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► **To cite this version:**

Michela Maschietto, Beatrice Battilani. Mathematics laboratory on geometric transformations at the museum. Proceedings of the Fourteenth Congress of the European Society for Research in Mathematics Education (CERME14), Free University of Bozen-Bolzano; ERME, Feb 2025, Bozen-Bolzano, Italy. hal-05199714

HAL Id: hal-05199714

<https://hal.science/hal-05199714v1>

Submitted on 5 Aug 2025

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Mathematics laboratory on geometric transformations at the museum

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Keywords: Mathematical machines, geometric transformations, laboratory, museum.

Mathematics laboratory and mathematical machines

The idea of the mathematics laboratory has evolved over time in teaching and learning mathematics (Maschietto & Trouche, 2010). In Italian documents for mathematics curriculum (e.g., AA.VV., 2004), the mathematics laboratory is related to the construction of mathematical meanings and a crucial role is played by the use of material and digital artefacts. Mathematical machines are material artefacts related to geometric transformations, conic sections and perspective; they were built for didactic purposes, but they also are significantly related with the history of mathematics. Laboratory sessions based on the use of mathematical machines are designed within the Theory of Semiotic Mediation (TSM, Bartolini Bussi & Mariotti, 2008). They have been studied in educational research, mainly at upper secondary school (Maschietto & Bartolini Bussi, 2011); they are also proposed in out-of-school context laboratory sessions, such as at the university museum. We are interested in designing laboratory sessions for lower secondary school classes at the university museum (Laboratory of mathematical machines, www.mmlab.unimore.it), focusing on the mathematical machine for reflection (Fig. 1a). Our research questions concern: 1) How can the laboratory sessions implemented with upper secondary school students be adapted for lower secondary ones, 2) If the work on the mathematical machine in a laboratory session can foster the emergence of the meaning of reflection. In this poster, we aim to present the experimented laboratory sessions for 13-year-old students.

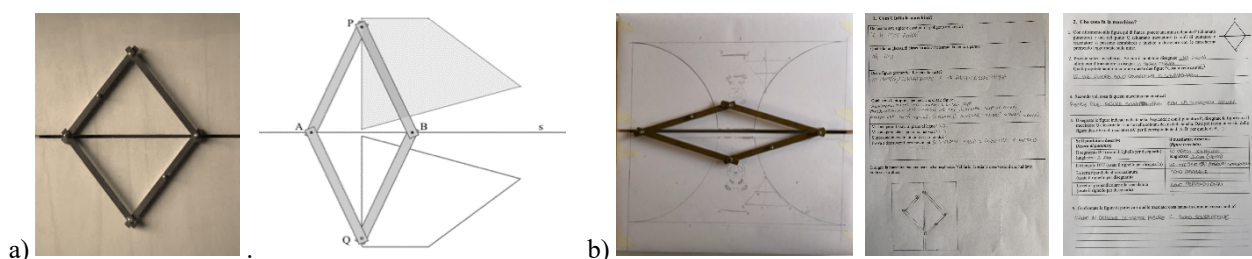


Figure 1: a) Machine for reflection, b) Students' drawing by the machine and worksheets

Methods

In previous research (Maschietto & Bartolini Bussi, 2011), the methodological elements of the TSM for teaching experiments in school have been adapted to a context beyond the classroom, where students go only once and are generally not familiar at all with mathematical machines. The exploration of the machines made through one worksheet and the final collective discussion has been maintained. To answer our first research question, we split the worksheet into two worksheets (the former concerning the description of the machine, and the latter guiding the identification of the reflection), considering linguistic issues, and added some support material to make the work with the machine easier and more pleasant for younger students. We also modified the structure of the

laboratory as follows: introduction of the geometric transformations; small-group work on the mathematical machine (Fig. 1a) guided by the first worksheet (Fig. 1b) with questions referring to the TSM (“How is the machine made?”); collective moment to share answers; group work on the machine with the second worksheet (“What does the machine make?”); collective discussion; final task. Each session lasts a maximum of two hours, including the visit to the exhibition of mathematical machines at the museum.

In spring 2024, we experimented with this new session with six classes of 13-year-old students. For each class, we collected the worksheets filled by the students, and the drawings they produced using the machine (Fig. 1b, left). Our analysis is based on these documents, as well as researchers’ reports of collective moments.

Analysis of students’ work

Regarding the first worksheet (Fig.1b, centre), students typically identified the rhombus and described its properties. In the last question of the worksheet, students were asked to represent the machine aiming to solicit their semiotic activity. The second worksheet (Fig.1b, right) asks students to draw using the machine and then to interpret/recognise the relationships between the obtained drawings. Although at the beginning of the session most students claimed that they didn’t know anything about geometric transformations, words that characterise symmetrical figures (“*equivalent*”, “*mirror*”, “*same perimeter*”, “*overlapping figures*”) appeared little by little, as well as descriptions of corresponding figures (“*The fire drawn following the stencil is upwards, while the fire drawn on the sheet is downwards. They are congruent*”; “[the machine] *makes two figures superimposable by reflection*”; “[the drawings] *are the same thing but they are upside down or mirrored*”). In the end, most students correctly identified the transformation, although without providing any justification, with a few exceptions (“*because the diagonals of the rhombus are perpendicular and bisect each other*”). Even if the definition of reflection is not stated with the students, the whole work with the machine allows words and action consistent with the meaning of reflection to emerge in the worksheets and during the final discussion. This suggests a positive answer to the second research question, but it also provides elements to revise worksheets for future work.

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