

Creating Painting Puzzles: Math, Art, Games and Technology

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Abstract

This workshop reproduces an activity developed with elementary students and aims to create a digital 8-piece sliding puzzle based on artistic self-portrait. The activity integrates mathematics, art, coding, and gaming by using Dynamic Geometric Software GeoGebra and other digital tools to edit artistic images. Workshop participants create their own digital 8-square puzzle, and have the opportunity to discuss implications for classroom practice, and how different steps can be adapted, implemented and extended to accommodate students of different abilities and interests.

Introduction

This workshop has been designed to promote the teaching of mathematics in which learners can connect art and games to enhance their learning of mathematics and logic. It is inspired by a successful semester course developed and applied with elementary students in a Canadian school. A similar workshop was also conducted in a mathematics education program at an Austrian university. The experience motivated us to create a shortened version of these activities targeting adults who are interested in mathematics, arts or games¹.

The experience has indicated that the strong emphasis on connecting mathematics to other areas was valuable for students to realize how entertainment activities can rely on mathematics. Using interdisciplinary thematics, like arts and games increased student motivation and achievement in logical comprehension and visual/spatial awareness. Boaler and Selling [1] highlight that “a number of studies have documented the value of instructional approaches in which students are actively, rather than passively, engaged in mathematics”. This workshop is designed to reinforce this view. Participants will become familiar with the software GeoGebra by building their own puzzle. Acting as learners themselves will, in turn, strengthen their learning/teaching, and allow them to bring innovations to their classrooms.

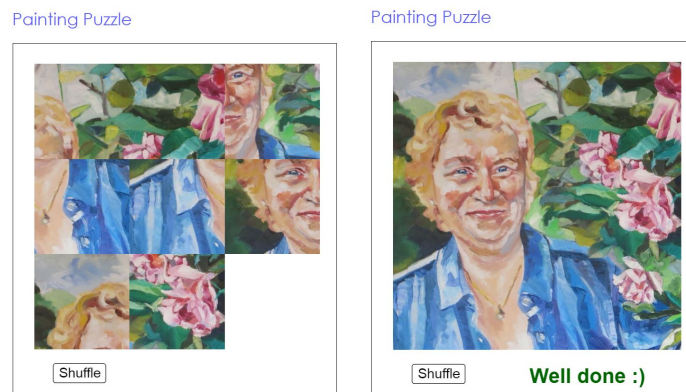


Figure 1: Puzzle based on painting of Barbara Kimeswenger, available on <https://ggbm.at/W87Rfz4D>

¹ Because of privacy and consent matters we decided not to use any of the games produced by students including their self-portrait photos in this paper.

The main activity of this workshop is to make an 8-sliding square digital puzzle as shown in Figure 1. It combines the use of different technologies and tools.

The work focuses on integrating geometry and coding to make a puzzle that can be played online by anyone. The tasks should increase students' motivation and enjoyment of mathematics; explore connections between mathematics, logic and art; broaden students' creative outlook and develop practical skills. Both coding and geometric constructions can be modified to adapt students' different learning styles and adjusted to various levels of difficulty.

Participants will also have opportunity to share ideas on how to replicate the activities in the classroom or other contexts. Practical instructions and guidelines related to the workshop will be provided.

Activities

In this section we briefly describe selected activities that will be offered in the workshop to create the sliding puzzle as shown in Figure 1. Detailed information and other ideas will be discussed during the workshop.

Warm-up. First, we will play a 6-piece sliding puzzle based on a famous Equatorian painting *Los Mutilados* (The Mutilated) created by Oswaldo Guayasamin (1976). The artwork (Figure 2) captures people who lost limbs addressing the Spanish Civil War.



Figure 2: *Los Mutilados* by Oswaldo Guayasamin, available on <https://www.geogebra.org/m/XZyk4jPn>

This painting has a strong combinatorics appeal as it is “mutilated” in six panels that can be moved and rearranged in multiple ways without changing the underlying message. Considering that, and ignoring the upside down symmetry, there are precisely $6! \cdot 4^6$ possibilities to combine the panels. During this activity we will briefly discuss it and offer some ideas on how students can be challenged to determine the different ways in which the panels can be arranged. We will also discuss how those arrangements turn up in some other games that use other regular polygons for its pieces shape. This brief discussion can lead to another discussion in how different shapes can be used to tessellate the plan, and why only three regular polygons can tessellate the Euclidean Plane.

Creating a self-portrait and applying artistic filters. Participants will take photos with their smartphone cameras. They will apply the Prisma app [3] to edit their portrait using different artistic filters. Figure 3 presents examples how the appearance of a photograph (see 3a) can be completely changed to

receive an artistic effect (3b, 3c and 3d). The use of filters and the square-chop tools will add a personal and artistic touch to the final product integrating technologies into the project.

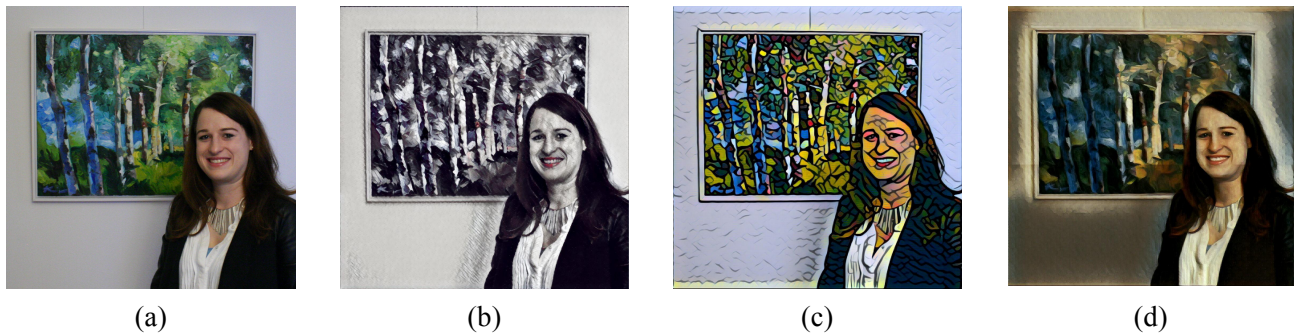


Figure 3: *Applying artistic filters*

Dividing the portrait into pieces. After creating artistic portraits, participants will digitally cut them into nine square pieces and upload them to the GeoGebra Materials Platform [2].

Applying GeoGebra. In this step, participants will use the Cartesian Plane as reference to allocate the pieces and to translate them properly at GeoGebra interface. When playing the game it is necessary to click in a piece next to a blank square in order to make the piece move or slide to an empty space. To produce this effect, it is necessary to develop strategies on how to implement it. This offers an excellent opportunity to introduce mathematical concepts involving coordinates and translations. Figure 4 illustrates a possible solution of such a 3x3 sliding puzzle based on the previously discussed example in Figure 1. In 4a the pieces are mismatched, while in 4b we see how the pieces should be arranged when the puzzle is solved. It is important to highlight that once the puzzle is solved the empty space is filled with the remaining piece and a message appears on the screen.

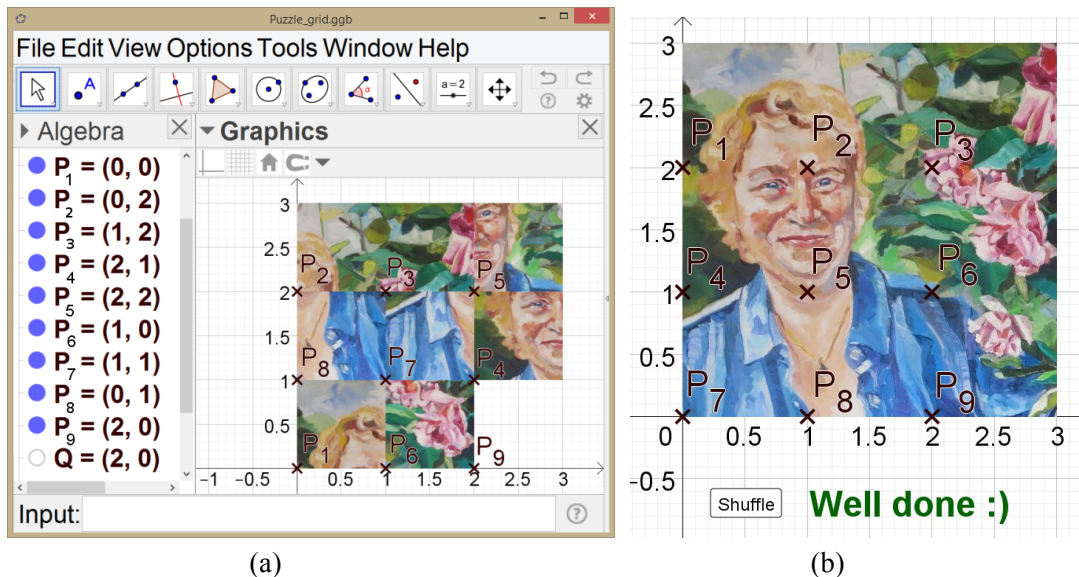


Figure 4: *Creating the 3x3 sliding puzzle by using GeoGebra*

Both screenshots in Figure 4 include the coordinate system containing important elements of the game's background. Each of the eight squares dividing the female portrait is connected to a point ($P_1, P_2,$

P_3, P_4, P_5, P_6, P_7 or P_8). For example, the four pieces showing the woman's face are related to the points P_1, P_2, P_4 and P_5 . In other words, the position of each square depends on these points' coordinates.

Adding coding. Participants will add code to the pieces of the puzzle. They will be challenged to predict the outputs and understand how to modify it accordingly. This activity works perfectly as a means to introduce the use of logical operators like *and/or* and *if/then* found in some many programming languages. One particular example of it is how to implement a code that will make a message appear when the puzzle is solved (Figure 5b). For instance, in our example the player receives the feedback “well done :)”, and afterwards can push the “shuffle” button to restart the game. For both situations, receiving a written message or having an action button, is necessary to program the software and understand the logic behind the code. For example, the piece related to the point P_9 complements the painting and is only displayed if all points have the correct coordinates. For this to happen the following mathematical statement has to be coded: “ $P_1 \stackrel{?}{=} (0, 2) \wedge P_2 \stackrel{?}{=} (1, 2) \wedge P_3 \stackrel{?}{=} (2, 2) \wedge P_4 \stackrel{?}{=} (0, 1) \wedge P_5 \stackrel{?}{=} (1, 1) \wedge P_6 \stackrel{?}{=} (2, 1) \wedge P_7 \stackrel{?}{=} (0, 0) \wedge P_8 \stackrel{?}{=} (1, 0)$ ”. During the workshop we will discuss and brainstorm some ideas in how code elements can be further explored, and how the constructions can be modified to other contexts using GeoGebra.

Sharing the puzzle. Participants will be encouraged to share their artistic puzzle using the GeoGebra Materials Platform [2]. The discussed game (see Figures 1 and 5) is available online at <https://ggbm.at/W87Rfz4D> and can be downloaded to further examine its construction and coding elements.

Discussion

This workshop will inform and educate participants on how to implement a cross-curricular activity involving art, programming and mathematical elements. The activities will provide techniques that can be further explored in various classroom settings and by learners of different abilities. The game to be created by the participants will explore different geometric properties, and GeoGebra will make it very visual and easier to understand. The process of creating the game will consider basic programming elements that will enrich the experience and the learning process. Moreover, participants will apply filters to add the final artistic touch and to highlight the visual appeal. These effects will be added online applying different digital tools and discovering smartphone apps.

We also hope that the strong emphasis on connecting mathematics to other areas will result in valuable experiences for the teachers who attend. We expect that the experience will inspire all participants to repeat the activities in their own classrooms, thereby enriching the minds of their learners.

References

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