# Weaving Mondrian with GeoGebra

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## Abstract

This workshop will introduce participants to the art of lap loom weaving. Each participant will create a small project, inspired by the artistic work of Piet Mondrian. Geometric connections will be explored through the use of GeoGebra. We will also explore ways in which mathematics curriculum is complemented by creative artistic activities such as weaving. Workshop participants will have the hands-on opportunity to produce their own artifact which will be theirs to keep at the end of the workshop. There will be a discussion on how different activities, related to weaving and GeoGebra, could be implemented or extended to accommodate for students of various abilities and interests. All materials needed for the workshop will be provided.

## Introduction

The mathematics that underlies some sophisticated weaving work can be difficult to teach to elementary students. In a sequence [1, 2, 3, 4, 5] of Bridges papers over the past few years, Ahmed and Deussen discussed the mathematics and algorithms used to produce different types of weaving designs. These include matrices and the use of binary numbers, concepts that are typically not taught as part of the high school curriculum in North America. McBurney [6] presents the development of the weaving process in a manner that is understandable to the middle and high school student. In her paper she emphasizes the algorithmic aspect of the weaving process through the LOGO programming language. However, some of the concepts and ideas behind lap loom weaving can be easily explored by elementary school students in a variety of ways. In this workshop we will discuss and apply some of these ideas in a way that is accessible to young students.

**Figure 1:** *Workshop with parents and their children.*

This workshop has been designed to promote the connection between geometry and art. Participants are inspired by the seamless integration of mathematics and art through the blending of textiles and technology. It is a modified version of a seven week course developed and applied with elementary students at a private school in Canada. The success of the course motivated the authors to create a shortened version for adults who are interested in mathematics and arts. A similar evening workshop was also conducted at the school with a group of parents and their children (Figure 1).

The main activity of this workshop is to create a small weaving artifact that mimics Piet Mondrian's art style (Figure 2). The work focuses on integrating art and geometry through the use of GeoGebra, the digital tool used for sketching the woven project. The combination of computer based design with hands-on weaving allows participants' to appreciate the beauty of geometry, and its applicability in the world of art and design. Participants further explore connections between mathematics and art, and their creative outlook is broadened by the harnessing of GeoGebra. Both geometric constructions and weaving skills can be modified to different learners and adjusted to various levels of difficulty. This allows even the youngest participant to develop practical skills working with GeoGebra and later with the lap loom. During the workshop participants will have the opportunity to share ideas on how to replicate the activities in the classroom or in other contexts. Practical instructions and guidelines related to the workshop will be provided, and will also be available on the GeoGebra platform [7].

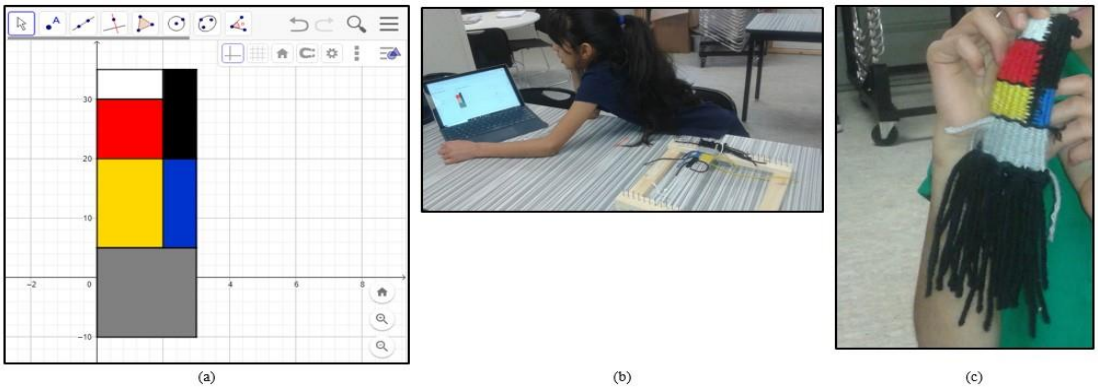


**Figure 2:** *(a) the final construction of the sketch in GeoGebra, (b) student checking it during the process of weaving, and (c) the final woven project (bookmark).*

Creating weaving patterns is an art that can be challenging when required to follow certain structures or rules. It is also very rewarding since it can produce beautiful artifacts. The GeoGebra software is a perfect geometric and algebraic tool that allows us to create visually appealing images based in mathematics properties and definitions. Piet Mondrian's simplistic style of art that is built on parallel and perpendicular black lines, asymmetry and bright primary colours provides the seamless inspiration to make the connection between weaving and GeoGebra. In the case of this workshop, Mondrian's style fits perfectly since the designs are simple and easy to replicate in both mediums: GeoGebra and weaving.

## Weaving

Weaving can be done in many different ways, but the type used in this workshop is called lap loom weaving. A lap loom is a smaller loom that looks similar to a wooden picture frame. Nails or notches are evenly spaced along the top and bottom of the frame, which allows for the warp threads to be strung vertically. Warp threads are the vertical strings usually strung with a sturdy cotton yarn that the weft threads (threads that are strung from left to right) are woven on to (Figure 3). The most basic weaving stitch is called tabby weaving. Tabby weaving is where the weft threads are woven in an over-under pattern along the warp. In lap loom weaving, a tapestry needle is used to thread the tabby stitch along the warp. This stitch is repeated to build the height of the weaving. Alternating colours of yarn for the weft allows the weaving to become more intricate and complex creating different patterns and designs. Changing colours or adding more yarn of the same colour is quite simple, and should always be done by leaving a two-inch tail at the beginning and end of each strand of yarn. The pieces of yarn being used should be cut no longer than the length of one's arm span to avoid tangling.

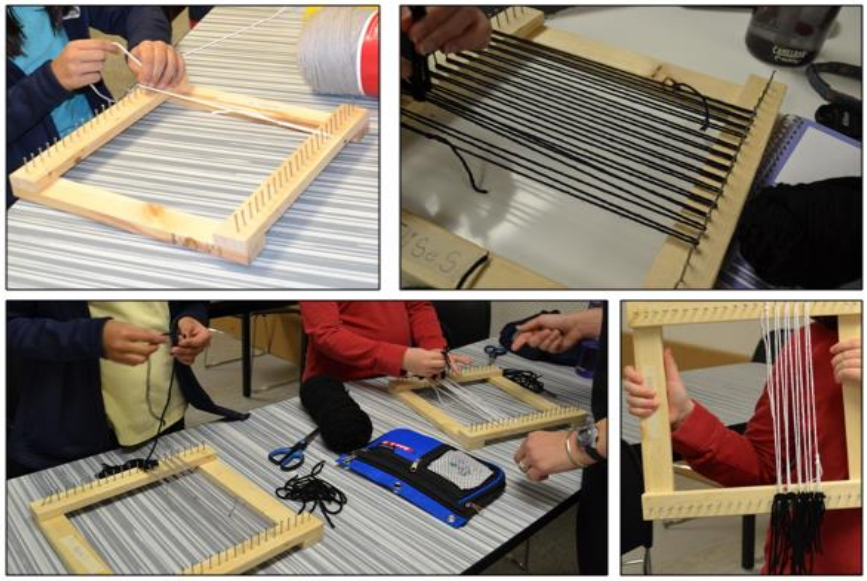

**Figure 3:** *(a) student warping the loom; (b) warped loom; (c) warping the loom; and (d) warped loom with tassels added at the bottom.*

As the weaving is being worked on, a wooden comb, or weaving comb, can be used to lightly pack the wefts into place after a row has been woven. In our workshop we will use a plastic fork in place of the wooden comb. Once all of the tabby weaving is complete, the two-inch tails at the beginning and end of each strand must be tucked into the back of the weaving. This is done by simply threading the tail through the weft on the back side of the weaving so that the front side remains polished. Then the warp threads can be popped off the nails of the loom, and tied in knots at the top of the weaving. This ensures that the weft is held in place. Any excess warp threads need to be tucked into the back of the weaving as well. It is now up the weaver to decide what finishing touches are to be made. For example, the weaving could be hung on a wooden dowel in order to create a wall hanging, or it could remain as is and be used as a coaster. In this workshop, the intended outcome will be a bookmark.

## Why sketching in GeoGebra?

GeoGebra has a friendly interface that allows the user to easily and quickly create beautiful constructions that can be attractive and fun for young students. In addition, a construction can be quickly and effortlessly modified. For example, a few students finished their first version of the sketch, but decided to change the colours or the shapes of their artwork. They were able to make these changes without any programming difficulties. From a mathematics perspective, GeoGebra stands out as a powerful tool that permits students to explore and learn about many mathematical concepts. For instance, in this course, students started by simply plotting points in a Cartesian system and drawing parallel and perpendicular lines to the abstract idea of input and output when customizing a new constructing tool.

## Activities

In this section we briefly describe selected activities that will be offered in the workshop to create the woven bookmark as shown in Figure 2. Detailed information and other ideas will be discussed during the workshop.

### *Warm-up*

First, we will briefly discuss our experience with students, our motivation to start the course and some of the learning that took place. We will show a bit of Piet Mondrian's famous artwork and ask participants to describe what they observe and the common themes among all of the images. Participants should notice the use of six colours (blue, red, grey, black, white and yellow), each shape is a quadrilateral, specifically a rectangle, outlined in black, and the use of parallel and perpendicular lines.

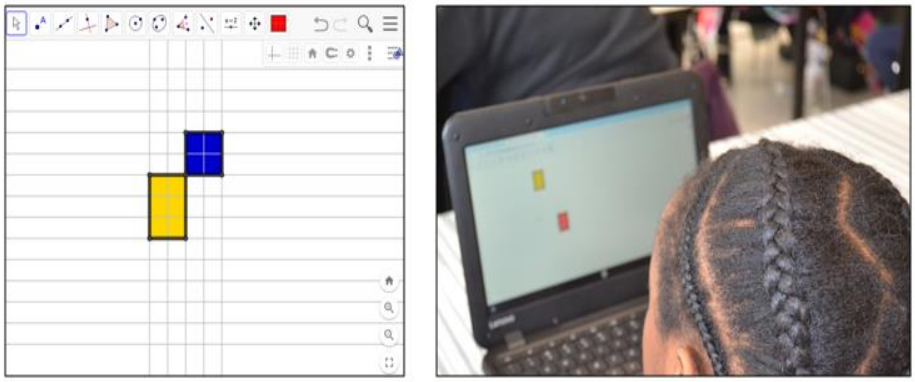

**Figure 6:** *(a) premade template with some of the customized tools applied; (b) student using the template and the tool to create her own sketch.*

### *Sketching on GeoGebra*

Through the use of GeoGebra, participants will create sketches of Mondrian's artwork focusing on the concepts of parallel and perpendicular lines, creating polygons and scaling shapes. They will be led through a quick tutorial of these processes and then create their own pattern using a pre-made template and tool

(Figure 6) that will be accessible to them on the GeoGebra platform. The pattern will be made on a coordinate plane spanning from the origin to the x-intercept of (5, 0) making it a manageable sized project. The vertical lines y=0, y=1, y=2, …, y=5 will scale to two warp threads on the weaving. Participants will build their pattern vertically using a pre-made GeoGebra tool to create a combination of rectangles in the six prescribed colours. While creating the sketch participants should think about the application of the sketch to a woven piece. For example, tiny rectangles will be harder to weave than medium to large sized rectangles. They will also have to consider the scaling required when going from the sketch to the actual weaving.

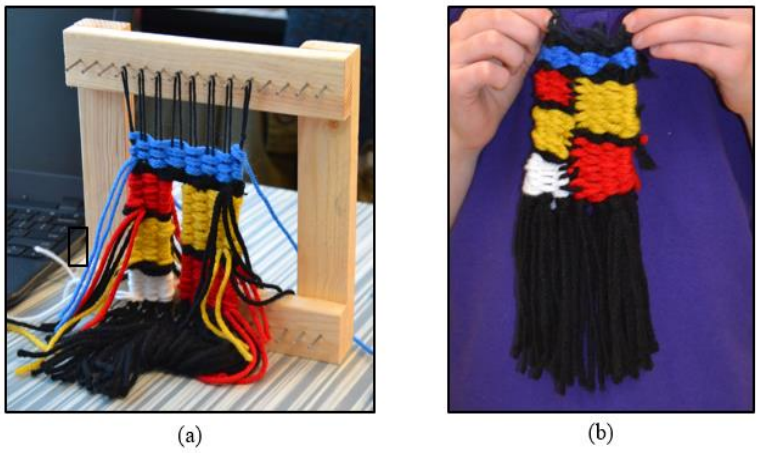


**Figure 7:** *(a) weaving not interlaced and with all lose strands and "yarn tails"; (b) final artifact in which it is possible to see the vertical black lines created using the technique of interlacing.*

***Weaving the artifact***

Once the sketch is created, participants will learn about the basics of lap loom weaving. They will be using small looms (4 inches by 8 inches) with nails placed one centimeter apart, as the intended woven artifact will be a small bookmark. The looms will be pre-warped over five nails and black tassels will already be added at the bottom of the weaving to give it a more finished look. Each vertical line on the GeoGebra sketch will map to two warp threads on the loom. Participants will follow the GeoGebra sketch by tabby weaving, starting from the bottom of the sketch and working their way up. They will change colours of yarn when appropriate making sure to weave a black row horizontally in between colours. Once most of the weaving is done, participants will use a technique called interlacing to connect each shape vertically. Interlacing with black yarn, applied in combination with the horizontal black row of tabby weaving, will create the outline of each polygon (Figure 7). To finish the weaving, participants will tuck all lose strands of yarn into the back of the weaving, and tie the warp threads in knots to secure the weaving at the top. Once this is complete, the weaving can be removed from the loom, resulting in a finished artifact.

***Discussion***

Students could create the GeoGebra sketch from scratch, meaning they do not use a pre-made tool; alternatively they could learn how to create a tool themselves. This involves more knowledge and introduces students to the idea of functions, spurring dialogue on the topic of inputs determining outputs.

Students could be given a completed sketch to then weave and learn the logistics of proportions through touch and application. Students could reverse the process by weaving a design first, and then create a sketch of the finished project in GeoGebra. Sketches and weavings of different sizes could be created and could also incorporate different geometric shapes and colours. The GeoGebra sketch allows for conversations about area and perimeter of each quadrilateral, and the area of each shape could be looked at as a fraction of the entire area. Conversations regarding fractions, decimals, and percentages could easily apply here. The possibilities to expand upon this workshop are endless.

## Conclusion

In summary, we hope this workshop proves to be a valuable resource for participants to use in the classroom by appealing to different types of learning and bridging the gap between mathematics and art. Exploring the student's creative side through weaving and GeoGebra can bring greater understanding of abstract geometric ideas and broaden artistic skills. The weaving piece created provides participants with a hands on experience of geometric properties, while the GeoGebra portion allows students to explore geometric concepts through a computer-based tool. We hope too, that the experience will result in a valuable opportunity for participants who attend to embrace creativity in mathematics. We expect that it will inspire them to repeat the activities in their own classroom or workshops, and further enrich the minds of others.

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