developed by the technical director of the CECATI school, James Metcalf. In the following section, a short biography of James Metcalf is presented to familiarize the reader with the artistic heritage that James Metcalf has brought to the CECATI.

2.1.3 Biography of James Metcalf²

James Metcalf was born in 1925 in New York City. His grandfather was a Swiss Mechanical Engineer manufacturing knitting machines and his father studied in the Pennsylvania academy of fine arts. James was first introduced to stained glass in his father studio in Closter, New Jersey. At 13 he joined his father to photograph the stained glass windows in France and Germany but returned to the U.S.A before the war broke to continue working in his father's studio. Metcalf enlisted in 1942 but was severely wounded in 1944 in Tuscany, so he returned to the U.S.A to attend the Pennsylvania academy of fine arts where he studied sculpture with Paul Manship and Walter Hancock.

In 1950 Metcalf traveled to Paris, to meet with the famous painters and sculptor Zadkine and Giacometti. In London, he enrolled in the Central School of Arts and Crafts. He won the Goldsmith's Hall prize for his work in silver. He then worked with Robert Graves and illustrated "Adams Rib" in Deya, Majorca. In 1956 Copley offered Metcalf a studio in France at Impasse Ronssin, where he won the William and Norma Copley Foundation award. Afterward James started to meet regularly with older artists (Marcel Duchamp, Man Ray, Mata, Magritte, Wilfredo Lam, Henri Cartier Bresson) at Copley Long Pont home outside of Paris. Then James started his individual exhibitions at Gallery du Dragon and Gallery Furstemberg (with Copley), Paris followed by the Bienalle de Sao Paulo, Brazil and many others in several Galleries in Barcelona, Baltimore, London , New York, Brussels.

In 1966 he visited Santa Clara del Cobre. The next year he establishes a shop with his student sculptor Ana Pellicer. In 1968 he won commission for the "Olympic Torch" at the 1968 Mexico's Olympic games, subsequently he won with the artisans of Santa Clara many other commissions for public pieces. In 1976 Metcalf and Pellicer founded the CECATI. Nowadays they continue to have exhibits and are still commissioned to create public sculptures and while they direct the CECATI, they run exchange programs with other artisan schools that they created in Oaxaca and Chiapas.

² Sumarized from the Copper, Stone and Fire

2.1.4 Computers in Santa Clara



Figure 8 Plate realized in AutoCAD by Salvador Saenz

James Metcalf first used computers to write a book using Adobe Page Maker, a desktop publishing and layout tool. He was then taught CAD by Michael Olmstead a packaging design manager from Gillette who was taking craft courses in the CECATI. James realized the potential of AutoCAD as soon as he started to learn it. He was mainly interested in the computer as a design tool because it provided “articulated lines”. The user could create a drawing using “perfect shapes” and concentrate in the theme and composition without requiring a drawing skill that would take years of practice to acquire.

The skill to draw a perfect hand-drawn circle takes years to develop, while a child can create a “perfect circle” in a CAD with a few clicks. The utility of CAD tools for drawing lies in the constraints they pose to the artisan or the elementary student. The CAD user is only allowed to make flawless straight lines or perfectly round circles. James Metcalf realized how the CAD tools would allow the child to play with composition elements he would never had the access until he acquired the motor skill to draw articulated lines. This does not mean that the computer is necessarily a superior medium to learn drawing; the computer can never replace hand drawing, but it can serve to explore drawing in different ways than hand drawing can.

He then realized that the Best Maugard technique could be adapted to be used with AutoCAD to create beautiful Mexican drawings. It was an appropriate technique since it uses motifs that can be recreated in AutoCAD and patterns that can be arranged with the rectilinear or circular matrix tools. Once he refined the drawing technique, he focused on

developing a manufacturing technique that would allow engraving the patterns created in AutoCAD in copper craft. The drawing confined to the screen or to a sheet of paper is worthless for the artisan in Santa Clara, since it does not have any commercial value. Metcalf first experimented with laser printers using plastic slides, ironing the pattern drawn with laser toner in the copper craft. This technique was not successful because the toner did not protect adequately the copper from the chemical solutions, resulting in a poor quality in the engravings.

Then James remembered how he had seen the router used in the signage industry. It was used to cut shapes that would be sandblasted into glass. Thus, he proceeded to buy a router and cut the AutoCAD shapes in a 3M auto-adhesive that would be resistant to the chemicals solutions. He placed the adhesive to protect the surfaces that he wanted to protect from etching and the pattern was transferred to the copper plates.

When James completed the creation of his manufacturing technique, he made possible to create craft using digital tools, since all the necessary supporting digital design existed:

- A relevant Drawing technique:

The Best Maugard technique lends itself to be adapted for CAD since it uses simple motifs.

- A relevant Manufacturing technique:

The created design can be transferred to a craft that has cultural and economic value

- A relevant Cultural and Economic value:

The created craft can be sold in Santa Clara del Cobre, a town now visited for its unique and refined copper craft.

2.2 Learning and Fieldwork Methodologies

2.2.1 Apprenticeship and Constructionism

In the CECATI, the artisans learn following an educational philosophy that borrows from the apprenticeship model and follows the Best Maugard technique. Their apprenticeship model is stated in their pedagogical principals as follows:

The artisan, in the relationship that he establishes between the master and the apprentice, learns by working, and it is through this activity of conceiving and doing that he broadens his capacities enriching permanently his craft. (Ana Pellicer & James Metcalf, 1997)

Best Maugard describes his technique as:

We shall give the student what he is unconsciously striving for: the materials and suggestions, which will make him utilize his creative energies but placing him in the proper environment. By giving him the general principles, we shall help him find the most direct route to self-expression through his own experience, thus eliminating unnecessary waste of effort and time. The most salient features of this system are the simplicity and rapidity with which results are obtained. (Adolfo Best Maugard, 1927)

This learning philosophy and technique are very akin to the Constructionist framework developed by Seymour Papert based on the constructivist learning theory of Jean Piaget.

Papert refers to constructionist learning as:

Learning happens felicitously in a context where learners are consciously engaged in constructing a public entity. (Seymour Papert, 1980)

The congruence of constructionism and apprenticeship stems from the emphasis on using authentic tasks for knowledge building. However, constructionism appreciates the tool more for its educational qualities while apprenticeship values the tool for its creative properties. These are not mutually exclusive learning methods, but they strive for different goals. While apprenticeship focuses on attaining the perfection of the end product, constructionism focuses on the learning of abstract ideas during the process of designing/building concrete artifacts.

One of the most difficult challenges of this thesis was creating an environment that was appropriate for both of these learning philosophies - a tool that focused on the learning of abstract ideas in the domains of geometry and programming while supporting the creative composition of an aesthetic authentic Mexican design.

2.2.2 Fieldwork

Computers and software never evolved in non-industrial environments in developing countries, they just materialized. In developed countries, the creation of crafting software has been following the advent of digital technologies. This is illustrated by the variety of crafting software and hardware that is available in the USA to create traditional crafts such as

quilting, embroidery and stained glass. However, in non-industrialized settings, computers are appearing without any previous history. Consequently, no software has specifically been developed for these environments, and even less with them. If the computer is to find its place in a non-industrial society in non-developed locations, it is important to develop applications that are specifically suited for their culture and infrastructure.

In order to create adequate tools for the intended audience, the programmer must go, on site, to understand the design criteria. The involvement of potential end-users for the design of a system stretches across a wide range of perspectives, backgrounds, and areas of concern but is formalized in several design approaches. Participatory design in particular, encourages the designers to work with users to better understand the implications of prototypes and scenarios for new designs (Greenbaum & Kyng, 1991).

2.3 Educational languages for drawing

A computational language for drawing generates graphics algorithmically. It executes programs whose commands produce visual alterations directly in a graphical computer environment. The use of languages for generating drawings has a long history in computers. Many of these languages have been created, for a variety of goals - 3D modeling, graphic user interface toolkits, and game graphics.

A segment of these languages have been designed to serve as educational entry points to programming and drawing. These languages attempt to make it easier for novice to program computer users by grounding themselves in the specific activity of drawing. They allow the user to start writing small programs using only a few commands linked with simple syntax.

In the following section presents a brief review of some of these languages for drawing, three graphical languages specifically designed with children in mind. I will first describe Logo, an environment for exploring geometry by programming followed by ETCH an environment for programming and manipulating drawings for fabrication applications. Then I will introduce the design by numbers language created with designers in mind to explore computational graphics. Finally, I will present the Shaper 2D an environment created for undergraduate architectural students in mind to explore shape grammars, and pattern a program for generating Indian artisan patterns based on shape grammars.

Logo

“The computer is used as a mathematically expressive medium, one that frees us to design personally meaningful and intellectually coherent and easily learnable mathematical topics for children.” Seymour Papert, (1980)

A team from MIT developed Logo, a computer programming language derived from Lisp. An early feature added to the Logo language was a graphic object know as “the turtle”. The turtle presented on the screen can be moved to any position or turned to a heading by typing commands such as `forward` or `turn`. In addition, the turtle can draw on the screen by leaving a trail while it moves, using a “pen”. Hence, geometric shapes can be drawn using “turtle geometry”, that is giving the turtle the commands to draw the desired shape. For instance children can draw a square by programming the turtle go forward a constant distance and turning a right angle four times

```
repeat 4 [ forward 10 leftturn 90].
```

Thus, Logo introduces children to a new geometric “microworld” -a self-contained world for exploring geometrical and mathematical ideas (Papert, 1980). For more information, refer to the Logo foundation web pages (<http://el.www.media.mit.edu/logo-foundation/>) and to the Logo Microworlds site (<http://www.microworlds.com/>).

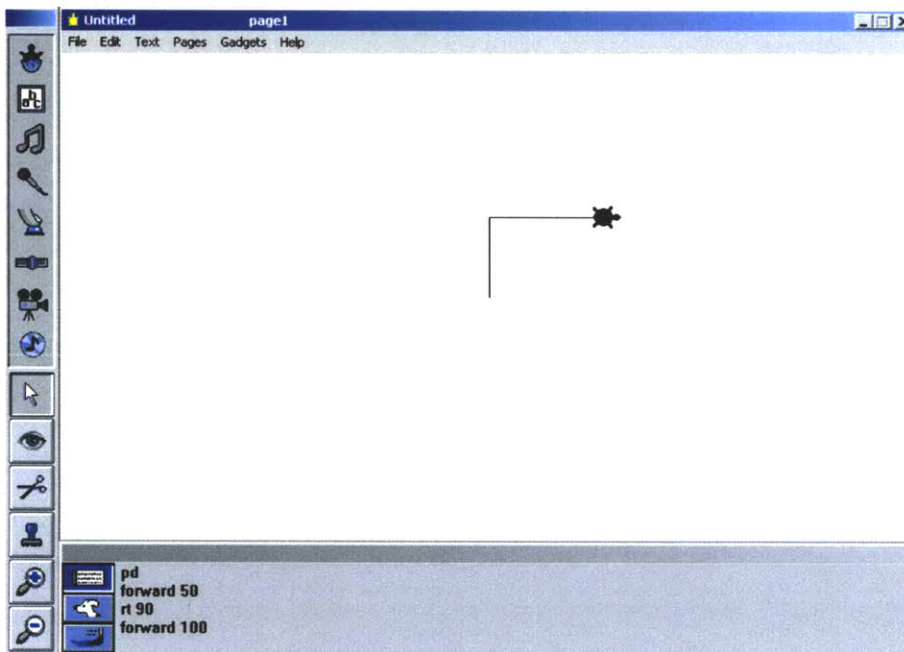


Figure 9 Microworlds Logo from LCSl

ETCH

Etch is a vector based graphic design environment, in which one can create objects not only by direct manipulation tools, but also parametrically through an object oriented version of the programming language Logo. Etch outputs in a variety of file formats supported by many fabrication tools both modern -- like laser cutters, Waterjet cutters, and 3D printers -- and traditional -- like computer numerically controlled lathe, milling, and sewing machines. In Etch, the graphical turtle serves as a concrete model for the machining tool tip (drill bits, laser, or needle), and Logo is a formal way of understanding and creating representations of tool paths underlying common file formats used in describing project files for common fabrication applications. (Bakhtiar Mikhak, Jeff Mellen and Andrew Begel)

As new technologies bring these types of tools to a new community of users, new design applications are required. ETCH expands the realm of creation of a Logo environment by providing an platform for the creation of concrete objects through computer aided manufacturing tools. One of the goals is to create unique programmable entry points to the world of machining and fabrication. For more information, the reader is referred to the Learning Webs group's fabrication page (<http://lw.media.mit.edu/projects/fabrication/>).

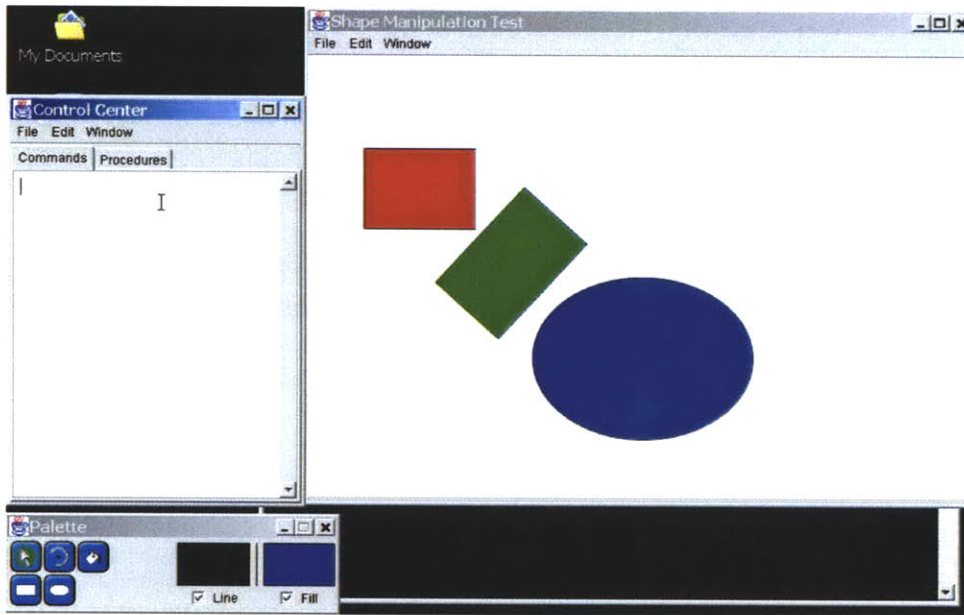


Figure 10 ETCH

Design by numbers

DBN is both a programming environment and language. The environment provides a unified space for writing and running programs and the language introduces the basic ideas of computer programming within the context of drawing. Visual elements such as dot, line, and field are combined with the computational ideas of variables and conditional statements to generate images. (John Maeda, 1999)

The Design by Numbers language was “designed specifically for visual people – artists, designers or anyone who can pick up a pencil and doodle” (John Maeda, 1999). It is composed of simple and concrete metaphors such as `paper`, `line`, `point` and basic control structures as `repeat`. As an extremely constrained drawing environment, design by numbers presents an excellent example in how well chosen constraints can support powerful scaffolding. Maeda transforms the drawing space, composed by a grid of 100 by 100 points into scenes, reactive graphics and a remarkable variety of graphics. For more information, consult the design by numbers web site (<http://dbn.media.mit.edu/>) or “Design By Numbers” book (<http://www.maedastudio.com/dbn/>) a detailed tutorial introducing the designing by numbers programmable language and philosophy.

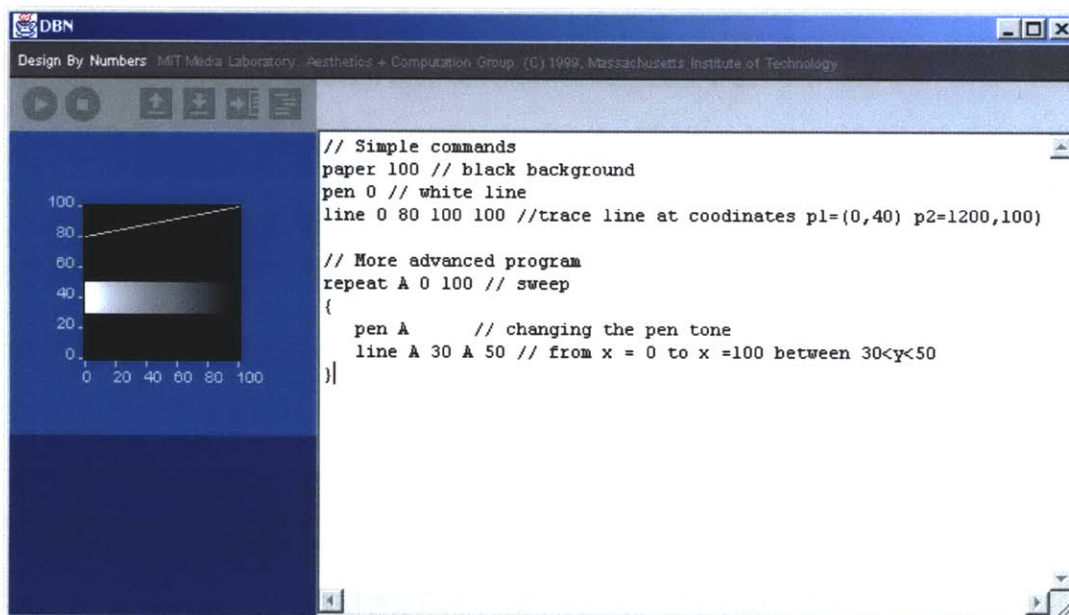


Figure 11 Design By Numbers

Shaper 2D

“Shape grammars are visual, spatial algorithms for creating, or computing, and understanding designs ... Presently, the preferred approach to the development of shape grammar interpreters is to design special tools for special functions, rather than “universal tools”. The program presented in this thesis, Shaper2D, was developed by the author as a dynamic, visual interpreter for exploring basic, two-dimensional shape grammars. (Miranda Clare McGill, 2001)

Shaper 2D is a constructionist environment for the learning and practice of shapes grammar. It is directed towards the designer who wishes to experiment with shape grammar without having to learn and understand all the theory behind it. The most remarkable part of the Shaper 2D is the constrained and graphical programming environment which allows the designer to easily explore a wide space of design, by controlling a few parameters. Moreover, its visual programming metaphors allow for a direct and interactive for the manipulation of simple shape grammars.

Shaper2D is treated in “A Visual Approach for Exploring Computational Design” (Miranda Clare McGill, 2001) (<http://architecture.mit.edu/~miri/shaper2d/index.html>) and can be downloaded freely (<http://architecture.mit.edu/~miri/shaper2d/index.html>).

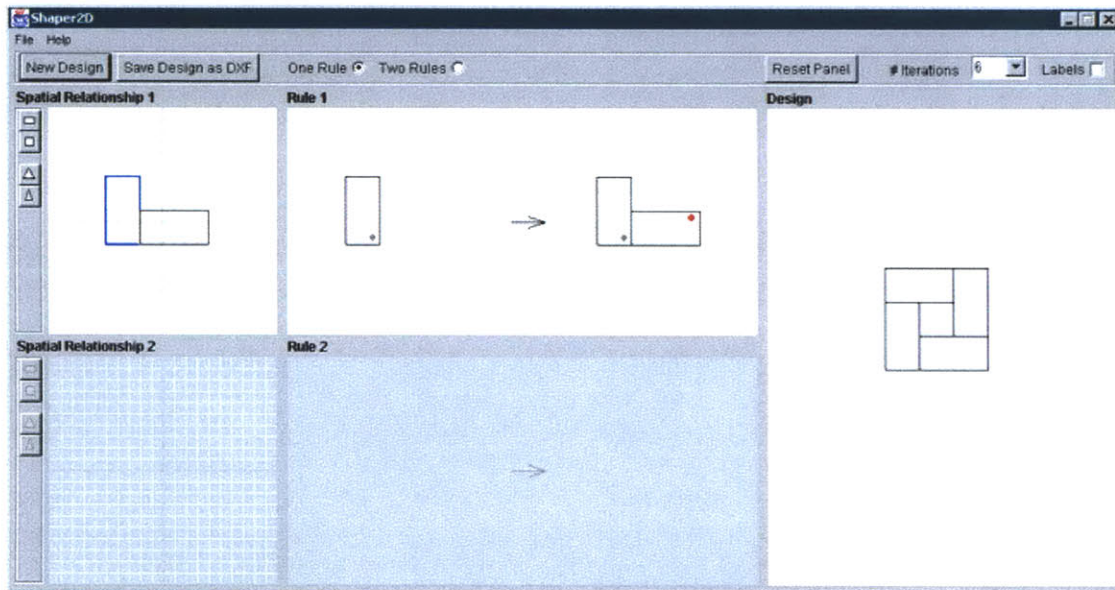


Figure 12 Shaper 2D

Pattern

Pattern reads in a shape description, builds a tree of shapes and renders the pattern. [Pattern] is meant for incorporation into design software that can be used by persons having minimal artistic skills. (Kendar S. Patil 2002)

Pattern is a promising environment for programming traditional patterns of india. It renders beautiful artisan drawings programmed in a Shape Grammars Descriptions Format into postscript files. The scripts uses metaphors Shapes, Compound Shapes and Pattern Trees to describe ornamental patterns. This Compound Shapes and Patterns Trees could be good metaphors for programming arrangements of flowers as show below.

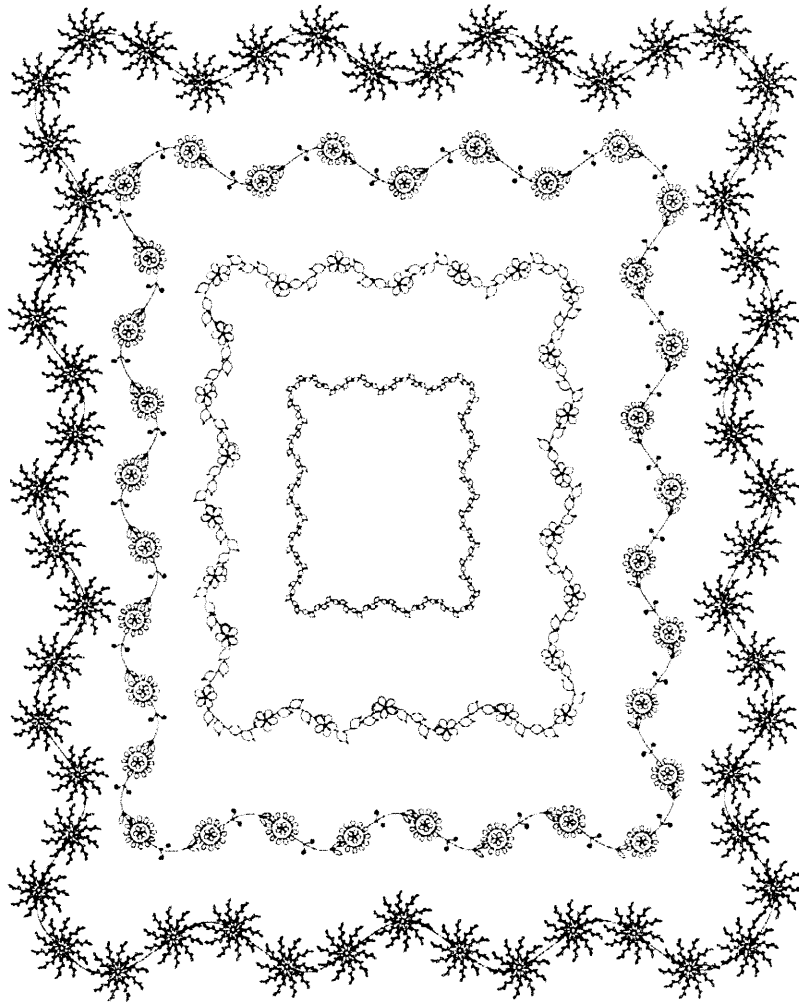


Figure 13 Border Patterns produced using *pattern*

2.4 Media Laboratories related projects

There are several groups working on technologies for developing nations in the Media Laboratories at MIT. The Human Design research group (<http://www-white.media.mit.edu/~sandy/students.html>) and the e-development group (<http://edev.media.mit.edu>) are centered on the information and communications divide. In the human design research group, the LINCOS project (<http://www.lincos.net/>) provides access to computers and Internet with a series of services and applications such as: Telemedicine, Internet, Electronic Communication, Videoconference, Electronic Trade, Educational Computer Science, etc. The e-development group focuses on e-commerce, communication, and system software that are appropriable and appropriate to emerging communities with projects like VAN a synchronous voice communication system and CONVIVO a broadband wireless network designed to work with the network realities of many rural communities in the developing world.

Other projects addressing the digital divide are focused in fostering constructionist activities supported by digital technologies. These initiatives provide the necessities social settings and technological building blocks to perform meaningful design activities. The Learning Independence Network from the Learning Webs (<http://lw.media.mit.edu>) group facilitates a “true transfer of technology” by enabling people and organizations in the developing world to design and create their own technological tools and solutions to community challenges. The goal is to foster a greater sense of independence and self-sufficiency. The Computer Clubhouse (<http://www.computerclubhouse.org/>) from the Lifelong Kindergarten group (<http://llk.media.mit.edu>), is a model that uses technology creatively to enable under-served youth to acquire the tools, problem solving skills, and confidence for successful lives (Resnick, M., Rusk, N., and Cooke, S., 1998). The Learning Hubs project from the Future of Learning group (<http://learning.media.mit.edu/>) devises innovative learning environments composed by "learning activists" who form local groups to develop, guide, research and help others appropriate successful models.

2.5 Ethics: Giving Back

While conducting my research in Santa Clara del Cobre, I attempted to behave ethically, without taking advantage of the community. As Ana Pellicer explains:

“Unfortunately the desire to loot – disguised in many ways – is the attitude that prevails: art students, university researchers, and amateur artisans think they have the inalienable right to exploit any cultural richness whatsoever that a community possesses, without caring that such a sanctuary of collective creativity may be irremediably damaged in the process” (Skodnick Roy 2000)

Thus during my stay in Santa Clara del Cobre I led several initiatives to assist in the most urgent computer related problems. In addition to the personal satisfaction, this experience gave me valuable insight for understanding the present and future uses of computers in the town. In the following section, I present some of the initiatives where I contributed.

2.5.1 Reconditioning of computer room

When I arrived in the computer room, it had several commonplace problems:

- There was only one chair per computer instead of two (to foster collaborative learning).
- Even if they had a hub and structured cabling the LAN was not connected.
- All the users logged in as Administrators.
- The Administrator lacked some of the essential concepts about networks such as:
 - - TCP/IP, DHCP, debugging abilities, configuration insights.
- Several of the computers were out of service, (the motherboards where irreparable).
- I assisted, or encouraged others to solve these problems. I was surprised by how little interest they had in having a LAN. The system administrator did not understand why it was interesting to have a Local Area Network if they did not have a good connection to the Internet.

2.5.2 Internet connection

I established a dial-up connection through a Linux server, which provided Internet access to the rest of the computers via DHCP. The dial-up connection had several problems, thus this system was only functioning for two months. Later, they were provided with a satellite connection by the Latin American Institute of Education Communication (ILCE), with a high latency but good bandwidth. I was shocked by all the problems that I had setting up the Linux sever. I tried my best to introduce the system administrators to the management of the

server. System administration requires a lot of background they were not familiar with, such as reading and understanding English. A solution for this problem is to provide good quality training for network administrator that go through a rigorous selection process.

2.5.3 WebPage tutorial

I taught several web page authoring courses. The pages that the artisans and personnel of CECATI created can be viewed from their Linux-based web server hosted in Santa Clara at (<http://www.cecati166.net>) or in a mirror site hosted at the Media Laboratories (http://web.media.mit.edu/~dkor/sc/cecati/cecati_web/)

This was a very interesting experience because it required the artisans and the personnel to explain their role in the CECATI. They had to explain the structure of the CECATI and place themselves in that structure. This presents an interesting challenge to them, since they had to use their writing skills in new ways to describe their craft and surroundings to a broad international audience.

Difficulties arose while using the Mozilla composer, the web-authoring environment I selected and during the writing of the content by the personnel and artisans. The software didn't have a friendly and intuitive user interface and posed many problems for the creation of hyperlinks in web pages.

2.5.4 E-mail

I encouraged the artisans and personnel of the CECATI to use e-mail. A general e-mail account was used for administrative purposes, but very few people had their own personal accounts for private messages. After asking several users, I concluded that the penetration had not reached the critical level where e-mail becomes a general-purpose communication medium, because artisans and personal in Santa Clara did not know family or friends that had access to e-mail. Furthermore, using email was inconvenient and public since you had to do it in the computer room instead of the privacy and convenience of doing it in your home or desk. Ubiquitous e-mail access is not useful in a rural non-industrial town if it does not support concrete relationships or actions. The one exception was the students in the Salvador Escalante School, who enjoyed chatting through instant messaging services.

2.5.5 Network administration tutorials

I introduced basic computers and network concepts to the network administrators. In addition to teaching them the technical concepts, I tried to familiarize them with debugging techniques. The acquisition of debugging skills is very demanding since it requires total investment and a substantial background for the learner: He must learn to never give up, find other paths and read technical information. The networks administrators were only left with some notion of the concepts and techniques. Perhaps more training time could have given them better networks managing abilities, but there were several motivational issues that impeded further progress.

2.5.6 Wireless connection

I attempted to set up a wireless connection in order to provide Internet to other elementary schools in Santa Clara. To that end a wave-guide antenna and outdoor casing were manufactured in the CECATI using blueprints found in the Internet link. I installed a WAPI1 multipoint bridge in the center of the town on a radio communication tower antenna, and tested the connection from $\frac{3}{4}$ mile away. Unfortunately, I lacked time for finishing-up the installation.



Figure 14 Wave-guide antenna and weather proof casing manufactured in the CECATI



Figure 15 Side view of wave-guide antenna

Chapter 3

Craft Computing in Santa Clara del Cobre

In this chapter I will first introduce the nature of the computers as an artisan tool. Then I will give a brief review of existing crafting software and its uses with artisans and children, followed by summary of the Best Maugard technique to introduce the characteristics of craft computing. Finally I will present the idea of Craft Computing describing its relevant, realizable and programmable properties.

3.1 The computer as an artisan tool (Based on conversations with James Metcalf)

To understand the role that the computer should play in the artisan's life, one must first understand the artisan-machine relationship. The artisan started to use machines when they began to appear, in the 16th century, before industry was born. Artisans have long used mechanical machines such as the ornamental turning lathe and other tools (Rolt, 1965). The ornamental lathe was designed to produce extremely intricate work, since it allowed new ways to creatively conceive a handcraft while exploring the material. The machine was not primarily used for raising productivity and lowering costs, as in industry, but rather to discover new creative pathways; for tools can mold matter where the hand doesn't have the shape or strength to do so. The defining characteristic of the end product was the intention of the artisan, unrestrained by fashion or price.

But in the 18th and 19th centuries, the machine became the artisan's worst enemy, in the hands of industry. The artisan couldn't compete against the efficiency of mass production powered by mechanism, steam and electricity. This decimation of artisans gave root to many movements, such as the "The Arts and Crafts Movement" in England in the 1860s. Some proponents, such as Ruskin, argued that the machine dehumanized the worker since it detached him from the artistic process, that, "all cast from the machine is bad, as work it is dishonest."(Ruskin, 1853). But other proponents of the "The Arts and Crafts Movement", such as William Morris, were not totally opposed to machines, although "he was deeply critical of the consequences of machine production in a capitalist society"(Harvey Charles, 1996). William Morris understood instead that the machine did have a place in the world of the artisan,

I would do some things by machinery which are now done by hand, and other things by hand which are now done by machinery: in short, we should be the masters of our machines and not their slaves, as we are now. It is not this or that tangible steel and brass machine which we want to get rid of, but the great intangible machine of commercial tyranny, which oppresses the lives of all of us. (Morris Willam, Late 1800)

Thus the apparent conflict between the artisan and the machine did not rise from the machine itself but from the displacement that the artisan was forced to endure by industry. The artisan is helpless when confronting the efficiency of mass-production in the industry. Quoting Mike Cooley³

One of the most perverse things about a mechanistic view of production is the way it attempts to eliminate all uncertainty from the work process, and consequently perceives the human being as a dangerous element of uncertainty. (Mike Cooley, 1982).

Thus for an artist to survive, he must find a product niche, which has and shall remain untouched by industry: the creation of original and unique pieces.

Just as the ornamental lathe was useful for exploring new pathways for crafting, the computer can allow the artisan to seamlessly manipulate preconceived shapes (such as motifs). Thus, the computer should not be used for its labor saving cost for easy mass production, such allowing the unskilled drawing technician to create perfect blue prints, on the contrary, the computer should be used by the skilled artisan for experimenting with different motifs and patterns. This is the main difference between the use of the computer by an unskilled technician and by a skilled artisan - the unskilled technician uses the machine only to reach a preconceived goal, whereas the artisan can use the machine in novel ways. For instance, James Metcalf developed a technique based on the Best Maugard Technique to use AutoCAD, to create composition using “the articulate” lines that a CAD tool offers to the user. Hopefully Estampa will add yet a new way, such as experimenting with the visualization of a pattern with different motifs and allowing for the creation of novel patterns that can only be created by programming, using the iterative power and the versatility of a computer language.

³ Mike Cooley worked for many years in the aerospace industry as a senior design engineer and was an active trade unionist.

3.2 Existing educational crafting software

3.2.1 Educational crafting software for Children

Crafting software for children is not a new idea; several projects that have tried to involve children to create craft using digital design tools. In “The Weaving Turtle” project a group of junior high school drew patterns inspired from African textiles (Mihich, 1993). They created Logo procedures to “weave” the shapes, fillings, and shading, decorating different African textile designs. Another instance of crafting combining art with mathematics can be found in the Escher’s World project that provided children with digital tools for exploring tessellations (Papert 1980, Shaffer 1995). The Craft Technologies at the University of Colorado has created several science-oriented crafting technologies to support a wide range of activities, as paper sculptures, robotics, and the creation of mechanical toys group (Eisenberg, M. and Eisenberg 2000).

3.2.2 Professional crafting software for the Craftsman

In the professional field, crafting software has existed for a long time. The more common software crafting such as CorelDraw or Illustrator, are intended for designers. However more specialized software does exist directed at specific craft such as quilting and stained glass. But specialized crafting applications remain scarce in non-industrial settings in the developing world, which have an important tradition in craft making. Thus, it is worthwhile to study and create computer assisted crafting applications because of their relevance in these communities.

3.3 Adolfo Best Maugard

The Adolfo Best Maugard method for learning to draw is currently used for teaching authentic Mexican drawing in the CECATI and in the Salvador Escalante elementary school in Santa Clara del Cobre. This method has been adapted for drawing with CAD software by James Metcalf. In the next section, I will describe the origins and elements of this method, since it was essential for the creation of the craft computing environment presented in this thesis.

3.3.1 The Best Maugard Technique

Best Maugard describes his technique in his book “A method for creative design” (Maugard, 1927). There are two versions of this book: one targeted for the Mexican elementary school and another was created for the U.S.A. These versions share the same design philosophy but illustrate it with different drawing themes. The Mexican book has themes akin to Mexican surroundings and culture, whereas in the American book the themes are more resonant with American society.

In the first part of the book, Best Maugard describes the seven motifs that form the cornerstone of his method, and their variations. The seven motifs are the spiral, circle, half-circle, s-form, wavy-line, broken zigzag and the line. He goes on to explain ways of combining motifs to form borders, rosettes or all-over patterns.



Figure 16 The 7 primary elements: spiral, circle, zigzag, half-circle, the line, s-form, and wavy-line.

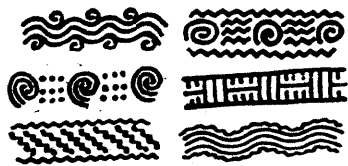


Figure 17 Border combining motifs

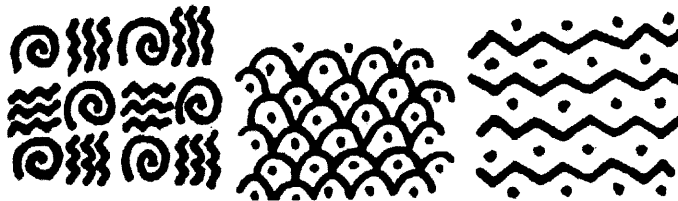


Figure 18 All-over patterns combining motifs.

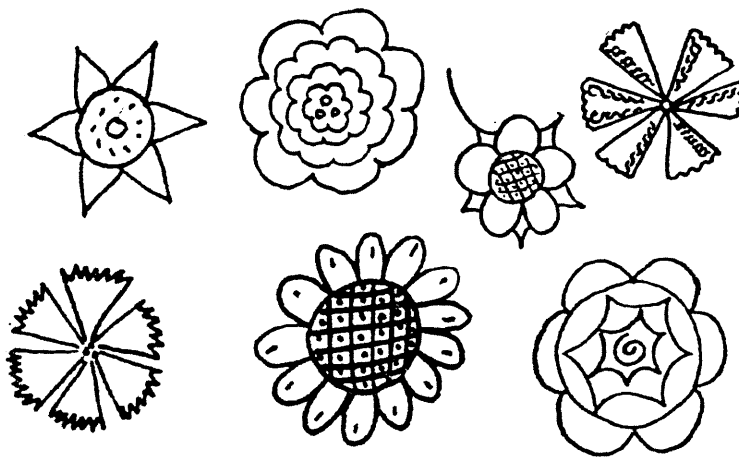


Figure 19 Rosettes representing flowers

In the second part of his book, Best Maugard discusses the flower designs by describing techniques to draw flowers, leaves, stems and flower composition. In the following parts he presents themes that are related to the general culture; these include animals, vegetation, rural and urban landscapes, coats of arms, the human figure, and other technical aspect of drawing like perspective, distance and shadings. Best Maugard does not limit himself to only describing his technique, he suggests to the learner and the teacher the approaches they should take to acquire the skill. He describes which exercises should be performed and how they should be carried out.

In another book, called “Creative Imagination”, Best Maugard treats in detail his educational approach to teaching art. Using the seven motifs in primitive arts, the archetype concept, and the whirling spiral to illustrate his ideas, he describes the development of the creative imagination, the psychology of creation, and the inner and outer causes of creation.

3.4 From computer aided crafting to craft computing

James Metcalf achieved the successful introduction of computer aided crafting in Santa Clara del Cobre. The two main characteristics that contributed to his success are that he created an environment where computer aided crafting was both *relevant* and *realizable*. When I refer to craft computing I will add to computer aided crafting the characteristic to be *programmable*. In the following section, I will present in detail the characteristics of craft computing.

3.4.1 Relevant

Craft computing must be socially, economically and culturally relevant in order to become a reality. In Santa Clara del Cobre, crafting is a socially respected occupation, a source of income, and a tradition that has existed for centuries. This creates a social and cultural environment where an application for craft computing can be deployed. In some urban settings, for instance, I think that the acceptance of digital design applications would gravely suffer from prejudice that labels crafting as a hobby rather than a profession.

3.4.2 Realizable

A craft-computing tool is useless without the necessary technique to produce an authentic tangible craft. Thus, a craft computing tools must have a direct relationship with concrete activities the artisans perform. In AutoCAD the activity was the generation of patterns that

artisans draw to engrave in their copper craft. James Metcalf developed the design and manufacturing techniques necessary for the creation of crafts assisted by computer.

Design Technique

In an educational video James Metcalf explains step-by-step how to construct the seven primary motifs using AutoCAD and how to combine them to create pattern and authentic Mexican drawings designed with a computer (James Metcalf, 2002). For instance he explains how to create a spiral with half circles that is to create bigger and bigger half-circles and place them to create a spiral.

Manufacturing Technique

James Metcalf has developed a technique for creating decorated copper plates using AutoCAD. This technique uses a router to cut the pattern in a 3M adhesive plastic sheet. This adhesive plastic sheet is then transferred in the plate to protect the places that should not be etched. The copper plate is then submerged into chemical solutions to etch the pattern and coat the plate.

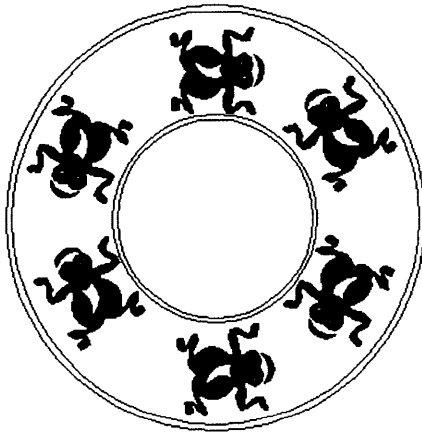


Figure 20 Plate mask created in AutoCAD

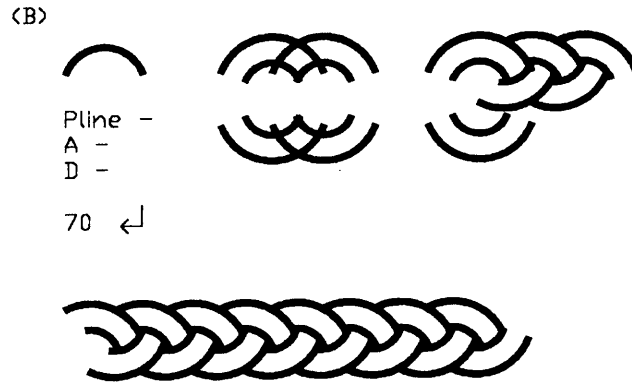


Figure 21 Plate mask created in AutoCAD

3.4.3 Programmable

The idea to create a craft by programming might seem inappropriate. Nonetheless, programming seems to naturally exist in the Best Maugard method. Take the following figure extracted from the Best Maugard AutoCAD tutorial that shows the steps for creating a braid. These steps are composed of AutoCAD commands (Pline-A-D-70) and other actions like copy, paste and trim. The ideal programming language would facilitate the repetitions of

these steps in predetermined order. Thus, the programming language should be limited to simple and understandable metaphors that map to the motifs and arrangements described in the Best Maugard Technique. Thus programming could simplify the creation of some pattern, or make possible the formation of new patterns by using the iterative properties and flexibility of a computer language.



2._ Desarrollo de grecas con el cuarto elemento.

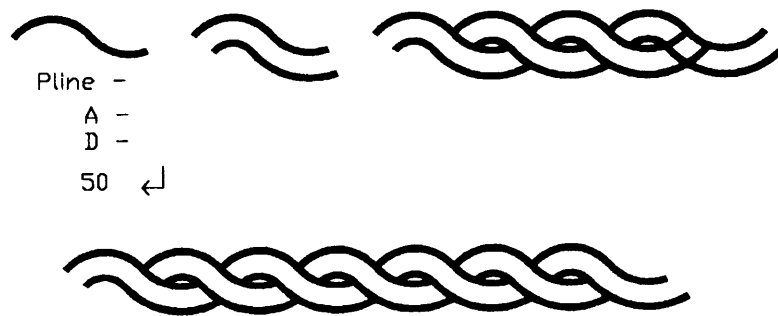


Figure 22 Best Maugard Method Tutorial with AutoCAD, by Salvador Saenz

In the previous figure, two examples for drawing a braid with AutoCAD are presented. First, the commands for creating a circle are presented:

- A command for creating a Polyline - Pline
- Then for creating an arc - A
- And finally the diameter of the arc - D 70

The rest of the construction is completed manually by trimming the half circle and creating a first link, which can be copied and pasted to create a braid.



Figure 23 Drawing following the Best Maugard Technique, by Salvador Saenz

Chapter 4

Design/Implementation of Estampa: Environment for Stamping Patterns

Estampa provides programming constructs and commands for generating patterns of primitive motifs based on the Best Maugard drawing method. Ideally, Estampa should expand the range of what people design and create, by providing a programmable environment where motifs can be arranged by applying transformations. Estampa aims to provide an environment where the artisan and young artisans in the elementary school get an understanding of what the word “programming”, means, by doing it.

Estampa was partly developed in Santa Clara del Cobre. In the following table, I present the chronology of my stays in Santa Clara del Cobre during the development of Estampa.

Stage	Description	Length	Location and Dates
Visit	Introduced to Santa Clara for the first time.	1 Day	Santa Clara del Cobre, MX March 2001
Analysis	Evaluation of the viability of a project.	2 Weeks	Santa Clara del Cobre, MX September 2001
Feasibility Study	Assessed the feasibility of a programmable environment for Santa Clara del Cobre		Boston, USA September to December 2001
Initial design and Implementation	Initial design and implementation of the 1 st prototype of Estampa	6 Weeks	Santa Clara del Cobre, MX December 2001 to January 2002
Implementation	Creation of the 2 nd through final prototypes of Estampa.		Boston, USA
Evaluation	User trails with students of the elementary school and an artisan of the CECATI	2 Weeks	Santa Clara del Cobre, MX June 2002

Figure 24Chronology of the development of Estampa

In this chapter, I will present the economical, technical, artistic, and research requirements of Estampa. Then I will present an analysis addressing the abstraction of the motifs and patterns to computational metaphors. Finally, I will present several prototypes that were created and the final version in the user trials.

4.1 Requirements

The design and implementation of Estampa was shaped by a series of compromises of many requirements. The first task in the design of Estampa was to constrain the design space, focusing on the following questions:

- Should I constrain the research to address very specialized and narrow requirements or should I try to encompass a broad set of needs?
- What are the type and the number of requirements it should fulfill?

I decided to prioritize breath over depth, thus trying to meet a large set of requirements: economical, technical, artistic and research. I realized that all the areas of the research would be compromised by their lack of depth, but I couldn't focus in only one requirement since the specialized research that would result wouldn't be useful in a non-developed setting. However, in industrialized countries narrow specialized research can rely on the industry or governmental institutions to bear the responsibility to transform and deploy their research into reality. But research in developing countries is radically different than research in developed countries. In developing nations, the design/implementation industry is almost non-existent; thus, issues such as the deployment and economic cost concerning the technology must be part of the research requirements. Constraining my research for specialized goals would have rendered it unusable for the very people it was addressing and only useful for industrialized countries: a betrayal of my principle.

4.1.1 Economical Requirements

One essential requirement for introducing crafting software in non-industrial communities is that it should be free and open source. Free CAD software is a necessity for the artisan in developing nations because he cannot afford prices for CAD software that are set in the economies of developed countries. The price and sophistication of today's commercial CAD software makes it unaffordable and unusable tool in non-developed environments. The average Mexican artisan has a relatively small income in pesos and they will never be able to have the capital to buy the CAD software that is created for industrial purposes; it would not justify the expense. Moreover, the cultural mindset to buy books or software is not present in Mexico. The books for public school are provided at no cost by the government, and the

schools do not have a budget for buying software, they just have a budget for buying computers. Thus a first requirement for the environment that I develop should be:

- Free
- Have a relatively low cost

Even if this requirement severely constrains the technologies that can be used, I think its better to have some rudimentary technology, and have the software available to a large community of artisans, rather than using the latest proprietary unaffordable technology.

4.1.2 Technical Requirements

Creating a CAD tool for artisans from the ground up would have been impossible due to time restraints, and it would have been a waste of time to recreate software already available. Thus, early it was decided to use a vector drawing program as platform that would be free and open source. The software needed to:

- Be a vector-based drawing program
- Open-source
- Have printing and saving utilities
- Have documentation, user guides and developer guides
- Be multi-platform

4.1.3 Artistic Requirements

The motivation behind the program was to create a digital environment supported and constrained by the Best Maugard Technique. This was possible because Best Maugard describes in his book a technique that can be easily formalized into a series of motifs and transforms that can be programmed in a computer. Thus, the first step in the creation of the tool was to create the motifs. The second problem was how to parameterize these motifs. Finally, the means to combine these motifs should be provided. Thus, the artisan should be able to:

- Create the motifs.
- Parameterize the motifs.
- Create patterns with the motifs.

The most demanding issue is combining the previously cited elements to invent for a creative space:

4.1.4 Research Requirements

In Santa Clara del Cobre, the use of the computer has reached a very sophisticated stage: it is employed for the design and manufacture of their crafts. The next step for the artisan is to actually manufacture the tool he uses. I hope to follow in the footsteps of James Metcalf who showed the artisans to create their own tools (such as the elliptical lathe in the PEFIPA project). The next step for the artisan, once he has learned to draw with CAD tools is to participate in the creation of his own computer-based tools. However, contributing to the creation of a graphical design application requires computer skills that demand a good understanding of the possibilities and limitations of computer design. Thus creating some environment where the artisan could create designs by programming seemed to be a very reasonable way to introduce them to programming. Moreover, for the young learners in the town's elementary school, it could provide a relevant and meaningful activity where they could start to learn programming and mathematics.

The requirement of implementing a *culturally syntonie* programmable environment for learning mathematical concepts was the most challenging since it needed a mathematical formalization of the Best Maugard technique. Shape grammars and turtle geometry provided two models for recreating primitive patterns. The turtle geometry was chosen due to its didactical and mathematical qualities, and the fact that the task to formalize the creation of primitive patterns into a simple and powerful programming language is a masters thesis in itself (Kendar S. Patil 2002) and should not be taken lightly. Thus, to introduce the artisans and students of the elementary school to a relevant computer activity, the tools would have the following properties:

- Programmable
- Turtle Geometry

4.2 Analysis

In this section, I analyze some of the important characteristics of the implementation of Estampa, mainly the parameterization of the motifs and the selection of the transformations.

4.2.1 Analysis of the Motifs

The first step for creating a language based on the Best Maugard method was to try to map the symbols to computational objects. I created static motifs, such as a spiral with a preset number of turns. The main problem in implementing the motifs is how to parameterize them.

Some of the motifs do not need any parameterization, as they can be deformed with the transformations available. For example, the circle can be deformed into any kind of ellipse by scaling horizontally or vertically and rotating it. For other motifs the parameterization was trivial, for instance the spiral needed a number of turns. Some others presented greater difficulty to deform, such as the wavy-line, which had several kind of possible deformations. Mapping organic deformation like the ones presented by Best Maugard is not trivial.

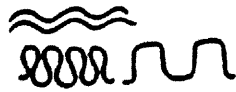


Figure 25 Wavy-line variations

Thus, I decided to implement the simplest deformations that I could perform.

Motif	Parameter	Example
Spiral	The number of turns	
Circle	No parameter	
Half-Circle	The arc of the angle	
S-Form	The arc of the angle	
Wavy-Line	The arc of the angle	
Zigzag	The inside angle	
Line	No parameter	

Figure 26 Parameterization of the Motifs

Many properties, such as length, are not parameters since they can be modified with the transformations. The motifs share these common properties:

- They are all the same size.
- They all grow out from the middle outwards.
- The center of rotation is the symmetric center.

For a more detail presentation of Estampa, consult Appendix A.

4.2.2 Analysis of the Transformations

The role of the transformations is to produce patterns like the ones in Best Maugard book, and to create new designs using features that are only available with programming. After using several metaphors turtle geometry was chosen, since it proved to be the most simple and coherent one for the intended novice programming audience, elementary school students and artisans.

The five transformations are *scale*, *rotate*, *forward*, *turn* and *move*, shown in the picture below. The *forward*, *turn* and *move* transformations affect the position of the motifs, while *rotate* and *scale* *directly* affect the motif drawing.

The *forward* transform displaces the motif in the direction of the heading. The *move* transform translates the motif following a vector described by an x and y module. The *turn* transform rotates the heading as in turtle geometry. The *rotate* and *turn* transformations should not be confused, the *rotate* transform refers to turning the shape while the *turn* transform refers to turn the motif's heading. Finally, the *scale* increases or decreases the size of the motif according to its present size.

After defining the transformations and how they are applied, I created several prototypes where programmed to find out the best way to apply these transforms. The objective was to create the simplest constructs that would replicate Best Maugard patterns.

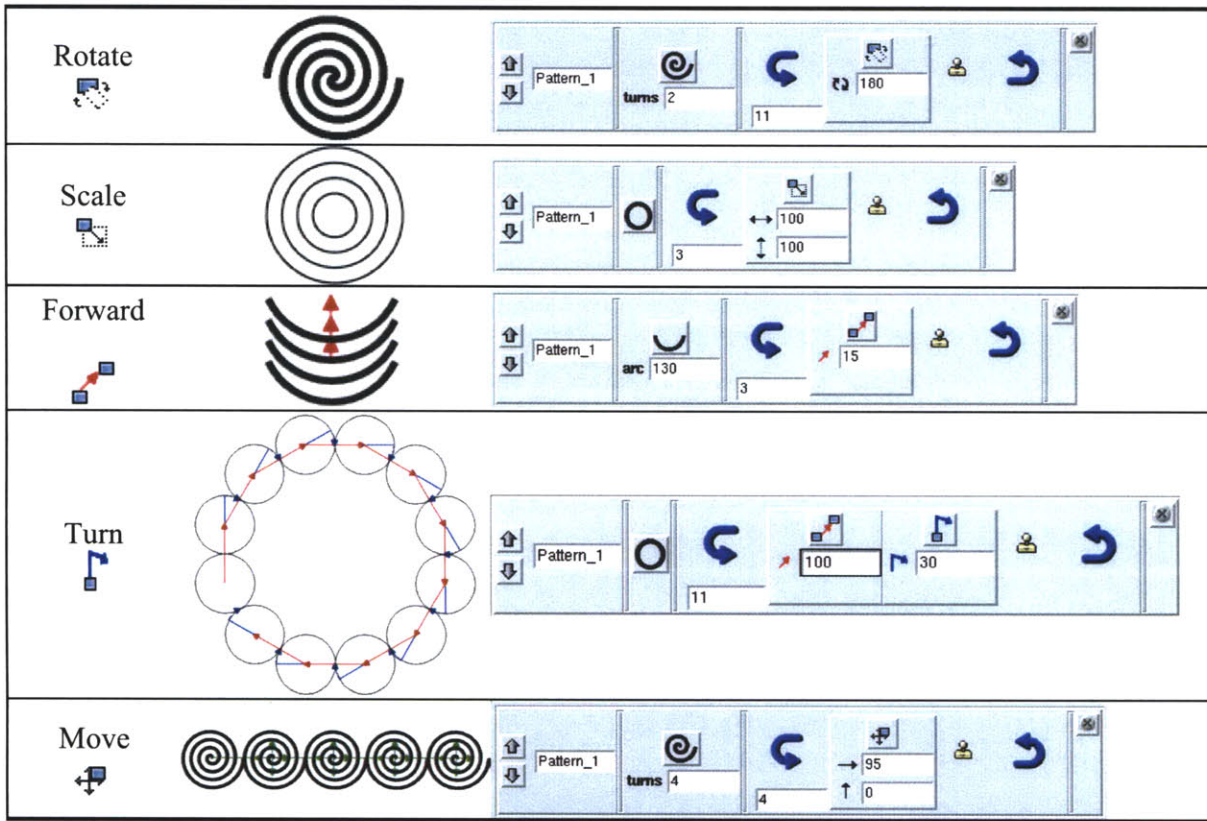


Figure 27 Transformations performed by Estampa

4.3 Prototypes

4.3.1 Text Prototype

My initial idea behind the creation of a computer-based Best Maugard design tool was to have a textual programming language for drawing patterns. James Metcalf quickly refused this proposal for various reasons. It first imposes a very hard and difficult learning curve for the learner since he must learn the syntax, grammar and semantics of a textual language. While using AutoCAD 10 he noted that the navigation through menus was a very confusing experience for the children. We then decided that the programming language should be a graphical language. James was reticent to use a programming language because he thought you could not experiment with programming and thus creativity in the designs would be hampered. Since James had never programmed, he thought the act of programming implied you implemented a preconceived goal. He believed that you could not experiment with the medium like you can when you are forging a piece. Thus, I rapidly created a first prototype

with Logo that had the Best Maugard motifs, in order to change his preconceived notions about programming.

4.3.2 First Prototype: Logo Prototype

The first prototype for a Craft computing tool that I made was created in Logo Micromundos (The Spanish version of Logo Microworlds).

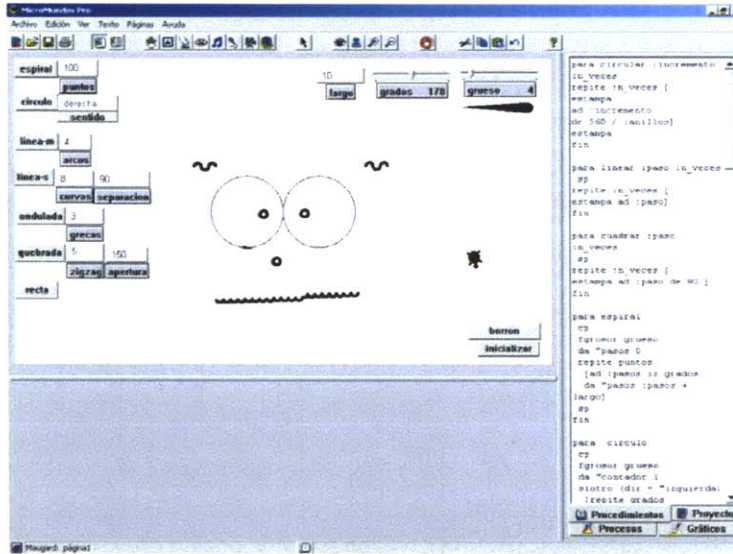


Figure 28 First Estampa prototype

I showed Metcalf how you could interactively be writing programs to create predictable and interesting patterns, and change them by changing the program. He then approved of a programmable tool for the creation of designs based on the Best Maugard method, but refused the use of a textual language for programming; he insisted that the language should be iconic. The Logo prototype had the basic features of a craft-computing tool.

The interface consisted of a predefined set of motifs (to the left). The size, thickness, and orientation of the motifs could be adjusted (upper right). The motifs had other individual properties that were variable:

- The spiral had a number of corners
- The circle a direction
- The half-circle a number of arcs
- The s-form had a number of curves an their separation
- The wavy-line a number of bumps

- The broken line a number of zigzag and the angle that separated them
- The straight line did not have any parameters

Problems

Object oriented vs. Pixel oriented

The pixel oriented nature of the Micromundos canvas poses several problem to the artisan, mainly in that he can not modify a motif once it's drawn; they can only erase or add pixels to it. The artisan is interested in modifying the selected motif characteristics, such as: thickness of line, orientations or size. They have no interest in just modifying the pixels that compose it. Furthermore, since the drawing is in a bitmap format, and not a vector format, it cannot be directly printed on the router for the engraving of the pattern.

Textual programming

Textual programming was another issue. Metcalf did not agree that textual programming would be an interesting medium for the artisan to explore. He said that words in themselves had a preconceived meaning that would prejudice programming. It was clear that if I had to work in Santa Clara del Cobre I had to take in account Metcalf's experience and advice, thus the programming language had to be a an icon based graphical language. Moreover, even if I believed that textual programming could have been an interesting avenue to pursue, it has a steeper learning curve and is more intimidating for the novice than visual programming. It was more important to have a user-friendly graphical visual language than a powerful textual language with a steeper learning curve.

Too expensive

Another problem of LCSi Microworlds Logo is its cost. It is too expensive for the artisans. to use widely As presented earlier, in my economic requirements, For artisans to adopt crafting software it should be low cost or free.

Selection of Graphic environment

There were several choices of free CAD environment, which I reduced to these three:

Platform	Advantages	Disadvantages
QCAD http://www.qcad.org/	Stable Documented Multi-platform	
Sketch http://sketch.sourceforge.net/	Stable Documented	Tcl/tk library
JCAD http://jcad.gnuchina.org/	Multi-platform	Unstable Undocumented

Figure 29 Comparison of possible platforms for Estampa

QCAD was the best candidate overall, but I discarded it because of its license. When I reviewed the QCAD software it was only free for non-commercial uses, fortunately it is now a full GPL program. I decided to use Sketch, which was written in Python and TCL/TK. Sketch has a plug-in interface that made it very simple to add a visual programming language. I counted on my expertise in the Python language, to allow for the rapid prototyping needed to comply with the restrictions.

4.3.3 Second Prototype: The Cloning tool

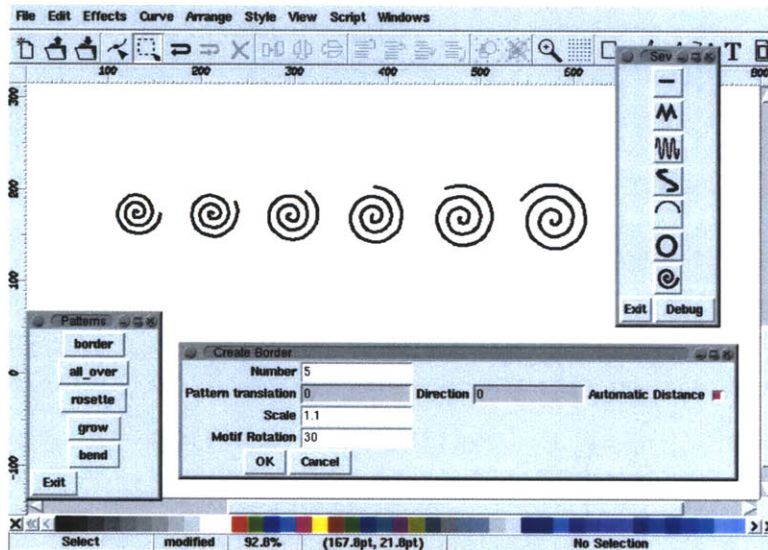


Figure 30 Second Estampa prototype

The first prototype was a very simple cloning tool to create different patterns, with a tool bar to create the motifs.

To create a pattern you selected the motifs you wanted to replicate and the pattern you wanted to draw. For example to use the border tool, you first selected the number of

motifs you wanted to create, then, you adjusted the distance and direction you wanted to separate them. Finally you pressed OK and the pattern was generated

In the screenshot, a spiral was first created by pressing the spiral button in the motifs toolbar. Then this motif was selected and a border was created with it. The dialog box for the border indicates that the selected spiral should be repeated five times at a direction of zero degrees, applying a transformation each time that would Scale it by 1.1 and rotate the motifs by 30 degrees.

Improvements

- The Shape was editable and creatable.
- This tool was vector based.

Problems

- Not programmable. In the cloning tool, the only parameters available are modifiable but it isn't a full-fledged programming environment since the types and order of actions can't be modified.

4.3.4 Third Prototype: The Cartesian tool

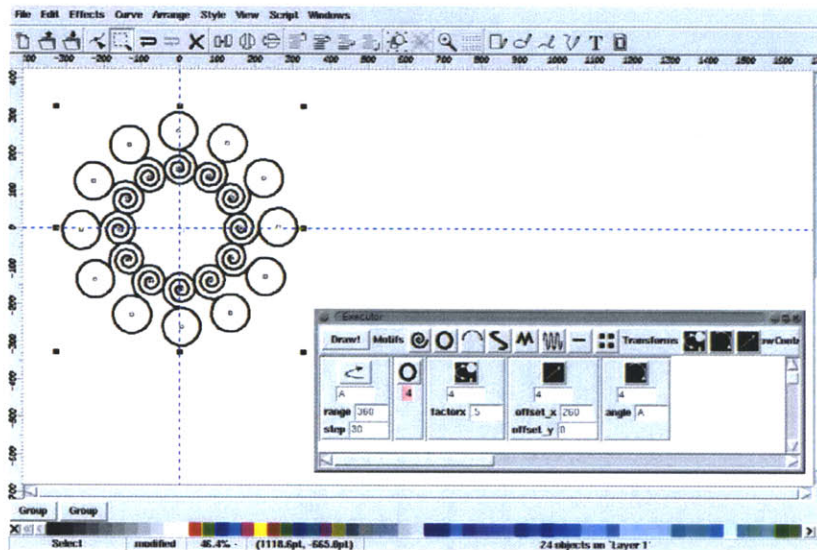


Figure 31 Third Estampa prototype

In the Cartesian tool, you could select motifs and apply transformations to them. The transformations were applied to the motif that directly preceded them. The geometric metaphor was based in an absolute Cartesian system. It was my attempt to create a distinct

geometric space, like turtle geometry. The geometric metaphor was unsuccessful because it was non-intuitive and highly abstract. It was very difficult to understand compared to the body-syntonic geometry of turtle geometry, even if it allowed flexibility to produce a wide range of patterns.

Improvements

- This is the first tool where the graphic programming of patterns could be performed.

Problems

- One-line programs rendered it unusable.
- The metaphor I created behind Cartesian mathematics made it confusing.

4.3.5 Final Prototype: The Stamp and multi-stamp tool

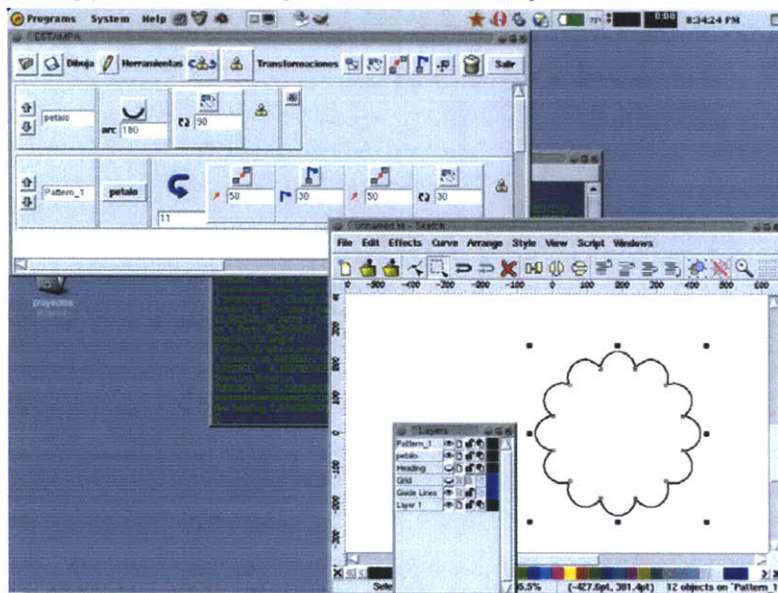


Figure 32 Final Estampa prototype

In the final program, each row was instantiated in a different layer on the Sketch drawing area. The rows would be executed from left to right, top to bottom. There were two kinds of stamps, the simple stamp which applied the transforms to the selected motifs, and the multi-stamp, which iterated several times over cloning the motifs and applying the transforms each time.

Technically, Estampa is subdivided into six modules, `estampa`, `interpreter_ui`, `motif_ui`, `pattern_maker`, `pattern_generator` and `motif` modules. The `estampa` module is the main module,

controlling all the objects that compose Estampa. It first instances the `interpreter_ui`, which contains all the graphic user interface definitions for the rows that make up a program. The rows contain graphic blocks defined in the `motif_ui` module.

When a program is executed, the graphic user interface is parsed by the `pattern_maker` module to create a python file that gets compile and interpreted by python in the `pattern_generator`, using the motifs predefined in the `motif` module

In the following block diagram, the modules that compose Estampa are shown with a visual representation of their role:

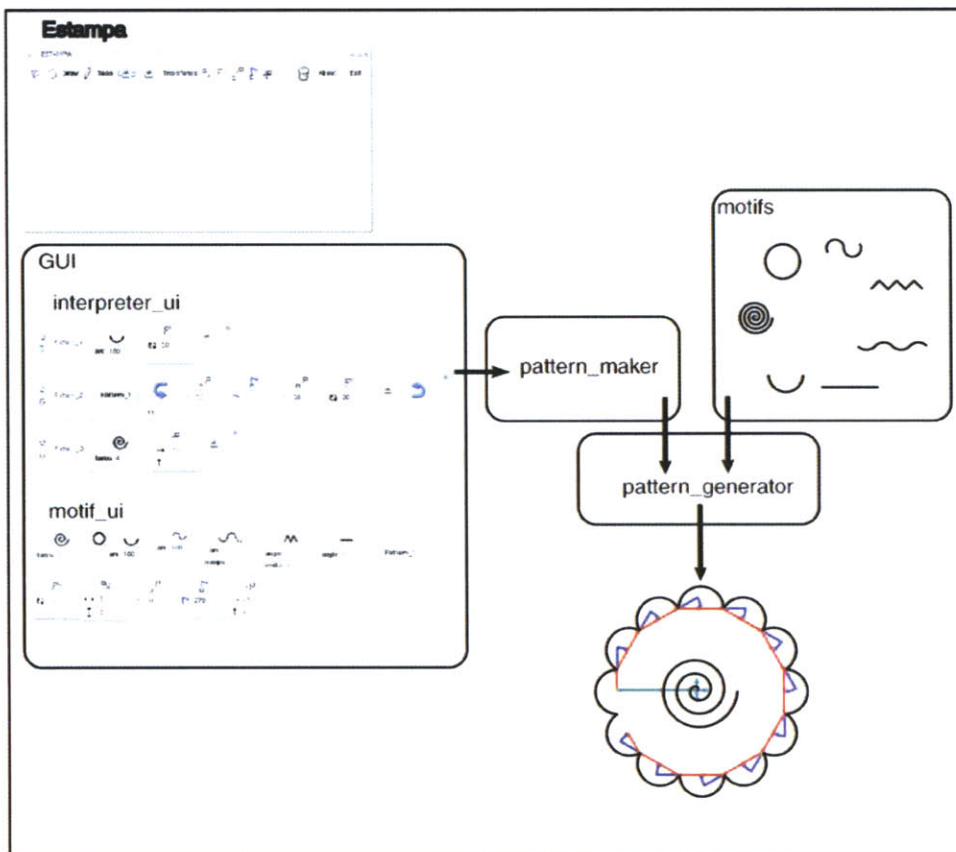


Figure 33 Estampa block diagram

Improvements

- Simple language
- Layer handling
- Debugging arrows

The metaphor for creating patterns was simpler; for example, no variables were required to create a circle. The layer handling allowed for a more flexible interface, where pattern previously made could be locked and the program could be modified and re-executed to only change one layer (See the two figures following). Debugging arrows were created for the user to have a better understanding of the execution of their program. The red arrows trace the path of the motifs when forward transformation is applied. The blue arrows show the heading each time it is the turn transformation is applied. The green arrows show the translation vector of the move transformation. This feature was useful because it is very difficult for the novice user to visualize the motif cloning. When confronted with the pattern they do not know where the initial pattern is and which follows. The arrows could be hidden to appreciate the drawing, since they were instanced in a different layer. The following examples illustrate the different layers that composed a drawing.

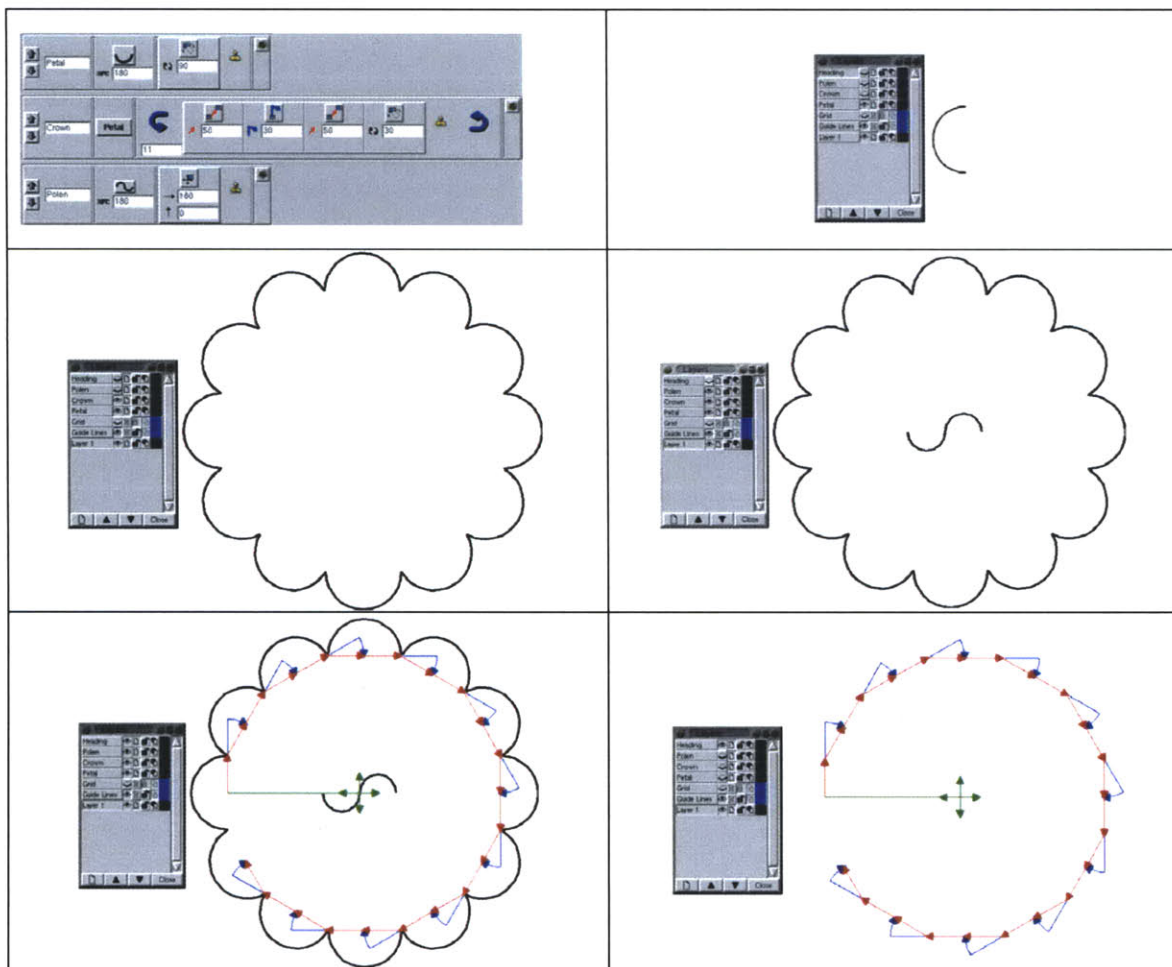


Figure 34 Illustration of the layers and debugging arrows features

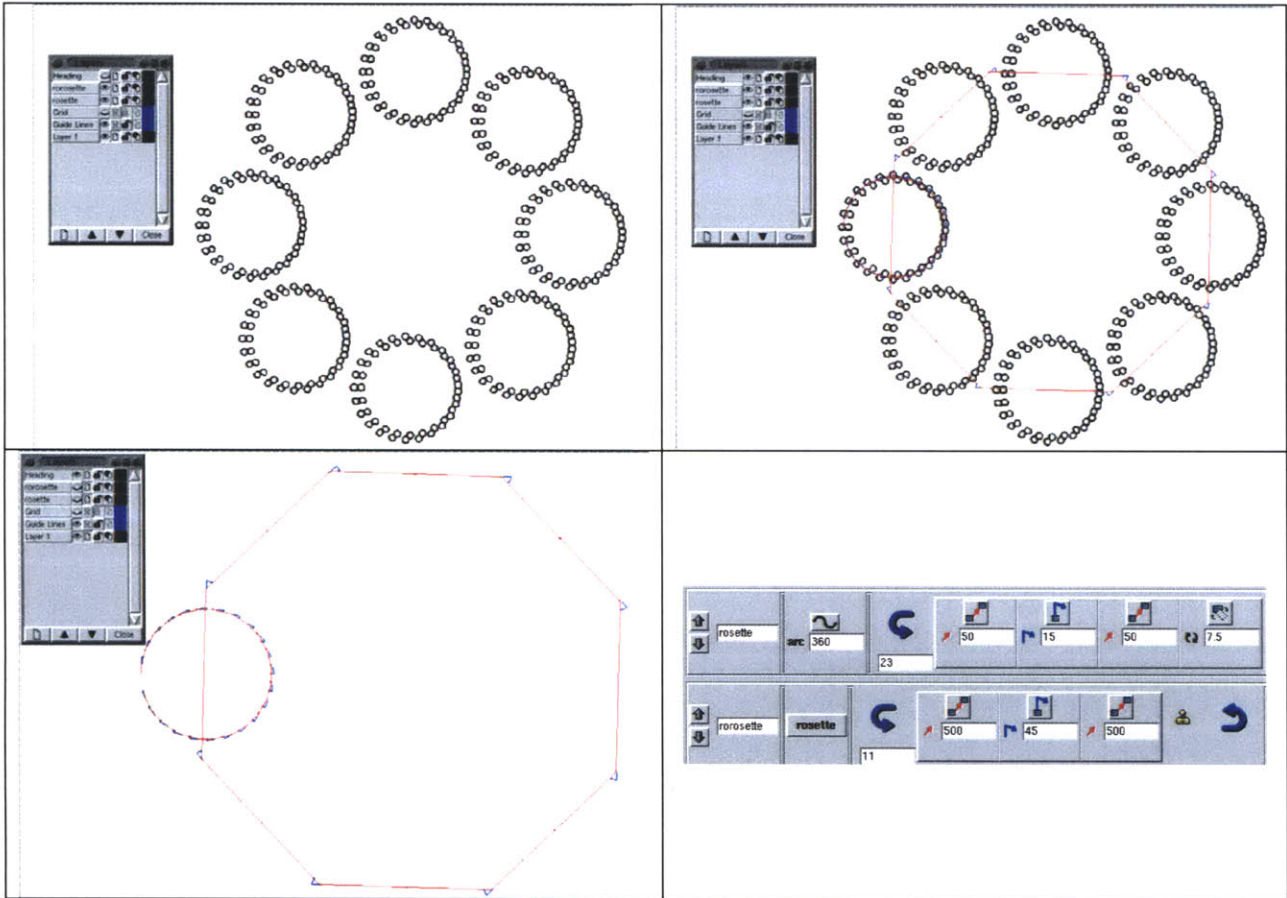


Figure 35 illustration of debugging arrows in nested iterations

Problems

- Lacks a more intuitive user interface
- Need variables, to create spiral patterns
- Need a more flexible parameterization of patterns

Chapter 5

Estampa Evaluation

Two kinds of evaluations were performed on Estampa, a functional evaluation and a field evaluation. The functional evaluation studied the feasibility and facility to recreate the motifs and patterns presented by Best Maugard. The field evaluation consisted of user trials in Santa Clara del Cobre. The user trials were not meant to be an exhaustive assessment of the software, but rather to be a quick and rough appraisal of the adequacy of the graphic user interface, the metaphor, and the creative space.

5.1 The functional evaluation

5.1.1 Low Floor, Low Ceiling

The functional evaluation of the software determined how well the Best Maugard technique was integrated in Estampa. In this evaluation, I proceeded to draw patterns found in the Best Maugard book “A Method for Creativity”.

The most basic patterns presented in the book could be drawn easily. Programs for doing simple patterns were quite simple, consisting of relatively few commands. Patterns that are more complicated proved difficult to recreate due to the amount of commands they required. The graphical user interface and the metaphor did not scale well to big programs, as is the case with many visual programming languages.

This evaluation verified that the minimum requirements for using Estampa were met, I was able to recreate the motifs and patterns illustrated in the first chapter of Best Maugard. Estampa seemed to have a “low floor”, its language and its metaphor were quite simple, but it seemed to have a low ceiling too in that it was laborious for me to recreate the complicated drawings in Best Maugard’s Book.

5.1.2 Examples

In the following section, I will present some examples of Estampa programs. They are two or three rows long and define typical or novel patterns that can be programmed with Estampa.

You can notice the arrows that are on a separate layer of the pattern and serve as debugging aids for the programmer.

Double-spiral border

The first row creates a spiral called `Pattern_1`, turns it 180 degrees to create a double spiral and clones it. The double-spiral then provides a motif for the second row `Pattern_1`. The second row creates a pattern called `Pattern_2`, which takes as its seed motif `Pattern_1`. The double-spiral border is created by moving the double-spiral a 100 points to the right horizontally and cloning it.

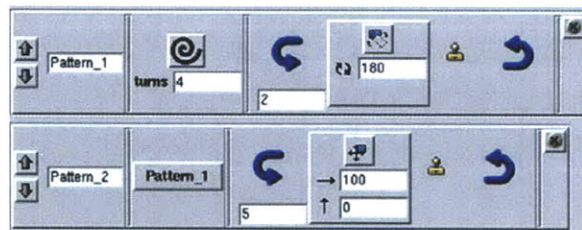


Figure 36 Double spiral program

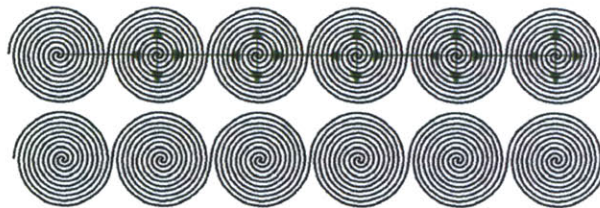


Figure 37 Double spiral border

S-form pattern

A s-form pattern can be created by cloning and turning an s-form



Figure 38 S-form rosette program



Figure 39 S-form pattern

Double spiral rosette

A double spiral rosette can be created by creating a spiral as shown in the first row. In the second row, the spiral is turned 90 degrees so its links are vertical. This allows the third row to create a spiral rosette by moving, turning, and cloning the spiral.

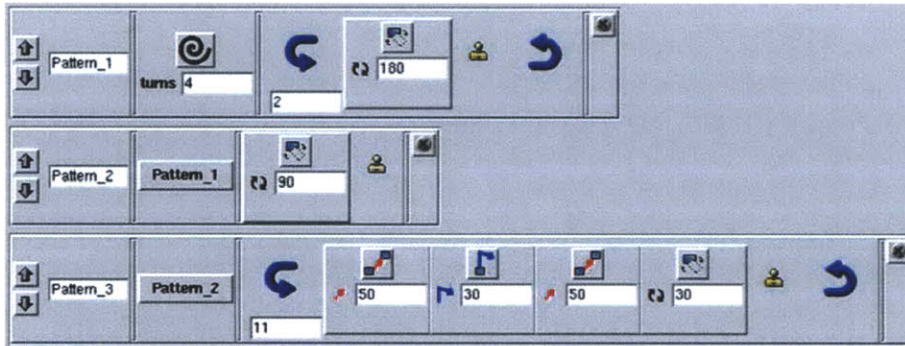


Figure 40 Double spiral rosette program

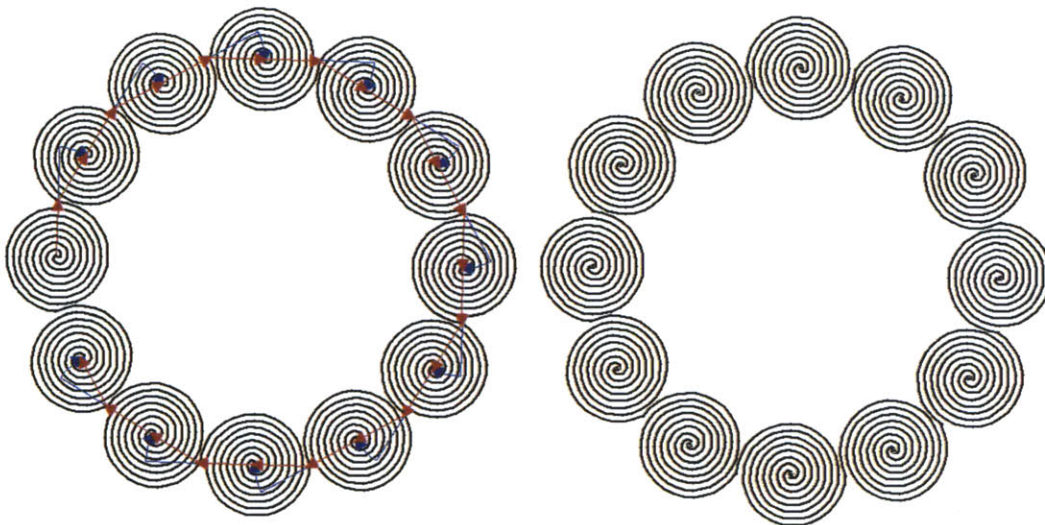


Figure 41 Double spiral rosette

S-form rosette

By changing the motif, one can explore visually the rosette pattern composed by different motifs. For instance, the above double spiral rosette was transformed into this s-form rosette below by only changing the seed motif, a spiral with four turns by an s-form composed by two arcs of 270 degrees.

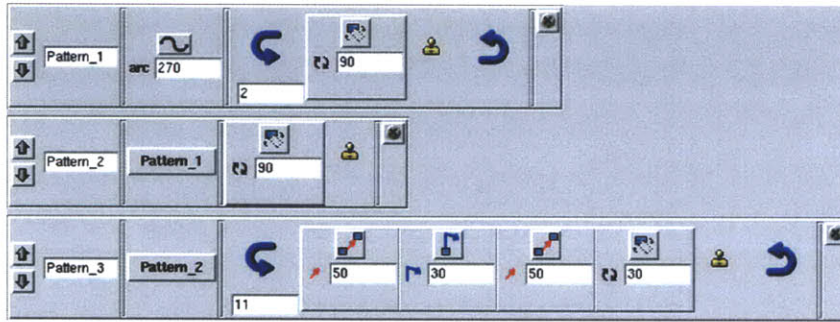


Figure 42 S-form rosette program

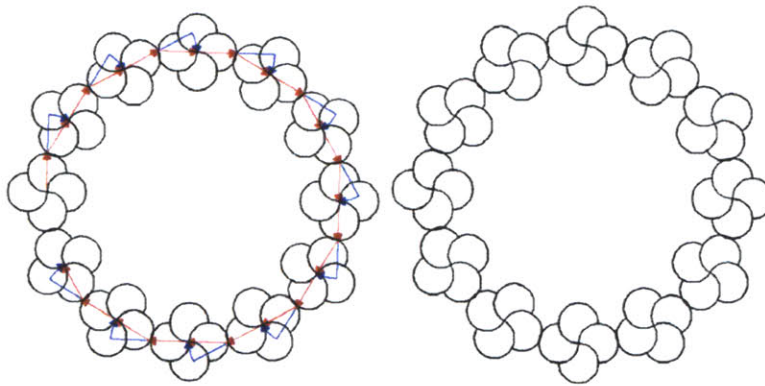


Figure 43 S-form rosette

Wavy-line all-over pattern

The wavy-line all-over pattern was created by rotating a wavy-line to form a wavy cross. The wavy cross was then repeated vertically with a forward command and horizontally with a translation command.

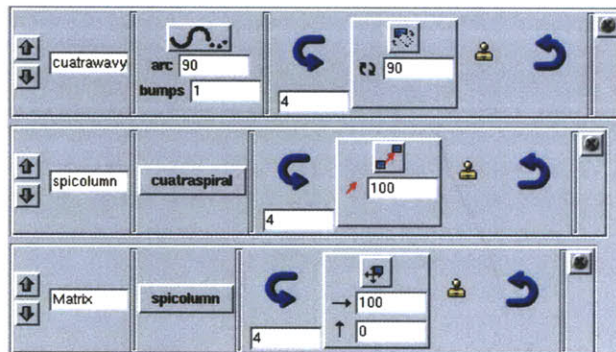


Figure 44 Wavy-line all-over pattern program

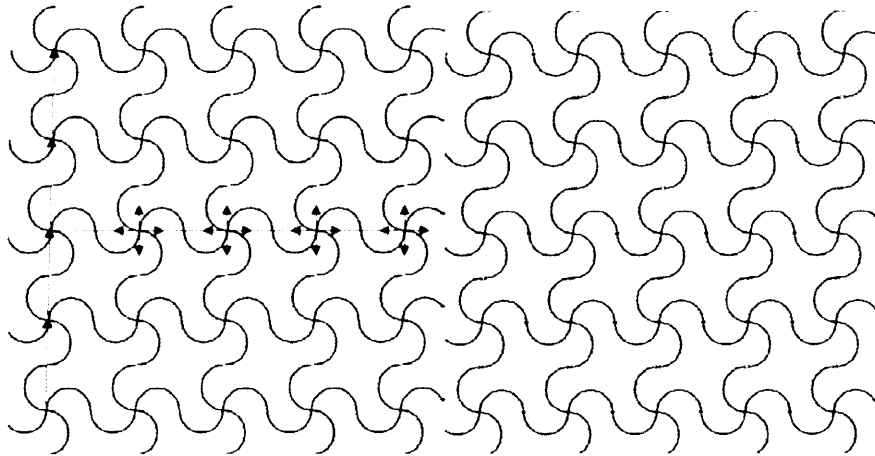


Figure 45 Wavy-line allover pattern

5.2 The field evaluation

5.2.1 User selection

The subjects of the software evaluation were 4 students of the Salvador Escalante elementary school and 1 artisan from the CECATI. The selection of candidates was made based on the availability of the users and the restrictions of getting participants for the software trials. The students from the elementary school were chosen by their teachers; I suggested that it would be ideal if I got an average CAD student and a talented CAD student. In this thesis, I present 2 children of the 4 interviewed, Conchita and Pancho. I only present 2 of them because the other two subjects were mostly passive, having a very similar outcome to the first interview presented.

5.2.2 The interview

The study of the user took place in two sessions lasting two hours each. In the first session, Estampa was introduced to the student while in the second session the user was encouraged to create his/her own designs.

5.2.3 Study Plan

First session

The first session was divided into 2 parts, a guided tutorial and a guided drawing exercise, as time allowed it. In the first part of the tutorial, I explained how to create patterns with Estampa and then I guided the user through all the features of Estampa to create a simple small program. I started by telling/asking them to click the stamp button. I then asked them to

push the pencil button. When they realized that the pencil executed the program, resulting in motifs displaying in the canvas, I asked them to change the motif of the stamp one by one. After they changed the motifs, I invited them to tinker with the parameters so they understood that the motifs were modifiable. Depending upon which motif was chosen, a different instance of the motif would appear. Then I showed them the result of applying each transform to the motifs, and asked them to change the parameters of the transformations. Finally, before showing the multi-stamp, I engaged them in a guessing game to see if they understood:

- How to change the motifs.
- How to apply the transforms.

After they correctly predicted the result of their programs, I introduced them to the multi-stamping mode.

I did this by directing them to create a flower. They created a petal by displaying a half circle, turned and stretched vertically. Then I asked them to take the petal and create a crown. The challenge was to introduce the right transformations and parameters in the multi-stamp. The objective of the exercise was to have a pretty crown where petals would touch at the edge of the half circles. Finally I showed them how to change the types of petals from half circles to circles or to spirals, and checked that they understood how the transforms were composed. If there was time remaining in this first session I invited the student to propose a theme for drawing and then assisted them step-by-step to achieve it.

Second session

The second session was more open ended. I encouraged the students to experiment with Estampa. I asked them to sketch in a notebook with a pencil what they would like to draw with Estampa. Then I gave them full control over Estampa and only provided advice or assistance when I perceived all avenues the student tried to use to reach his goal came to a dead end.

Assessment

During the first session, I assessed two aspects of the tool, the adequacy of the metaphors and the overall usability.

The metaphor stands for the ability of the user to understand the causal consequences of their actions in the visual programming language. This ability can be tested at different levels depending on the proficiency of the user with Estampa.

At the highest level, the metaphor addresses the creation and modification of a program to reach a preconceived design and to explore different possibilities within that design. In order to evaluate the metaphor, the user was suggested to draw a shape he previously sketched with pencil and paper, and he was then given the challenge to create it with Estampa.

At its lowest level, the metaphor deals with the capacity of the user to predict how one command will entail a result. For probing the understanding of the user about the action of a single block, I asked them to predict the result that the variation of a parameter would entail on the design.

The usability concerns the ability of the user to understand what the elements of the graphic user interface mean and how to interact with them. I mainly tried to gauge if they understood the structure of the graphic programming language.

In the second session, I assessed the creative dimensions of the medium. I asked the student what they wanted to draw, and depending if I thought their goal was achievable or not, I encouraged to change his thematic. I explained to them that Estampa was meant for something that had a repetitive pattern, and asked them if they could think of anything if their surrounding that was composed of patterns. When the student was drawing, I was attentive to the variations that would occur in the design, and observed the attention of the student in the activity. to evaluate if they were interested in exploring new designs by changing parameters in the program.

At the end of the second session, to conclude the interview, I posed the student some final questions. I asked them to describe the purpose of the icons in the upper tool bar of Estampa, to observe if they were able to describe verbally the transformation that the icon represents, This would demonstrate an understanding of the programming language.

5.3 Case studies

5.3.1 The 8 year old girl: Conchita

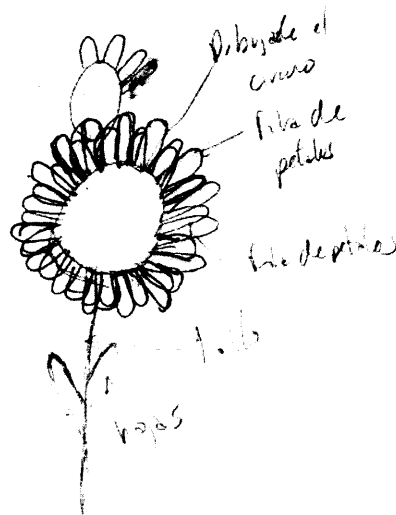


Figure 46 Sunflower drawn by hand by Conchita

Observations

Conchita, eight years old, was a very calm, well-behaved girl. Once the session started it became quite clear that Conchita did not have an intuition for numerical angles. She understood what an angle was, but could not imagine it without seeing it drawn. She had difficulty understanding the Estampa programming model, thus I directed her to move the icons and just tried to gauge the comprehension she had of her actions.

In evaluating her experience with Estampa, I mainly based my observations on two types of questions. In the first type of question, I tried to determine if she understood the graphic user interface. I asked her to modify a program I had previously composed and then gave her control over the graphic user interface. She did not know where to start, so I directed her step by step. She understood and executed my directions but I do not think she had much idea of the program she was creating, because she never took the initiative and only followed my commands blindly.

The second type of question gauged her comprehension of the metaphors of Estampa. I had the control of the graphic user interface and asked her to predict the alteration on the drawing when I adjusted a parameter in a small program I had previously created. She had

some idea of what would happen since she responded correctly to the simple question. However, she refused to reply to harder questions. A simple question would be:

Daniel: "What tool would you use to turn the petals of the flower?"

Conchita: [she would point to the turn shape icon]

Another activity consisted of placing the spiral in the center of the flower and resizing it correctly. She needed minimum guidance to perform the task. For example, when I asked:

D: "In what coordinates would you place the spiral to be in the flower's center?"

C: "100 and a 100" [She replied quickly]

But when I would pose a more abstract question, such as explaining the program, she stayed silent. After showing her how to create a flower program step by step, I asked her

D: "What angle would you use to make a flower with 4 petals? "

C: [silence]

There are several possible reasons why Conchita remained silent. She may have had a lack of familiarity with numerical angles and/or programming. It became clear early on that she couldn't manipulate numerical angles. However, when I drew a half circle and a full circle, she understood that one was a 180-degree circle and the other was 360 degrees. But if I asked her to draw a 180-degree circle she remained still. Additionally, She may not have had the language to verbalize the replies to my questions. When confronting new activities, such as, programming with new metaphors like the turtle geometry it is problematical for a child talk about these concepts. Thus, her silence could have been due to a lack of vocabulary for expressing her ideas.

She also perhaps needed a lengthier and more detailed introduction to Estampa. Two sessions of two hours, each was a very short time to evaluate Estampa. More evaluation sessions would be necessary to pinpoint the cause that contributed to the scarce interaction that Conchita had with Estampa.



Figure 47 The time lapse of a screenshot from the flower tutorial for Conchita.

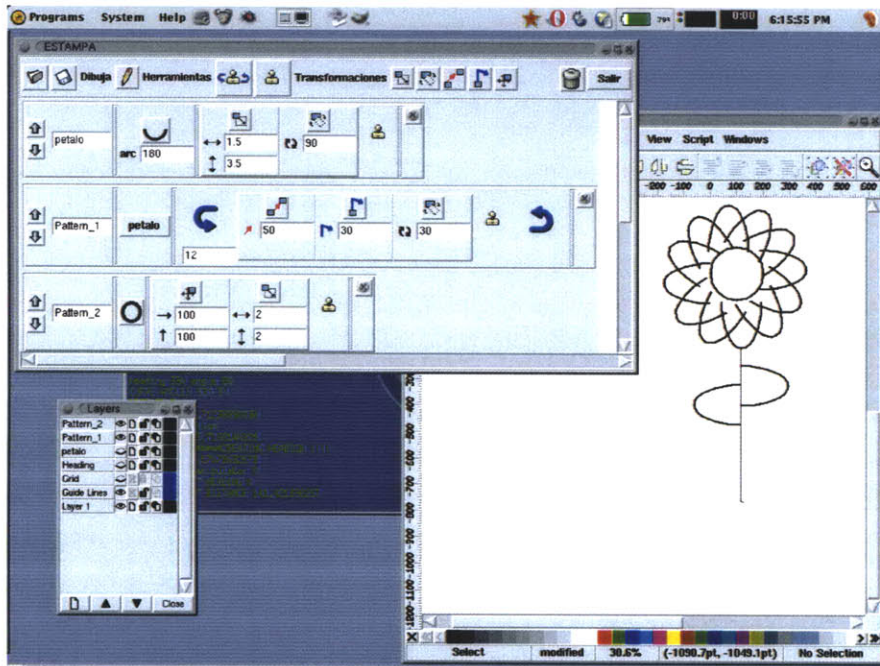










Figure 48 Sunflower drawn in Estampa

Final Questions

In the final dialog, I asked her the role that each icon on the upper toolbar had:

- D: "What does the pencil does?" [Pointing to ]
- C: "It draws"
- D: "The seal with blue arrows?" [Pointing to ]
- C: [Silence]
- D: "The seal without blue arrows?" [Pointing to ]
- C: "I forgot"
- D: "To draw a spiral or the circle or the half-circle, the line "
- D: "This symbol " [pointing to ]
- C: "It's to stretch"
- D: "This symbol" [pointing to ]
- C: " To turn"
- D: "This one"
- C: " To go up" [pointing to ]
- D: "This one" [pointing to ]

- C: “ To turn”
- D: “So What is the difference with the one that turn and the one that turn”
- C: “ Turn is for making it turn all, and the other one to not make it turn all.”
- D: “And this one to turn?”
- D: “And this one” [pointing to ]
- C: “To move to another place”
- D: “So how would you call this” [I point to the first part of the row]
- D: “And this one “
- C: “To make a circle” [I point to the second part of the row]
- D: “And this one “
- C: “ To make a movement ” [I point to the third part of the row]

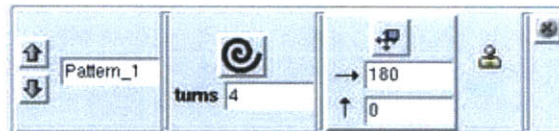


Figure 49 Command row of Estampa use in the interview with Conchita

I presume that Conchita did not have a thorough understanding of several key concepts to Estampa’s programming metaphor based on the replies to my questions. For example, she did not have a precise definition for the stamp and remained silent when asked about the multi-stamp. Moreover, she had a limited understanding of the transforms; for example when I pointed to the forward transform she described it as “ to go up”.

Reflections

At eight years old, Conchita did not appear to have a good intuition for the handling of angles, nor for the causal relationships behind a program during the interview. This may be because she was either too young to understand these concepts or because she had never confronted them in this way before. This posed for a very difficult evaluation, since I was in control of the interface most of the time. I conclude that she was too young for using my program. I asked in the next interview to work with the oldest student in the elementary school, who was twelve years old.

5.3.2 The 12 year old boy: Pancho

Pancho is a 12-year-old boy. The session took place in his home, a rustic but well kept house. His 14-year-old brother and 19-year-old sister accompanied us in the session. They even participated, but they understood that their involvement was constrained to an advisory role. When they intervened, they mostly explained the subject I presented to Pancho in other ways. Sometimes the 14-year-old brother got too excited and “gave away” the answers to the challenge Pancho was confronting. I now realized that I should have done trials with Pancho’s brother and sister since they were very motivated to use Estampa. Unfortunately, I was too focused during the trial and did not grasp this interesting opportunity.

The tutorial with Pancho went swiftly. He replied to every question I posed correctly and completed all the challenges. Thus, after the tutorial, there was enough time to create a spider web drawing.

The spider web, trees, cars

The spider web: Pancho can create a drawing with only slight assistance

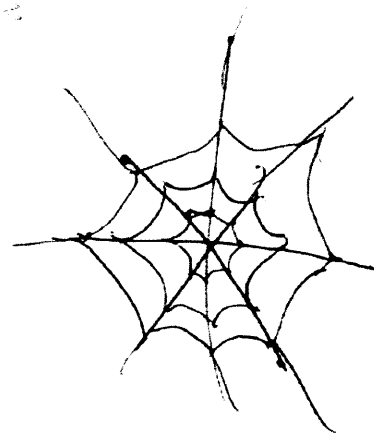


Figure 50 Spider web drawn by hand by Pancho

I will now proceed to relate a brief account of my session with Pancho the reader should follow this text with the following figure, a time lapse of screenshot from spider web.

When I asked Pancho what he wanted to draw, he immediately replied “a spider web”. I was surprised by how quick he answered and how well he had understood my explanation of the constrained design space that this tool was meant for. I asked him to draw the spider web with a pencil and paper and we then proceeded to create the spider web in Estampa.

I asked him what part he wanted to draw first and he pointed at the radial thread that composed his drawing. I then asked him to do it. He immediately pressed on the multi-stamp, set the motif to line, and pressed the pencil button. Nothing happened, he frowned his eyebrows, thought for a moment, and realized he was lacking the transformations.

He chose the rotation transformation and started playing with the angle and iterations until he got a radial structure that satisfied him. Then he started to program the tangential threads. He first drew a half-circle and tried to place it perpendicular to a radial thread. He realized that the radial threads should be bigger and applied a resize command. He was really intrigued that the result was not the one he expected. I proceeded to explain to him that the transforms were applied differentially in multi-stamp; if he wanted to apply the transform to the whole radial threads he should use a stamp with the previous pattern he had made.

After the radial thread was scaled, he continued to try to place it appropriately. When he thought it was in the right place, he proceeded to make a rosette of half circles. He first tried to do it with the rotation symbol but he then realized that he had to use “the blue and red arrows”. The rosette was not centered when it was instanced so he adjusted them a little more. When he was done with the first rosette, I asked him how he could create the other rosettes that composed the spider web with the pattern he had just made. He immediately realized that he could scale the one that he had made with a multi-stamping. So he proceeded to scale it and created the final spider web. Finally, I showed him how he could change the half circle radial threads to an s-form radial thread. He was not impressed with the s-form threads; preferring his half circle threads because they looked like a real spider web to him.

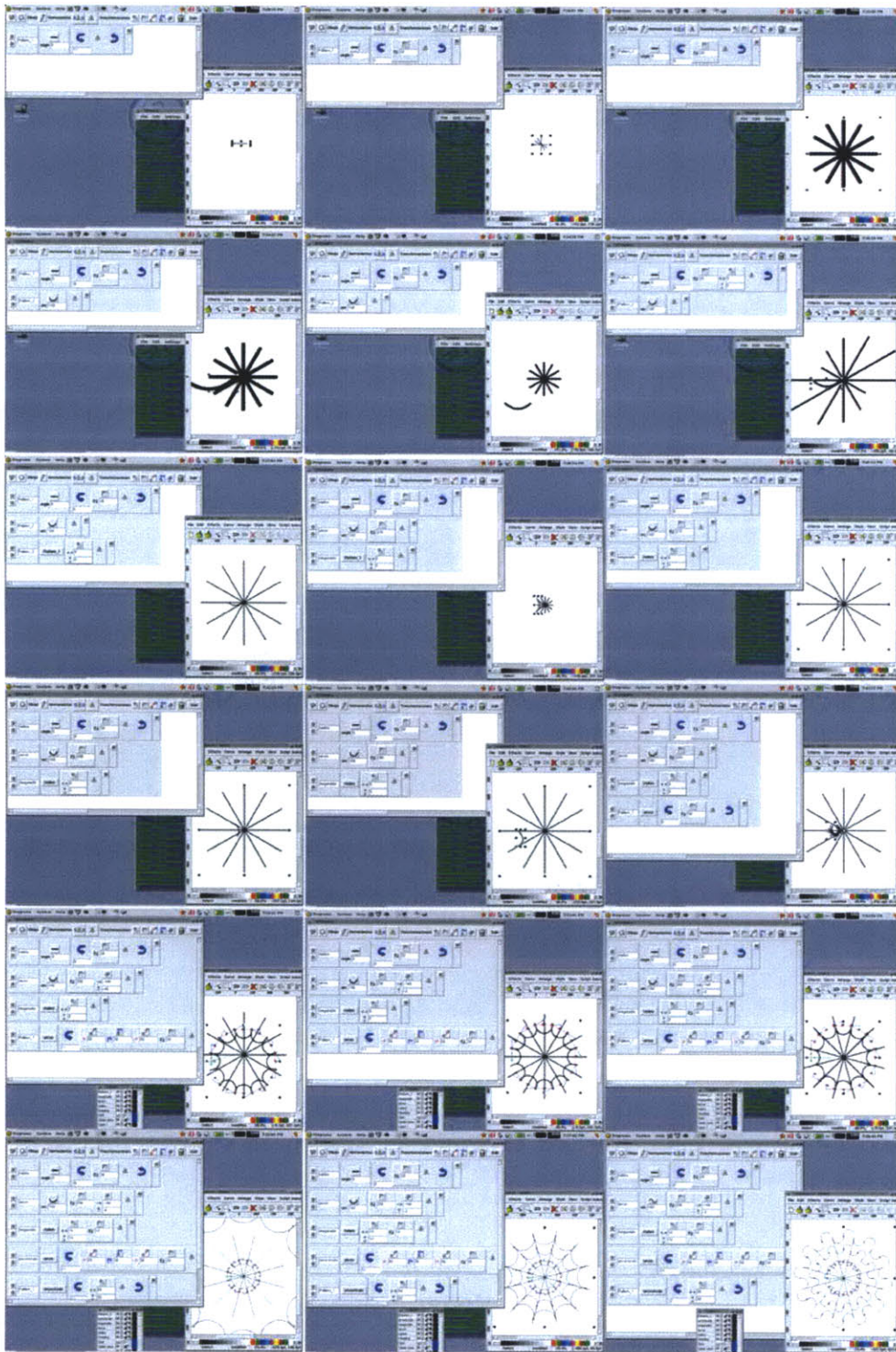


Figure 51 The Time lapse of screenshot from spider web drawn by Pancho.

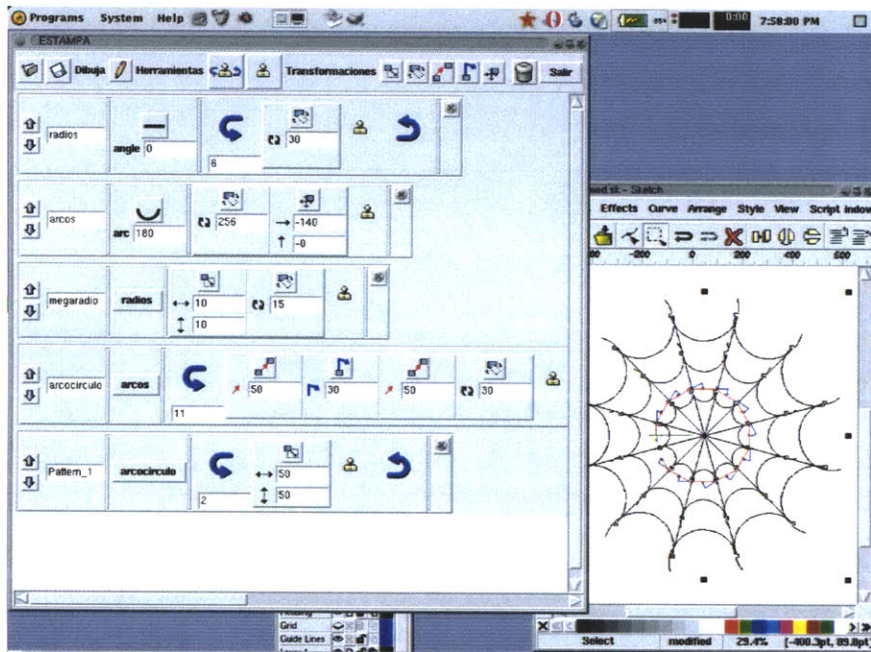


Figure 52 Spider web drawn in Estampa by Pancho

The tree: Pancho can tinker with motifs to create his tree made of circles



Figure 53 Tree drawn by hand by Pancho

At the end of the first session, I asked Pancho what he would want to draw next time and he said, “A tree”. Thus, he started second session by drawing a tree. He drew a tree composed by zigzags growing horizontally. Then he turned the zigzag structure nineteen degrees to have a vertically growing structure. Then I invited him to change the motif, to explore different patterns that would change depending upon the motif used. After checking every from he decide he wanted the circles. Then he painted the tree green and he was satisfied. I tried to carry further the session by asking him if he could do a forest. He did not understand my question, so I asked him directly to make several copies of the tree. He still did not quite understand what I meant, so I showed him how you could replicate several tree. He was interested but he still said that he preferred his green tree.

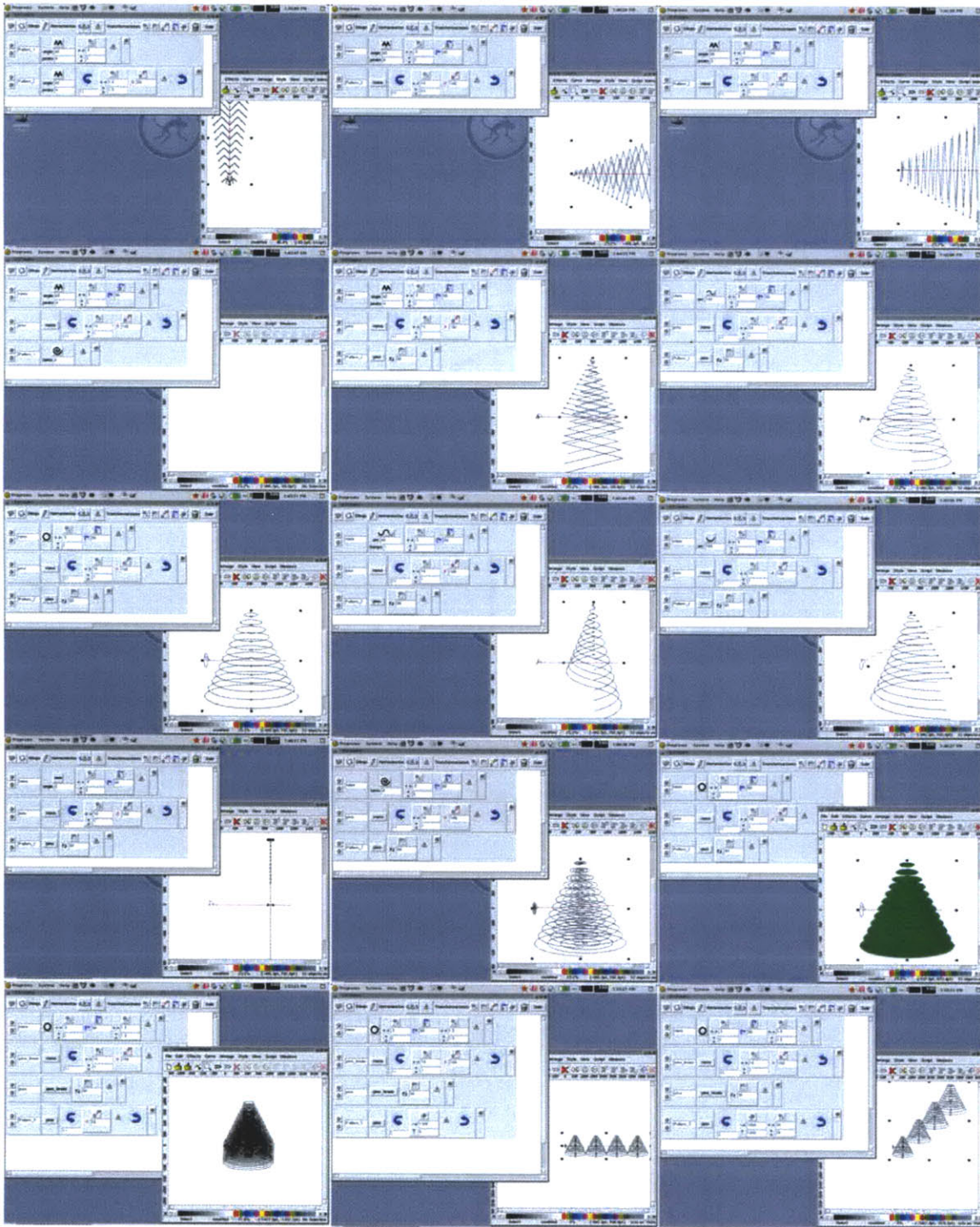


Figure 54 Time lapse of Screenshots from the tree drawn by Pancho

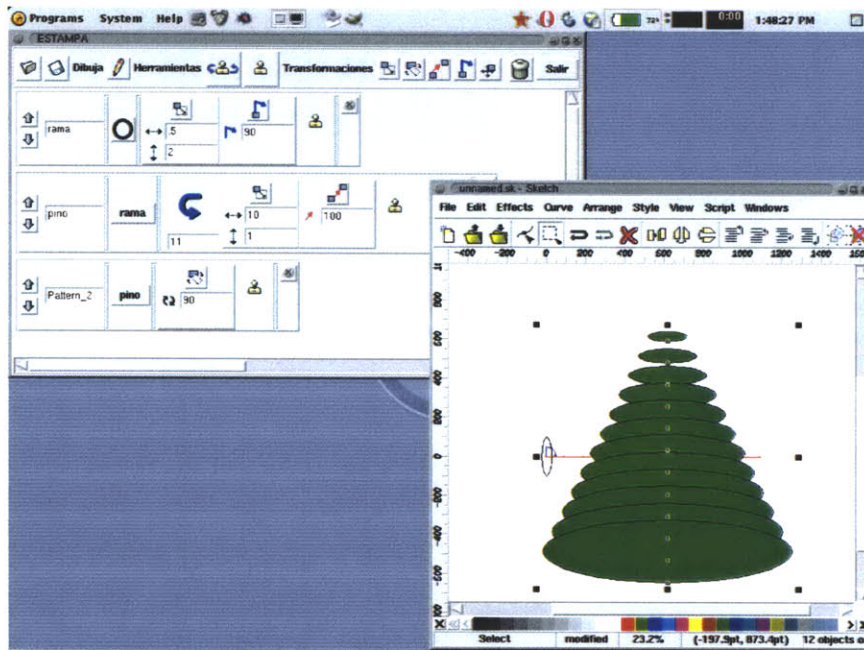


Figure 55 Tree drawn in Estampa by Pancho

The car: Pancho draws a car, figurative drawings with patterns should be explicitly encouraged.

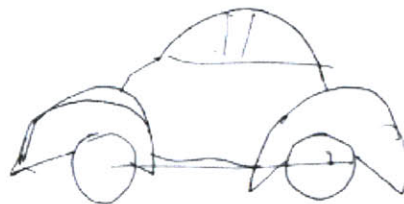


Figure 56 Car drawn by hand by Pancho

During the second hour of the second session, I left Pancho with the computer for one hour. I left the room and went for a walk in Santa Clara del Cobre. When I returned he had drawn a car even though I had encouraged him to draw themes where patterns would be found, such as flowers or seashells. I asked him if he had any problems and he said that he had closed the program inadvertently when he had almost completed the car and had to restart the drawing from scratch. The program contains almost all transformations, thus I conclude that Pancho had quite some understanding of the visual language, if his brother or sister did not take over (which I do not think they did).

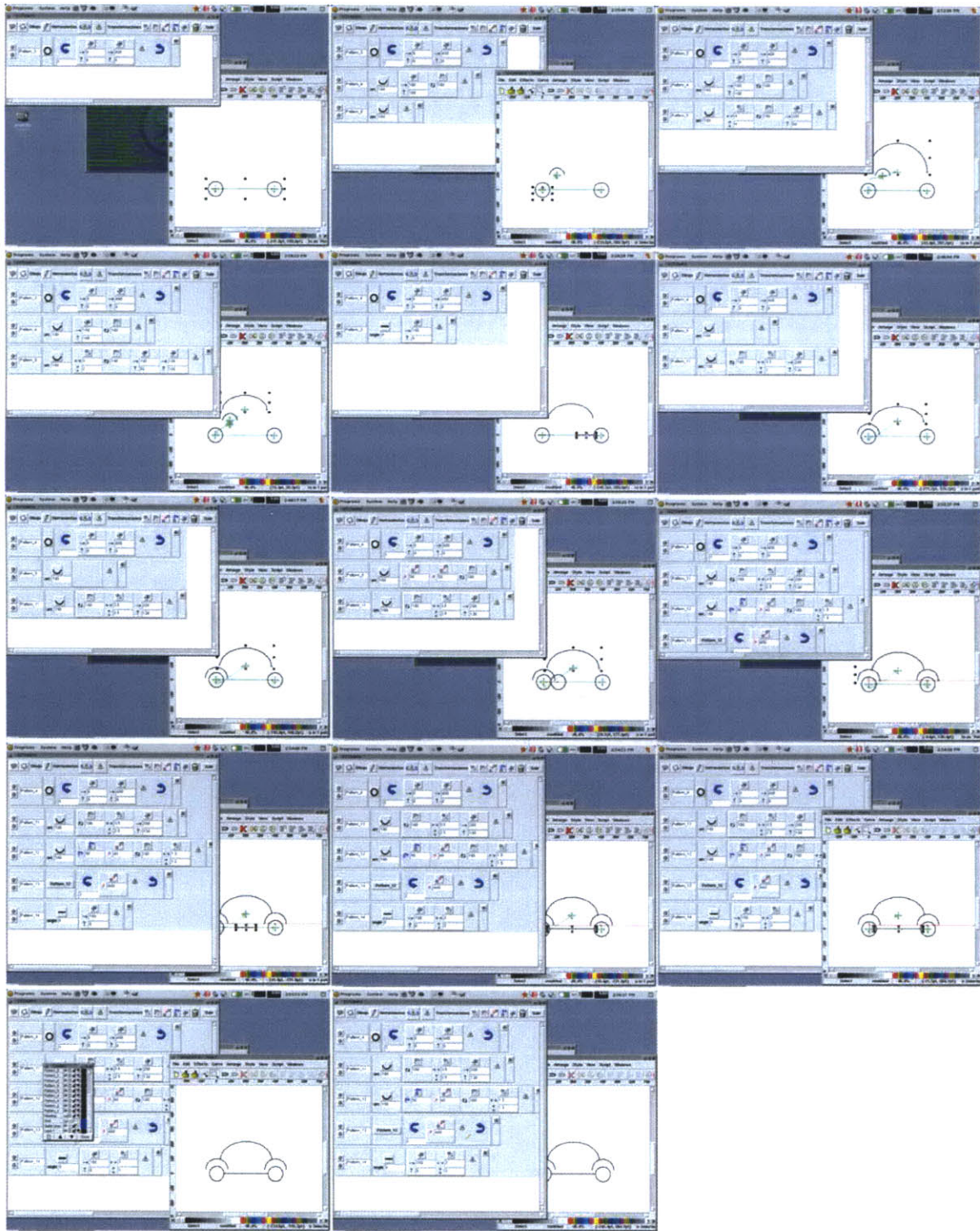


Figure 57 The time lapse of Screenshots from the car drawn by Pancho.

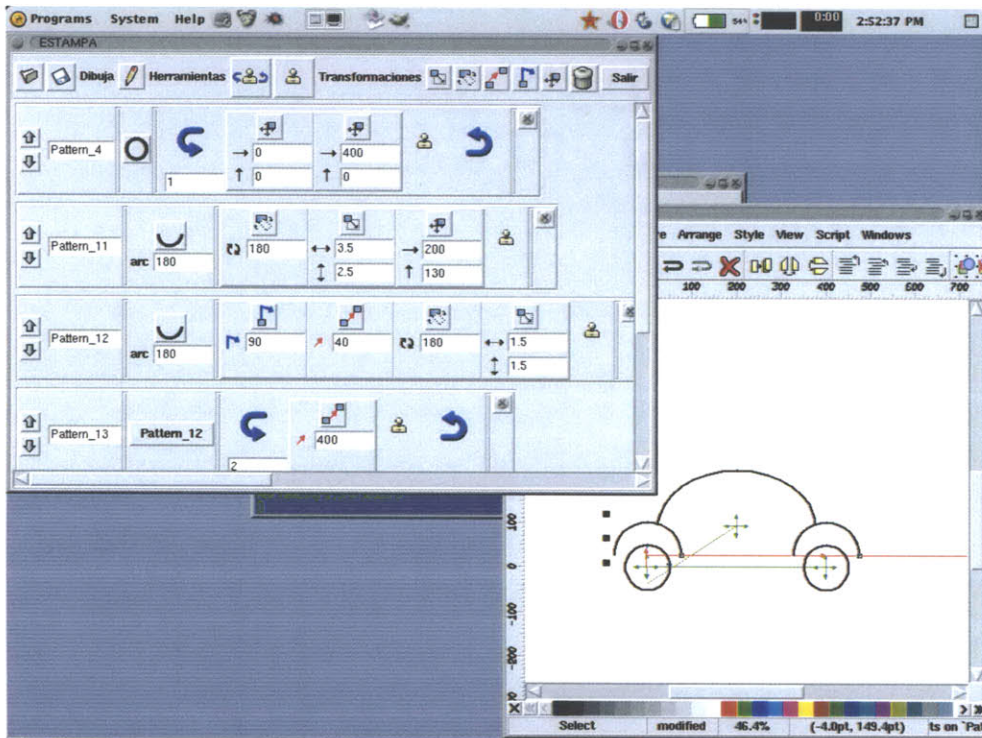




Figure 58 Car drawn in Estampa by Pancho

Final Questions


In final dialog I asked him the role that each icon on the upper toolbar had:

Daniel: “What is this icon for?” [Pointing to ]


Pancho: You give your commands when you give orders, you push the pencil and the computer makes them

D: “And this one?” [Pointing to ]


P: “ When you are going to do several shapes you use it “

D: “And this one?” [Pointing to ]


P: “ When you are going to do one shape

D: “And this one?” [Pointing to ]


P: “ To make it turn it”

D: “And this one?” [Pointing to ]


P: “ To move it”

D: “And this one?” [Pointing to ]

P: “ To turn in but in a different way from the second icon.

D: “So the blue arrow?” [Pointing to ]

P: “ is to turn but in a different way

D: “and this last one?” [Pointing to ]

P: “ to move.

Pancho replied quickly and clearly to the questions. He had a fair understanding of the use of the stamp, multi-stamp, and transforms.

Reflections

The 12-year-old boy understood the graphic user interface tool and did three drawings successfully: A spider web, a tree, and a car. He had a good understanding of the angles and the programming and he responded correctly questions that called for non-intuitive answers. I was actually surprised that he mostly did not need any help to do the drawings. He mainly had problems when he did not have a clear understanding of the graphic user interface or when he encountered some metaphor or some bug in my program.

5.3.3 The Artisan: Salvador Saenz

Observations

The tutorial with Salvador went smoothly. He understood all the commands as I explained them. However, when I asked him to use the program, he was not interested in the tool. So I tried to get him interested by asking him about what he wanted to draw, but he described patterns unfeasible in Estampa. I tried to explain that in order to use Estampa he should constrain his design space to the sort of patterns that were realizable with Estampa, but he told me that he didn't work that way; when he worked with AutoCAD, he thought of a pattern and the just drew it in AutoCAD.

Since we weren't getting anywhere, he decided to create in Estampa a simple pattern - a rosette of double spirals. I decided to take the lead and create another pattern for engraving, since the craft that we were going to manufacture was going to serve for demonstration purposes of my software.

Reflections

The introduction of a programmable computer tool to the artisan is a complicated, long-term process. Since I did not have enough time to introduce it to him, I could not evaluate if

Estampa would be a creative tool within his crafting practice. However, I think it is worthwhile to comment on the experience I had while presenting him the tool. These commentaries are inspired from conversations I had with James Metcalf and Anna Pellicer and my own observations.

I think the disinterest he had for the tool stems from several causes. Even if they are somewhat speculative, its worthwhile mentioning them since they can provide the basis for planning user trial with artisans in the future. In order to introduce new technologies to the artisan, he must have time in his schedule to incorporate them. Thus the artisan must have some free time to learn and explore with the technology. The artisan with whom I was working had several other responsibilities such as:

- Arranging the gardens for the visit that the Mexican Secretary of Education, who was going to visit later in the week.
- Giving children miniature-forging workshops.
- Giving courses of AutoCAD to CECATI personnel.

Thus, I speculate that independently of whether my tool could have been a creative medium for him, he had to many other activities to do rather than trying to learn some “esoteric” tool that a “stranger” presented to him. Why should the artisan take advice of a person that does not create handcraft? One of the reasons Metcalf could introduce new tools in Santa Clara was because he would demonstrate how you could achieve better quality or find new creative original designs with the new tools he promoted such as AutoCAD.

Metcalf has several methodologies for introducing tools to the artisan community. For example, he takes an artisan and practically obliges him to use the new tool. Then, if this artisan realizes the value of the tool and adopts it given that it is useful tool for his craft, other artisans follow his footsteps, mostly guided because of “envy”. The “envy” can result because the tool improves the work in some aspect:

- The new tool can allow him to produce more quickly his handiwork.
- The new tool produces unique characteristics, which are impossible to create with their actual tools.



Figure 59 The time-lapse of the manufacture of a copper plate in an Estampa pattern.



Figure 60 Copper craft etched and plated with a pattern created with Estampa

Chapter 6

Reflections

6.1 Encountered Challenges

Estampa complied with several of the stated requirements: it is a graphical language for creating patterns composed by motifs based on the Best Maugard technique using turtle geometry. However, several problems arose in the usability, metaphor, creative, technical and logistical aspects of the tool. These problems may be addressed in future work by limiting the requirements to a manageable set of constraints that will not compromise each other, and by conducting a long term introduction and development of the tool within the community. In the following sections I will review the encountered challenges.

6.1.1 Inadequate development platform

The platform for creating the stamping environment was inappropriate for several reasons. Initially I believed developing Estampa within a general vector-drawing program was advantageous since it would provide the following advantages:

- The user could modify the patterns more intrinsically in the same environment (Sketch) where he programmed them using the Estampa.
- The API plug-in from Sketch would speed up my development.
- Sketch would be free and thus could be used in other places lacking CAD programs such as AutoCAD.

My assumptions proved to be erroneous in the following ways:

- The users did not interact with the drawings when they were creating the patterns.
- The disadvantages of a primitive GUI such as TCL/TK undermined the advantages of using the Sketch plug-in API.
- Estampa does not need to be integrated into Sketch, it can be designed an independent tool that saves its drawings into a standard vector graphics rather than embedding it in a vector drawing program.

6.1.2 Graphic user interface and drawing themes

The Graphic user interface was usable by a 12-year-old boy. He was able to create a spider web, trees and a car with only slight assistance. Nonetheless, several aspects of the GUI and drawing metaphor were confusing:

- The purpose of the command blocks and the role of their parameters.
- The selection of a drawing theme that take advantage of programmability by naturally incorporating patterns composed of multiple motifs.

To correct these problems in Estampa, I suggest the following:

- More time should be spent in designing the GUI, with more sophisticated GUI toolkit.
- Estampa should be accompanied with activities to draw easily programmable subjects (such as trees, flowers, fruits, seashells, and spider webs).

The turtle geometry metaphor alone is not enough for implementing the Best Maugard technique; examples of drawing subjects must accompany Estampa to guide its usage, as in Best Maugard's book. Even if the programming model and the GUI were understandable and usable by a 12-year-old boy, this did not guarantee that he would be motivated to draw themes that naturally incorporated programmable patterns such as plants, flowers, and other figurative drawings. Pancho was intrigued by the challenge to understand the programming paradigm, but he chose to create programs for figurative drawings (such as a car) that do not naturally incorporate programmable patterns. Programmable environments for drawing should be constrained to drawing subjects that are naturally formed of patterns composed by basic motifs.

Need for longer-term involvement and follow up

Two sessions of two hours provided only a very brief glimpse into use of the Estampa environment in the field, more time should be spent in introducing the tool. Moreover, a technique should be developed for using Estampa, like the one Metcalf developed for using AutoCAD. Creativity stems from adequately well-constrained handling of a polished technique.

6.2 Future work

Many hurdles that impede digital design in non-industrial rural settings are disappearing. Any average computer can be used as a CAD workstation, something impossible only 5 years ago. Digital design software remains expensive, but freeware versions are under development and becoming available⁴.

Thus, the priority in breaching the digital design divide is to create spaces like Santa Clara del Cobre, where design and manufacturing techniques are created. Outside efforts should concentrate on supporting these settings technically, providing training for computer and network administration, and creating custom software appropriate to their cultural background and educational level.

I believe that simple programmable drawing environments for children should be introduced with figurative drawing themes, and can provide a platform for acquiring programming skills and consequently better general debugging skills. These methods can prove valuable in situations where they will confront the intricacies of adopting digital technologies. For instance, installing new software or configuring new devices still poses many problems in communities where the expertise of a good system administrator is non-existent. These problems can be solved using common debugging techniques for programming, such as isolating the problem by recreating the malfunction under different conditions.

Furthermore artisan should be specifically trained and encouraged to program their computational tools, I hope in the future some artisans in non-industrial non-developed settings can also be called hackers who will craft their software tools for designing their craft. Since the artisan has traditionally built his own mechanical tools, it is only natural that he tries to build his own digital tools. This will provide him the uniqueness he strives for and the partial autonomy from the industry he needs to survive.

Software developed for a non-industrial community should primarily support its main activities while providing pathways to branch into new interests. Additionally, the artisan should be shown how to find other publicly available software or services relevant for their craft or other computer related activities they need to perform.

⁴ QCAD <http://www.qcad.org>

From this experience I realize that creating new mediums of expression is not the only urgent research to perform in communities, it is as well urgent that they are introduced to computers in a meaningful way. Quality training should be provided to the network facilitator, he should be taught how to install, maintain and expand its hardware and software base. A possible way to provide this training is with apprenticeship programs where a network facilitator student would spend several month learning the networks facilitator skill and philosophies in some flagship institution.

For instance in Santa Clara del Cobre the printer wasn't shared on the network, it was moved around from computer to computer when different persons wanted to print. The end result was that everybody wanted to use only the computer that had the printer, since they didn't want to move the heavy printer around. Thus, lot of training has to be given for the administration of computer resources to. This can only be achieved by more training and education, not by new software environments.

One of the most fascinating parts of the experience of living in Santa Clara was to understand the priorities of the research that needs to be done for integrating meaningfully the computer to Santa Clara.

The computer is often advertised as a cornerstone for development but it cannot be. The computer can only form part of a larger effort, it can amplify the effort but it cannot be the seed. The seed will be found in the community's activity, and can be fed by a good computer facilitator. The facilitator with a deep understanding of the tool and its representational advantages is very difficult person to find or educate since he must have the social and human skills to understand the needs of the user and the technical skills to guide the user in the use of the computer.

6.3 Conclusion

This thesis presents the design and implementation of a craft-computing environment for non-industrial settings. The goal of the software's development was to provide a drawing-centered digital design space for artisans and students of an elementary school. I feel that the economical and technical requirements were fulfilled but the research and artistic requirements where only partly satisfied.

For the elementary school students, Estampa should be redesigned to constrain the drawing themes to figurative subjects composed by patterns that children are naturally inclined to draw. This will prevent children from drawing subjects that do not incorporate patterns and thus are problematical or tedious to programming (such as Pancho's car). A plausible avenue for finding programmable drawing subjects based on patterns would be to take a subset of those described in Best Maugard's book, such as flowers, and customize an Estampa specifically for creating them. The language would directly address the creation of a petal row by defining the shape, size, number and orientation of petals.

Another essential requirement for using digital design is that quality technical training is provided to the network administrator. A CAD system is rendered unusable if the computer where it is hosted is out of service. Furthermore, the network administrator should become more of a network facilitator. After the initial setup of the computer infrastructure, the network administrator should take the professional role of an advisor for the user, ready to guide and explain the tool and how it could be useful to him.

The utility of Estampa for the artisan remains inconclusive. Though the programming metaphor was clearly understood by the artisan, the method for introducing the tool must be refined by conducting a longer-term introduction. The introduction should focus on strategies for introducing the tool to the artisan in such a way that he is directly convinced of the distinct value it brings to his work. As explained to me by Metcalf - it is naive to think that an artisan will adopt a tool because it is new or better than his present tools. The artisan will only adopt a tool if he is convinced that it raises the uniqueness or quality of his work, or decreases his manufacturing time while maintaining that uniqueness and quality of his work.

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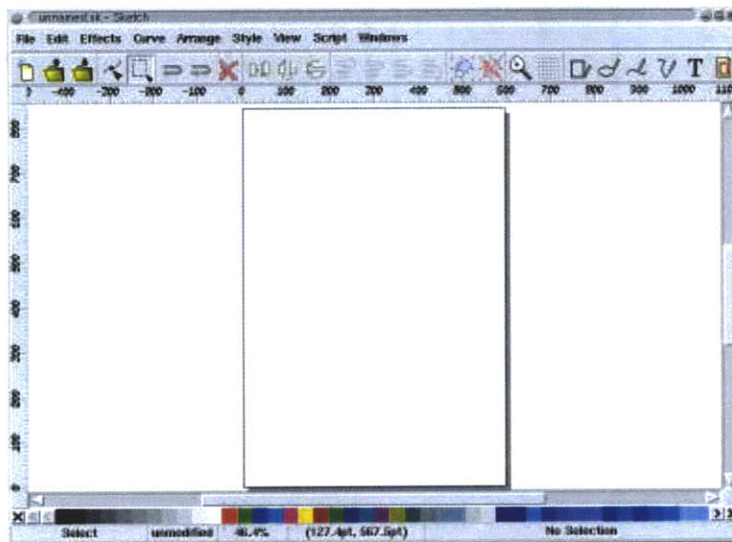
Skodnick R (1998). *James Metcalf of Santa Clara del Cobre*, Metalsmith Volume 18 Number 1.

Appendix A

Estampa Walkthrough

A. 1 Overview of Estampa

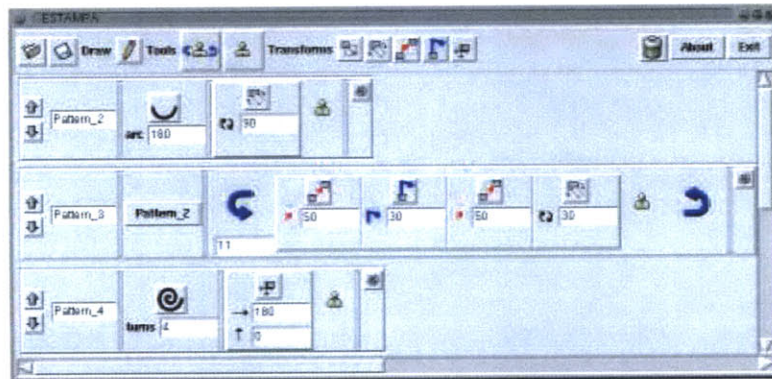
The Estampa tool was created around a method for drawing that Adolfo Best Maugard described in his book "A Method for Creative Design"(Best Maugard, 1927). This method uses seven primary motifs to create patterns. These motifs are the spiral, circle, half-circle, s-form, wavy-line, zigzag and line. They are combined to form different patterns, border arrangements, all-over patterns and rosettes. Estampa (Environment for stamping patterns) is a plugin for a vector drawing program called Sketch.



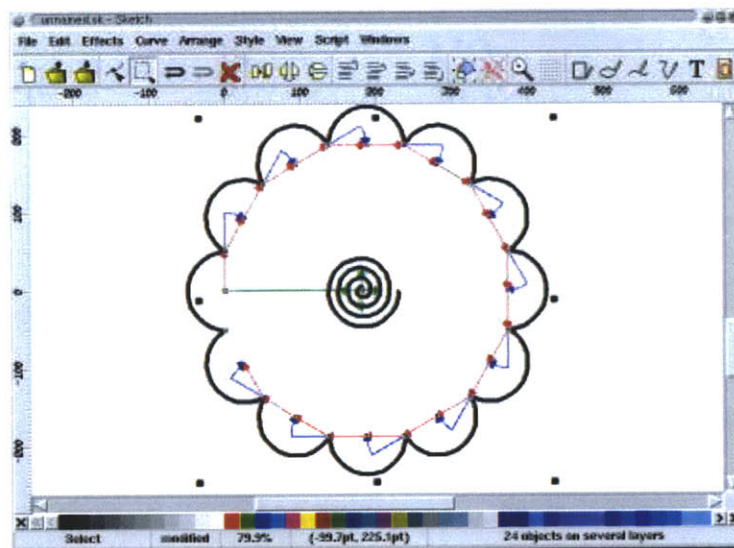
It is important to have some basic understanding of how a vector drawing program works. I would advise you to try to play around with it a little bit and if you feel that the interface isn't intuitive enough for you to read the to be comfortable. The Skech user's guide and tutorial are good sources for more advanced information.

A.1.1 How does Estampa work?

To draw a pattern with Estampa, you create a program that consists of several rows. Each row uses either a stamp or a multi-stamp tool, as seen below.



If executed, the previous program it will create the following pattern.

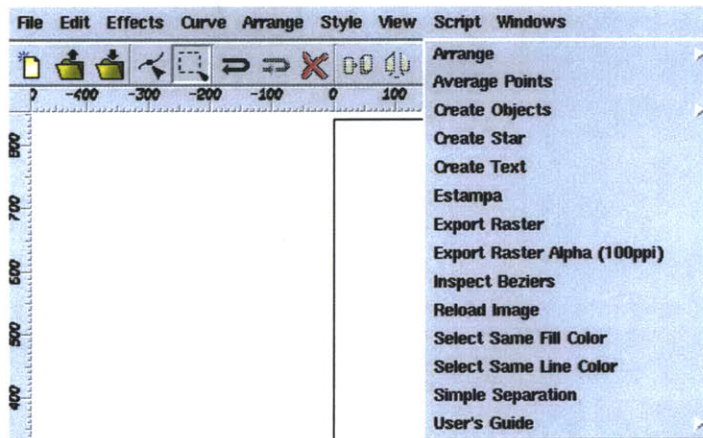


The pattern consists of the drawing (the black thick lines), while the green, red, and blue arrows are auxiliary lines that represent the execution of the program. They provide you with better insight about what the program is doing.

A.2 Getting Started

A.2.1 Starting Estampa

To start Estampa, select Estampa from the script menu.




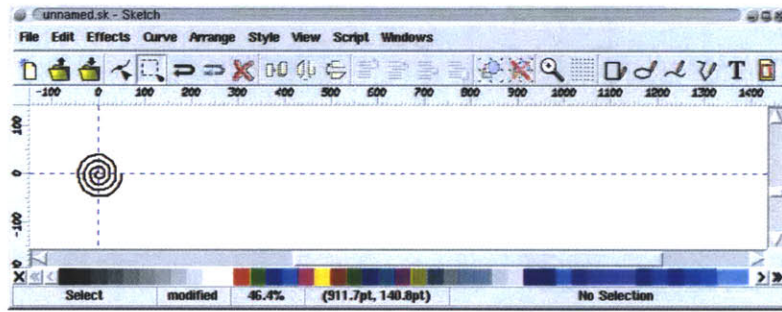
A new window will pop up where you will be able to create stamping rows. This is the main Estampa interface where you will do all your programming.



A.2.1.2 Stamping rows

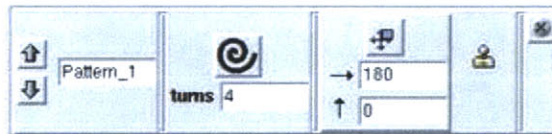
Now let's make our first stamp. Click the stamp icon  and a row then appear within the Estampa window.



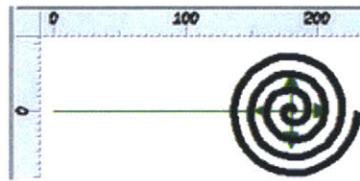
If you then press the drawing icon , a spiral with four turns will be drawn in the Sketch drawing area.




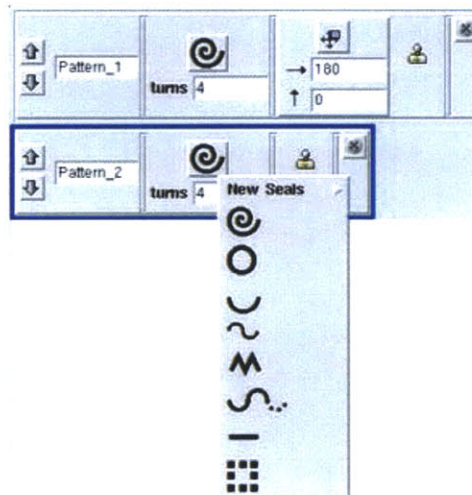
Let's now apply a transformation to the pattern. Click on the move icon  and type the number 180 next to the horizontal arrows and 0 in next to the vertical arrow. Click the drawing icon  to execute your program again




You can note that the spiral was stamped at the (180,0) coordinate, a little to the right of where it was before.



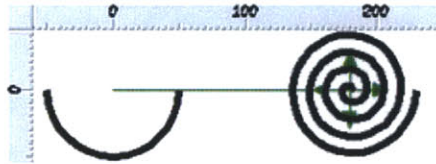
Now let's say we want to stamp another pattern, a half circle. Press on the stamp button  again, and then press on the spiral in the new row that appears.




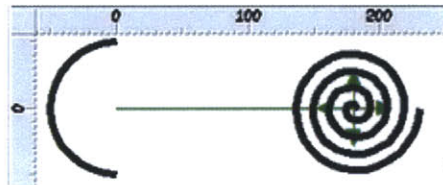
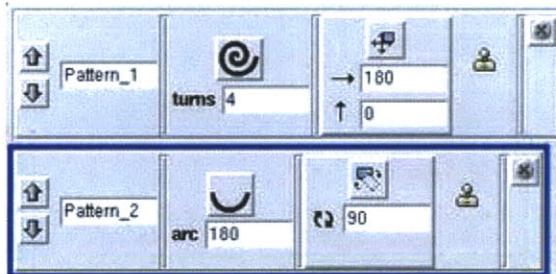
Now press on the half-circle :




This would execute the following drawing:




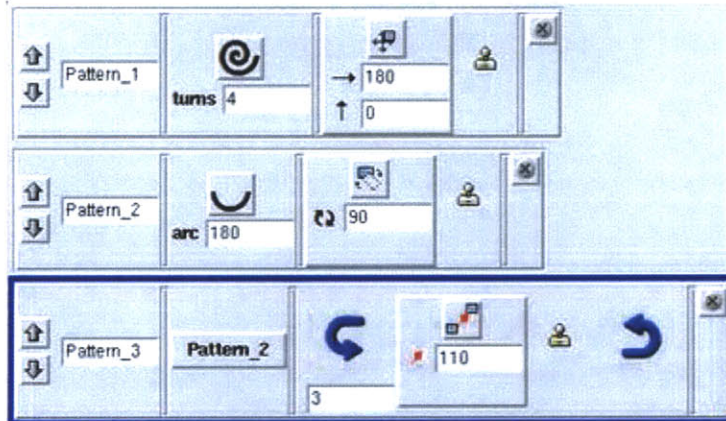
Now let's rotate the circle the right 90 degrees. The rotate command  must be used to achieve this:



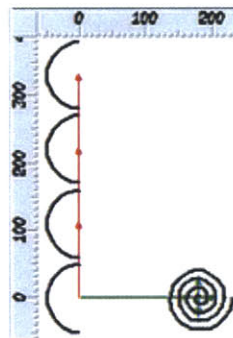
A.2.3 Multi-Stamping

Let's use the multi-stamp  tool to stamp several patterns. Change the number below the turning arrow. To alter how many of our seed motif will be stamped, let's now change the seed motif from a spiral to `Pattern_2`. Press the name of the previous pattern, the spiral and the seed motif menu will appear. Now, press the "New Seals" and under the submenu select `Pattern_2`. The seed for this row will now be the `Pattern_2`, the half circle we just rotated. If you look of the second row, on the left you see that it is named `Pattern_2` too. Press the




forward transformation  and change the number underneath the icon to 110 and the following program will result:



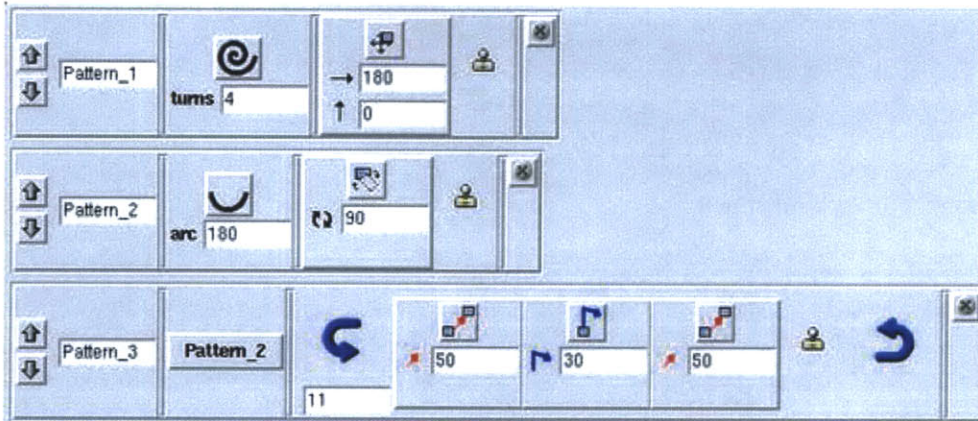
After pressing the drawing button , the following pattern will appear.



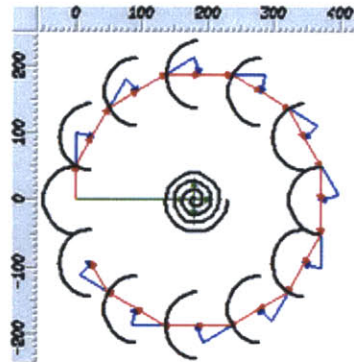
Now let's make a circle of half-circles:


- Change the forward transformation  to be 30 points
- Add a turn transformation  with 30 degrees
- And another forward transformation  with 30 points

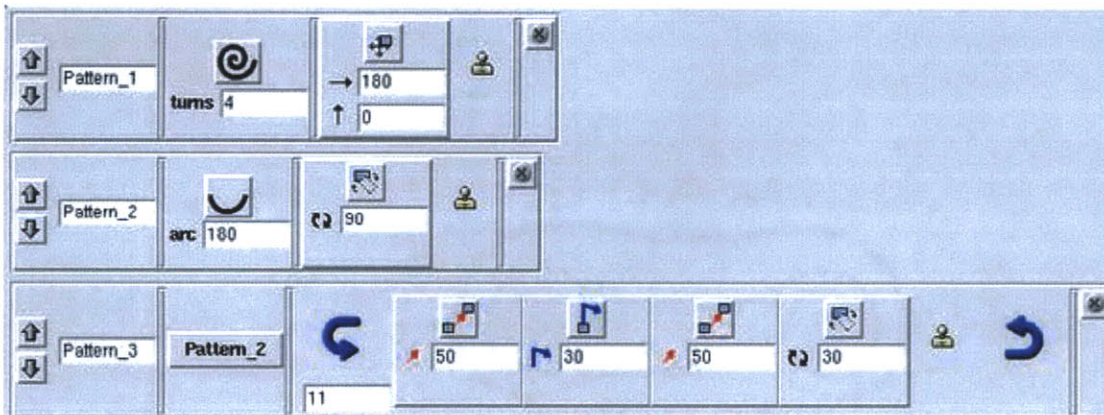
The resulting program will appear as:



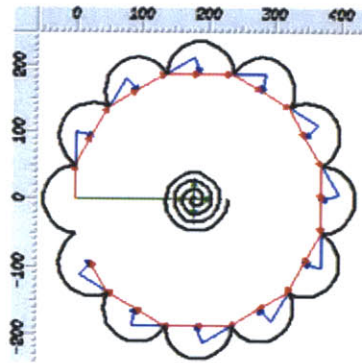
creating the following figure



Now let's make the half circles look inwards by inserting a rotate  in the multi-stamp:














Note how the half-circles are oriented to the center of the flower.



A.3 A Closer look at Estampa

A.3.1 The Toolbar

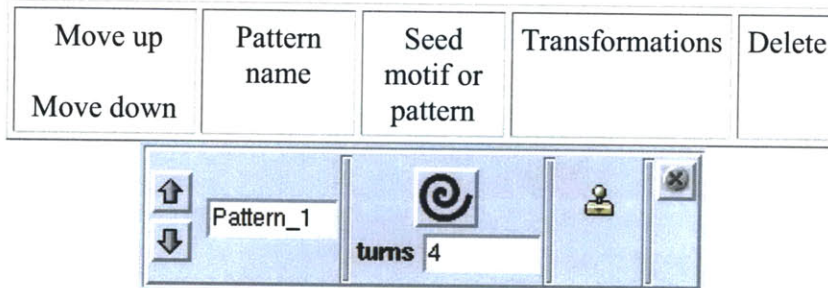
The toolbar contains the buttons that allow us to create, save and load an iconic program. The next table briefly explains the role of each button in the tool bar.

	Open	Opens Estampa files
	Save	Saves the programmed pattern
	Draw	Draws the programmed pattern
	Multi-Stamp	Creates a new multi stamp row
	Stamp	Creates a new stamp row
	Rotate	Rotates the shape
	Scale	Scales the shape
	Forward	Moves the pattern forward in the direction of its heading
	Turn	Sets the direction in which the pattern will step forward
	Move	Moves the pattern according to an arrow defined in x, y coordinates
	Clear	Clears all the rows

A.3.2 The Row

There are two types of rows in Estampa, a stamping row and a multi-stamping row:

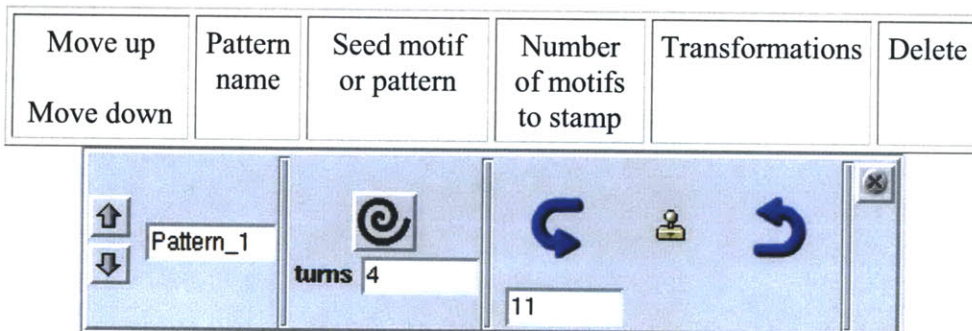
Stamping row



A stamping row allows applying transforms to a single motif or a pattern which can be moved, scaled or rotated.

Multi-stamping row

A multi-stamping row allows for creating a pattern with a motif or a previously made pattern. In order to create this pattern, the seed shape is deformed (scaled, rotated), duplicated, then moved to another location by using a command for translation (forward, turn and move).











Let's look in detail at what the stamp row program means. From left to right, the stamp row is composed by:

- Arrow that allows moving the row up or down.
- The name of the Pattern the row will create.
- A seed motif that can be a spiral, circle, half-circle, s-form, wavy-line, zigzag, line or another row in your program.

- The transformations that will be applied to the selected motif or pattern.
- A button for deleting the row.

A.3.3 The Motifs

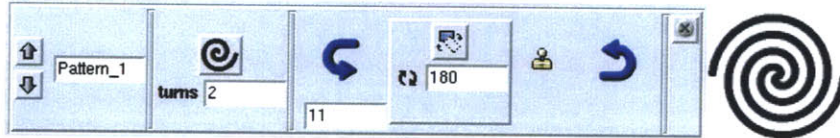
Estampa can be used with the seven primary motifs of a selected pattern.

 turns 4	Spiral	Creates a spiral. The parameter indicates the number of turns.
	Circle	Create a circle.
 arc 180	Half Circle	Create a half-circle The parameter indicates the length of the arc. The minimum value is 0 the maximum value is 360 which creates a circle.
 arc 180	S-Form	Create an S-form The parameter indicates the arc of the two half circles that compose the motif. The minimum value is 0 the maximum value 360, which creates two circles side by side horizontally.
 arc 45 bumps 1	Wavy-line	Create a Wavy-line: The first parameter indicates the angle of the arcs that compose the wavy-line, the second parameter indicates the number of bumps that the Wavy-line will have (a bump equals a half circle). The minimum value of the arc is 0 the maximum value is 360.
 angle 45 peaks 4	Zigzag	Create a Zigzag: The first parameter indicates the inward angle between two segments. The second parameter indicates the number of segments of segments that the zigzag has.
 angle 0	Line	Create a line: The parameter is the angle of the line. The minimum value is 0; the maximum value is 360.
	Selected Motif	Create the Selected Motif

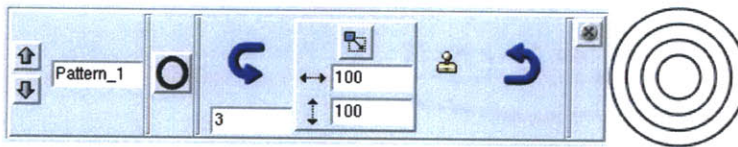
A.4. Stamping Common Patterns

A.4.1 Equidistant Motifs

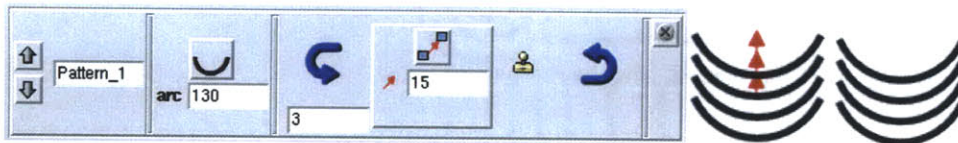
Double Spiral



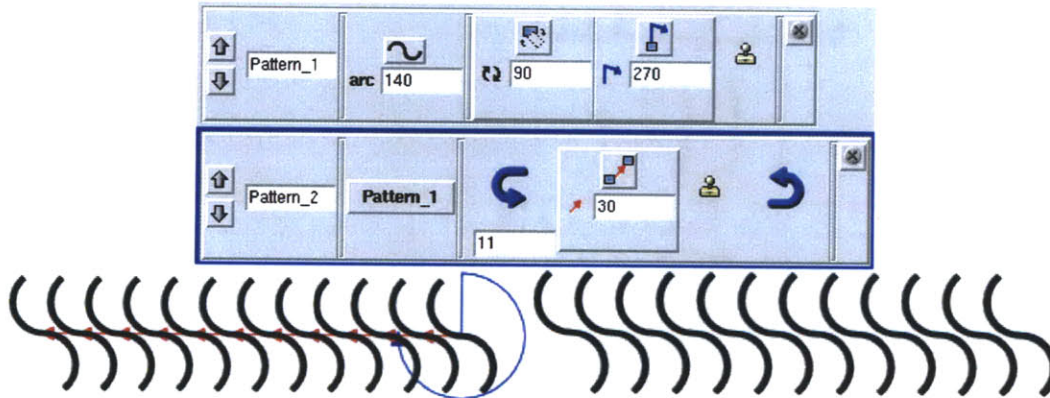
Concentric Circles



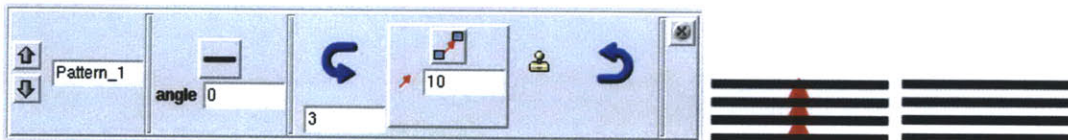
Upward Half Circles



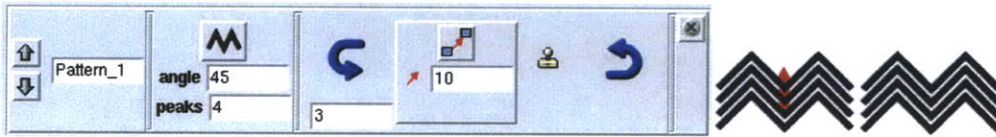
Equidistant S-Form



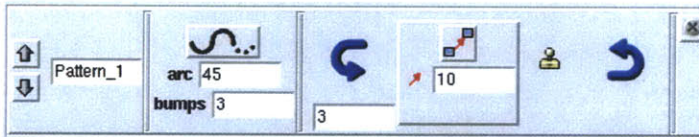
Parallel Lines



Parallel Zigzag

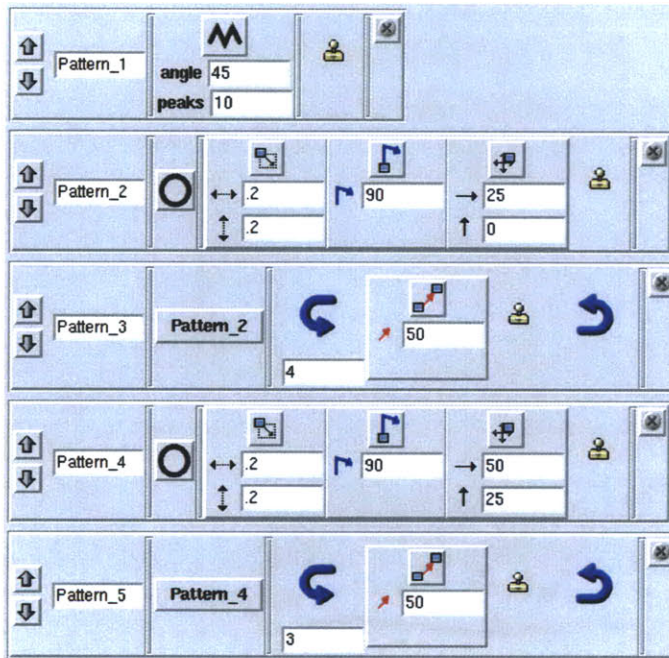


Parallel Wavy-line

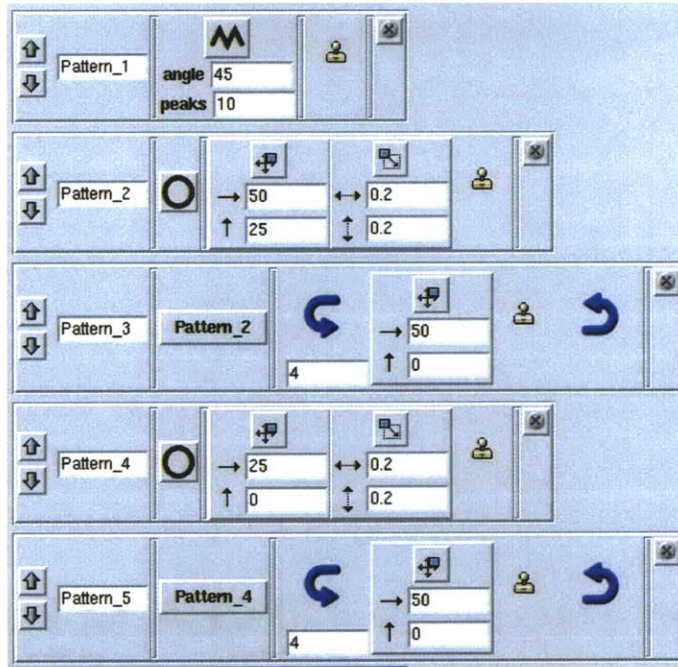


Combined Borders

Solution 1

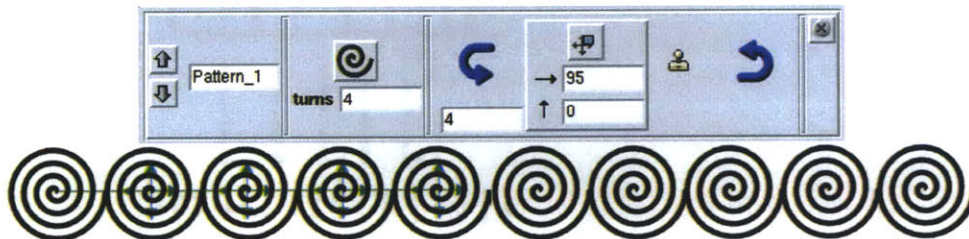


Solution 2

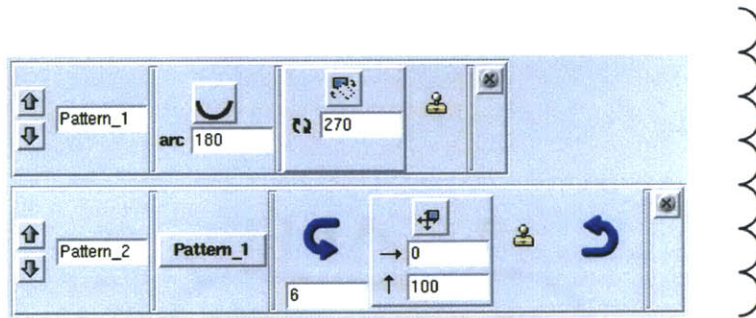


A.4.2 Position of Motifs

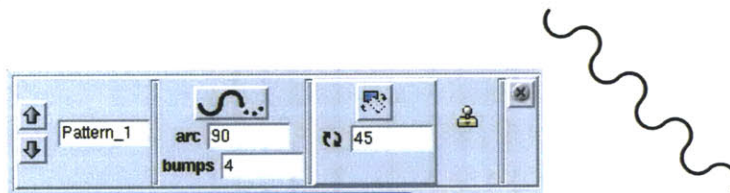
Horizontal



Vertical



Right-hand Oblique



Left-hand Oblique



A.4.3 Rosettes

